School of Ocean and Earth Science and Technology
Hawai'i Natural Energy Institute

UNIVERSITY of HAWAI'I
MĀNOA

September 25, 2012

Mr. Gary Hooser
Director
Office of Environmental Quality Control
235 South Beretania Street, Suite 702
Honolulu HI 96813

Dear Mr. Hooser:

Subject: Draft Environmental Assessment for Hawai'i Natural Energy Institute Electrolyzer-based Hydrogen Production System to Support Additional Variable Wind and Solar Renewable Energy Sources on the Grid and Provide the Hydrogen to Fuel Public Transportation Environmental Assessment, TMK 1-4-001:002 (por.) & 2-2-058:018 (por.), South Hilo and Puna Districts, Island of Hawai'i.

The Hawaii Natural Energy Institute hereby transmits the draft environmental assessment and anticipated finding of no significant impact (DEA-AFONSI) for the subject project for publication in the next available edition of the Environmental Notice.

Enclosed is a completed OEQC Publication Form, two copies of the DEA-AFONSI, a CD with an Adobe Acrobat PDF file of the same and an electronic copy of the publication form in MS Word.

Simultaneous with this letter, we have submitted the summary of the action in a text file by electronic mail to your office.

Please contact Mitch Ewan at 956-2337, if you have any questions.

Sincerely,

Brian Taylor for
Richard Rocheleau
Director
Hawaii Natural Energy Institute

Attach: As noted above

c: (w/o attach) Ron Terry, Ph.D., Project Environmental Consultant

12-138

1680 East-West Road, POST 109, Honolulu, Hawai'i 96822
Telephone: (808) 956-8890 Fax: (808) 956-2336

OEQC Publication Form
The Environmental Notice

Name of Project:	**Hawaiʻi Natural Energy Institute Electrolyzer-based Hydrogen Production System to Support Additional Variable Wind and Solar Renewable Energy Sources on the Grid and Provide the Hydrogen to Fuel Public Transportation**
Applicable Law:	Chapter 343, HRS
Type of Document:	Draft EA
Island:	Hawai\`i
District:	South Hilo and Puna
TMK:	(3^{rd}.) 1-4-001:002 (por.) & 2-2-058:018 (por.)
Permits Required:	County of Hawaiʻi: Planning Department: Plan Approval State of Hawaiʻi; State Historic Preservation Division Determination of No Effect
Name of Applicant or Proposing Agency:	State of Hawaiʻi, Hawaiʻi Natural Energy Institute
Address	1680 East-West Road, POST 109
City, State, Zip	Honolulu, Hawaiʻi 96821
Contact and Phone	Mitch Ewan, 956-2337
Approving Agency:	State of Hawaiʻi, Hawaiʻi Natural Energy Institute
Address	1680 East-West Road, POST 109
City, State, Zip	Honolulu, Hawaiʻi 96821
Contact and Phone	Mitch Ewan, 956-2337
Consultant	Geometrician Associates
Address	PO Box 396
City, State, Zip	Hilo HI 96721
Contact and Phone	Ron Terry, 969-7090

Project Summary. The Hawaiʻi Natural Energy Institute (HNEI) plans a project that will demonstrate the use of hydrogen as a potential energy storage technology, with an ancillary benefit of providing hydrogen for fuel cells that will power a County of Hawaiʻi Mass Transit Agency (MTA) bus. The project consists of three on-the-ground components: 1) Production with a hydrogen electrolyzer at the Puna Geothermal Venture plant to separate water into hydrogen and oxygen, store it in a low pressure buffer tank prior to being compressed to 450 bar and stored in composite high pressure cylinders specifically designed and manufactured to store hydrogen. 2) Transport of cylinders on U.S. DOT-approved 450-bar hydrogen tube trailers carrying about 230 pounds of hydrogen to the MTA base yard facility in Hilo (as well as to Hawaiʻi Volcanoes National Park). 3) Dispensing of hydrogen into a 19-passenger ElDorado MTA shuttle bus with a 10 kg-capacity tank.

A critical project element is analysis of the data from the electrolyzer operations. HNEI will characterize the performance and durability of the electrolyzer under dynamic operating conditions and conduct performance/cost analysis to identify the benefits of grid-integrated hydrogen systems, including grid ancillary services and off-grid revenue streams. The Puna and Hilo project sites together comprise about 0.25 acres. They have been completely graded and developed for industrial purposes and contain no valuable natural, historical or cultural resources. No natural streams or water features would be affected. Noise would be minimal, scenic values would not be adversely affected, and the activities would be compatible with nearby land uses. Hydrogen production, storage, transport and dispensing would be appropriately conducted in conformance with standard industry practice and all applicable regulations. The public would benefit from the first of what could be many clean, quiet buses with a locally generated fuel.

Distribution List for Hawai‘i Natural Energy Institute Electrolyzer-based Hydrogen Production System to Support Additional Variable Wind and Solar Renewable Energy Sources on the Grid and Provide the Hydrogen to Fuel Public Transportation Draft Environmental Assessment

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Dear Participant:

Attached for your review is a Draft Environmental Assessment (DEA) prepared pursuant to the EIS law (Hawaii Revised Statutes, Chapter 343) and the EIS rules (Administrative Rules, Title 11, Chapter 200).

Project Name: **Hawaiʻi Natural Energy Institute Electrolyzer-based Hydrogen Production System to Support Additional Variable Wind and Solar Renewable Energy Sources on the Grid and Provide the Hydrogen to Fuel Public Transportation**
Location: Island: **Hawaiʻi** District: **South Hilo and Puna**
Tax Map Key Number: **(3rd.) 1-4-001:002 (por.) & 2-2-058:018 (por.)**

Your comments must be received or postmarked by: **TBD**

Please send original comments to the:
Consultant: **Geometrician Associates**
Address: **PO Box 396**
Hilo HI 96721
Contact: **Ron Terry** Phone: **969-7090**

Copies of the comments should be sent to:

Proposing/Approving
Agency: **State of Hawaiʻi, Hawaiʻi Natural Energy Institute**
Address: **1680 East-West Road, POST 109**
Honolulu, Hawaiʻi 96821
Contact: **Mitch Ewan** Phone: **956-2337**

If you no longer need the Draft EA, please recycle it. Thank you for your participation in the Environmental Assessment process.

Hawai‘i Natural Energy Institute Electrolyzer-based Hydrogen Production System to Support Additional Variable Wind and Solar Renewable Energy Sources on the Grid and Provide the Hydrogen to Fuel Public Transportation

DRAFT ENVIRONMENTAL ASSESSMENT

Submitted Pursuant to Chapter 343, Hawai‘i Revised Statutes (HRS)

Hawai‘i Natural Energy Institute

October 2012

Hawai‘i Natural Energy Institute Electrolyzer-based Hydrogen Production System to Support Additional Variable Wind and Solar Renewable Energy Sources on the Grid and Provide the Hydrogen to Fuel Public Transportation

DRAFT ENVIRONMENTAL ASSESSMENT

Tax Map Key Number: (3rd) 1-4-001:002 (por.) & 2-2-058:018 (por.)

PROPOSING/APPROVING
AGENCY:

State of Hawai‘i
Hawai‘i Natural Energy Institute
1680 East-West Road, POST 109
Honolulu, Hawai‘i 96821

CONSULTANT:

Geometrician Associates
P.O. Box 396
Hilo, Hawai‘i 96721

CLASS OF ACTION:

Use of State Funds
Use of County Lands

This document is prepared pursuant to:
Hawai‘i Environmental Policy Act,
Chapter 343, Hawai‘i Revised Statutes (HRS), and
Title 11, Chapter 200, Hawai‘i Department of Health Administrative Rules (HAR)

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SUMMARY

The Hawai‘i Natural Energy Institute (HNEI) plans a project that will demonstrate the use of hydrogen as a potential energy storage technology, with an ancillary benefit of providing hydrogen for fuel cells that will power a County of Hawai‘i Mass Transit Agency (MTA) bus. The project consists of three on-the-ground components:

1. Production with a hydrogen electrolyzer at the Puna Geothermal Venture plant that will separate water into hydrogen and oxygen, and then store it in a low pressure buffer tank prior to being compressed to 450 bar and stored in composite high pressure cylinders specifically designed and manufactured to store hydrogen.
2. Transport of cylinders on DOT-approved 450-bar hydrogen tube trailers carrying about 230 pounds of hydrogen to the MTA base yard facility in Hilo (as well as to Hawai‘i Volcanoes National Park).
3. Dispensing of hydrogen into a 19-passenger ElDorado MTA shuttle bus with a 10 kg-capacity tank.

A critical element of the project is analysis of the data from the electrolyzer operations. HNEI will be characterizing the performance and durability of the electrolyzer under dynamic operating conditions, and conducting performance/cost analysis to identify the benefits of grid-integrated hydrogen systems, including grid services and off-grid revenue streams.

The Puna and Hilo project sites that together make up about a quarter of an acre have been completely graded and developed for industrial purposes and contain no valuable natural, historical or cultural resources. No natural streams or water features are present or would be affected. Noise would be minimal, scenic values would not be adversely affected, and the activities would be compatible with nearby land uses. Hydrogen production, storage, transport and dispensing would be appropriately conducted in conformance with standard industry practice and all applicable regulations. The public would benefit from the first of what could be many clean, quiet buses with a locally generated fuel.

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Appendix 2 Hydrogen Safety Information

LIST OF ABBREVIATIONS

BEV	Battery electric vehicles
BMP	Best Management Practice
DLNR	Hawai‘i State Department of Land and Natural Resources
DOE	(U.S.) Department of Energy
DOT	(U.S.) Department of Transportation
DWS	Hawai‘i County Department of Water Supply
EA	Environmental Assessment
EIS	Environmental Impact Statement
FCEV	Fuel cell electric vehicles
FIRM	Flood Insurance Rate Map
FONSI	Finding of No Significant Impact
HDOH	Hawai‘i State Department of Health
HAR	Hawai‘i Administrative Rules
HAVO	Hawai‘i Volcanoes National Park
HCEI	Hawai‘i Clean Energy Initiative
HCGP	Hawai‘i County General Plan
HELCO	Hawai‘i Electric Light Company
HEPA	Hawai‘i Environmental Policy Act
HNEI	(University of Hawai‘i) Hawai‘i Natural Energy Institute
HRS	Hawai‘i Revised Statutes
msl	Mean sea level
OEQC	Hawai‘i State Office of Environmental Quality Control
PGV	Puna Geothermal Venture
SHPD/O	State Historic Preservation Division/Officer
SMA	Special Management Area
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USNRCS	U.S. Natural Resources Conservation Service

1 PROJECT LOCATION, DESCRIPTION AND ALTERNATIVES

1.1 Project Location, Description and Purpose and Need

Project Background and Purpose and Need

When Hawai‘i residents envision electricity facilities, they normally think of *energy generation*, which occurs in Hawai‘i in large plants mostly powered by fossil fuels, with smaller contributions from wind, solar, geothermal and hydroelectric sources. Another increasingly critical component is *energy storage*. Many renewable resources are intermittent and pose challenges to utilities as they strive to maintain the quantity and frequency quality of the electricity grid for its customers. The more energy storage available on the electricity grid, the more intermittent renewables such as wind and solar can be added to the grid. Currently grids use backup, fast-start generators that are switched off or at idle power setting, ready to ramp up quickly to support the grid when the wind is gusting or photovoltaic arrays are subjected to cloud cover. This is an inefficient and expensive system.

The Hawai‘i Natural Energy Laboratory (HNEI) at the University of Hawai‘i has a mandate to develop alternatives to imported fossil fuels for electricity and transportation, and has established a major hydrogen fuel cell research and development program. On the Big Island of Hawai‘i, Hawai‘i Electric Light Company (HELCO) has identified a need for energy storage technologies to support the large and growing share of electricity generated by intermittent renewable energy sources.

HNEI has developed a project on the Big Island of Hawai‘i to evaluate the feasibility of using an electrolyzer-based hydrogen production and storage system as a grid management tool. An electrolyzer uses electric current to convert water into pure hydrogen. HNEI scientists will test the use of the electrolyzer as a controllable, rapidly variable load that can potentially provide grid ancillary services such as “up regulation”, “down regulation”, and off-peak load, simulating the impacts of variable renewable energy sources such as wind and solar on the Big Island electrical grid. If successful, the hydrogen system could ultimately replace fast-start generators, saving fuel and reducing greenhouse gas emissions.

The demonstration project has the substantial ancillary benefit of providing hydrogen for fuel cells that can be used to power vehicles. Fuel cells produce electricity through the electrochemical reaction of hydrogen and oxygen (or air). Fuel cells have double or more the efficiency of internal combustion engines, produce no emissions except pure water, offer fuel flexibility and generate little noise, and are thus ideally suited for mass transit applications.

For this demonstration project, the Puna Geothermal Venture (PGV) plant near Pahoa has agreed to host the hydrogen production system at their site and supply electricity and water. Hydrogen produced from the system will be used for hydrogen-fueled buses at the County of Hawai‘i Mass Transit Agency (MTA) and at Hawai‘i Volcanoes National Park (HAVO).

Optimized use of the electrolyzer, storage, secondary generation, and high value products are intended to increase the use of renewable energy resources, and reduce barriers to the introduction of the hydrogen infrastructure required to advance the "Hydrogen Economy".

Project Location

The project would consist of an electrolyzer located in an existing pipeyard at the entrance area of the PGV plant on TMK (3^{rd}) 1-4-001:002. The hydrogen will be road transported by U.S. DOT-approved 450-bar hydrogen tube trailers carrying about 230 pounds of hydrogen to a hydrogen dispenser site located within the existing fuel dispensing area at the Hawai‘i County Mass Transit Agency Baseyard, on East Lanikaula Street in the Kanoelehua Avenue Industrial Area of Hilo, at TMK (3^{rd}) 2-2-058:018. The project also involves transport to HAVO for dispensing in park vehicles; environmental compliance for elements of that action inside the Park is being covered separately through National Environmental Policy Act (NEPA) documentation by HAVO. Figure 1-1 is an overview of project locations and transport routes; Figure 1-2 provides aerial imagery of the two sites; Figure 1-3 provides ground photos of the two sites; Figure 1-4 provides site plans for the electrolyzer location at the PGV site and the dispenser location at the Hilo MTA baseyard; Figure 1-5a provides a photo of a Proton OnSite PEM 65 kg per Day Electrolyzer; Figure 1-5b shows a Hydrogen Transport Trailer; and Figure 1-5c is a Powertech Hydrogen Fueling Dispenser.

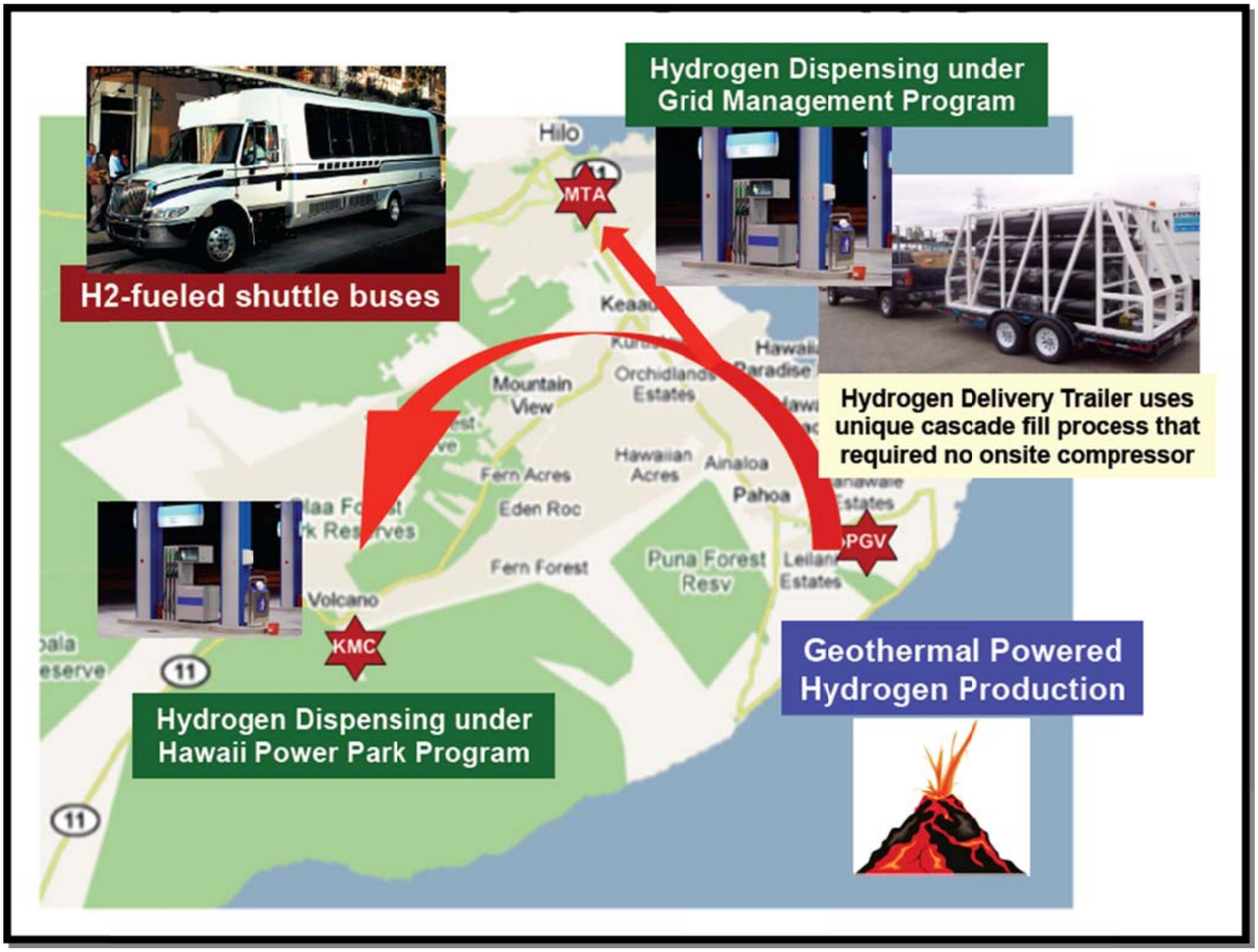
Project Description

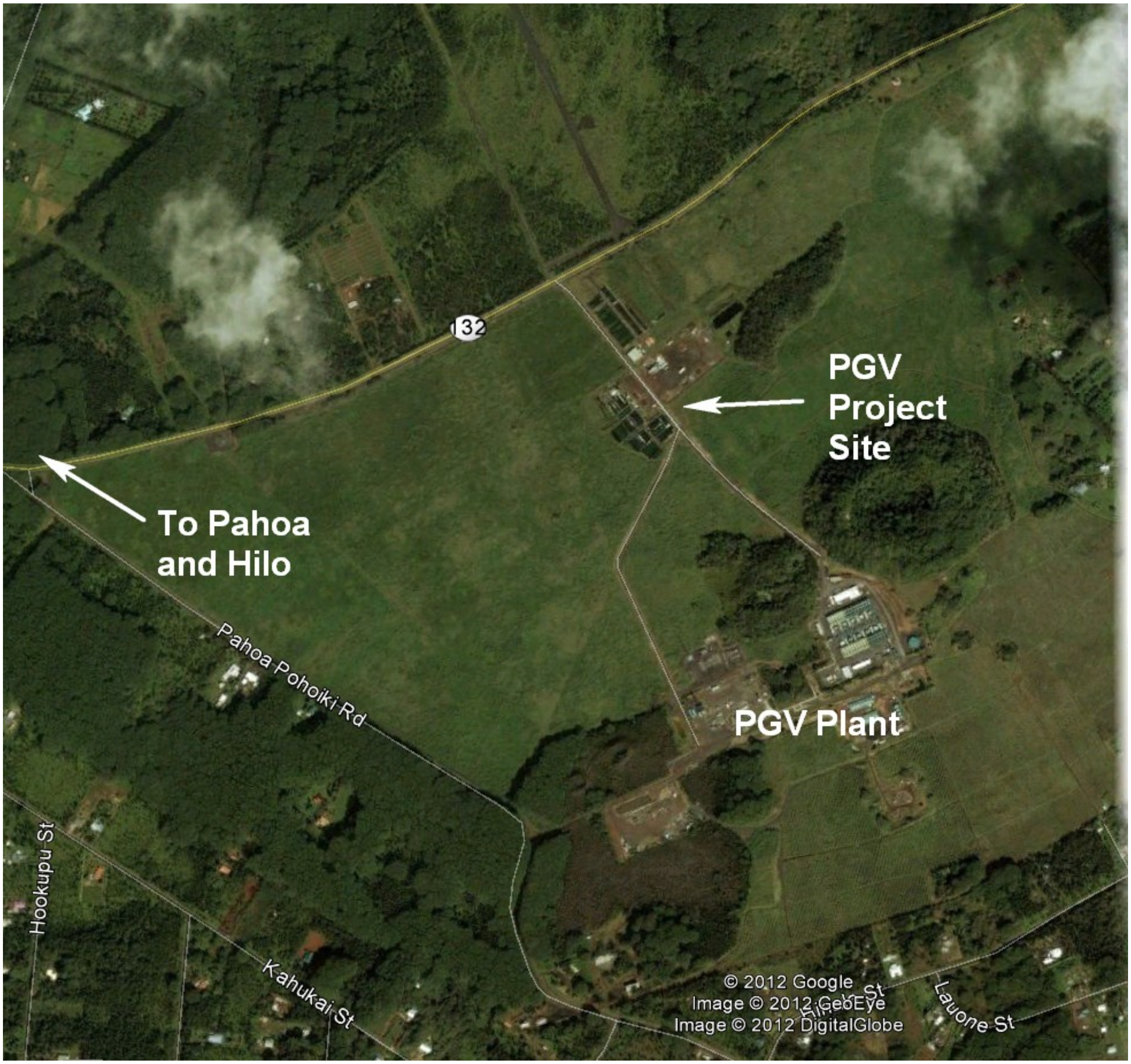
As discussed above, the hydrogen electrolyzer will use PGV-supplied electricity to separate water into hydrogen and oxygen. The electrolyzer will discharge the hydrogen into a low pressure buffer tank, which will then undergo compression to a pressure of 450 bars for storage in composite high pressure cylinders specifically designed and manufactured to store high pressure hydrogen. These cylinders are mounted on transport trailers that will be used to deliver the hydrogen to dispensers that will fuel the buses at the County MTA base yard in Hilo.

HNEI will provide funds to the County of Hawai‘i to buy a 19-passenger ElDorado shuttle bus and to exchange a hydrogen fuel cell for the gasoline engine, which will be done in Honolulu by the Hawai‘i Center for Advanced Transportation Technologies (HCATT). The extra-quiet bus will have a 10 kg-capacity tank and can travel up to 180 miles before refueling. It will also have energy-regenerative braking, similar to hybrid autos, to increase efficiency.

A critical element of the project is analysis of the data from electrolyzer operation. HNEI will be characterizing the performance and durability of the electrolyzer under dynamic operating conditions, and conducting performance/cost analysis to identify the benefits of grid-integrated hydrogen systems, including grid services and off-grid revenue streams.

Figure 1-1
Project Location and Transport and Transport Routes





© Google Earth

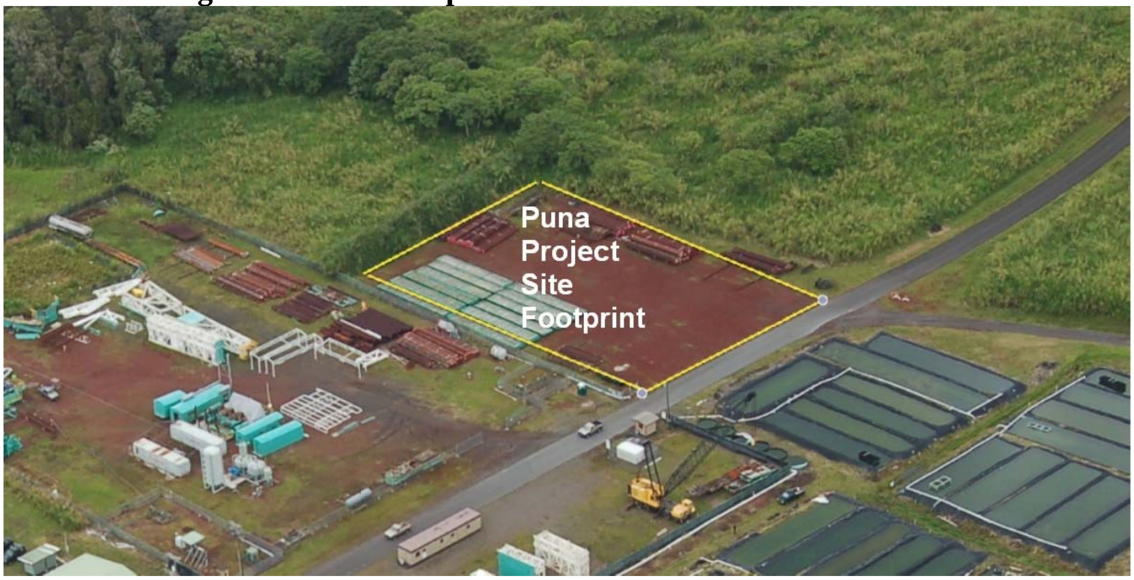
Figure 1-2b
Aerial Image, Hawai'i County Mass Transit Baseyard

© Google Earth

Figure 1-3a. Project Site Photos, Proposed PGV Electrolyzer Location

Figure 1-3b. Project Site Photos, Hawai‘i County Mass Transit Baseyard

Figure 1-4a. Conceptual Site Plan – Puna PGV Plant Site



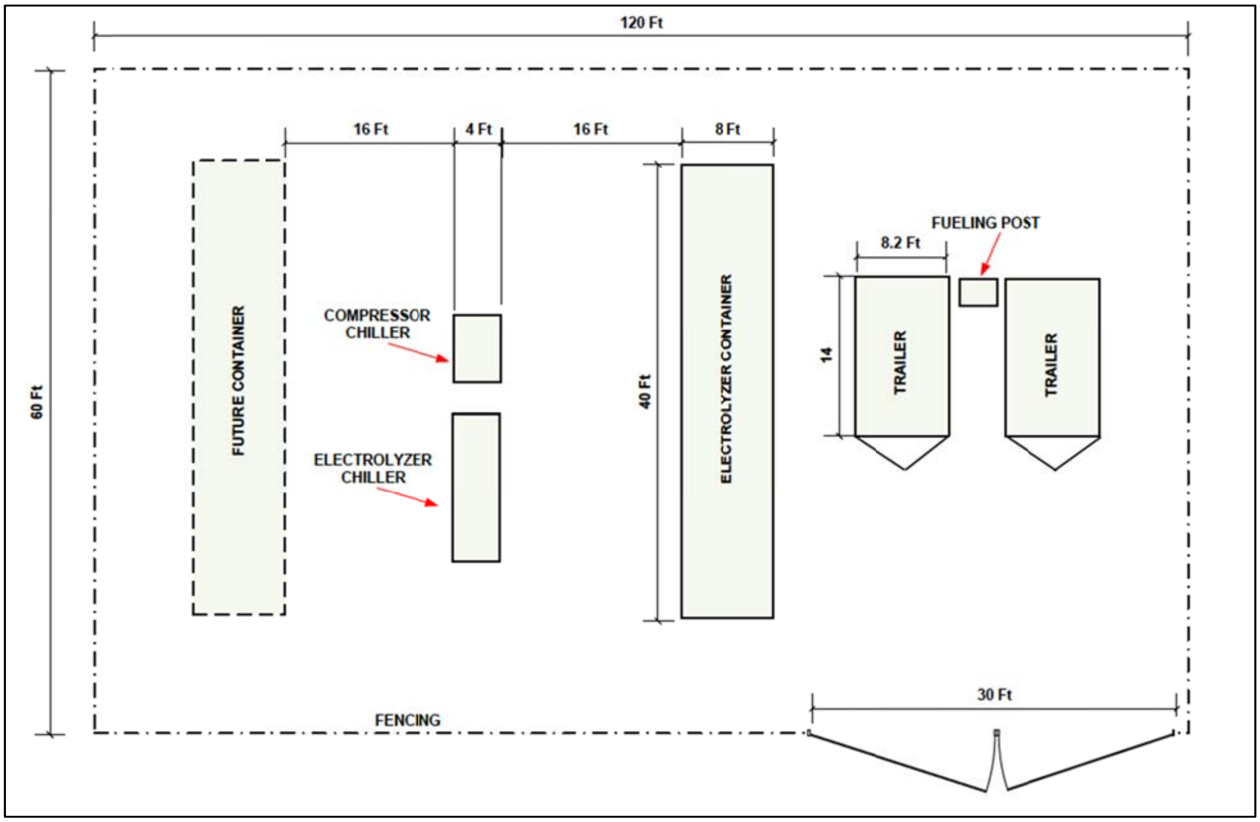


Figure 1-4b. Conceptual Site Plan – Hilo MTA Site

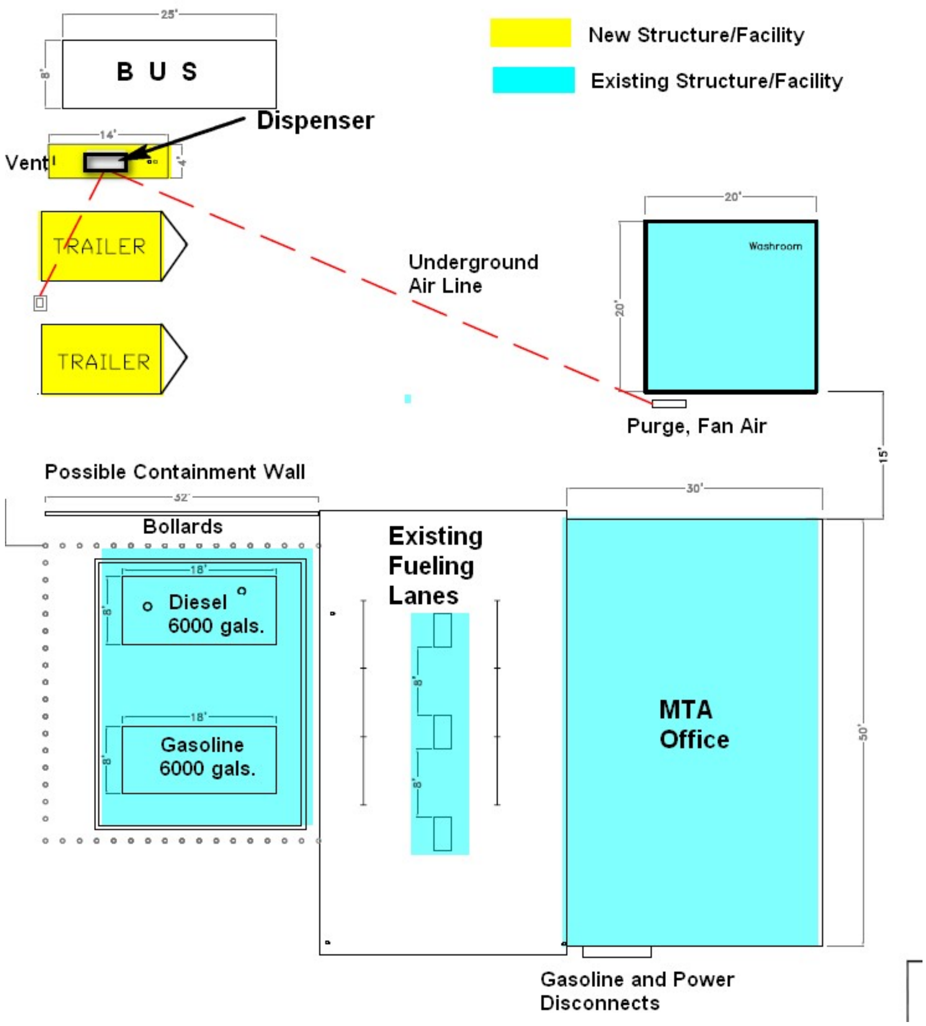
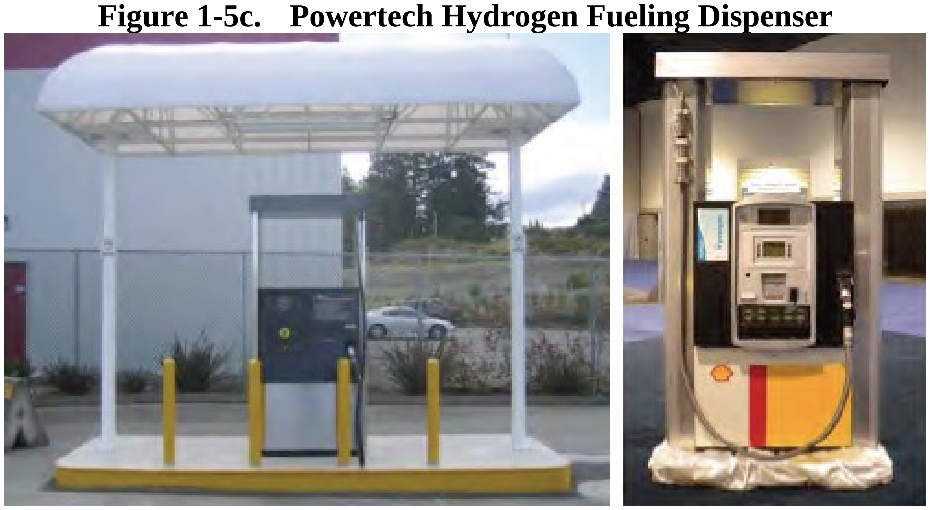


Figure 1-5a. Proton OnSite PEM 65 kg per Day Electrolyzer

Figure 1-5b. Hydrogen Transport Trailer

Figure 1-5c. Powertech Hydrogen Fueling Dispenser



1.2 Alternatives

1.2.1 Alternatives Evaluated and Then Dismissed from Further Consideration

Although the electrolyzer could be located in any number of locations, the PGV plant offered to host the project at a site with convenient water, electricity supply and existing electrical infrastructure, and is not charging the project a leasing fee, which represents a generous cost share. Also, the general area is in existing industrial use but is low-density and remote from any populated areas. The site has good security near the entrance of the plant. The combination of these factors made the site ideal, and HNEI knows of no other sites with similar characteristics.

HNEI does not envision any reasonable alternative approaches aside from providing an electrolyzer to produce hydrogen, and then beneficially using that hydrogen, that could accomplish the research goals of the project.

1.2.2 No Action Alternative

Under the No Action alternative, the project would not be undertaken and there would be no way to test the feasibility of utilizing a hydrogen production and storage system as a grid management tool to mitigate the impacts of variable renewable energy sources such as wind, solar, on the Big Island electrical grid. Furthermore, there would be no ancillary benefits of hydrogen-fueled buses for use and testing by the County and HAVO. However, the No Action alternative provides a baseline for measuring the environmental impacts of the proposed project.

1.3 Consistency with Government Plans and Policies

The project is generally consistent with government plans and policies, relevant sections of which call for research and development of renewable energy programs that promote sustainability while minimizing environmental degradation. The following sections discuss consistency with key plans.

1.3.1 Hawai‘i State Plan

The Hawai‘i State Plan was adopted in 1978. It was revised in 1986 and again in 1991 (Hawai‘i Revised Statutes, Chapter 226, as amended). The Plan establishes a set of goals, objectives and policies that are meant to guide the State’s long-run growth and development activities. The proposed project is consistent with State goals and objectives that call for increases in employment, income and job choices, and a growing, diversified economic base extending to the neighbor islands.

The sections of the Hawai‘i State Plan most relevant to the proposed project are centered on the theme of energy. These include, among others, the following:

§226-18 Objectives and policies for facility systems--energy. (a) Planning for the

> State's facility systems with regard to energy shall be directed toward the achievement of the following objectives, giving due consideration to all:
> (1) Dependable, efficient, and economical statewide energy systems capable of supporting the needs of the people;
> (2) Increased energy self-sufficiency where the ratio of indigenous to imported energy use is increased;
> (3) Greater energy security in the face of threats to Hawaii's energy supplies and systems; and
> (4) Reduction, avoidance, or sequestration of greenhouse gas emissions from energy supply and use.
> (b) To achieve the energy objectives, it shall be the policy of this State to ensure the provision of adequate, reasonably priced, and dependable energy services to accommodate demand.
> (c) To further achieve the energy objectives, it shall be the policy of this State to:
> (1) Support research and development as well as promote the use of renewable energy sources;
> (2) Ensure that the combination of energy supplies and energy-saving systems is sufficient to support the demands of growth;….
> (5) Ensure to the extent that new supply-side resources are needed, the development or expansion of energy systems utilizes the least-cost energy supply option and maximizes efficient technologies;
> (6) Support research, development, and demonstration of energy efficiency, load management, and other demand-side management programs, practices, and technologies;
> (7) Promote alternate fuels and energy efficiency by encouraging diversification of transportation modes and infrastructure;
> (8) Support actions that reduce, avoid, or sequester greenhouse gases in utility, transportation, and industrial sector applications; and

The Hawai'i State Plan also includes Functional Plans for various subject areas, including Energy. The Functional Plan for Energy supports the goals discussed in the Hawai'i State Plan, adding, among others, the following:

> OBJECTIVE B: DISPLACE OIL AND FOSSIL FUELS THROUGH ALTERNATE AND RENEWABLE ENERGY RESOURCES
> POLICY B(1): Displace Oil and Fossil Fuels Consumption through the Application of Appropriate Alternate and Renewable Energy Resources and Technologies
> ACTION B(1)(o): Support Hydrogen Production from Renewable Energy Sources.
> Lead Organization(s): DBED
> Assisting Organization(s): UH-HNEI, PICHTR

Because the project would promote increased energy self-sufficiency, reduce greenhouse gas emissions, demonstrate energy efficiency and load management, and support hydrogen production from a renewable energy source, it is highly consistent with and supports all relevant objectives and policies of the Hawai‘i State Plan and is specifically consistent with the Functional Plan for Energy.

1.3.2 Hawai‘i County General Plan

The *General Plan* for the County of Hawai‘i is the document expressing the broad goals and policies for the long-range development of the Island of Hawai‘i. The latest plan was adopted by ordinance in 2005. The *General Plan* is organized into thirteen elements, with policies, objectives, standards, and principles for each. There are also discussions of the specific applicability of each element to the nine judicial districts comprising the County of Hawai‘i. Below are pertinent Goals, Objectives, Policies and Standards, and Courses of Action, followed by a discussion of conformance. In addition, the most relevant sections of aspects of the General Plan are briefly discussed.

ENERGY GOALS

(a) Strive towards energy self-sufficiency.
(b) Establish the Big Island as a demonstration community for the development and use of natural energy resource.

ENERGY POLICIES

(a) Encourage the development of alternate energy resources.
(e) Ensure a proper balance between the development of alternative energy resources and the preservation of environmental fitness and ecologically significant areas.
(h) Seek funding from both government and private sources for research and development of alternative energy resources.
(k) Strive to diversify the energy supply and minimize the environmental impacts associated with energy usage.

ECONOMIC GOALS

(d) Provide an economic environment that allows new, expanded, or improved economic opportunities that are compatible with the County’s cultural, natural and social environment.

ENVIRONMENTAL QUALITY POLICIES

(a) Take positive action to further maintain the quality of the environment for residents both in the present and in the future.

ENVIRONMENTAL QUALITY STANDARDS

(a) Pollution shall be prevented, abated, and controlled at levels that will protect and preserve the public health and well being, through the enforcement of appropriate Federal, State and County standards.
(b) Incorporate environmental quality controls either as standards in appropriate ordinances or as conditions of approval.

HISTORIC SITES GOALS

(a) Protect, restore, and enhance the sites, buildings, and objects of significant historical and cultural importance to Hawaii.

AGRICULTURAL LAND GOALS

(a) Identify, protect and maintain important agriculture lands on the island of Hawaii.
(b) Preserve the agricultural character of the island.

FLOOD CONTROL AND DRAINAGE GOALS

(c) Control pollution.
(d) Prevent damage from inundation.
(e) Reduce surface water and sediment runoff.

FLOOD CONTROL AND DRAINAGE POLICIES

(g) Development-generated runoff shall be disposed of in a manner acceptable to the Department of Public Works and in compliance with all State and Federal laws.

FLOOD CONTROL AND DRAINAGE STANDARDS

(a) Applicable standards and regulations of Chapter 27, "Flood Control," of the Hawaii County Code.
(b) Applicable standards and regulations of the Federal Emergency Management Agency (FEMA).
(c) Applicable standards and regulations of Chapter 10, "Erosion and Sedimentation Control," of the Hawaii County Code.

NATURAL BEAUTY GOALS

(a) Protect, preserve and enhance the quality of areas endowed with natural beauty, including the quality of coastal scenic resources.
(b) Protect scenic vistas and view planes from becoming obstructed.

NATURAL BEAUTY POLICIES

(h) Protect the views of areas endowed with natural beauty by carefully considering the effects of proposed construction during all land use reviews.
(i) Do not allow incompatible construction in areas of natural beauty.

NATURAL RESOURCES AND SHORELINES GOALS

(a) Protect and conserve the natural resources of the County of Hawaii from undue exploitation, encroachment and damage.
(f) Ensure that alterations to existing land forms and vegetation, except crops, and construction of structures cause minimum adverse effect to water resources, and scenic and recreational amenities and minimum danger of floods, landslides, erosion, siltation, or failure in the event of earthquake.

Discussion: The project is consistent with the General Plan. It will provide critical research on a technology that can utilize a renewable resource to manage the grid, reducing energy waste and greenhouse gases, while supplying an ancillary benefit that also reduces environmental impact. It is located and designed to avoid environmental impact. It will encourage economic ventures that are compatible with the County's cultural, natural and social environment, the quality of which will be maintained. Historic sites or agricultural lands will not be adversely impacted. The project avoids encroachment into the flood zone and does not involve adverse drainage impacts. Finally, the natural beauty and natural resources of both Puna and Hilo will not be adversely affected directly or indirectly by the proposed project.

1.3.3 Puna Community Development Plan

The Puna Community Development Plan (CDP) encompasses the judicial district of Puna, and was developed under the framework of the February 2005 County of Hawaiʻi General Plan. Community Development Plans are intended to translate broad General Plan Goals, Policies, and Standards into implementation actions as they apply to specific geographical regions around the County. CDPs are also intended to serve as a forum for community input into land-use, delivery of government services and any other matters relating to the planning area.

In Section 3.6 of the Puna CDP there are goals, objectives and actions related to energy:

> Goal c. Puna lowers its dependence on fossil fuel as an energy source, becoming a demonstration area for alternative sources, systems and fuels.

The project is highly consistent with this goal. The Puna CDP also states within the Transportation-Traffic Demand Management Section the goal of reducing reliance on fossil fuels, and the Mass Transit section calls for increases in mass transit options for Puna residents and increases in the number of commuters using mass transit, both of which will be facilitated by this project. As the project involves use of already developed land for energy purposes, it is not inconsistent with any other aspect of the CDP.

1.3.4 State and County Land Use Designations and Property Ownership

The Puna project site is part of TMK 1-4-001:002, a 557.18-acre property owned by the Kapoho Land and Development Company. According to the Hawaiʻi County Planning Department (see letter of June 18, 2012 in Appendix 1a), the Puna project site is within the State Land Use Agricultural District, and the County Zoning on the property is A-10a (minimum lot size 10 acres). It is designated on the County General Plan Land Use Designation Maps (LUPAG) as Important Agricultural Land. On October 3, 1989, the Planning Commission approved Geothermal Resource Permit No. 2 (GRP-2), which was amended on February 6, 2001. Condition No. 1 of the 2001 amendment specifically allows "any other proposed uses of the geothermal resource or improvements to the land."

The Hilo project site is part of TMK 2-2-058:018, a 10.559-acre property owned by the State of Hawaiʻi and under Executive Order 1219 to the County of Hawaiʻi for garage and utility yard purposes. The property is within the State Land Use Urban District and County zoning is General Industrial District (MG-1a). The Hawaiʻi County Code, Chapter 25, Section 25-5-152(a) (47) states: "Public uses, structures and buildings and community buildings are permitted uses in any district, provided that the director has issued plan approval for such use." The General Plan LUPAG designation is Industrial, which is characterized as: "Industrial development includes manufacturing and processing, wholesaling, large storage and transportation facilities, power plants, and government baseyards." The bulk storage of flammable products and explosive products is a permitted use in the MG district.

Neither site is within the Special Management Area. The project is a legal use on both properties and is consistent with all land use designations and permits. The project will undergo Plan Approval prior to obtaining any needed building permits.

1.3.5 Hawaiʻi Clean Energy Initiative

The Hawaiʻi Clean Energy Initiative (HCEI) is a partnership between the State of Hawaiʻi and the U.S. Department of Energy. Launched in 2008, the HCEI was meant to bring together business leaders, policy makers, and concerned citizens committed to leading Hawaiʻi to energy independence. The project supports attainment of the HCEI goals in three of the four major HCEI energy sector areas: (1) electricity generation and delivery, (2) transportation, and (3) fuels, as follows:

> *Electricity Generation & Delivery*. HCEI calls for the introduction of renewable energy resources on the grid to displace fossil fuel electricity generation by increasing the penetration of solar, wind, and geothermal electricity. The problem being experienced on the HELCO grid is that as the level of intermittent renewables is increased, it has become increasingly more difficult to manage the grid, which sometimes requires additional fossil fuel generation to provide the necessary grid stability support. The technology being

developed in the project of using electrolyzers operating as variable loads has the potential to mitigate the problem, while at the same time producing hydrogen that can be used to displace fossil transportation fuels.

Transportation. The hydrogen produced by the electrolyzers operating as a grid load management tool can be used for transportation. HCEI calls for the introduction of electric vehicles to displace fossil fuels utilizing renewable electricity to recharge their batteries. Fuel cell electric vehicles (FCEVs) support the goal of displacing fossil fueled vehicles in that they are also electric vehicles that utilize hydrogen fuel cells to generate electricity onboard the vehicle to power the electric drive train. The FCEVs have a much greater range than battery electric vehicles (BEVs) and the fueling operation can be completed faster (5 minutes) rather than several hours of battery charging required for BEVs.

Fuels. HCEI calls for meeting as much of in-State demand for fuels as is feasible utilizing indigenous fuel sources. Hydrogen supports this objective in that it can be produced from all Hawaii’s renewable energy sources including biomass, wind, solar, and geothermal using a variety of conversion technologies. In this project hydrogen is produced by utilizing electricity from a geothermal energy plant.

2 ENVIRONMENTAL ASSESSMENT PROCESS

The project involves the use of State of Hawaiʻi funds and land and therefore requires compliance with Chapter 343, Hawaiʻi Revised Statutes (HRS), the Hawaiʻi Environmental Policy Act (HEPA). The Hawaiʻi Natural Energy Institute (HNEI) is both the proposing and approving agency for this Environmental Assessment (EA).

This EA process is being conducted in accordance with Chapter 343 of the Hawaiʻi Revised Statutes (HRS). This law, along with its implementing regulations, Title 11, Chapter 200, of the Hawaiʻi Administrative Rules (HAR), is the basis for the environmental impact process in the State of Hawaiʻi. According to Chapter 343, an EA is prepared to determine impacts associated with an action, to develop mitigation measures for adverse impacts, and to determine whether any of the impacts are significant according to thirteen specific criteria.

Part 6 of this document states the finding (anticipated in the Draft EA) that no significant impacts are expected to occur based on HNEI's findings for each significant criterion. In the EA process, if the approving agency determines after considering comments to the Draft EA that no significant impacts would likely occur, then the agency issues a Finding of No Significant Impact (FONSI), and the action is permitted to occur. If the agency concludes that significant impacts are expected to occur as a result of the proposed action, then an Environmental Impact Statement (EIS) is prepared.

3 ENVIRONMENTAL SETTING AND IMPACTS

This section describes the existing social, economic, cultural, and environmental conditions pertinent to the proposed project along with the probable impacts of the proposed action and mitigation measures designed to reduce or eliminate adverse environmental impacts. As discussed above in Section 1.2, the No Action Alternative would not involve any on-ground impacts. Therefore, unless explicitly mentioned, discussion of impacts and mitigation below relates to the proposed project only.

The pipeyard site at PGV and the fueling area at the County MTA Baseyard are referred to throughout this EA as the *Puna and Hilo project sites*.

3.1 Physical Environment

3.1.1 Geology, Soils and Hazards

Existing Environment

Geologically, the Puna project site is located on a Kilauea lava flow from 1790. The Hilo project site is located on the flanks of Mauna Loa volcano, on lava flows dated between 750 and 1,500 years before the present (Wolfe and Morris 1996).

Soil at the Puna project site is classified by the U.S. Natural Resources Conservation Service (formerly Soil Conservation Service) as Lava flows, a‘a, a substrate that has had little or no soil development. The Hilo project site has Papai extremely stony muck, 3 to 25 percent slopes (U.S. Soil Conservation Service 1973). This well-drained soil is very rocky, with 40-60 inches to lithic bedrock. Permeability is very rapid, runoff is slow, and erosion hazard is slight.

The Puna project site is within the East Rift Zone of Kilauea Volcano, in Lava Flow Hazard Zone 1, the most hazardous zone on a scale of ascending risk from 9 to 1 (Heliker 1990:23). Since 1955, over 30 percent of the East Rift Zone and the slope to its south has been covered by lava flows. The latest eruption of the East Rift Zone began in 1983 and continues as of 2012. The Hilo project site is rated Lava Flow Hazard Zone 3 on a scale of ascending risk from 9 to 1. The hazard risk in Hilo is based on the fact Mauna Loa is an active volcano. Volcanic Hazard Zone 3 areas have had up to 5 percent of their land area covered by lava or ash flows since the year 1800, and between 15 and 75 percent of the areas have been covered in the past 750 years.

In terms of seismic risk, the entire Island of Hawai‘i is rated Zone 4 Seismic Hazard (Uniform Building Code, Appendix Chapter 25, Section 2518). Zone 4 areas are at risk from major earthquake damage, especially to structures that are poorly designed or built.

Impacts and Mitigation Measures

In general, geologic conditions impose no overriding constraints on the project, which is not imprudent to construct in terms of geologic hazard. HNEI recognizes that most of the surface of Hawaiʻi Island is subject to eventual lava inundation, particularly on the East Rift Zone, and that infrastructure in places such as Puna and Hilo face risk. Given the benefits of the project and the ability to move any critical infrastructure (which will be encapsulated in shipping containers) that might be at risk of imminent inundation by a lava flow within a period of days, HNEI has determined that it is economically and environmentally sensible to invest in the project, despite the eventual risk of lava flows. Project design will take the seismic setting into account, and no mitigation measures are expected to be required.

3.1.2 Floodplains, Drainage and Surface Water Quality

Existing Environment

An average annual rainfall East Hawaiʻi of between 60 and 200 inches (UH Hilo Dept. of Geography 1998) generates substantial runoff in some locations. However, the Flood Insurance Rate Maps (FIRM) place both the Puna and Hilo project sites (FM1556611375C, 9/16/88, and FM1551660885C, 9/16/88, respectively), which are located in an area of fairly recent lava that drains rapidly, in Flood Zone X, outside the 100-year floodplain. No known areas of local (non-stream related) flooding are present on or near the project sites. The relatively recent lava surface leads to excellent drainage. No streams or drainage facilities are located nearby.

The Puna project site is located 600 feet above sea level, outside the area affected by coastal hazards. Maps printed by the Pacific Tsunami Warning Center and the Hawaiʻi County Civil Defense Agency locate the Hilo project site outside the area that should be evacuated during a tsunami warning; the closest boundaries are at the intersection of Leilani and Hinano Streets, three blocks *makai* (http://www.co.hawaii.hi.us/cd/tsunami/Map1.pdf).

Impacts and Mitigation Measures

Placement of the equipment, including the electrolyzer and its utility connections and the hydrogen dispenser, will not require grading, will not add to the area of impermeable surface and will not adversely affect drainage.

3.1.3 Climate and Air Quality

Existing Environment

Average annual rainfall is about 120 inches at the Puna project site and about 138 inches in Hilo. The average maximum temperature is approximately 80 degrees F, with an average minimum of 65 degrees. Winds are generally light and northeasterly (UH Hilo Dept. of Geography 1998).

Impacts and Mitigation Measures

The proposed project does not involve grading and will not produce any substantial temporary or permanent air quality impacts.

3.1.4 Noise and Scenic Value

Existing Environment, Impacts and Mitigation Measures

Both the Puna and Hilo project sites are in areas of existing industrial uses. The Puna project site is near an active geothermal plant, in an area used for storage, where noise is generally low but can be moderate and intermittently high, with no scenic value. The Hilo project site is a large baseyard complex where there is fueling, maintenance and repair of automobiles, trucks, buses and equipment, and noise is intermittently high. There are no scenic resources at the baseyard. The noise will not affect the proposed uses, and there will be no additional noise impacts from construction or operation the electrolyzer or dispenser. No visual impacts will occur.

3.1.5 Hazardous Materials

Existing Environment

No professional evaluation such as a Phase I Environmental Site Assessment (ESA) was performed for either project site. HNEI is not aware of any spills or other incidents involving hazardous or toxic substances that would require precautions during placement of equipment at the sites beyond those that would normally occur in an industrial setting, where flammable and hazardous substances are stored and used as part of various operations in conformance with all State laws and regulations.

Impacts and Mitigation Measures

Although, as with any fuel, there are hazards involved in hydrogen production, storage and transportation, these can be mitigated to minor levels by adhering to standard industry practices codified in regulations.

Appendix 2 provides a Hydrogen Safety Brief. In overview, the project consists of three components involving hydrogen, each with its own set of industry standard precautions that will meet all safety regulations:

1. Production with a hydrogen electrolyzer that will separate water into hydrogen and oxygen, and then store it in a low pressure buffer tank prior to being compressed to 450 bar and stored in composite high pressure cylinders specifically designed and manufactured to store hydrogen.

2. Transport of cylinders on DOT-approved 450-bar hydrogen tube trailers carrying about 230 pounds of hydrogen to the County of Hawai'i Mass Transportation Agency (MTA) base yard facility in Hilo (as well as to Hawai'i Volcanoes National Park).
3. Dispensing of hydrogen into a 19-passenger ElDorado MTA shuttle bus with a 10 kg-capacity tank.

All of the hydrogen systems that will be deployed at the Puna and Hilo project sites are commercial, off-the-shelf systems that meet rigorous safety system design requirements, meet all appropriate hydrogen codes and standards requirements, have been thoroughly tested by the manufacturers, and have undergone third party Factory Acceptance Testing requirements. They will undergo a rigorous commissioning and testing procedure during installation at the sites. The site infrastructure designs will meet all applicable hydrogen safety codes and standards and will be installed by experienced and reputable contractors. All operators including vehicle drivers and first responders will receive hydrogen safety training before they are allowed to operate the equipment. The equipment is located in controlled environments that limit unauthorized access.

It is worth noting that the lower detonation limit of hydrogen is around 13% (fuel/air), which is two times higher than that of natural gas and 12 times higher than that of gasoline. An explosion would thus require very unusual circumstances in which hydrogen accumulated and reached the 13% concentration in a confined space without an ignition source, and only then could an ignition source be triggered. The explosive energy would be approximately 22 times less than the same space filled with gasoline vapor. Given standard precautions, hydrogen is generally a safer fuel than gasoline, which is another benefit of converting to hydrogen fueled buses.

Project safety objectives will follow the *Safety Planning Guidance for Hydrogen Projects and Fuel Cells* dated April 2010, published by the US DOE (included as Exhibit B of Appendix 2.). HNEI will prepare an overall Project Safety Plan that will be submitted for peer review by the US DOE. Critical components of that plan are the design and operational procedures required for safe operation of the hydrogen fuelling system. The Project Safety Plan is meant to help identify and avoid potential hydrogen and related incidents. This plan will serve as a guide for project personnel throughout the life of the project. A detailed Hazard and Operability Study dated March 2011 and a Hydrogen Fueling Station Permitting Guide Check List are included as Exhibits C & D of Appendix 2. Readers interested in illustrations, standards and other safety details are referred to Appendix 2 for a full discussion.

3.2 Biological Environment

Existing Environment

The original vegetation at both sites would have been lowland forest dominated by *'ohi'a* (*Metrosideros polymorpha*) and *uluhe* (*Dicranopteris linearis*) (Gagne and Cuddihy 1990). However, this has been completely eliminated at both project sites through agricultural and then industrial development, and there are no longer any traces of natural vegetation. As shown in Figure

1-3a, vegetation at the Puna project site is low weeds periodically managed through cutting and herbicides. The Hilo project site is fully paved and weeds are managed through herbicide (see Figure 1-3b). Botanical inspections in May and June 2012 determined that no rare, threatened or endangered plant species were present.

No natural streams, ponds or wetlands are present in or near the two project sites.

Birds at both project sites consist mostly of a wide array of non-native species typical of urban, lowland Hawaiʻi, none of which are of conservation concern. Few species of native forest birds would be expected at either the Hilo or Puna site due to the low elevations (40 and 600 feet above sea level, respectively) and lack of key native plants, although the Hawaiʻi ʻAmakihi (*Hemignathus virens virens*) might occasionally be present at the Puna site. There are no trees at either project site that would offer nesting habitat for the endangered Hawaiian Hawk or *ʻIo* (*Buteo solitarius*). There is also no woody vegetation taller than 15 feet that would offer roosting habitat for Hawaiʻi's only land mammal, the endangered *ʻopeʻapeʻa* or Hawaiian hoary bat (*Lasiurus cinereus semotus*), which is known to forage for insects in native forests and near agricultural fields.

It is possible that small numbers of the endangered endemic Hawaiian Petrel (*Pterodroma sandwichensis*) and the threatened Newell's Shearwater (*Puffinus auricularis newelli*) over-fly the project sites between the months of May and November. The Hawaiian Petrel nests high in the mountains was formerly common on the Island of Hawaiʻi. It has within recent historic times been reduced to relict breeding colonies in a few locations. Newell's Shearwaters were also once common on the Island of Hawaiʻi but it population has dropped precipitously since the 1880s. This pelagic species nests high in the mountains in burrows excavated under thick vegetation, especially *uluhe* fern. Biologists believe that the leading cause of death in Hawaiʻi for both these species is predation by alien mammals at the nesting colonies, followed by collision with man-made structures. Exterior lighting disorients these night-flying seabirds, especially fledglings, as they make their way from land to sea during the summer and fall. When disoriented, seabirds often collide with manmade structures and, if not killed outright, the dazed or injured birds are easy targets for feral mammals. There is no suitable nesting habitat at or near the project sites for these seabirds.

Impacts and Mitigation Measures

The minor clearing of low, weedy herbaceous vegetation needed for the improvements at the project sites will involve or affect habitat for rare plants, Hawaiian Hawks or Hawaiian hoary bats. No unshielded exterior lighting will be installed, which will prevent impacts to listed seabirds.

3.3 Socioeconomic

3.3.1 Land Use and Social Factors

Existing Environment, Impacts and Mitigation Measures

Improvements associated with the project would occur within industrial properties and the project would not involve any relocation of residences, businesses, community facilities, farms or other activities. Impacts to the social environment may be regarded as largely beneficial, because the project represents a critical step in developing more renewable energy and providing an alternate fuel to make cleaner, quieter and more environmentally friendly public transit.

3.3.2 Utilities and Transportation

Utilities

An important reason the PGV site was selected is that it offered electricity and water in a location that was accessible, convenient, spacious and safe for the proposed use. If utilized all day long at full power (which would seldom be the case), the electrolyzer would use about 4 megawatt hours per day, the equivalent of about a hundred average homes. Most days the use would be considerably less. The additional power demand of the proposed project is relatively minor and would not adversely affect the ability of PGV to provide and HELCO to deliver electrical power.

In full operation, the electrolyzer uses 14 gallons of water per hour, half of which is converted to hydrogen. The other half is drained to a French drain. The water is purified before entering the electrolyzer so the water coming out is cleaner than when fed into the system. The water demands of the proposed project are minor and completely capable of being met by the existing PGV water well at the Puna project site.

The hydrogen dispenser at the Hilo project site will require minimal power to dispense fuel. The hydrogen dispensing would occur in a baseyard area already used for gasoline and diesel fueling, with all necessary utilities and safety facilities.

Minimal traffic would be involved in site work, which will involve hauling prefabricated equipment from Hilo Harbor to the two project sites via State and County highways. Once in operation, the project would generate a total of approximately one round trip every two days depending on the daily bus route, using US DOT-approved 450-bar hydrogen tube trailers carrying about 230 pounds of hydrogen in cylinders, which would not affect traffic congestion. As discussed above, a Project Safety Plan would cover transport of the hydrogen, which is, in general, less hazardous to transport than other fuels.

3.3.3 Cultural and Archaeological Resources

The traditional cultural value of the project sites was assessed by determining whether they support any traditional gathering uses, are vital for access to traditional cultural sites, or have other important symbolic associations for native Hawaiians or other cultural groups.

Of critical importance in this assessment is the fact that both project sites are small (in Puna, roughly 10,000 square feet; in Hilo, about 1,000 square feet) and located on fully graded, industrial land (see Figures 1-3a-b). Visual reconnaissance clearly indicates that no archaeological sites are present in this fully developed and artificial settings. The sites are within properties that for safety and security reasons are not open to the general public. Property managers who have a long familiarity of the sites indicated that no cultural practices occur at or near either site. Review of particular sites with cultural associations listed in various compendia of the cultural sites for the respective areas did not reveal any cultural sites or practices on or near these particular sites. The sources for this assessment include *Archaeological and Historical Literature Search and Research Design: Lava Flow Control Study, Hilo* (Holly McEldowney's 1979 background research for a proposed lava flow control project for Hilo), *Native Planters in Old Hawai'i* (Handy and Handy 1972), *A Chronological History, Land and Water Use in the Hilo Bay Area, Island of Hawai'i (*Kelly, Nakamura and Barrére 1981), Kepā Maly's historical study of the *ahupua'a* of Waiākea (1996), and archaeological and cultural sites discussed in the 1992 *Puna Community Development Plan Technical Reference Report* (Community Management Associates, Inc. 1992).

The State Historic Preservation Division (SHPD) was requested by letter of August 14, 2012, to concur with a determination of no-effect to historic properties.

As it currently appears that no resources or practices of a potential traditional cultural nature (e.g., caves, springs, *pu'u*, native forest groves, gathering resources or other natural features) are present on or near the project sites, and there is no evidence of any traditional gathering uses or other cultural practices, the proposed use for the electrolyzer and hydrogen storage and dispensing purposes would not likely impact any culturally valued resources or cultural practices. Although there are no indications so far from literature review or consultation with SHPD, the Office of Hawaiian Affairs, or the facility managers that there are any traditional cultural properties or practices on the project sites, various parties including the Office of Hawaiian Affairs and SHPD were supplied a copy of the Draft EA in order to help finalize this finding.

Regardless, as a further precaution, in the unlikely event that archaeological resources are encountered during future use of the project site, work in the immediate area of the discovery will be halted and DLNR-SHPD contacted as outlined in Hawai'i Administrative Rules 13§13-275-12.

3.4 Secondary and Cumulative Impacts

3.4.1 Secondary Impacts

Infrastructure expansion projects – whether highways, utilities, or schools – can sometimes induce secondary physical and social impacts that are only indirectly related to the project. This minor project has no secondary impacts. As it is a demonstration to test the efficacy of a technology, the project may ultimately lead to the benefit of further development of hydrogen production at renewable energy facilities, as a means of both regulating the electrical grid and making hydrogen for a growing transportation market.

3.4.2 Cumulative Impacts

Cumulative impacts result when implementation of several projects that individually have limited impacts combine to produce more severe impacts or conflicts in mitigation measures. The adverse impacts of the project are limited to very minor temporary impacts related to transportation on State and County highways of equipment to be placed on the project sites, and then very minor permanent impacts related to transportation of one truck every two days of hydrogen fuel.

The only other project known to be occurring in the area is a minor renovation of the MTA facility. MTA plans to improve its baseyard facilities into a “One-Stop Transportation Facility” to improve service and maintenance of its Hele-On Bus operating fleet. It will expand the office structure from 900 square feet to 1,080 square feet. The building and parking will then be reconfigured to use the space more efficiently, including addition of a handicapped-accessible parking space. The bus repair shop building will be renovated, with wider and higher stalls, enabling easier maintenance of buses, including the County’s new double-decker bus. An existing asphalt-paved area near the repair shop will be resurfaced with concrete so that it can better bear the weight of buses. Finally, MTA will raise and improve the roof of the diesel fueling area, which is used by MTA and other County Departments, to ease fueling of larger vehicles. It is likely that the project will begin in Fall 2012 and will be complete by the time the subject project commences. If project construction schedules overlap, the Mass Transit Agency, which will have some oversight responsibility for both projects, can readily resolve any conflicts.

3.5 Required Permits and Approvals

The project has requested a determination of no-effect to significant historic properties from the State Historic Preservation Division, as discussed above in Section 3.3.3. The project will undergo Plan Approval by the County Planning Department prior to obtaining any needed building permits from the County. At the current time, HNEI does not anticipate the need for any other permits or approvals, a finding that will be revisited after review of agency comments on the Draft EA.

4 COMMENTS AND COORDINATION

4.1 Agencies and Organizations Contacted

The following agencies received a letter inviting their participation in the preparation of the Environmental Assessment.

County of Hawai‘i

- Civil Defense Agency
- County Council
- Department of Environmental Management
- Department of Public Works
- Department of Water Supply
- Fire Department
- Planning Department, Director
- Planning Department, Puna Community Development Plan Implementation Comm.
- Police Department

State of Hawai‘i

- Department of Business, Economic Development and Tourism, Energy Resources and Technology Division
- Department of Health
- Department of Land and Natural Resources, Land Division
- Department of Land and Natural Resources, State Historic Preservation Division
- Office of Hawaiian Affairs

Copies of correspondence from parties with substantive comments during the preparation of the EA are included in Appendix 1a and are cited in appropriate sections of the text of this EA.

The project proponents plan a public informational meeting during the comment period for the Draft EA.

5 LIST OF DOCUMENT PREPARERS

This Environmental Assessment was prepared for the Hawai‘i Natural Energy Institute by Ron Terry, Ph.D., of Geometrician Associates.

6 STATE OF HAWAI‘I ENVIRONMENTAL ASSESSMENT FINDINGS

Section 11-200-12 of the State Administrative Rules sets forth the criteria by which the significance of environmental impacts shall be evaluated. The following discussion paraphrases these criteria individually and evaluates the project’s relation to each.

1. *The project will not involve an irrevocable commitment or loss or destruction of any natural or cultural resources*. No valuable natural or cultural resources are present at either of the project sites, which are small portions of industrial yards that have been completely graded and disturbed and are in industrial use.

2. *The project will not curtail the range of beneficial uses of the environment*. Future beneficial uses of the environment will in general be maintained by the proposed project, which will provide research to reduce Hawai‘i’s use of fossil fuels and facilitate sustainable energy use from locally produced fuels.

3. *The project will not conflict with the State’s long-term environmental policies*. The State’s long-term environmental policies are set forth in Chapter 344, HRS. The broad goals of this policy are to conserve natural resources and enhance the quality of life. A number of specific guidelines support these goals. The project’s goals are highly supportive of all State environmental policies.

4. *The project will not substantially affect the economic or social welfare of the community or State*. The project will benefit the social and economic welfare of Hawai‘i by reducing dependence on fossil fuels and providing a clean, quiet locally produced transportation fuel.

5. *The project does not substantially affect public health in any detrimental way*. No adverse effects to public health are anticipated. Although, as with any fuel, there are hazards involved in hydrogen production, storage and transportation, these can be mitigated to minor levels by adhering to standard industry practices codified in regulations.

6. *The project will not involve substantial secondary impacts, such as population changes or effects on public facilities*. No adverse secondary effects are expected.

7. *The project will not involve a substantial degradation of environmental quality*. The implementation of best management practices during as part of the project will ensure that the project will not degrade environmental quality in any substantial way.

8. *The project will not substantially affect any rare, threatened or endangered species of flora or fauna or habitat*. No endangered species of flora or fauna is located on either project site or would be affected in any way by the project.

9. *The project is not one which is individually limited but cumulatively may have considerable effect upon the environment or involves a commitment for larger actions*. The adverse impacts of the project are limited to very minor temporary impacts related to transportation on State and County highways of equipment to be placed on the project sites, and then very minor permanent impacts related to transportation of one truck every two days of hydrogen fuel. There are no other known projects with which these very minor traffic impacts would be likely to accumulate.

10. *The project will not detrimentally affect air or water quality or ambient noise levels.* The project will have negligible effects in terms of water quality, air quality and noise.

11. *The project will not affect or will likely be damaged as a result of being located within an environmentally sensitive area such as flood plains, tsunami zones, erosion-prone areas, geologically hazardous lands, estuaries, fresh waters or coastal waters*. No floodplains or tsunami zones are involved in the areas planned for use. Given the benefits of the project and the ability to move any infrastructure that might be at risk of imminent inundation by a lava flow, HNEI has determined that it is economically and environmentally sensible to invest in the project, despite the eventual risk of lava flows. Project design will take the seismic setting into account, and no mitigation measures are expected to be required.

12. *The project will not substantially affect scenic vistas and viewplanes identified in county or state plans or studies.* No protected viewplanes will be impacted by the project, which will have no adverse scenic effects.

13. *The project will not require substantial energy consumption*. If utilized all day long at full power (which would seldom be the case), the electrolyzer would use about 4 megawatt hours per day, the equivalent of about a hundred average homes. Most days the use would be considerably less. The additional power demand of the proposed project is relatively minor and would not adversely affect the ability of HELCO and PGV to provide power. The demonstration project will produce energy and will provide research that has the potential to facilitate substantial sustainable energy production in the future.

Based on the findings above, the Hawai‘i Natural Energy Institute has determined that the proposed project will likely not have any significant effect in the context of Chapter 343, Hawai‘i Revised Statues and section 11-200-12 of the State Administrative Rules, and expects issue a Finding of No Significant Impact (FONSI). This conclusion will be finalized after review of comment letters on the Draft EA.

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Hawai‘i Natural Energy Institute Electrolyzer-based Hydrogen Production System to Support Additional Variable Wind and Solar Renewable Energy Sources on the Grid and Provide the Hydrogen to Fuel Public Transportation

DRAFT ENVIRONMENTAL ASSESSMENT

Appendix 1a
Responses to Early Consultation Letter

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William P. Kenoi
Mayor

Harry S. Kubojiri
Police Chief

Paul K. Ferreira
Deputy Police Chief

County of Hawai'i

POLICE DEPARTMENT
349 Kapiolani Street • Hilo, Hawai'i 96720-3998
(808) 935-3311 • Fax (808) 961-8865

June 7, 2012

Mr. Ron Terry
Principal
Geometrician Associates, LLC
P. O. Box 396
Hilo, HI 96721

Dear Mr. Terry:

Subject: Early Consultation for Environmental Assessment for Proposed Electrolyzer-based Hydrogen Production System at Puna Geothermal Plant to Support Mass Transit Agency Hydrogen Fueled Buses, Island of Hawai'i, TMK (3rd)1-4-001:002 (por) 2-2-058:018

Staff, upon reviewing your letter and map of May 25, 2012, does not anticipate any significant impact to traffic and/or other public safety concerns.

Thank you for allowing us the opportunity to comment.

If you have any questions, please contact Captain Samuel Jelsma, Puna District Commander, at 965-2716.

Sincerely,

HENRY J. TAVARES, JR.
ASSISTANT POLICE CHIEF
AREA I OPERATIONS BUREAU

SJ:lli
120322

NEIL ABERCROMBIE
GOVERNOR OF HAWAII

LORETTA J. FUDDY, A.C.S.W., M.P.H.
DIRECTOR OF HEALTH

STATE OF HAWAII
DEPARTMENT OF HEALTH
P. O. BOX 3378
HONOLULU, HI 96801-3378

In reply, please refer to:
File:

12-102 EA for
Electrolyzer-Puna

June 4, 2012

Mr. Ron Terry
Geometrician Associates
P.O. Box 396
Hilo, Hawaii 96721

Dear Mr. Terry:

SUBJECT: **Early Consultation for Environmental Assessment for Proposed Electrolyzer-based Hydrogen Production System at Puna Geothermal Plant to Support Mass Transit Agency Hydrogen Fueled Buses, Island of Hawai`i TMK: (3) 1-4-001: 002 (por.), 2-2-058: 018**

The Department of Health (DOH), Environmental Planning Office (EPO), acknowledges receipt of your letter, dated **May 25, 2012.** Thank you for allowing us to review and comment on the subject document. We look forward to reviewing the Draft Environmental Assessment. We have no comments at this time, but reserve the right to future comments. We strongly recommend that you review all of the Standard Comments on our website: www.hawaii.gov/health/environmental/env-planning/landuse/landuse.html. Any comments specifically applicable to this application should be adhered to.

The United States Environmental Protection Agency (EPA) provides a wealth of information on their website including strategies to help protect our natural environment and build sustainable communities at: http://water.epa.gov/infrastructure/sustain/ . The DOH encourages State and county planning departments, developers, planners, engineers and other interested parties to apply these strategies and environment principles whenever they plan or review new developments or redevelopments projects. We also ask you to share this information with others to increase community awareness on healthy, sustainable community design. If there are any questions about these comments please contact me.

Sincerely,

Laura Leialoha Phillips McIntyre, AICP
Environmental Planning Office Manager
Environmental Health Administration
Department of Heath
919 Ala Moana Blvd., Ste. 312
Honolulu, Hawaii 96814
Phone: 586-4337
Fax: 586-4370
laura.mcintyre@doh.hawaii.gov

William P. Kenoi
Mayor

Darren J. Rosario
Fire Chief

Renwick J. Victorino
Deputy Fire Chief

County of Hawai'i

HAWAI'I FIRE DEPARTMENT

25 Aupuni Street • Room 2501 • Hilo, Hawai'i 96720
(808) 932-2900 • Fax (808) 932-2928

June 5, 2012

Mr. Ron Terry
Geometrician Associates
PO Box 396
Hilo, HI 96721

Dear Mr. Terry,

SUBJECT: EARLY CONSULT FOR EA FOR PROPOSED ELECTROLYZER-BASED HYDROGEN PRODUCTION SYSTEM AT PUNA GEOTHERMAL PLANT TO SUPPORT MASS TRANSIT AGENCY HYDROGEN FUELED BUSES
TMK: (3RD) 1-4-001:002 (POR.), 2-2-058:018

At this time, regarding the above-referenced early consultation on Environmental Assessment, the Hawai'i Fire Department advises that the installation of above-ground storage tanks for flammable and combustible liquids shall comply with NFPA 1 and NFPA 55.

Thank you for the opportunity to comment. A copy or Notice of Availability of Environmental Assessment is not needed when completed.

Sincerely,

DARREN J. ROSARIO
Fire Chief

RP:lc

William P. Kenoi
Mayor

West Hawai'i Office
74-5044 Ane Keohokalole Hwy
Kailua-Kona, Hawai'i 96740
Phone (808) 323-4770
Fax (808) 327-3563

County of Hawai'i
PLANNING DEPARTMENT

BJ Leithead Todd
Director

Margaret K. Masunaga
Deputy

East Hawai'i Office
101 Pauahi Street, Suite 3
Hilo, Hawai'i 96720
Phone (808) 961-8288
Fax (808) 961-8742

June 18, 2012

Mr. Ron Terry
Geometrician Associates, LLC
P.O. Box 396
Hilo, Hawai'i 96721

Dear Mr. Terry:

SUBJECT: Early Consultation for Environmental Assessment for Proposed Electrolyzer-based Hydrogen System at Puna Geothermal Plant to Support Mass Transit Agency Hydrogen Fueled Buses, Island of Hawai'i
Tax Map Keys: (3) 1-4-001:002 (por.) & 2-2-058:018

This is in response to your letter dated May 25, 2012 requesting our comments regarding the Draft Environmental Assessment for the subject project your firm is preparing.

The Puna Geothermal Plant operates on an approximately 25-acre portion of TMK 1-4-001:002, a 557.18-acre parcel situated in the State Land Use Agricultural district and zoned Agricultural (A-10a) by the County of Hawai'i. On October 3, 1989 the Planning Commission approved Geothermal Resource Permit No. 2 (GRP-2), which the Planning Commission amended on February 6, 2001. Condition No. 1 of the February 2001 amendment to GRP-2 specifically allows "any other proposed uses of the geothermal resource or improvements to the land".

The Puna Community Development Plan, as amended, was adopted by Ordinance No. 08-116 on September 10, 2008 and specifically calls for "a direct use of geothermal agreement for agricultural uses as a part of any expansion of the capacity of the Puna Geothermal Venture plant". Also, while not specifically mentioning hydrogen production, the Puna CDP also calls for the "development of renewable energy sources". Within the Transportation-Traffic Demand Management section of the Puna CDP the goal of reducing reliance on fossil fuels is identified; and the Mass Transit section clearly calls for increases in mass transit options for Puna residents and increases in the number of commuters using mass transit.

The County of Hawai'i Mass Transit base yard operations are sited on a portion of the 10.559-acre parcel identified by TMK 2-2-058:018. This parcel is situated in the State Land Use Urban district and zoned General Industrial (MG-1a) by the County of Hawai'i. The bulk storage of flammable products and bulk storage of explosive products is listed as a permitted use in the MG district.

Thank you for the opportunity to provide these pre-consultation comments. Should you have questions, please feel welcome to contact Larry Brown of my staff at 961-8135.

Sincerely,

BJ LEITHEAD TODD
Planning Director

LMB:cs
\\Coh33\planning\public\wpwin60\Larry\EA-EIS Comments\Geometrician 1-4-1-2 & 2-2-58-15 Hydrogen Production.doc

cc: Director, Office of Environmental Quality Control
235 South Beretania Street, Suite 702
Honolulu HI 96813

PCDP Action Committee
GPR-2

NEIL ABERCROMBIE
GOVERNOR OF HAWAII

WILLIAM J. AILA, JR.
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
LAND DIVISION

POST OFFICE BOX 621
HONOLULU, HAWAII 96809

June 25, 2012

Geometrician Associates
Attention: Mr. Ron Terry
P.O. Box 396
Hilo, Hawaii 96721

via email: rterry@hawaii.rr.com

Dear Mr. Terry:

SUBJECT: Early Consultation for Environmental Assessment for Proposed Electrolyzer-based Hydrogen Production System at Puna Geothermal Plant to Support Mass Transit Agency Hydrogen Fueled Buses, Geometrician Associates, LLC for Hawaii Natural Energy Institute, South Hilo and Puna, Hawaii; TMK: (3) 1-4-001:002 and 2-2-058:018

Thank you for the opportunity to review and comment on the subject matter. The Department of Land and Natural Resources' (DLNR) Land Division distributed or made available a copy of your report pertaining to the subject matter to DLNR Divisions for their review and comments.

At this time, enclosed are comments from (i) the Engineering Division, (ii) the Division of Forestry and Wildlife, and (iii) the Hawaii District Land Office on the subject matter. Should you have any questions, please feel free to call Kevin Moore at (808) 587-0426. Thank you.

Sincerely,

Russell Y. Tsuji
Land Administrator

Enclosure(s)

NEIL ABERCROMBIE
GOVERNOR OF HAWAII

WILLIAM J. AILA, JR.
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
LAND DIVISION

POST OFFICE BOX 621
HONOLULU, HAWAII 96809

May 31, 2012

MEMORANDUM

TO: **DLNR Agencies:**
X Div. of Aquatic Resources
__Div. of Boating & Ocean Recreation
X Engineering Division
X Div. of Forestry & Wildlife
X Div. of State Parks
X Commission on Water Resource Management
X Office of Conservation & Coastal Lands
X Land Division – Hawaii District
X Historic Preservation

FROM: Russell Y. Tsuji, Land Administrator
SUBJECT: Early Consultation for Environmental Assessment for Proposed Electrolyzer-based Hydrogen Production System at Puna Geothermal Plant to Support Mass Transit Agency Hydrogen Fueled Buses
LOCATION: South Hilo and Puna, Hawaii; TMK: (3) 1-4-001:002 and 2-2-058:018
APPLICANT: Geometrician Associates, LLC for Hawaii Natural Energy Institute

Transmitted for your review and comment on the above referenced document. We would appreciate your comments on this document. Please submit any comments by June 25, 2012.

If no response is received by this date, we will assume your agency has no comments. If you have any questions about this request, please contact Kevin Moore at 587-0426. Thank you.

Attachments

( ) We have no objections.
( ) We have no comments.
(✓) Comments are attached.

Signed: [signature]
Date: 6/18/12

cc: Central Files

DEPARTMENT OF LAND AND NATURAL RESOURCES
ENGINEERING DIVISION

LD/KevinMoore
Ref.: EarlyConsultElectrolyserbasedHydrogenProductionSystem
Hawaii.567

COMMENTS

( ) We confirm that the project site, according to the Flood Insurance Rate Map (FIRM), is located in Flood Zone ___.

(X) **Please take note that according to the Flood Insurance Rate Map (FIRM), the project sites are located in Minimal Tsunami Inundation areas and Zone X. The National Flood Insurance Program does not have any regulations for developments within the Minimal Tsunami Inundation areas and Zone X.**

( ) Please note that the correct Flood Zone Designation for the project site according to the Flood Insurance Rate Map (FIRM) is ___.

( ) Please note that the project must comply with the rules and regulations of the National Flood Insurance Program (NFIP) presented in Title 44 of the Code of Federal Regulations (44CFR), whenever development within a Special Flood Hazard Area is undertaken. If there are any questions, please contact the State NFIP Coordinator, Ms. Carol Tyau-Beam, of the Department of Land and Natural Resources, Engineering Division at (808) 587-0267.

Please be advised that 44CFR indicates the minimum standards set forth by the NFIP. Your Community's local flood ordinance may prove to be more restrictive and thus take precedence over the minimum NFIP standards. If there are questions regarding the local flood ordinances, please contact the applicable County NFIP Coordinators below:

( ) Mr. Mario Siu Li at (808) 768-8098 or Ms. Ardis Shaw-Kim at (808) 768-8296 of the City and County of Honolulu, Department of Planning and Permitting.
( ) Mr. Frank DeMarco at (808) 961-8042 (Hilo) or Mr. Kiran Emler at (808) 327-3530 (Kona) of the County of Hawaii, Department of Public Works.
( ) Mr. Francis Cerizo at (808) 270-7771 of the County of Maui, Department of Planning.
( ) Ms. Wynne Ushigome at (808) 241-4890 of the County of Kauai, Department of Public Works.

( ) The applicant should include water demands and infrastructure required to meet project needs. Please note that projects within State lands requiring water service from the Honolulu Board of Water Supply system will be required to pay a resource development charge, in addition to Water Facilities Charges for transmission and daily storage.

( ) The applicant should provide the water demands and calculations to the Engineering Division so it can be included in the State Water Projects Plan Update.

( ) Additional Comments: ____________________

( ) Other: ____________________

Should you have any questions, please call Ms. Suzie S. Agraan of the Planning Branch at 587-0258.

Signed: [signature]
CARTY S. CHANG, CHIEF ENGINEER

Date: 6/19/12

NEIL ABERCROMBIE
GOVERNOR OF HAWAII

WILLIAM J. AILA, JR.
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
LAND DIVISION

POST OFFICE BOX 621
HONOLULU, HAWAII 96809

May 31, 2012

MEMORANDUM

TO: **DLNR Agencies:**
X Div. of Aquatic Resources
__Div. of Boating & Ocean Recreation
X Engineering Division
X Div. of Forestry & Wildlife
X Div. of State Parks
X Commission on Water Resource Management
X Office of Conservation & Coastal Lands
X Land Division – Hawaii District
X Historic Preservation

FROM: Russell Y. Tsuji, Land Administrator
SUBJECT: Early Consultation for Environmental Assessment for Proposed Electrolyzer-based Hydrogen Production System at Puna Geothermal Plant to Support Mass Transit Agency Hydrogen Fueled Buses
LOCATION: South Hilo and Puna, Hawaii; TMK: (3) 1-4-001:002 and 2-2-058:018
APPLICANT: Geometrician Associates, LLC for Hawaii Natural Energy Institute

Transmitted for your review and comment on the above referenced document. We would appreciate your comments on this document. Please submit any comments by June 25, 2012.

If no response is received by this date, we will assume your agency has no comments. If you have any questions about this request, please contact Kevin Moore at 587-0426. Thank you.

Attachments

( ) We have no objections.
(X) We have no comments.
( ) Comments are attached.

Signed: Paul J. Conry
Date: 6/1/12

cc: Central Files

NEIL ABERCROMBIE
GOVERNOR OF HAWAII

WILLIAM J. AILA, JR.
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

2012 JUN -4 P 1:43

RECEIVED
LAND DIVISION
HILO, HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
LAND DIVISION

POST OFFICE BOX 621
HONOLULU, HAWAII 96809

May 31, 2012

MEMORANDUM

TO: **DLNR Agencies:**
X Div. of Aquatic Resources
__Div. of Boating & Ocean Recreation
X Engineering Division
X Div. of Forestry & Wildlife
X Div. of State Parks
X Commission on Water Resource Management
X Office of Conservation & Coastal Lands
X Land Division – Hawaii District
X Historic Preservation

FROM: Russell Y. Tsuji, Land Administrator
SUBJECT: Early Consultation for Environmental Assessment for Proposed Electrolyzer-based Hydrogen Production System at Puna Geothermal Plant to Support Mass Transit Agency Hydrogen Fueled Buses
LOCATION: South Hilo and Puna, Hawaii; TMK: (3) 1-4-001:002 and 2-2-058:018
APPLICANT: Geometrician Associates, LLC for Hawaii Natural Energy Institute

Transmitted for your review and comment on the above referenced document. We would appreciate your comments on this document. Please submit any comments by June 25, 2012.

If no response is received by this date, we will assume your agency has no comments. If you have any questions about this request, please contact Kevin Moore at 587-0426. Thank you.

Attachments

( ) We have no objections.
(✓) We have no comments.
( ) Comments are attached.

Signed: [signature]
Date: 6/12/12

cc: Central Files

William P. Kenoi
Mayor

BJ Leithead Todd
Director

Margaret Masunaga
Deputy Director

County of Hawai'i
PLANNING DEPARTMENT
PUNA COMMUNITY DEVELOPMENT PLAN ACTION COMMITTEE

Aupuni Center • 101 Pauahi Street, Suite 3 • Hilo, Hawai'i 96720
Phone (808) 961-8288 • Fax (808) 961-8742

July 10, 2012

Mr. Ron Terry
Geometrician Associates, LLC
P.O. Box 396
Hilo, Hawaii 96721

Dear Mr. Terry,

<u>Subject</u>: Early consultation for environmental assessment for proposed electrolyzer-based hydrogen system at Puna Geothermal plant to support mass transit agency hydrogen fueled buses, Island of Hawaii Tax Map Keys: (3) 1-4-001:002 (por.) & 2-2-058:018

This is in response to your letter dated May 25, 2012 requesting comments from the Puna Community Development Plan Action Committee regarding the Draft Environmental Assessment for the subject project your firm is preparing.

The Puna Community Development Plan addresses land use, transportation, social services, historical and cultural resources and community needs. The Plan was developed through intensive work with all of the constituencies of the district of Puna and continues its vital work in guiding the growth of the area.

The Puna Community Development Plan supports aspects of this proposal, increased access to mass transit and the development of renewable energy sources. We are intrigued by the process of electrolyzed hydrogen fuel production as it may be a way for Hawaii to reduce its use of imported fuels.

We request that as a part of your assessment, that in considering "social and community impacts; cultural impacts; historic sites" that our communities, most particularly Hawaiian communities, have the opportunity to learn about this process and to be informed as to the impacts, benefits and other consequences of the project, including health and safety issues.

Mahalo for the opportunity to comment on this project and please keep us informed of your progress. We can be reached through Larry Brown in the Planning Department at (808) 961-8135 or lbrown@co.hawaii.hi.us.

Sincerely,

Dan Taylor, Chair
Puna Community Development Plan Action Committee

LMB:lmb
\\Coh33\planning\public\wpwin60\CDP\PUNA CDP\Action Committee\Communications\PCDP AC Ltrhead.doc

xc: BJ Leithead Todd, Planning Director

Hawai‘i Natural Energy Institute Electrolyzer-based Hydrogen Production System to Support Additional Variable Wind and Solar Renewable Energy Sources on the Grid and Provide the Hydrogen to Fuel Public Transportation

DRAFT ENVIRONMENTAL ASSESSMENT

Appendix 2
Hydrogen Safety Information
Exhibit A
Hydrogen Safety Brief

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Exhibit A

Hydrogen Safety

Objective

Provide hydrogen safety information related to the Island of Hawaii Geothermal Hydrogen Project.

General

Project safety objectives will follow the Safety Planning Guidance for Hydrogen Projects and Fuel Cells dated April 2010, published by the US DOE (Exhibit B).

In general, a good safety plan identifies immediate (primary) failure modes as well as secondary failure modes that may come about as a result of other failures. In effective safety planning, every conceivable failure is identified, from catastrophic failures to benign collateral failures. Identification and discussion of perceived benign failures may lead to the identification of more serious failures. Potential hazards in any work, process, or system should always be identified, analyzed, and eliminated or mitigated as part of sound safety planning. Other safety aspects that may be adversely affected by a failure should be considered. These aspects include threats or impacts to:

- Personnel
- Equipment
- Business Interruption
- Environment

Safety Plan Elements

Elements of a hydrogen safety plan will include:

- Organizational Safety Information
  - Organizational Policies and Procedures
  - Hydrogen Experience
- Project Safety
  - Identification of Safety Vulnerabilities (ISV);
  - Risk Reduction Plan;
  - Operating Procedures
    - Operating Steps
    - Sample handling and transport
  - Equipment and Mechanical Integrity
  - Management of Change Procedures
  - Project Safety Documentation

- Communications Plan
  - Employee Training
  - Safety Reviews
  - Safety Events and Lessons Learned
  - Emergency Response
  - Self Audits

- Safety Plan Approval
- Other Comments or Concerns

Geothermal Hydrogen Production & Distribution Project

HNEI has been awarded a contract by the Naval Research Laboratory (NRL) to install a hydrogen production system at the Puna Geothermal Ventures (PGV) plant on the Island of Hawaii.

The hydrogen production system (Figure 1) consists of: 1) a hydrogen electrolyzer that uses PGV-supplied electricity to separate water into hydrogen and oxygen; 2) a low pressure buffer tank that receives low pressure hydrogen discharged from the electrolyzer; 3) a hydrogen compression system to compress hydrogen to 450 bar; and 4) a hydrogen storage system comprised of composite high pressure cylinders specifically designed and manufactured to store high pressure hydrogen. These cylinders are mounted on transport trailers that will be used to deliver the hydrogen to fuel hydrogen fuel cell electric buses at Hawaii Volcanoes National Park, and the County of Hawaii Mass Transit Agency (MTA) base yard facility in Hilo. The trailers shall be fully US DOT approved for use on public roads. The hydrogen will be delivered by road to the Hilo Hele-on Bus base yard where it will fuel a fuel cell shuttle buses using a hydrogen dispenser illustrated in Figure 7.

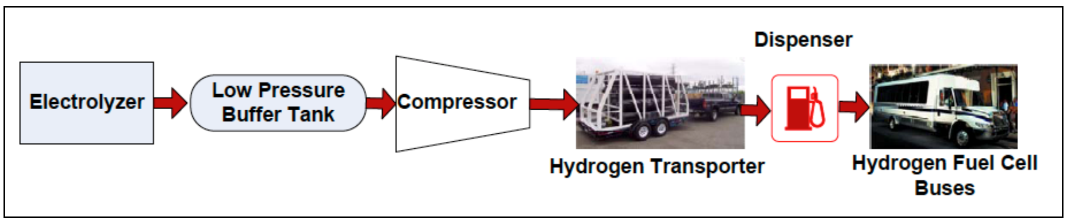

Figure 1: Geothermal Hydrogen Production & Distribution Schematic

The hydrogen system is designed to be installed outdoors and this is a major contribution to safety. The complete system is monitored and controlled by a system of sensors and computer controlled valves and switches. This allows the station to operate unattended similar to a normal gasoline station. The control system is designed to automatically shut the system down if a problem is detected. The system is also fitted with manually operated emergency shut down (ESD) switches in the event of an event that is outside the ability of the control system to monitor. The system will be designed and tested by Powertech, a subsidiary of BC Hydro and an acknowledged industry leader in designing and assembling hydrogen systems. They have built many systems for a variety of customers including GM, Shell, and BC Hydro.

The main components of the hydrogen system include the following:

- **Electrolyzer.** Electrolysis is the process of using electricity to split water into hydrogen and oxygen. This reaction takes place in a unit called an electrolyzer. The hydrogen is discharged from the electrolyzer and captured in a low pressure buffer tank that provides a feed to a hydrogen compressor. The oxygen is normally vented to atmosphere unless there is a use for it. Interest has been expressed to utilize the oxygen produced in this project to support a local aquaculture operation. The electrolyzer illustrated in Figure 2, is being supplied by Proton OnSite (http://www.protononsite.com). This is a proton exchange membrane (PEM) electrolyzer that uses a solid-state electrolyte – an environmentally benign polymer. There are no hazardous materials associated with this type of electrolyzer. The electrolyzer contains a very small amount of onboard hydrogen entrained in its piping system. These electrolyzers are commercial units and meet relevant hydrogen safety codes and standards.

Figure 2: Proton OnSite PEM 65 kg per Day Electrolyzer

- **Buffer Tank**. The low pressure buffer storage tank is a pressurized vessel that equalizes pressure differences and provides product gas flow from the electrolyzer to a compressor. It is located upstream of the compressor.

- **Compressor.** The compressor takes a suction from the low pressure buffer tank and compresses the gaseous hydrogen produced by the electrolyzer to a designated working pressure. In this project the compressor will compress the hydrogen to 450 bar (~6,500 psi). The compressor discharges the compressed hydrogen to compressed gas cylinders. Hydrogen compressors are technically mature commercial units and are manufactured to relevant hydrogen safety codes and standards. Figure 3 shows a hydrogen compressor of the type being used in this project.

Figure 3: Hydrogen Compressor

- **Compressed Hydrogen Gas Cylinders.** The energy density of gaseous hydrogen can be improved by storing hydrogen at higher pressures. Compressed gas cylinders are manufactured from a variety of materials and are designed to be used at a variety of pressures depending on the end-use requirement. The most common are high tensile steel cylinders that are used to store industrial gases at a variety of pressures. New technology materials include carbon reinforced 5000 psi and 10,000 psi tanks. Figure 4 shows carbon fiber wrapped cylinders similar to those that will be used in the hydrogen transport trailers. The system as currently configured is designed to dispense hydrogen at a pressure of 350 bar (5,000 psi).

Figure 4: Compressed Hydrogen Storage Cylinders

Figure 5: Dynetek Type 3 Cylinder Design

The Dynetek cylinders are a “Type 3” pressure vessel design, consisting of a seamless aluminum liner with carbon fiber / epoxy reinforcing over-wrap as shown in Figure 5. The cylinders have a maximum service life of 15 years and require a hydrostatic retest every 5 years.

Hydrogen Transport Trailer. The hydrogen transport trailer, similar to the one shown in Figure 6, is a transportable storage unit for compressed high pressure hydrogen. This unit is comprised of 12 “Type 3” carbon fiber composite storage cylinders with a total hydrogen carrying capacity of 105 kg at a service pressure of 450 bar (6,600 psi). The cylinders are mounted in a protective steel frame designed to withstand acceleration loads of 8g in each of the principal directions. A finite element stress analysis (FEA) was performed on the frame as modeled in Figure 7. The frame is constructed of A500 high strength steel tubing. The outer skin of the trailer consists of aluminum sheeting to protect the cylinders from the road environment. The cylinders and frame are mounted on an 8ft wide x 20 ft long trailer and the complete system is approved to US DOT requirements to transport hydrogen on US public roads.

Figure 6: Hydrogen Transport Trailer

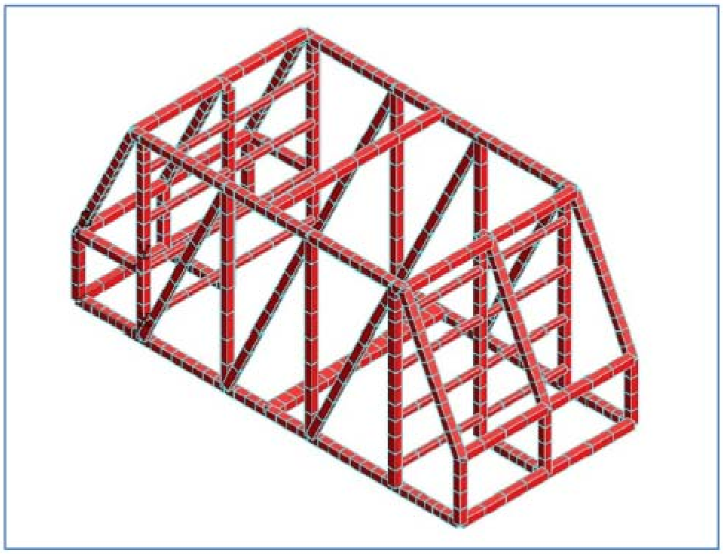

Figure 7: Structural Frame – Finite Element Stress Analysis

Figure 8: Hydrogen Transport Trailer with aluminum Skin Removed

Figure 9: Hydrogen Transport Trailer Showing Manifolded Tanks

- **Hydrogen Dispenser.** A fueling dispenser similar to the ones illustrated in Figure 10 will be used to transfer hydrogen from the tube trailer to the bus onboard hydrogen storage system at a pressure of 350 bar. The fuel dispenser that will be located at the MTA site will have all necessary controls, sensors, and data acquisition to monitor performance and ensure safe operation. An interface to allow remote monitoring of operation will be provided. The fuel dispenser will be weatherized to allow operation in a corrosive, subtropical, high humidity environment.

Figure 10: Powertech Hydrogen Fueling Dispenser

- **Site Equipment Layout.** Figure 11 shows the proposed layout at the PGV site. The footprint of the facility will only require an area of 60’x120’. There will be plenty of room for additional storage trailers to be parked within the fenced compound.

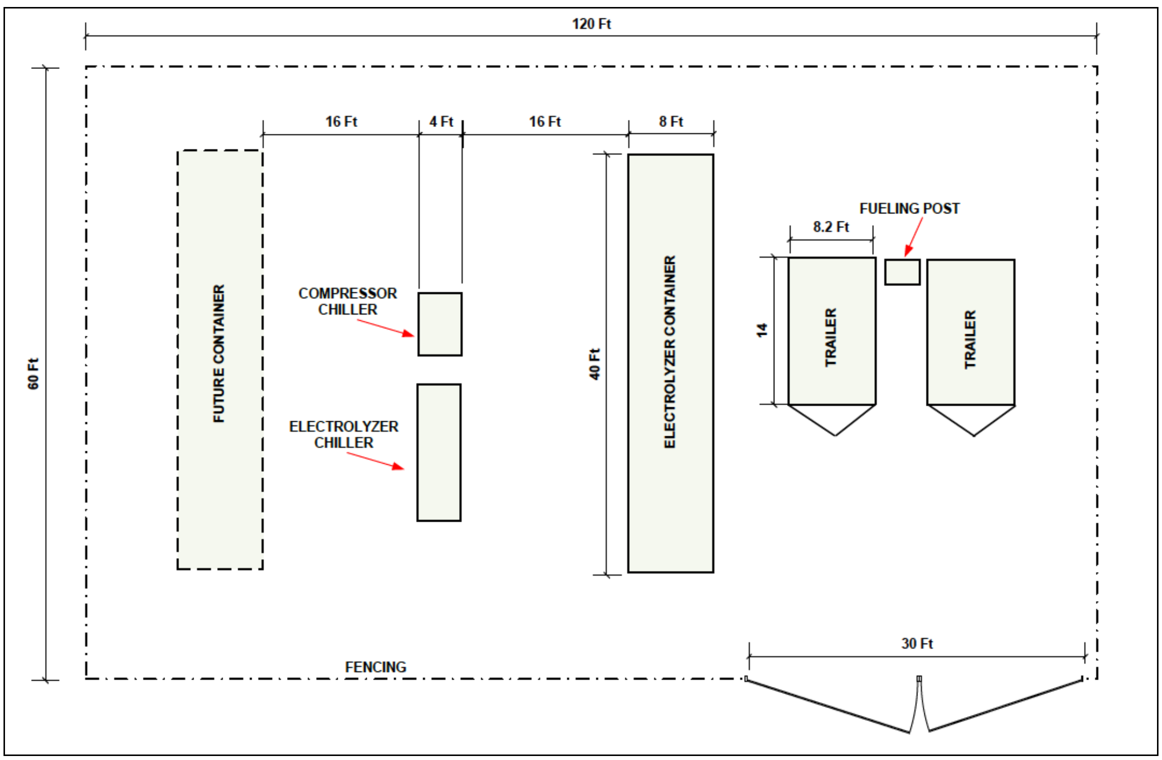

Figure 11: Equipment Layout at the PGV Location

The layout for the equipment at the fueling facilities at the MTA site is shown below in Figure 12. The dispenser can be located at a convenient location in the yard with underground piping leading back to the fenced trailer compound. Currently there are plans to install a control room inside the compound to house the data acquisition equipment. In the future, a compressor can be installed at this location if more vehicles are required to be fuelled.

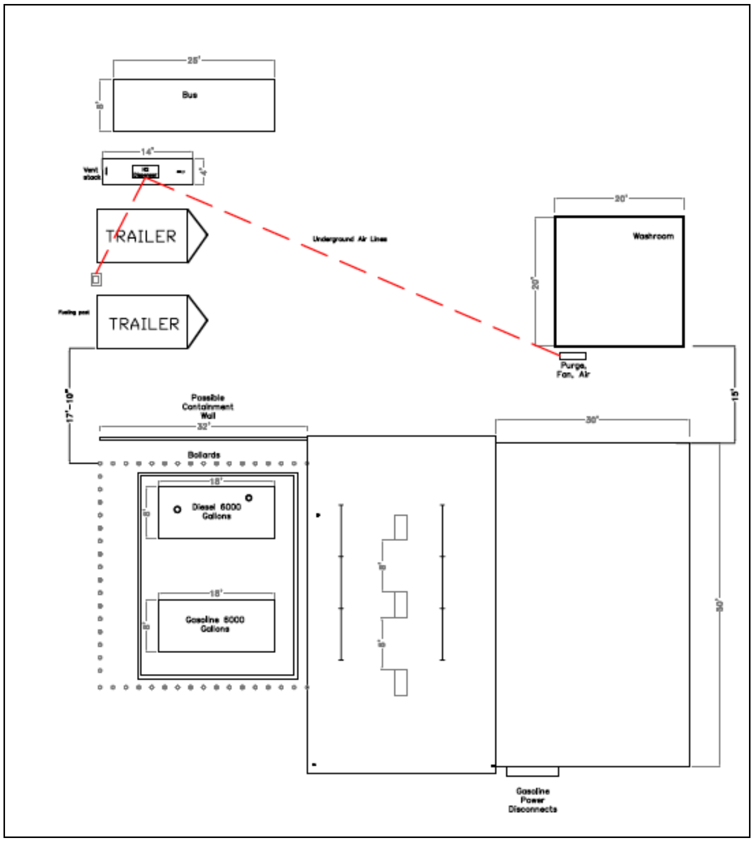

Figure 12: Equipment Layout at the MTA Location

- **System Safety**. HNEI will prepare an overall Project Safety Plan that will be submitted for peer review by the US DOE. Critical components of that plan are the design and operational procedures required for safe operation of the hydrogen fuelling system. The project safety plan is meant to help identify and avoid potential hydrogen and related incidents. This safety plan will serve as a guide for project personnel throughout the life of the project. A typical detailed Hazard and Operability Study dated March 2011 and a Hydrogen Fueling Station Permitting Guide Check List are included as Exhibits C & D.

  Specific safety risk mitigations actions include the following:
  - **HAZOP**: Hazard and Operability Study (HAZOP) conducted on all Hydrogen Fuelling Station designs;
  - **Codes and Standards**: All systems are designed to meet the following codes and standards relevant to the location in Hawaii:
    - NFPA 2, Hydrogen Technologies Code (2011 Edition). With the increased interest in hydrogen being used as a fuel source, the National Fire Protection Association (NFPA) was petitioned to develop an all-encompassing document that establishes the necessary requirements for hydrogen technologies. This code is largely extracted from other NFPA codes and standards (e.g., NFPA 52, NFPA 55, and NFPA 853) and is organized in a fashion that is specific for hydrogen.
    - CGA PS-21, Adjacent Storage of Compressed Hydrogen and Other Flammable Gases (Compressed Gas Association, 2005)
    - CGA G-5.4, Standard for Hydrogen Piping Systems at Consumer Locations (Compressed Gas Association, 2005)

        - CGA G-5.5, Hydrogen Vent Systems (Compressed Gas Association, 2004)
        - SAE J2600, Compressed Hydrogen Surface Vehicle Refuelling Connection Devices (Society of Automotive Engineers, 2002);
        - SAE TIR J2799, 70 MPa Compressed Hydrogen Surface Vehicle Fuelling Connection Device and Optional Vehicle to Station Communications
        - ASME B31.3, Process Piping (American Society of Mechanical Engineers, 2006)
    - **Containment**: Station containment divided into compartments each with continuous hydrogen gas detection and fire detection systems;
    - **Pressure Sensors**: Pressure sensors will be installed throughout the system to ensure no leakage, and correct functioning of the station;
    - **Temperature Sensors**: Temperature sensors will be installed in key locations to ensure correct function of the station;
    - **Electrical Classification**: The hydrogen storage compartment is rated as a Class 1 Division 2 location with all electrical components approved for hazardous locations;
    - **Compressor Compartment**: The compressor compartment is rated as a Class 1 Division 2 location with all electrical components approved for hazardous locations;
    - **Emergency Shutdown System**; The Emergency Shutdown System is run pneumatically – air valves shut and isolate the system if any of the shutdown safety systems are activated;
    - **Emergency Shut Down Buttons (ESD):** Emergency Shut Down buttons will be located in key areas and will isolate and shut down the system when manually activated;
    - **Gas Detectors**: Gas detectors will provide a warning at a hydrogen gas concentration of 15% of the lower flammability limit (LFL) of hydrogen and a system shutdown at a hydrogen gas concentration of 25% LFL;
    - **Temperature Activated Pressure Relief Devices**: Pressure activated pressure relief devices for fire protection and pressure relief valves to deplete any possible over-pressure are installed on all hydrogen cylinders;
    - **Warnings and Alarms**: All warnings and alarms will be communicated through text massages and emails;
    - **Safety Training**: Powertech is under contract to develop and deliver a safety training course including "train-the-trainer", initial operator training, and training course materials for ongoing training. All operators are required to complete the course before they are allowed to use the equipment. This ensures that only properly trained personnel are allowed to work on the equipment. A list of approved operators shall be maintained by HNEI;
    - **First Responder Training**: First responder training shall be provided to the local fire department as part of commissioning of the fueling station. The training shall be delivered by Powertech and/or other professional training organizations such as an industrial gas supplier. Annual refresher courses shall be provided.
    - **Maintenance Contract**: Powertech or other suitably qualified organization shall be awarded an annual maintenance contract that includes onsite inspections to ensure the equipment is working within specifications.

- **Facility Safety Manual**: A facility safety manual shall be provided to ensure the equipment is operated in accordance with approved operating procedures and that pre-planned responses are in place should there be a safety incident.
- **Security measures to prevent theft, vandalism, etc:**
  - **PGV Geothermal Hydrogen System.** The system is located inside a fenced perimeter fence that is under video surveillance 24 hours per day by the PGV operational staff. The system will be enclosed by a secondary fence with a locked gate. Cement crash barriers will be deployed around the station.
  - **MTA Hydrogen System:** The system is located inside a fenced perimeter. The system will be enclosed by a secondary fence with a locked gate. Cement crash barriers will be deployed around the station.

- **24/7 System Remote Monitoring**: All systems will be capable of being remotely monitored and operated through a system of sensors, and remotely operated valves and circuit breakers. The system shall be able to:
  - Monitor all hydrogen detection and heat sensors;
  - Monitor critical sensors (pressure, temperature, etc.) and perform simple validation including alarm triggering;
  - Trigger System Shutdown by deactivating pneumatically controlled self-closing shutdown valves (requires power / signal for normal operations;
  - Activate and deactivate visual and audio alarms;
  - Send an alarm notification to the MTA or PGV external monitoring system;
  - Watchdog appliance shall shut down system if the FSCS is not responsive;
  - Permanent communication with the Master System Controller required, response if interrupted TBD;
  - Data shall be buffered locally in case of communication interruption:
- **US DOE Safety Team Review**: The US DOE provides a team of safety experts who will conduct an onsite inspection of all equipment and review safety plans before the system is placed in service.

Worst Case Scenario

The worst-case scenario would be a fire or explosion of one of the hydrogen storage tanks. This is highly unlikely. In arriving at this conclusion the following information is germane:

- **Outdoor Systems:** The systems are located outdoors with appropriate separation from buildings and public areas. Because hydrogen is exceptionally buoyant in air, it will disperse faster than any other fuel, particularly outdoors. This serves to prevent a build-up of an explosive mixture.
- **HNEI Experience in Hydrogen System Design and Operation**: HNEI has designed, built, and operated a hydrogen storage system at its Cooke Street fuel cell test facility for over 7 years with no incidents.
- **System Design**: The design of the hydrogen storage and distribution system is based on preventing the build-up of a potentially explosive mixture, restricting the amount of hydrogen that can be used to feed a fire, providing adequate separation between hydrogen storage and the general public, and following established codes and safety procedures in handling hydrogen.
- **Lower Flammability Level**: A key factor when assessing a leak hazard is the lower flammability limit (LFL) as defined by the minimum concentration of a combustible

substance that is capable of propagating a flame under specified conditions. Hydrogen's LFL is four times higher than gasoline and 1.9 times higher than propane, which means that much more hydrogen must be present for a flame to exist.

- **Lower Detonation Level**: The lower detonation limit (LDL) of hydrogen is around 13% (fuel/air), which is two times higher than that of natural gas and 12 times higher than that of gasoline. Because the LFL is so low (4%) hydrogen would require an unusual (although feasible) scenario for explosion: it would first have to accumulate and reach the 13% concentration in a confined space without an ignition source, and only then could an ignition source be triggered. The explosive energy would be approximately 22 times less than the same space filled with gasoline vapor.
- **Sensor Systems**: Our safety system includes hydrogen leak sensors, and infra red and ultra violet sensors in key areas of the facility. There are no indoor areas where hydrogen will be used. If a leak or fire is detected, the safety system will automatically shut all hydrogen supply lines thus isolating the system.
- **Fire Hazards**: The low emissivity of hydrogen flames means that near-by materials will be much less likely to ignite by radiant heat transfer. There are no toxic fumes produced by hydrogen combustion (water vapor is the only by-product) as is the case with burning gasoline. The fumes and soot from a gasoline fire pose a risk to anyone inhaling the smoke.
- **Facility Safety System**: Our facility control system has automatic and manual shutdown systems that will cut off the supply of hydrogen in the event of an emergency condition.

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Hawai‘i Natural Energy Institute Electrolyzer-based Hydrogen Production System to Support Additional Variable Wind and Solar Renewable Energy Sources on the Grid and Provide the Hydrogen to Fuel Public Transportation

DRAFT ENVIRONMENTAL ASSESSMENT

Appendix 2
Hydrogen Safety Information
Exhibit B
Safety Planning Guidance for Hydrogen and Fuel Cell Projects

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Safety Planning Guidance

for

Hydrogen and Fuel Cell Projects

April 2010

U.S. Department of Energy
Fuel Cell Technologies Program

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Safety Planning Guidance for Hydrogen and Fuel Cell Projects

A. Introduction

This guidance document provides applicants and recipients with information on safety requirements for hydrogen and fuel cell projects funded by the U. S. Department of Energy (DOE) Fuel Cell Technologies Program.

Safe practices in the production, storage, distribution, and use of hydrogen are essential for the widespread acceptance of hydrogen and fuel cell technologies. A catastrophic failure in any project could damage the public's perception of hydrogen and fuel cells. The project safety plan is meant to help identify and avoid potential hydrogen and related incidents. This guidance document aims to assist recipients in generating their safety plan, which will serve as a guide for the safe conduct of all project work.

In general, a good safety plan identifies immediate (primary) failure modes as well as secondary failure modes that may come about as a result of other failures. In effective safety planning, every conceivable failure is identified, from catastrophic failures to benign collateral failures. Identification and discussion of perceived benign failures may lead to the identification of more serious failures.

Potential hazards in any work, process or system should always be identified, analyzed and eliminated or mitigated as part of sound safety planning. Other safety aspects that may be adversely affected by a failure should be considered. These aspects include threats or impacts to:

- **Personnel.** Any hazards that pose a risk of injury or loss of life to personnel and the public at-large must be identified and eliminated or mitigated. A complete safety assessment considers not only those personnel who are directly involved in the work, but also others who are at risk due to these hazards.
- **Equipment.** Damage to or loss of equipment or facilities must be prevented or minimized. Damage to equipment can be both the cause of incidents and the result of incidents. An equipment failure can result in collateral damage to nearby equipment and property, which can trigger additional equipment failures or even present additional risks. Effective safety planning considers and minimizes serious risk of equipment and property damage.
- **Business Interruption.** The prevention of business interruption is important for commercial entities. Hazardous events may lead to interruption in providing service or product. A complete safety plan in these instances would also include a contingency plan for providing needed services or manufacturing.
- **Environment.** Damage to the environment must be prevented. Any aspect of a natural or built environment that can be harmed due to a failure should be identified and analyzed. A qualification of the failure modes resulting in environmental damage must be considered.

B. Requirements and Procedures

All projects funded by the DOE Fuel Cell Technologies Program will be required to submit a project safety plan with the exception of those projects relating to non-experimental computational or analytical work. Safety plans will be required to cover the work of the award recipient and any subcontractors. This guidance document, in addition to any example project safety plans provided by the DOE project officer, should provide sufficient background for preparing the safety plan. However, the responsibility of selecting and using a specific safety methodology falls upon the applicant or principal investigator and collaborating groups. A variety of practices exist for the identification and analysis of safety hazards and the team can choose an approach that is best suited for their project.

DOE will identify specific safety plan deliverable requirements at the time of award; the specific instructions will be stated on the "Federal Assistance Reporting Checklist" (Form DOE F 4600.2) within the award package. The specific procedure for each project may differ. Generally, though, the draft project safety plan will be required 90 days after the award has been signed. The safety plan should not contain any proprietary or confidential information since it will be reviewed by a panel external to DOE. Once submitted, the plan will be reviewed and specific comments and feedback will be provided to the recipient. In some cases, the recipient will then be required to address all necessary comments and submit a revised safety plan. For any project involving multiple phases, the updating and resubmitting of the safety plan may also be required.

A preliminary safety plan may be required during the submission of the application package as part of the Funding Opportunity Announcement (FOA) issued by DOE. If a preliminary safety plan is required, the FOA will provide further direction regarding specific requirements.

All project safety plan submissions and questions should be sent via e-mail to the project officer identified in Block 11 of the Notice of Financial Assistance Award.

C. The Safety Plan

A project safety plan addresses potential threats and impacts to personnel, equipment and the environment. As an integral part of any project, a safety plan should reflect that sound and thoughtful consideration is given to the identification and analysis of safety vulnerabilities, prevention of hazards, mitigation of risks and effective communications. Safety plans should be "living documents" that recognize the type of work being conducted, the factors of human error, the nature of equipment life and the inevitable changes that occur over the project life.

A project safety plan should be prepared using a graded approach based on level of risk and project complexity. The plan should cover all experimental/operational work being conducted with particular emphasis on the aspects involving hydrogen, hazardous materials handling and fuel cell systems. The elements of a good safety plan are described in Appendix IV and summarized as follows:

1. Scope of Work
2. Organizational Safety Information

- Organizational Policies and Procedures
  - Hydrogen and Fuel Cell Experience
3. Project Safety
   - Identification of Safety Vulnerabilities (ISV)
   - Risk Reduction Plan
   - Operating Procedures
     - Operating steps
     - Sample handling and transport
   - Equipment and Mechanical Integrity
   - Management of Change Procedures
   - Project Safety Documentation
4. Communication Plan
   - Employee Training
   - Safety Reviews
   - Safety Events and Lessons Learned
   - Emergency Response
   - Self-Audits
5. Safety Plan Approval
6. Other Comments or Concerns

Each element is briefly described in the following sections. The text boxes included in the following sections provide useful background information on good safety practices and should be thoughtfully considered in preparing your safety plan. Detailed documentation related to this background information does not need to be included in the safety plan itself. Project teams may also find H_2 Safety Best Practices (http://h2bestpractices.org) to be a useful reference for safety planning. This website captures the experience that already exists in a wide variety of industrial, aerospace and laboratory settings with topics covering safety practices, design and operations. An extensive reference list is also supplemented with lessons learned from incidents and near-misses.

1. Scope of Work. The plan should briefly describe the specific nature of the work being performed to set the context for the safety plan. It should distinguish between laboratory-scale research, bench-scale testing, engineering development, and prototype operation. All intended project phases should be described. In describing the work, it is valuable to quantify the amounts of hazardous materials generated, used and stored. Even laboratory-scale experiments may result in substantial risks when a quantity of hydrogen or other hazardous material is stored in or near the laboratory.

The plan should discuss the location of activities (description of facilities, types of personnel, other operations/testing performed at the facility, adjacent facilities) and describe how the activities will be coordinated across the total project. **Safety plans should cover the work of any subcontractors.** Any relevant permits that apply to current and planned operations should be listed.

2. Organizational Safety Information

Organizational Policies and Procedures. The plan should describe how the safety policies and procedures of the organization are implemented down to the project and staff member levels for the work being performed. Staff member involvement is important in the development and implementation of comprehensive project safety plans.

Hydrogen and Fuel Cell Experience. Knowledge gained over a period of time can be an important asset in effective safety planning. The plan should describe the types of previous operations, degree of experience of project personnel, and how previous organizational experience with hydrogen and fuel cells will be applied to the project.

3. Project Safety

Identification of Safety Vulnerabilities (ISV). Assessment of the potential hazards associated with work at any scale from laboratory to operations begins with the identification of an appropriate assessment technique. The ISV is the formal means by which potential safety issues associated with laboratory or process steps, materials, equipment, operations, facilities and personnel are identified. The plan should describe:

- The ISV method that is used for this project
- Who leads and stewards the use and results of the ISV process
- Significant accident scenarios identified (e.g. higher consequence, higher frequency)
- Significant vulnerabilities (risks) identified
- Safety critical equipment

Hazardous Materials. The plan should discuss the storage and handling of hazardous materials and related topics including possible ignition sources, explosion hazards, material interactions, possible leakage and accumulation, and detection. For hydrogen handling systems, the plan should describe the source and supply, storage and distribution systems including volumes, pressures and with estimated use rates.

Two other questions should be addressed in the ISV:

- What hazard associated with this project is most likely to occur?
- What hazard associated with this project has the potential to result in the worst consequence?

The plan should describe how the ISV will be updated as new information becomes available. Typical ISV methods are described in Appendix I.

Risk Reduction Plan. The purpose of a risk reduction plan is to reduce or eliminate significant risks. The plan should describe prevention and mitigation measures for the significant safety vulnerabilities previously identified. The development of prevention and mitigation measures is usually done in conjunction with the ISV which assesses the scenarios and identified hazards. Risk binning is one available analysis tool used to classify vulnerabilities, as shown in Appendix II.

Operating Procedures

Operating Steps. The plan should list existing and planned procedures that describe the operating steps for the system, apparatus, equipment, etc. It should also reference specific safe work practices used to control hazards during operations such as lockout; confined space entry; opening equipment or piping; and control over entrance into a facility by maintenance, contractor, laboratory, or other support personnel.

> *Background Information: Procedures should be developed for each process or laboratory-scale experiment with the active involvement of project personnel. These written procedures should provide clear instructions for conducting processes or experiments in a safe manner. The procedures should include:*
> - *Steps for each operating phase, such as startup, normal operation, normal shutdown, emergency shutdown*
> - *Operating limits*
> - *Safety considerations, such as precautions necessary to prevent exposure and measures to be taken if physical contact or airborne exposure occurs*
> - *Safety systems and their functions*
>
> *Operating procedures should be updated promptly to reflect changes to chemicals and other materials, equipment, technologies and facilities*

Sample handling and transport. The plan should discuss any anticipated transport of samples and materials and identify the relevant policies and procedures that are in place to ensure their proper handling.

Equipment and Mechanical Integrity. The plan should describe how the integrity of equipment, piping, tubing, and other devices associated with the hazardous material handling systems will be assured.

> *Background Information: Mechanical integrity generally involves*
> - *Written procedures*
> - *Proper design, testing and commissioning*
> - *Validation of materials compatibility*
> - *Preventative maintenance plan*
> - *Calibration for safety related devices – The frequency should be consistent with applicable manufacturers' recommendations, adjusted as indicated by operating experience.*
> - *Testing and inspection – The types and frequency of inspections and*

tests should be consistent with applicable manufacturers' recommendations, adjusted as indicated by operating experience.

- *Training for maintenance, calibration, testing and inspection personnel.*
- *Documentation – Each calibration, inspection and test should be recorded. Typical records include date, name of the person, identifier of the device, description of what was done, and results. Any deficiencies outside acceptable limits should be highlighted.*
- *Correcting deficiencies that are outside acceptable limits*

Management of Change Procedures. The plan should describe the method that will be used to review proposed changes to materials, technology, equipment, procedures, personnel and facility operation for their effect on safety vulnerabilities.

Background Information:[1] *For changes resulting in a change to the safety information such as to the ISV or an operating procedure, the applicable safety information should be updated accordingly. Employees whose job tasks will be affected by the change must be informed of the change and retrained prior to resumption of work.*

Scale-up of the process, modification of equipment and changes in materials are commonly encountered and should be considered as changes that may result in the need to update the safety plan. Change may also refer to new personnel involved in the work, necessitating training.

Project Safety Documentation. The plan should describe how safety documentation is maintained for the project, including who is responsible, where documents are kept, and how it is accessed by project personnel.

Background Information: Safety documentation includes

- *Information pertaining to the technology of the project*
  - *A block flow diagram or simplified process flow diagram*
  - *Process chemistry*
  - *Maximum intended inventory of materials*
  - *Safe upper and lower limits for such items as temperatures, pressures, flows and concentrations*
  - *An evaluation of the consequences of deviations, including those affecting the safety and health of employees*
- *Information pertaining to the equipment or apparatus*
  - *Materials of construction*
  - *Electrical classification*
  - *Pressure relief system design and design basis*
  - *Ventilation system design*

[1] *Management of Change*, U.S. Chemical Safety and Hazard Investigation Board, Safety Bulletin No. 2001-04-SB, August 2001.

- *Design codes and standards employed*
- *Material and energy balances*

- *Safety systems (e.g. alarms, interlocks, detection or suppression systems)*
- *Safety review documentation, including the ISV*
- *Operating procedures (including response to deviation during operation)*
- *Material Safety Data Sheets*
- *References such as handbooks and standards*

Safety documentation should be updated regularly to reflect changes to chemicals/other materials and their quantities, equipment, technologies, and facilities.

4. Communications Plan. The plan should describe how project safety information is communicated and made available to all project participants, including external partners.

Employee Training. The plan should describe formal programs and planned hazard-specific training related to the various hazards associated with the project. It should describe how the organization stewards training participation and verifies understanding.

Background Information: It is crucial to provide hydrogen and other safety training for all project personnel responsible for handling equipment and systems containing hazardous materials. The training program should include

- *Initial training that includes an overview of the process, a thorough understanding of the operating procedures, an emphasis on the specific safety and health hazards, emergency operations including shutdown, and safe work practices applicable to the employee's job tasks.*
- *Refresher training that is provided to each employee involved in operating a process to assure that the employee understands and adheres to the current standard operating procedures.*
- *Training documentation that shows each employee involved in operating a process has received and understood the training.*
- *For people maintaining process equipment, performing calibrations, etc., training needs to ensure that the employee can perform the job tasks in a safe manner.*

Safety Reviews. The plan should describe safety reviews that will be conducted for the project during the design, development and operational phases. The involvement and responsibilities of individual project staff in such reviews and how the reviews will be documented should be included. The ISV is expected to be one of the safety reviews performed for the project. Other safety reviews may be needed during the life of the project, including those required by organizational policies and procedures.

Safety Events and Lessons Learned. The plan should describe how safety events (incidents and near-misses) will be handled by the project team. The description should include:

- The reporting procedure within the organization and to DOE
- The method and procedure used to investigate events
- How corrective measures will be implemented
- How lessons learned from incidents and near-misses are documented and disseminated

By learning about the likelihood, severity, causal factors, setting and relevant circumstances regarding safety events, project teams are better equipped to prevent similar, perhaps more serious, events in the future. To be effective, this process requires a good investigation, a good report, and a great deal of information sharing as openly and thoroughly as possible.

An **INCIDENT** is an event that results in:

- a lost-time accident and/or injury to personnel
- damage to project equipment, facilities or property
- impact to the public or environment
- an emergency response or should have resulted in an emergency response

A **NEAR-MISS** is an event that, under slightly different circumstances, could have become an incident. Examples include:

- any unintentional hydrogen release that ignites, or is sufficient to sustain a flame if ignited, and does not fit the definition for an incident
- any hydrogen release which accumulates above 25% of the lower flammability limits within an enclosed space and does not fit the definition of an incident

Note that the definitions do not include all possible events that should be reported. The definitions are indicative of events that should be reported. All incidents and near-misses must be reported to the appropriate DOE project officer as soon as possible after the safety event has occurred. For DOE national laboratory-led projects, all incidents and near-misses should be reported to the appropriate DOE technology development manager as soon as possible after the safety event has occurred.

<u>Background Information</u>: *The investigation of an incident should be initiated as promptly as possible. An event investigation team should consist of at least one member who is independent from the project team, at least one person knowledgeable in the process chemistry and actual operation of the equipment and process, and other persons with the right knowledge and experience to thoroughly investigate and analyze the incident. The event report should include:*

- *Date of incident*
- *Date investigation began*
- *A description of the incident*
- *The factors that contributed to the incident*

- *Lessons learned from the incident*
- *Any recommendations resulting from the investigation*

The project team should promptly address and resolve the incident report findings and recommendations. Resolutions and corrective actions should be documented. The report should be reviewed with all affected personnel whose job tasks are relevant to the incident findings.

***Hydrogen Incident Reporting and Lessons Learned (**www.h2incidents.org), is a database which provides a voluntary mechanism for anyone to report an incident or near-miss and to benefit from the lessons learned from other reported incidents. All identifying information, including names of individuals, companies, organizations, vendors of equipment and locations are removed to ensure confidentiality and to encourage the unconstrained future reporting of events as they occur.*

Emergency Response. The plan should describe the emergency response procedures that are in place, including communication and interaction with neighboring occupancies and local emergency response officials.

Self-Audits. The plan should describe how the project team will verify that safety-related procedures and practices are being followed throughout the life of the project.

Background Information: Verification is usually accomplished via a compliance audit that is conducted by at least one person knowledgeable in the process who is external to the project. A report of the findings of the audit should be developed. The project team should promptly determine and document an appropriate response to each of the findings of the compliance audit with an appropriate action plan.

5. Safety Plan Approval. The review and approval process used for the project safety plan must be documented. It should be consistent with the organization's policies, and can be done by briefly describing the approval process used and/or completing an approval form. An example approval form is shown in Appendix III. In most cases, this approval process will include a review by the next management level and approved by the organization's safety representative.

6. Other Comments or Concerns. If appropriate, provide information on any topics not covered above, and any issues that may require assistance from DOE. Appendix IV – Safety Plan Checklist is also provided for use as a resource in preparing safety plans.

Appendix I – Acceptable ISV Methods

Background Information: Identification of Safety Vulnerabilities (ISV) can be done using any of several established industry methods. The ISV should be done at the project's earliest stages. The ISV helps the project team identify potential safety issues, discover ways to lower the probability of an occurrence, and minimize the associated consequences.

The ISV should address:

- The potential hazards of the operation
- Previous incidents and near misses
- Engineering and administrative controls applicable to the hazards and their interrelationships, e.g. the use of hydrogen detectors and emergency shutdown capability
- Mechanisms and consequences of failure of engineering and administrative controls
- A qualitative evaluation of a range of the possible safety and health effects resulting from failure of controls
- Facility location

The ISV should be performed by a team with sufficient expertise in all aspects of the work to be performed. At least one team member should have experience and knowledge specific to the set of processes, equipment and facilities being evaluated. Also, one member of the team needs to be knowledgeable in the specific ISV method being used.

Method	Description	References
FMEA Failure Modes and Effects Analysis	The FMEA process has these elements ○ Identify top level hazards and events ○ Identify related equipment, components, and processes ○ Identify potential failure modes and effects ○ Identify designs that provide inherent safety ○ Identify potential prevention and mitigation corrective action	○ http://www.fmeainfocentre.com/ a non-commercial web-based inventory dedicated to the promotion of FMEA ○ Government documents, including MIL-STD-882C and MILSTD-1629A ○ NASA Scientific and Technical Information http://www.sti.nasa.gov/ ○ A discussion and worked example can be found in *Guidelines for Hazard Evaluation Procedures*, *Second Edition with Worked Examples*, Center for Chemical Process Safety, American Institute of Chemical Engineers, 1992.
"What If" Analysis	A speculative process where questions of the form "What if … (hardware, software, instrumentation, or operators) (fail, breach, break, lose functionality, reverse, etc.)..?" are formulated and reviewed.	A discussion and worked example can be found in *Guidelines for Hazard Evaluation Procedures*, *Second Edition with Worked Examples*, Center for Chemical Process Safety, American Institute of Chemical Engineers, 1992.
HAZOP Hazard and Operability Analysis	Systematically evaluates the impact of deviations using project information. Method was developed to identify both hazards and operability problems at chemical process plants.	An extensive description and worked example of the HAZOP procedure can be found in *Guidelines for Hazard Evaluation Procedures*, *Second Edition with Worked Examples*, Center for Chemical Process Safety, American Institute of Chemical Engineers, 1992.

Method	Description	References
Checklist Analysis	Method evaluates the project against existing guidelines using a series of checklists. This technique is most often used to evaluate a specific design, equipment or process for which an organization has a significant amount of experience.	○ A discussion and worked example can be found in *Guidelines for Hazard Evaluation Procedures*, *Second Edition with Worked Examples,* Center for Chemical Process Safety, American Institute of Chemical Engineers, 1992. ○ Risk-based decision-making guidelines, United States Coast Guard (http://www.uscg.mil/hq/g-m/risk/e-guidelines/RBDM/html/vol3/02/v3-02-cont.htm)
Fault Tree Analysis	Fault Tree Analysis is a deductive (top-down) method used for identification and analysis of conditions and factors that can result in the occurrence of a specific failure or undesirable event. This method addresses multiple failures, events, and conditions.	A discussion and worked example can be found in *Guidelines for Hazard Evaluation Procedures*, *Second Edition with Worked Examples,* Center for Chemical Process Safety, American Institute of Chemical Engineers, 1992.
Event Tree Analysis	This method is an inductive approach used to identify and quantify a set of possible outcomes. The analysis starts with an initiating event or initial condition and includes the identification of a set of success and failure events that are combined to produce various outcomes. This method identifies the spectrum and severity of possible outcomes and determines their likelihood.	A discussion and worked example can be found in *Guidelines for Hazard Evaluation Procedures*, *Second Edition with Worked Examples,* Center for Chemical Process Safety, American Institute of Chemical Engineers, 1992.
Probabilistic Risk Assessment	A Probabilistic Risk Assessment (PRA) is an organized process for answering the following three questions: 1. What can go wrong? 2. How likely is it to happen? 3. What are the consequences?	A detailed description of this method can be found in *Guidelines for Chemical Process Quantitative Risk Analysis*, Center for Chemical Process Safety, American Institute of Chemical Engineers, 2000.
Others	Other methods or combinations of methods, including those developed by the project team's organization, may be used.	See *Guidelines for Hazard Evaluation Procedures*, *Second Edition with Worked Examples,* Center for Chemical Process Safety, American Institute of Chemical Engineers, 1992.

Appendix II – Risk Binning Matrix[2]

Risk binning is one analysis tool used to classify vulnerabilities. Each vulnerability can be assigned a qualitative risk using a frequency-consequence matrix, such as the one shown below. Highest consequences are generally assigned to events that could reasonably result in an unintended release of hazardous material, destruction of equipment and/or facilities, or injury to people.

Risk Binning Matrix: Frequency/Consequence Criteria

		Frequency			
		Beyond extremely unlikely	Extremely unlikely	Unlikely	Anticipated
Consequence	High		7	4	1
	Moderate	10	8	5	2
	Low		9	6	3
	Negligible	12	11		

Higher risk

Lower risk

Moderate risk

Negligible risk

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2 *Preliminary Safety Evaluation for Hydrogen-fueled Underground Mining Equipment*, DA. Coutts and J.K. Thomas, Westinghouse Safety Management Solutions, Aiken, SC, Publication WSRC-TR-98-00331, September 1998. (This reference includes information from *Preparation Guide for US Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports,* DOE-STD-3009-94, July 1994.)

Frequency criteria used for risk-binning

Acronym	Description	Frequency level
A	Anticipated, Expected	> 1E-2/yr
U	Unlikely	1E – 4 < f ≤ 1E – 2/yr
EU	Extremely Unlikely	1E – 6 < f ≤ 1E – 4/yr
BEU	Beyond Extremely Unlikely	≤ 1E – 6/yr

Consequence criteria used for risk-binning

Consequence Level	Impact on Populace	Impact on Property/Operations
High (H)	Prompt fatalities Acute injuries – immediately life threatening Permanent disability	Damage > $50 million Production loss in excess of 1 week
Moderate (M)	Serious injuries Non-permanent disability Hospitalization required	$100,000 < damage ≤ $50 million Equipment destroyed Critical equipment damaged Production loss less than 1 week
Low (L)	Minor injuries No hospitalization	Damage ≤ $100,000 Repairable damage to equipment Significant operational down-time Minor impact on surroundings
Negligible (N)	Negligible injuries	Minor repairs to equipment required Minimal operational down-time No impact on surroundings

Appendix III – Example Project Safety Plan Approval Form

DOE Award Number: ____

Project Title: ____

Organization: ____

Safety Plan submitted by: ____

The attached safety plan is being submitted to the U.S. Department of Energy in compliance with the Fuel Cell Technologies Program requirement under the terms of the above-referenced award. The completed approvals noted below are consistent with organization's policy for such submittals.

Project safety plan prepared by: (**EXAMPLE:** Primary Author/PI)
Name
Title
Department/Division

Project safety plan reviewed by: (**EXAMPLE:** Next Level of Management Above PI)
Name
Title
Department/Division

Project safety plan approved by: (**EXAMPLE:** Organization's Safety Representative)
Name
Title
Department/Division

Appendix IV – Safety Plan Checklist

This checklist is a summary of desired elements for safety plans. The checklist, referring to page numbers in this document, is intended to help project teams verify that their safety plan is complete and can be a valuable tool over the life of the project.

Page	Element	The Safety Plan Should Describe
1	**Scope of Work**	• Nature of the work being performed
3	**Organizational Policies and Procedures**	• Application of organizational safety-related policies and procedures to the work being performed
3	**Hydrogen and Fuel Cell Experience**	• How previous organizational experience with hydrogen, fuel cell and related work is applied to this project
4	**Identification of Safety Vulnerabilities (ISV)**	• What is the ISV methodology applied to this project, such as FMEA, What If, HAZOP, Checklist, Fault Tree, Event Tree, Probabilistic Risk Assessment, or other method • Who leads and stewards the use of the ISV methodology • Significant accident scenarios identified • Significant vulnerabilities identified • Safety critical equipment • Storage and Handling of Hazardous Materials and related topics o ignition sources; explosion hazards o materials interactions o possible leakage and accumulation o detection • Hydrogen Handling Systems o supply, storage and distribution systems o volumes, pressures, estimated use rates
4	**Risk Reduction Plan**	• Prevention and mitigation measures for significant vulnerabilities

Page	Element	The Safety Plan Should Describe
4	**Operating Procedures**	• Operational procedures applicable for the location and performance of the work including sample handling and transport • Operating steps that need to be written for the particular project: critical variables, their acceptable ranges and responses to deviations from them
5	**Equipment and Mechanical Integrity**	• Initial testing and commissioning • Preventative maintenance plan • Calibration of sensors • Test/inspection frequency basis • Documentation
6	**Management of Change Procedures**	• The system and/or procedures used to review proposed changes to materials, technology, equipment, procedures, personnel and facility operation for their effect on safety vulnerabilities
6	**Project Safety Documentation**	• How needed safety information is communicated and made available to all project participants, including partners. Safety information includes the ISV documentation, procedures, references such as handbooks and standards, and safety review reports.
7	**Employee Training**	• Required general safety training - initial and refresher • Hydrogen-specific and hazardous material training - initial and refresher • How the organization stewards training participation and verifies understanding
7	**Safety Reviews**	• Applicable safety reviews beyond the ISV described above

Page	Element	The Safety Plan Should Describe
7	**Safety Events and Lessons Learned**	• The reporting procedure within the organization and to DOE • The system and/or procedure used to investigate events • How corrective measures will be implemented • How lessons learned from incidents and near-misses are documented and disseminated
9	**Emergency Response**	• The plan/procedures for responses to emergencies • Communication and interaction with local emergency response officials
9	**Self-Audits**	• How the project will verify that safety related procedures and practices are being followed throughout the life of the project
9	**Safety Plan Approval**	• Safety plan review and approval process
9	**Other Comments or Concerns**	• Any information on topics not covered above • Issues that may require assistance from DOE

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Hawai‘i Natural Energy Institute Electrolyzer-based Hydrogen Production System to Support Additional Variable Wind and Solar Renewable Energy Sources on the Grid and Provide the Hydrogen to Fuel Public Transportation

DRAFT ENVIRONMENTAL ASSESSMENT

Appendix 2
Hydrogen Safety Information
Exhibit C
Hazard and Operability Study
HNEI Hydrogen Fueling Station

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Hazard and Operability Study

HNEI Hydrogen Fueling Station

Powertech Labs Inc.
March 2011

Prepared by:
Angela Nanalal
Joe Wong

1.0 Introduction

The Hazards and Operability Study (HAZOP) involves systematically questioning every part of a process to establish how deviations from the design intent can arise. The deviation and its consequence are rated based on the severity of the deviation and the frequency of it. If necessary, action is taken to remedy the situation.

Keywords are used to focus the attention of the HAZOP team on deviations that may occur and their possible causes. These keywords are divided into two groups, primary keywords and secondary keywords. Primary keywords are associated with a particular process condition or parameter, such as ‘flow’ or ‘temperature’. Secondary keywords, when combined with a primary keyword, suggest possible deviations, such as ‘no flow’ or ‘more temperature’.

The primary keywords that were used in this HAZOP are pressure, flow, and temperature. Vent and purge were added to this as relevant operational words.

The standard secondary keywords are listed below.

No	The design intent does not occur (e.g. Flow/No), or the operational aspect is not achievable (Isolate/No)
Less	A quantitative decrease in the design intent occurs (e.g. Pressure/Less)
More	A quantitative increase in the design intent occurs (e.g. Temperature/More)
Reverse	The opposite of the design intent occurs (e.g. Flow/Reverse)
Also	The design intent is completely fulfilled, but in addition some other related activity occurs (e.g. Flow/Also indicating contamination in a product stream, or Level/Also meaning material in a tank or vessel which should not be there)
Other	The activity occurs, but not in the way intended (e.g. Flow/Other could indicate a leak or product flowing where it should not, or Composition/Other might suggest unexpected proportions in a feedstock)
Fluctuation	The design intention is achieved only part of the time (e.g. an air-lock in a pipeline might result in Flow/Fluctuation)

The results from the HAZOP study were recorded in a table as shown below.

Deviation	Cause	Consequence	Safeguards	Action

Deviation is the keyword combination that was applied (e.g. Flow/No).

Cause is the potential cause, which could result in the deviation occurring.

Consequence is the consequence arising from both the deviation occurring and the cause itself if appropriate.

Safeguards are any existing protective devices in place, which would either prevent the cause or remedy the adverse consequences.

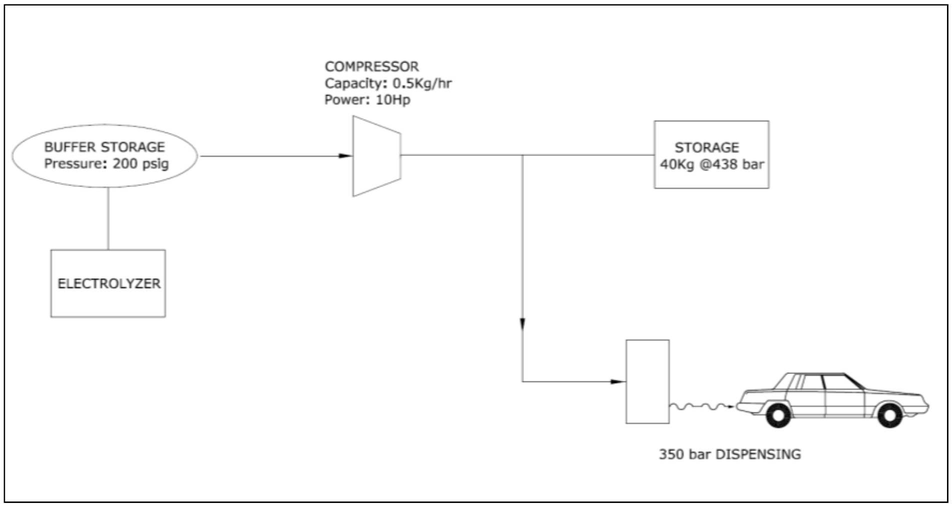
The Action column indicates what action needs to be taken. If the safeguards are adequate, then no action needs to take place. However, if there is a high possibility of a negative consequence, than some corrective action must take place.

Participants in the HAZOP included:

- Joe Wong, Project Manager
- Angela Nanalal, Lead Engineer, system designer
- Graeme Trigg, Senior Gas Systems Specialist, lead installer
- Andrew Parsons-Nunn, Lead Electrician
- Charles Pereira Da Cost. Controls Engineer

2.0 Process Description

The Hydrogen Fuelling Station is designed as a self contained unit that houses the dispenser, compressor, storage, and controls necessary to operate the station. This compact design allows for easy transport to remote sites and minimizes the time and cost for installation on site. The unique design has three separate compartments to ensure the equipment will meet the required separation distances.



Schematic of the 350 bar fueling station

Hogen elctrolyser

350 bar fueling station container

The hydrogen is supplied on site with an HOGEN H Series Hydrogen Generator, producing 12 kg of hydrogen per 24 hours The output of the electrolyser is discharged into a large low pressure hydrogen buffer tank which acts as the supply to the hydrogen fuelling station. The electrolyser is packaged into a 20 ft long container that has 2 separate compartments, one that houses the hydrogen generator, and the other housing the electrical utilities and controls.

The compressor is a two stage piston type compressor with complete gas and drive cylinder isolation to prevent hydrogen contamination. It is used to fill the onboard high pressure storage to give vehicles full pressure fills.

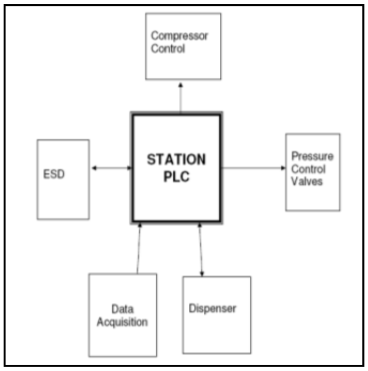
In order to optimize the fast filling capability without requiring continuous replenishment by the compressor, a “cascading” method is used to fill the vehicles. The storage bank is divided into three banks. Filling of a vehicle starts with the low bank, then switches to the medium bank, and the high pressure bank tops off the fill. This method allows a greater number of full fills compared to a one-bank system. The switching of banks is based on the flow rate. This storage design allows for three consecutive fills at 350 bar.

The dispenser is integrated into the side of the container allowing for a much smaller footprint for the station. The dispenser includes the following main features:

- WEH TK 16 nozzle with 4 m filling hose including breakaway coupling
- Max filling pressure of up to 438 bar to allow for temperature compensation
- 350 bar fast fill of 5 kg in under 5 minutes at a rate not exceeding an internal tanks temperature of 85°C.
- Flow control to allow slow fills
- Smart algorithm for non-communication fills
- Mass flow meter included

Controls

The Powertech fuelling station is designed for unattended operation. Manual local emergency shutdowns (ESD) will be located in operational areas, and a remote shutdown will be located at a designated supervisory station. The station PLC located in the electrical room will provide control of the fuelling station. A separate PLC controls the operation of the Electrolyser. The fueling station will have remote monitoring as follows:



- Alert station operator/entity in charge of maintenance of system failures.
- Provide capability to remotely collect fueling and related data (via internet access).
- All warnings and alarms are communicated through text messages and emails

3.0 Scope of Discussion

The HAZOP analysis did not cover the internal operations of the Proton Electrolyzer. An informal safety discussion was conducted on the electrolyzer. These systems were treated as "black boxes" and associated overall hazards were reviewed. Proton has performed such safety reviews as part of their design process.

4.0 Results

The HAZOP analysis was used as a safety verification process. One of the most serious hazards identified is the leakage of hydrogen. Depending on the severity of the leak, a potential explosive mixture could result and be ignited. The safeguard to prevent the leakage of hydrogen is regular maintenance and inspection of the system. In the case of the compressor enclosure, the hydrogen gas detector acts as an additional safeguard for hydrogen leakage.

Another serious hazard is the ingress of air into the hydrogen system, which is considered in the case of the compressor where it is most possible. A safeguard contained in the compressor system to prevent this occurrence is a low suction pressure alarm that prevents the possibility of the compressor pulling a vacuum.

Finally, the potential to over pressure the system was analyzed. This could potentially result in failure of the system. The two main causes behind this hazard are over filling of the storage cylinders on a cold day or a fire. Also, in the case of the 875 bar compressor, over pressure is also possible due to failure of a regulator. The safeguard that is present for these situations are pressure relief valves, which are safely designed to prevent ignition of the released hydrogen.

An Emergency Shut-down (ESD) system also acts as a safeguard in an emergency situation. A heat detector, detects fire in the compreesor room. A gas detector is also located in the compressor box to pick up large hydrogen gas leaks above 20% LEL by volume in air. The ESD system is also triggered by activation of a push button.

The HAZOP analysis showed that any potential failures or accidents have a safeguard to mitigate most dangerous situations. The HAZOP worksheets sheets are included in Appendix A.

Appendix A

HNEI Station - Node 1 - H2 Supply Line from elctrolyser to buffer tanks to compressor inlet

No.	Deviation	Cause	Consequence	Safeguards	Action
1	Pressure/No	BV-1 left in vent position, BV-2 or BV-3 left closed or PV-2 left open	Inability to provide hydrogen to compressor.	PT-1 and PT-4 are monitored before compressor starts.	None
2	Pressure/No	Electrolyser not connected.	Inability to provide hydrogen to compressor.	PT-1 and PT-4 are monitored before compressor starts.	None
3	Pressure/No	Loss of containment	Inability to provide hydrogen to compressor; hydrogen leakage	Pressure tested and designed to ASME 31.3; Regulator leakage checks	None
4	Pressure/Less	BV-1 left in vent position, BV-2 or BV-3 left closed or PV-2 left open	Inability to provide hydrogen to compressor.	PT-1 and PT-4 are monitored before compressor starts.	None
5	Pressure/Less	Loss of containment of Buffer tank		Piping pressure tested and designed to ASME 31.3; Regulator leakage checks. Buffer tank designed to ASME section 8	None
6	Pressure/More	Electrolyser provides hydrogen above working pressure	Overpressure of piping and components	Pressure relief valve PSV-1 in supply line.	None.
7	Pressure/Also	Air in line (caused after maintenance).	Mixture of air in hydrogen line	Proper purge procedures, check valve to hold hydrogen pressure	None.
8	Temperature /Low	No credible scenario could be identified. Operating within station temperature limits.			None.
9	Temperature /High	Fire or other external heat source.	Overpressure of piping and components	Pressure relief valve PSV-1 in supply line.	None.
10	Isolate-Maintain/No	Failure of isolation valves	Inability to isolate system. Operational issue with no significant hazard.	Three levels of valves in place including check valves, air-actuated ball valves, and manual ball valves.	None.
11	Vent-Purge/No	Blocked vent valve	Inability to vent or purge the gas line. Operational issue with no significant hazard.	Ability to vent downstream.	None.

HNEI Station - Node 2 - CP-1 Compressor Inlet

No.	Deviation	Cause	Consequence	Safeguards	Action
1	Pressure/No	PV-3 left open	Potential vacuum in line could result in air ingress causing contamination or explosion hazard. Damage to compressor.	Pressure transducer (PT-4) on suction side shuts off compressor at 400 psig suction pressure.	None
2	Pressure/No	No gas supply.	Potential vacuum in line could result in air ingress causing contamination or explosion hazard. Damage to compressor.	Pressure transducer (PT-4) on suction side shuts off compressor at 400 psig suction pressure.	None
3	Pressure/No	Clogged components (filter)	Potential vacuum in line could result in air ingress causing contamination or explosion hazard. Damage to compressor.	Pressure transducer (PT-4) on suction side shuts off compressor at 400 psig suction pressure.	None
4	Pressure/No	Failure of compressor inlet air actuated valve	Potential vacuum in line could result in air ingress causing contamination or explosion hazard. Damage to compressor.	Pressure transducer (PT-4) on suction side shuts off compressor at 400 psig suction pressure.	None
5	Pressure/No	Loss of containment.	Potential vacuum in line could result in air ingress causing contamination or explosion hazard. Damage to compressor. Uncontrolled hydrogen leak.	Pressure transducer (PT-4) on suction side shuts off compressor at 400 psig suction pressure. Gas detector takes system into ESD mode.	None
6	Pressure/Less	Insufficient gas supply	Low suction pressure to the compressor	Pressure transducer (PT-4) on suction side shuts off compressor at 400 psig suction pressure.	None
7	Pressure/Less	Clogged components (filters)	Low suction pressure to the compressor.	Pressure transducer (PT-4) on suction side shuts off compressor at 400 psig suction pressure.	None
8	Pressure/Less	Loss of containment.	Low suction pressure to the compressor and uncontrolled hydrogen leak.	Pressure transducer (PT-4) on suction side shuts off compressor at 400 psig suction pressure.	None
9	Pressure/Less	Leak through purge valve (PV-3)	Operational issue with no significant hazard.		None
10	Pressure/More	Reverse flow of hydrogen through compressor	Overpressure of suction side tubing	Check valves in compressor and relief valve PSV-2.	None
11	Pressure/More	High pressure gas leakage past CV-8 and AV-1	Overpressure of tubing with 875 bar gas	Relief valve PSV-7 protects tubing from overpressure.	
12	Flow/No	No gas supply.	No suction pressure to the compressor.	Pressure transducer (PT-4) on suction side shuts off compressor at 400 psig suction pressure.	None
13	Flow/No	Clogged components (filters, regulator, etc)	No suction pressure to the compressor.	Pressure transducer (PT-4) on suction side shuts off compressor at 400 psig suction pressure.	None
14	Flow/No	Failure of inlet air actuated valve.	No suction pressure to the compressor resulting in potential vacuum.	Pressure transducer (PT-4) on suction side shuts off compressor at 400 psig suction pressure.	None
15	Flow/No	Loss of containment.	No suction pressure to the compressor and uncontrolled hydrogen leak.	Pressure transducer (PT-4) on suction side shuts off compressor at 400 psig suction pressure. Gas detector takes system into ESD mode.	None

16	Flow/Less	Insufficient gas supply	Low suction pressure to the compressor.	Pressure transducer (PT-4) on suction side shuts off compressor at 400 psig suction pressure.	None
17	Flow/Less	Clogged components (filter)	Low suction pressure to the compressor	Pressure transducer (PT-4) on suction side shuts off compressor at 400 psig suction pressure.	None
18	Flow/Less	Loss of containment.	Low suction pressure to the compressor and uncontrolled hydrogen leak.	Pressure transducer (PT-4) on suction side shuts off compressor at 400 psig suction pressure. Gas detector takes system into ESD mode.	None
19	Flow/More	No credible scenario could be identified.			None.
20	Reverse Flow	Reverse flow of hydrogen through compressor	Overpressure of suction side tubing	Check valves in compressor and relief valve PSV-2.	None
21	Temperature/Less	No credible scenario could be identified.			None.
22	Vent-Purge/No	Blocked vent line.	Inability to vent system. Operational issue with no significant hazard.	Proper design of vent line with end caps.	None.
23	Startup	Air ingress during maintenance	Contamination of hydrogen	Purge cycle procedure in place to do three cycles from 500 psig to 5 psig.	None.

HNEI Station - Node 3 - CP1 Compressor Outlet

No.	Deviation	Cause	Consequence	Safeguards	Action
1	Pressure/No	Compressor failure.	Inability to fill storage. Operational issue with no significant hazard.	None.	None.
2	Pressure/No	Failure open of relief valve.	Uncontrolled discharge of gas to atmosphere	Pressure switch (PS-1) in vent header puts compressor in ESD mode when PSV-3 activated and shuts down compressor.	None.
3	Pressure/No	False signals from instruments causing compressor to shutdown.	Inability to fill storage. Operational issue with no significant hazard.	Regular maintenance, inspection and calibration of instruments.	None.
4	Pressure/No	Clogged components	Inability to replenish storage. Operational issue with no significant hazard.	Regular maintenance and inspection of components.	None
5	Pressure/No	Loss of containment.	Uncontrolled hydrogen leak.	Gas detector takes system into ESD mode.	None
6	Pressure/Less	Failure of compressor valves.	Low pressure in storage resulting in inability to get a complete fill. Operational issue with no significant hazard.	Regular calibration and maintenance of compressor.	None.
7	Pressure/Less	Clogged components	Low pressure in storage resulting in inability to get a complete fill. Operational issue with no significant hazard.	Regular maintenance and inspection of components.	None
8	Pressure/Less	Loss of containment.	Uncontrolled hydrogen leak.	Gas detector takes system into ESD mode.	None
9	Pressure/More	Pressure transducer not working properly and prevently compressor from turning off.	Over pressure surge in discharge line.	Relief valve (PSV-3) and pressure switch (PS-1) in vent header will shut compressor down due to high pressure detection.	None.
10	Pressure/More	Failure closed of discharge air actuated valve.	Over pressure surge in discharge line.	PT-5 in discharge line detects over pressure and shuts compresor off. Relief valve (PSV-3) and pressure switch (PS-1) in vent header will shut compressor down due to high pressure detection.	None.
11	Flow/No	Compressor failure.	Inability to replenish storage pressure. Operational issue with no significant hazard.	None.	None.
12	Flow/No	Failure open of relief valve.	Uncontrolled discharge of gas to atmosphere	Pressure switch (PS-1) in vent header puts compressor in ESD mode and shuts down compressor	None.
13	Flow/No	Failure closed of discharge air actuated valve.	Inability to replenish storage. Operational issue with no significant hazard.	None.	None.

14	Flow/No	False signals from instruments causing compressor to shutdown.	Inability to replenish storage high bank. Operational issue with no significant hazard.	Regular maintenance and inspection of instruments.	None.
15	Flow/No	Clogged components	Inability to replenish storage. Operational issue with no significant hazard.	Regular maintenance and inspection of components.	None
16	Flow/No	Loss of containment.	Uncontrolled hydrogen leak.	Gas detector takes system into ESD mode.	None
17	Flow/Less	Failure of compressor valves.	Low pressure in storage resulting in inability to get a complete fill. Operational issue with no significant hazard.	Regular calibration and maintenance of compressor.	None.
18	Flow/Less	Clogged components	Low pressure in storage resulting in inability to get a complete fill. Operational issue with no significant hazard.	Regular maintenance and inspection of components.	None
19	Flow/Less	Loss of containment.	Uncontrolled hydrogen leak.	Gas detector takes system into ESD mode.	None
20	Flow/More	Failure closed of discharge air actuated valve.	Over pressure surge in discharge line.	Relief valve (PSV-3) and pressure switch (PS-1) in vent header will shut compressor down due to high pressure detection.	None.
21	Flow/Reverse	Backflow of hydrogen from 438 bar storage.	Reverse flow through compressor.	Check valve CV-3 prevents backflow. AV-D closes when compressor not running.	None.
22	Temperature/Less	No credible scenario could be identified.			None.
23	Temperature/More	Coolant system failure.	Over heating of components.	Thermocouple (TT-2) shuts down compressor on high temperature.	None.
24	Vent-Purge/No	Vent line clogged.	Inability to vent. Operational issue with no significant hazard.	Proper design of vents including end caps.	None.

HNEI Station - Node 4 - 438 bar H2 Storage

No.	Deviation	Cause	Consequence	Safeguards	Action
1	Pressure/No	H2 depleted from 438 bar storage due to fast filling	Inability to fill at 438 bar. Operational issue with no significant hazard.	Tube trailer available to supply hydrogen and compressor available to fill storage.	None
2	Pressure/No	Loss of containment	Inability to fill at 438 bar and uncontrolled leakage of high pressure H2	Regular leak checks on systems components and maintenance program. Certification testing of cylinders.	None
3	Pressure/No	H2 depleted from 438 bar storage due to an internal leak	H2 carried back through the system. Operational issue with no significant hazard.	Pressure transducers have low alarm set at 200 psig. Three levels of valves in place including check valves, air-actuated ball valves, and manual ball valves.	None
4	Pressure/No	H2 depleted from 438 bar storage due to relief valve activation.	Inability to fill at 438 bar and uncontrolled leakage of high pressure H2.	Regular leak checks on systems components and maintenance program. Properly designed vent stack to safely discharge gas.	None.
5	Pressure/Less	No gas storage due to inability for CP-1 compressor to provide gas	Inability to fill at 438 bar. Operational issue with no significant hazard.	Regular maintenance program on compressor.	None
6	Pressure/Less	H2 depleted from 450 bar storage due to fast filling	Inability to fill at 438 bar. Operational issue with no significant hazard.	Tube trailer continuously supplying hydrogen and compressor filling storage.	None
7	Pressure/Less	Loss of containment	Inability to fill at 438 bar and uncontrolled leakage of high pressure H2.	Regular leak checks on system components and maintenance program. Certification testing of cylinders.	None
8	Pressure/Less	H2 depleted from 438 bar storage due to an internal leak	H2 carried back through the system. Operational issue with no significant hazard.	Pressure transducers have low alarm set at 200 psig. Three levels of valves in place including check valves, air-actuated ball valves, and manual ball valves.	None
9	Pressure/Less	H2 depleted from 438 bar storage due to relief valve activation	Inability to fill at 438 bar and continuous uncontrolled leakage of high pressure H2	Regular leak checks on systems components and maintenance program. Properly designed vent stack to safely discharge gas.	None.
10	Pressure/More	438 bar storage fill at low ambient temperature followed by high ambient temperature after filling	Overpressure of cylinder.	Pressure relief valve PSV-4 set to 480 bar. Certification testing of cylinders. PLC controls monitor amibent temperature swings and fill storage to lower pressure to prevent relief valve activation. Ambient temperature monitoring in storage room to prevent overfilling	None.
11	Pressure/More	Fire or other external heat source.	Catastrophic failure of the storage system which includes cylinders, valves, etc.	Pressure relief valve PSV-4 release over pressure. Heat detectors in storage room.	None.
12	Pressure/ Fluctuation	Temperature change and storage cylinder filling	Overpressure of cylinder.	Pressure relief valves set to 480 bar. Certification testing of cylinders including cycle testing.	None.
13	Temperature /Less	Fast blowdown of cylinders.	Premature aging of the storage system causing failure of components.	System components tested to -40C. Controlled venting rates with needle valves.	None.

14	Temperature /More	Fire or other external heat source.	Catastrophic failure of the storage system which includes cylinders, valves, etc.	Pressure relief valves release pressure. Linear heat detection alerts of fire condition.	None.
15	Temperature/More	High ambient temperatures.	Over pressure of system.	Storage system designed to withstand 85C.	None.
16	Isolate-Maintain/No	Failure of isolation valves	Inability to isolate system. Operational issue with no significant hazard.	Three levels of valves in place including check valves, air-actuated ball valves, and manual ball valves.	None.
17	Isolate-Isolate/No	Leaking relief valves on the storage bank.	Inability to isolate system. Operational issue with no significant hazard.	Ability to replace the relief valve.	None.
18	Vent-Purge/No	Failure closed of purge valves.	Inability to vent system. Operational issue with no significant hazard.	Low probably of failure as shown through history.	None.
19	Vent-Purge/No	Blocked vent valve	Inability to vent system. Operational issue with no significant hazard.	Vent caps on all vent lines and proper vent design.	None.

HNEI Station - Node 5 - 438 bar medium bank to dispenser sequence valve

No.	Deviation	Cause	Consequence	Safeguards	Action
1	Pressure/No	No gas supply	Inability to fill vehicle. Operational issue with no significant hazard.	None.	None.
2	Pressure/No	Clogged components	Inability to fill vehicle. Operational issue with no significant hazard.	Regular maintenance and inspection of components	None.
3	Pressure/No	Failure closed of air actuated valve	Inability to fill vehicle. Operational issue with no significant hazard.	Regular maintenance and inspection of components	None.
4	Pressure/No	Loss of containment.	Inability to fill vehicle and hydrogen leak.	Gas detector takes system into ESD mode.	None.
5	Pressure/Less	Insufficient gas supply	Inability to fill vehicle. Operational issue with no significant hazard.	None.	None.
6	Pressure/Less	Clogged components	Inability to fill vehicle. Operational issue with no significant hazard.	Regular maintenance and inspection of components	None.
7	Pressure/Less	Loss of containment.	Inability to fill vehicle and hydrogen leak.	Gas detector takes system into ESD mode.	None.
8	Flow/No	No gas supply	Inability to fill vehicle. Operational issue with no significant hazard.	None.	None.
9	Flow/No	Clogged components	Inability to fill vehicle. Operational issue with no significant hazard.	Regular maintenance and inspection of components	None.
10	Flow/No	Failure closed of air actuated valve	Inability to fill vehicle. Operational issue with no significant hazard.	Regular maintenance and inspection of components	None.
11	Flow/No	Loss of containment.	Inability to fill vehicle. Operational issue with no significant hazard.	Gas detector takes system into ESD mode.	None.
12	Flow/Less	Insufficient gas supply	Inability to fill vehicle. Operational issue with no significant hazard.	None.	None.
13	Flow/Less	Clogged components	Inability to fill vehicle. Operational issue with no significant hazard.	Regular maintenance and inspection of components	None.
14	Flow/Less	External leak.	Inability to fill vehicle and hydrogen leak.	Gas detector takes system into ESD mode.	None.
15	Flow/More	No credible scenario could be identify.			None.
16	Flow/Reverse	Leakage of hydrogen through AV-3 sequence valve	Over pressure of some tubing and 438 bar bank.	Check valve CV-6 and CV-8 prevent backflow. Relief valve PSV-4 protects 438 bar bank and PSV-7 protects low pressure tubing.	None.
17	Vent-Purge/No	Blocked vent line.	Inability to vent or purge the gas line. Operational issue with no significant hazard.	Proper design of vent line with end caps.	None.

HNEI Station - Node 6 - high bank to dispenser sequence valve

No.	Deviation	Cause	Consequence	Safeguards	Action
1	Pressure/No	No gas supply	Inability to fill vehicle. Operational issue with no significant hazard.	None.	None
2	Pressure/No	Clogged components	Inability to fill vehicle. Operational issue with no significant hazard.	Regular maintenance and inspection of components	None
3	Pressure/No	Failure closed of air actuated valve	Inability to fill vehicle. Operational issue with no significant hazard.	Regular maintenance and inspection of components	None
4	Pressure/No	Loss of containment.	Inability to fill vehicle and hydrogen leak.	Gas detector takes system into ESD mode.	None
5	Pressure/Less	Insufficient gas supply	Inability to fill vehicle. Operational issue with no significant hazard.	None.	None
6	Pressure/Less	Clogged components	Inability to fill vehicle. Operational issue with no significant hazard.	Regular maintenance and inspection of components	None
7	Pressure/Less	Loss of containment.	Inability to fill vehicle and hydrogen leak.	Gas detector takes system into ESD mode.	None
8	Flow/No	No gas supply	Inability to fill vehicle. Operational issue with no significant hazard.	None.	None
9	Flow/No	Clogged components	Inability to fill vehicle. Operational issue with no significant hazard.	Regular maintenance and inspection of components	None
10	Flow/No	Failure closed of air actuated valve	Inability to fill vehicle. Operational issue with no significant hazard.	Regular maintenance and inspection of components	None
11	Flow/No	Loss of containment.	Inability to fill vehicle. Operational issue with no significant hazard.	Gas detector takes system into ESD mode.	None
12	Flow/Less	Insufficient gas supply.	Inability to fill vehicle. Operational issue with no significant hazard.	None.	None
13	Flow/Less	Clogged components.	Inability to fill vehicle. Operational issue with no significant hazard.	Regular maintenance and inspection of components	None
14	Flow/Less	Loss of containment.	Inability to fill vehicle and hydrogen leak.	Gas detector takes system into ESD mode.	None
15	Flow/More	No credible scenario could be identified.			None.
16	Flow/Misdirected	Backflow of hydrogen from Xhigh Bank to High bank	Equilization of banks. Operational issue with no significant hazard.	Check valve CV-5 prevents back flow.	None.
17	Flow/Misdirected	Backflow of hydrogen due to sequence valve failure to close.	Flow back towards low and medium banks causing over pressure of banks.	Check valve CV-6, CV-8 prevent backflow. Relief valve PSV-1 and PSV-4 prevent over pressure in case of check valve failure.	None.
18	Vent-Purge/No	Blocked vent line.	Inability to vent or purge the gas line. Operational issue with no significant hazard.	Proper design of vent line with end caps.	None.

HNEI Station - Node 7 - 350 Bar Dispensing

No	Deviation	Cause	Consequence	Safeguards	Action
1	Pressure/No	No gas supply	Inability to fill vehicle. Operational issue with no significant hazard.	None.	None
2	Pressure/No	Clogged components	Inability to fill vehicle. Operational issue with no significant hazard.	Regular maintenance and inspection of components	None
3	Pressure/No	Failure closed of air actuated valve	Inability to fill vehicle. Operational issue with no significant hazard.	Regular maintenance and inspection of components	None
4	Pressure/No	Loss of containment.	Inability to fill vehicle. Operational issue with no significant hazard.	PLC monitors excess flow. Gas detector takes system into ESD mode. PT-7 does a pressure check before fill starts.	None
5	Pressure/Less	Insufficient gas supply	Inability to fill vehicle. Operational issue with no significant hazard.	None.	None
6	Pressure/Less	Clogged components	Inability to fill vehicle. Operational issue with no significant hazard.	Regular maintenance and inspection of components	None
7	Pressure/Less	Loss of containment.	Inability to fill vehicle and hydrogen leak.	PLC monitors excess flow. Gas detector takes system into ESD mode. PT-7 does a pressure check before fill starts.	None
8	Pressure/More	Failure of regulator REG-2	Over pressure of vehicle	PT-7 will stop gas flow by closing all air actuated valves upon over pressure detection. PSV-5 prevents over pressure.	None.
8	Flow/No	No gas supply	Inability to fill vehicle. Operational issue with no significant hazard.	None.	None
9	Flow/No	Clogged components	Inability to fill vehicle. Operational issue with no significant hazard.	Regular maintenance and inspection of components	None
10	Flow/No	Failure closed of air actuated valve	Inability to fill vehicle. Operational issue with no significant hazard.	Regular maintenance and inspection of components	None
11	Flow/No	Loss of containment.	Inability to fill vehicle. Operational issue with no significant hazard.	PLC monitors excess flow. Gas detector takes system into ESD mode. PT-6 does a pressure check before fill starts.	None
12	Flow/Less	Insufficient gas supply	Inability to fill vehicle. Operational issue with no significant hazard.	None.	None
13	Flow/Less	Clogged components	Inability to fill vehicle. Operational issue with no significant hazard.	Regular maintenance and inspection of components	None
14	Flow/Less	Loss of containment.	Inability to fill vehicle and hydrogen leak.	PLC monitors excess flow. Gas detector takes system into ESD mode. PT-7 does a pressure check before fill starts.	None

15	Flow/More	Hose rupture	Uncontrolled hydrogen leak.	PLC monitors excess flow. Gas detector takes system into ESD mode. PT-7 does a pressure check before fill starts.	None.
16	Flow/More	Hose rupture/hose breakaway	Hose rupture.	Breakaway on hose. PLC monitors excess flow. Gas detector takes system into ESD mode. PT-7 does a pressure check before fill starts.	None.
17	Temperature /Less	No credible scenario could be identified.			None.
18	Temperature /More	No credible scenario could be identified.			None.
19	Vent-Purge/No	Blocked vent line.	Inability to vent or purge the gas line. Operational issue with no significant hazard.	Proper design of vent line with end caps.	None.

Hawai‘i Natural Energy Institute Electrolyzer-based Hydrogen Production System to Support Additional Variable Wind and Solar Renewable Energy Sources on the Grid and Provide the Hydrogen to Fuel Public Transportation

DRAFT ENVIRONMENTAL ASSESSMENT

Appendix 2
Hydrogen Safety Information
Exhibit D
HNEI 350 bar Hydrogen Fueling Station
Permitting Guide Check List for BC Safety Authority

HNEI 350 bar HYDROGEN FUELING STATION
PERMITTING GUIDE
CHECK LIST FOR BC SAFETY AUTHORITY

CLAUSE	COMMENTS
Part 1 – Technical Requirements	
0 Introduction	
1. Scope	
2. References	
3. Interpretation	
3.1 Conflicts Between Manufacturer's Instructions and this Code Where a conflict exists between the manufacturer's certified installation instructions and this Code, the more stringent requirement shall prevail.	
3.2 Regulations and Other Codes A fuelling station shall comply with local requirements such as fire regulations, electrical safety codes, building codes, and zoning requirements.	
3.4 Permitted Components An accessory, component, equipment, or material used in an installation shall be (a) of a type and rating approved for the specific purpose for which it is to be employed; (b) installed in accordance with the manufacturer's recommendations (see also Clause 3.1); and (c) in compliance with the Canadian Electrical Code, Part I.	
3.5 Electrical Classification Areas Where different and overlapping electrical classification areas are created by different components or systems, the electrical classification shall be the most restrictive level.	

CLAUSE	COMMENTS
4. General Requirements	
4.1 Pressure retaining components All pressure retaining components in a hydrogen refueling system shall be designed to the maximum allowable operating pressure of the system. The design of pressure vessels designed manufactured and registered in accordance with CSA B 51, latest edition or any other Code acceptable to the BC Safety Authority for such use. Pressure piping shall be designed and installed in accordance with the applicable part of CSA B51.	Comply
4.6 Dispensing Pressure — Temperature Compensation Hydrogen shall be dispensed to vehicles at a pressure not exceeding any of the following: (a) a pressure that would settle to 700 bar (10 000 psi) at a settled temperature of 15^0 C (59^0 F); (b) a settled pressure of 875 bar (12 500 psi) at 85^0 C (185^0 F); or (c) 875 bar (12 500 psi) immediately after filling, regardless of temperature. The dispensed pressure shall be temperature-compensated to prevent pressures from exceeding the maximum pressures defined. This compensation is based on a Hydrogen that follows the equation P (bar) = 178.6 + [1.43 × T(C)]. For gases or mixtures that do not follow this equation, the dispensed pressure should o be reduced to protect the container in the case of exposure to heat or fire. The integrity of the entire system shall be compatible with the service pressure.	350 bar @ 15°C 438 bar @ 85°C
4.7 Defuelling Not Allowed Defuelling shall not be allowed in fuelling stations unless equipment designed for the purpose is used and operated by trained personnel.	No defuelin
5 Design, Installation, and Testing of Piping, Tubing, and Fitting	
5.1 Pressure Piping Systems Over 414 kPa (60 psi) The design, installation, and testing of the following pressure piping systems shall be in accordance with CSA B51: (b) from the inlet to the compressor assembly through to the dispenser nozzle, except for the mechanical parts of the compressor and any subsystems designed for 414 kPa (60 psi) or less; and (c) fuel container appurtenances and pressure piping.	CSA B51, Part 1
5.2 Pressure Piping Systems for 414 kPa (60 psi) or Less All pressure piping systems designed for 414 kPa (60 psi) or less shall be in accordance with **CSA B51**.	comply

CLAUSE	COMMENTS
5.3 Shutoff Valves **5.3.1 Before the Compressor** A manual shutoff valve shall be installed in an accessible location, external to any compressor enclosure, to control the Hydrogen supply to the compressor.	
5.3.2 After the Compressor The following valves shall be installed after the compressor: (a) A back check valve shall be installed on the outlet line from a compressor. (b) A manual shutoff valve shall be installed downstream of, and external to, any compressor enclosure, in the Hydrogen supply line serving each container or group of containers manifolded together. (c) A manual shutoff valve, which may be the valve referred to in Item (b), shall be installed downstream of the back check valve referred to in Item (a). (d) Safety relief valves for the protection of the pressure vessels and the pressure piping will be installed as required by CSA B51 Part 3.	
5.3.3 Before the Dispensing Point Automatic normally closed shutoff valves shall be installed in a safe and secure location upstream from the dispensing point so as to limit any accidental discharge of hydrogen to 200 L water capacity in the event of damage to the dispenser These valves shall close when any of the following occurs: (a) the dispenser is deactivated, upset, or sheared from its foundation; (b) the power supply to the dispenser is off; or (c) any ESD button at the fuelling station is activated	
5.4 Manual Shutoff Valves A manual shutoff valve shall be provided at a station, immediately upstream of the vent system used in Clause 8.11.2, where it is accessible to maintenance personnel for the purpose of connecting the fuelling hose. Each supply line between a Hydrogen storage facility and a dispenser at a station shall have at least one fast-closing manual shutoff valve, which may be the valve referred to in the previous paragraph.	
5.5 Vent to Outdoors A relief device shall be vented to a safe outdoor location, not less than 3 m (10 ft) above grade, using piping that does not reduce the flow capacity of the relief device and in accordance with Clause 8.18.	10 ft vent stacks
6 Compressors and Compressor Packages	

CLAUSE	COMMENTS
6.1 Mounting of Compressor Packages A compressor package shall be mounted on a reinforced concrete slab or equivalent structure, which may be integral to a compressor enclosure, and placed directly above an area that has been prepared using good engineering practice for drainage and support. Compensation for vibration and movement shall be provided between interconnected systems at a fuelling station and between the hydrogen supply piping and the compressor suction piping.	Concrete slab see site drawing
6.2 Electrical Classification The space surrounding a compressor and the space surrounding a building or other enclosure housing a compressor shall be electrically classified in accordance with Table 1. Distances in Table 1 shall be measured as follows: (a) When a Hydrogen-tight wall is located within 3 m (10 ft) of the compressor or compressor enclosure, the distances shall be measured around the end of the wall, over the wall, or through any doors, windows, or openings in the wall. (b) Where the enclosure is designed and built to ensure that its walls and ceiling are Hydrogen-tight except for required openings, distance shall be measured from its openings.	comply see classification drawing
6.3 Distances to Property Lines A compressor shall be installed such that the area electrically classified in accordance with Table 1 does not extend beyond a property line.	comply see classification drawing
6.4 Compressor Enclosure Where a compressor enclosure shares one wall of an existing building, the shared wall shall be Hydrogen-tight and have at least a 2 h fire resistance rating. A compressor enclosure shall be of a designed as to provide the ventilation required by the designer of the compressor enclosure. Any successive modification shall maintain as a minimum that level of ventilation. A compressor enclosure large enough to admit service personnel shall have an access door that opens outwards and, if equipped with a latch, shall be equipped on the inside with fast-release hardware that can be operated without a key. Equipment shall be installed in such a manner so as to provide adequate access for operation, inspection, and maintenance. Passageways required for egress shall be at least 1 m (3 ft) in width. Lesser distances will need approval of the authority having jurisdiction.	- N/A - yes, ventilation - comply - approved by gas inspector
6.9 Protection from Unauthorized Access A compressor shall be protected from unauthorized access by a fenced or walled area, building, or enclosure made of noncombustible materials that shall not be used for any other purpose, except that the fenced or walled area may also enclose a Hydrogen storage facility. When a fence or wall is used, it shall be 1.8 m (6 ft) high, measured from the ground level.	Fence

CLAUSE	COMMENTS
7 Hydrogen Storage Systems	
7.1 Site Layout **7.1.1 Distance from Property Line** A Hydrogen storage facility shall be located not less than the distances given in Table 2. Distances shall be measured from any portion of the Hydrogen storage facility that contains pressurized Hydrogen to the nearest property line. If a 4 h fire resistance wall is provided and used in the calculation of distances, the wall shall be located between the Hydrogen storage facility and the property line and shall be (a) the greater of either the height of the Hydrogen storage facility or 1.8 m (6 ft) in height measured from grade level; and (b) not less than the overall length of the portion of the Hydrogen storage facility exposed to the wall.	3 m from the property line to the fence of the storage area
7.1.2 Permissible Locations A Hydrogen storage facility shall be installed where the containers are readily accessible to authorized personnel, outdoors or in a shelter that has at least the equivalent of 25% of the total area of its perimeter wall open to the outside and a ventilated roof that cannot accumulate Hydrogen.	comply
7.1.3 Building Faces Exposed to Hydrogen Storage Facility Where a building other than a compressor enclosure is within the distances specified in Clause 7.4 of a Hydrogen storage facility, the building face exposed to the Hydrogen storage facility shall: **(a)** have a 4 h fire resistance rating; **(b)** have Hydrogen-tight walls and no door, window, or other opening within the distances specified in Clause 7.4 unless the building is electrically classified as Class I, Zone 1 (Division 1, Group B) or Class 1, Zone 2 (Division 2, Group B) as appropriate; and **(c)** be not closer than 1.5 m (5 ft) to the nearest Hydrogen storage container if the aggregate storage volume is greater than 10 000 L water capacity.	N/A
7.2 Structural Support A Hydrogen storage container or assembly shall be supported on a reinforced concrete slab or equivalent structure, which may be integral to the storage container assembly, and placed directly above an area that has been prepared using good engineering practice for drainage and support. The Hydrogen container shall be installed in accordance with the requirements of this Code and the manufacturer's instructions, and the container shall be protected from physical damage. The canopy design includes lightning rods on top of the supports to direct lightning-strikes away from the Hydrogen tanks.	Concrete Pad
7.3 Accessibility Sufficient space shall be provided for visual observation of each container in the Hydrogen storage facility. An unobstructed space shall be provided for each group of fuel containers such that individual container valves and fittings are accessible within a distance of 1 m (3 ft).	comply

CLAUSE	COMMENTS
7.4 Electrical Classification of Surrounding Space **7.4.1 General** The space surrounding a Hydrogen storage facility shall be electrically classified in accordance with the distances specified in Clauses 7.4.2 and 7.4.3. Distance shall be measured as follows: (a) Distances shall be measured from any opening in the Hydrogen storage container, except that permanently fitted bushings or other fittings such as plugs that are not subject to accidental shear or similar damage shall not be included in the calculations. (b) When a wall with a 4 h fire resistance rating is located within these distances, the distances shall be measured either around the end of or over the wall, but not through it. This wall shall not be located closer than 1 m (3 ft) from a fuel container up to 10 000 L in storage volume, or mass of 500 stored Hydrogen, whichever is greater, and 1.5 m (5 ft) from a fuel container with a storage volume greater than 10 000 L, or mass of 500 stored Hydrogen, whichever is greater, .	comply see classification drawing
7.4.2 Small Hydrogen Containers The space surrounding individual Hydrogen storage containers of less than 455 L water capacity with openings of 10 mm or less shall be electrically classified as follows: (a) Class 1, Zone 1 (Division 1, Group B) — The distance 100 orifice diameters, within 15° of the line of discharge of the orifice; or (b) Class 1, Zone 2 (Division 2, Group B) — The distance 1.8 m (6 ft) in all directions from the orifice, excluding the Zone 1 envelope. The calculation shall be based on the size of the orifice from the tubing, piping, or appurtenance that exists after installation of the Hydrogen storage system and be rounded up to the nearest 50 mm distance. For sample calculations, see Table 3.	comply see classification drawing
7.4.3 Large Hydrogen Containers The space surrounding Hydrogen storage containers of greater than 455 L water capacity or with openings in Hydrogen containers of greater than 10 mm shall be electrically classified as shown in Table 4.	N/A
7.5 Protection from Fire **7.5.1 General** If a fence or wall is provided for fire protection, it shall (a) have a 4 h fire resistance rating; (b) be located between the Hydrogen storage facility and the potential source of fire; (c) be the greater of either the height of the Hydrogen storage facility or 1.8 m (6 ft) in height measured from grade level; (d) be not less than the overall length of the portion of the Hydrogen storage facility exposed to the wall; and (e) be of solid construction when closer than 0.6 m (2 ft) to a fuel container.	N/A

CLAUSE	COMMENTS
7.5.2 Combustible Material No combustible material shall be stored closer to any part of the Hydrogen storage system than the distances specified in Table 5. Distances shall be measured from any portion of the storage facility that contains pressurized Hydrogen to the combustible material.	3 m clearance
7.5.5 Fence Materials A fence or wall that makes use of combustible material shall not be located closer than 1.5 m (5 ft) to any fuel container.	chain link fence
7.7 Protection from Vehicular Impact **7.7.1 General** Each side of a storage facility that may be subject to impact by vehicles shall be protected as follows: **(a)** Where the vehicles may be expected to travel at 8 km/h (5 mph) or less, it shall be protected by means of a chain link fence located at least 0.6 m (2 ft) from a container or fitting. The chain link fence shall be constructed from 9 gauge wire hot-dip galvanized with mesh size of 51 mm (2 in). The posts shall be not less than 7.5 cm (3 in) diameter, hot-dip galvanized, be spaced no more than 3 m (10 ft) apart, and extend no less than 0.9 m (3 ft) above grade. **(b)** Where the vehicles may be expected to travel between 8 km/h (5 mph) and 50 km/h (30 mph), it shall be protected by means of concrete filled steel pipe posts 100 mm (4 in) or more in diameter located at least 0.9 m (3 ft) from a container or fitting. The posts shall measure at least 0.9 m (3 ft) from grade to the top of the post and be set in concrete on 0.75 m (2.5 ft) centers. **(c)** Where the vehicles may be expected to travel in excess of 50 km/h (30 mph), it shall be protected by means of **(i)** a steel beam guardrail at a height not less than 0.75 m (2.5 ft) when measured to the top of the rail from grade level, measuring 310 mm (1 ft) wide, located at least 0.9 m (3 ft) from a container or fitting, and supported by pressure-treated square wooden posts having a minimum dimension of 190 mm (7.5 in), set on centers not more than 1.9 m (75 in) apart and buried not less than 0.9 m (3 ft) below grade; or **(ii)** a guardrail of the reinforced concrete type, commonly referred to as the New Jersey Turnpike barrier, having a height not less than 0.75 m (2.5 ft) when measured to the top of the rail from grade level and located at least 0.9 m (3 ft) from a container or fitting. **(d)** As an alternative to Item (a), (b), or (c), this requirement may be met by barriers designed by a professional engineer that provide an equivalent level of protection to that provided in Item (a), (b) or (c).	comply see site drawing

CLAUSE	COMMENTS
7.8 Signs **7.8.1 General** Signs with the words "AUTHORIZED PERSONNEL ONLY"* and "NO SMOKING — FLAMMABLE HYDROGEN" in letters not less than 45 mm (1.8 in) high shall be posted at every hydrogen storage facility in conspicuous places where readily visible, and at least one of each sign shall be placed near the gate(s) referred to in Clause 7.6.1.	comply
7.8.2 When Other than All-Steel Containers are Used Open flames shall be prohibited within 3 m (10 ft) of non-all-steel containers unless they are protected by a fireproof barrier. Signs with the words "NO OPEN FLAMES"* in letters not less than 45 mm (1.8 in) high shall be posted at the hydrogen storage facility in conspicuous places where readily visible.	comply sign
8 Dispensing **8.1 Location, Protection, and Clearance for Hydrogen Dispensing Points**	
8.1.1 A Hydrogen dispensing point shall (a) be located (b) be protected from vehicular damage; and (c) have minimum clearances as specified in Table 6.	comply
8.1.2 Hydrogen dispensers shall be (a) located on an island at least 150 mm (6 in) above grade; (b) neither beneath a canopy nor within 0.9 m (3 ft) of the vertical projection of the canopy to the island, except where the canopy is not capable of accumulating Hydrogen in pockets or between its ceiling and roof; and (c) protected from vehicular impact by means of 100 mm (4 in) diameter or larger concrete filled steel pipe posts each having a height not less than 0.75 m (2.5 ft) above grade, or an equivalent structure, placed at least 300 mm (1 ft) from the dispenser	comply

CLAUSE	COMMENTS
8.1.3 Fire Protection Fire extinguishers having a minimum rating of 20 BC shall be provided. Vapour processing equipment shall be located at or above grade not less than 10 feet from property lines and buildings. Sources of ignition shall be located at least 50 feet from fuel transfer areas. *Exception*: Where separations from property lines, buildings or fuel transfer areas cannot be met, fire exposure protection shall be provided such as a water spray extinguishing system or a fire resistant protective enclosure extending 18 inches above equipment. Metal containers with tight-fitting lids shall be provided for combustible trash.	comply N/A N/A
8.2 Hydrogen Dispenser Activation A valve shall be installed to prevent Hydrogen from flowing from the dispenser unless the dispenser has been activated.	comply
8.3 Electrical Classification of Space Surrounding Hydrogen Dispensers The electrical classification of space surrounding Hydrogen dispensers shall be as shown in Table 7.	comply
8.5 Permitted Fuelling Nozzles A fuelling nozzle shall be of a design that is certified to ANSI/AGA NGV1/CGA NGV1	SAE J2600
8.7 Protection of Fuelling Nozzles A fuelling nozzle for dispensing Hydrogen shall be securely supported and protected from the accumulation of foreign matter (e.g., snow, ice, or sand) that could impede operation.	comply
8.8 Activation of Nozzles Nozzle shall be positioned such that it must be removed from their mounting before the dispenser can be activated. A mechanism shall be provided to depressurize Type 2 nozzles, as defined in ANSI/AGA NGV1/ CGA NGV1. This mechanism shall be located no more than 200 mm from the vehicle end of the nozzle.	comply

CLAUSE	COMMENTS
8.10 Fuelling Hose Assemblies A fuelling supply hose assembly for dispensing Hydrogen shall be (a) in compliance with ANSI/IAS NGV 4.2/CSA 12.52; (b) located outdoors unless in conformity with Clause 10 of this Code; (c) not more than 4.5 m (15 ft) in length; (d) protected against abrasion and formation of kinks; (e) prevented from contacting the ground; and (f) free of cuts, abrasions, kinks, or any other damage.	comply
8.11 Breakaway Devices **8.11.1 General** A breakaway device shall be in compliance with all of the following conditions: (a) It shall be installed on a fuelling hose between the dispensing point and fuelling nozzle. (b) It shall be certified. (c) It shall disconnect when subjected to a maximum force of 667 N (150 lbf) but not less than 222 N (50 lbf). (The effect of any retrieval mechanism on the operation of the breakaway device shall be considered in determining these values.) (d) It shall automatically shut off the source of supply Hydrogen to the nozzle when disconnected.	comply
11.2 Release of Hydrogen The volume of Hydrogen required to be vented in order to reconnect the breakaway shall be limited to the contents of the fuelling hose and the piping within the dispensing cabinet.	comply
8.12 Signs at Points of Transfer The following warnings shall be prominently displayed within 3 m (10 ft) of a point of transfer at a Hydrogen dispensing point: (a) a general purpose warning “NO SMOKING”* and “TURN IGNITION OFF DURING VEHICLE FUELLING”; or (b) international symbols for "NO SMOKING"* and "IGNITION OFF" at least 50 mm (2 in) in diameter coloured red and black on a white background.	comply
8.15 Sheltered Dispensing Equipment **8.15.1 Electrical Classification** For electrical classification purposes, where dispensing equipment is sheltered by an enclosure, that equipment is considered to be located outdoors when (a) the shelter is constructed of noncombustible or limited-combustible materials; (b) it has the equivalent of at least 25% of the total area of its perimeter walls open to the outdoors; and (c) it has a roof designed so that it will not accumulate Hydrogen	comply

CLAUSE	COMMENTS
8.15.2 Passageways Passageways required for egress shall be at least 1 m (3 ft) wide. Each shall have an access door that opens outward and if equipped with a latch shall be equipped on the inside with fast-release hardware that can be operated without a key. The passageway shall be identified as an emergency exit.	comply
8.15.3 Shared Walls Where a dispensing enclosure shares one wall with a building and is separated from the building by a vehicle door or loading door, the door shall be interlocked so that it must be fully closed before fuelling can occur. In the event that the vehicle or loading door is opened during fuelling, the flow of Hydrogen shall automatically stop. Interlocking of the Hydrogen flow is not required for human access doors, which are required to be self-closing under the building code.	N/A
8.15.4 Exception to Clause 8.15.3 The interlock in Clause 8.15.3 is not required if 20% of the LEL inside the building is not exceeded after a discharge for 15 min of the full capacity of the Hydrogen storage or for 15 min of the full capacity of the compressor.	N/A
8.15.5 Electrical Classification of Surrounding Space Inside an Enclosure The space surrounding a dispensing point inside the enclosure shall conform to the electrical classification specified in Clause 8.3.	comply
8.16 Valves for Purging and Releasing Hydrogen A valve for the purging and releasing of hydrogen from the piping system at a fuelling station shall be located in an area inaccessible to the public or protected by a locking mechanism to restrict unauthorized use.	comply
8.17 Vents Required A vent shall be provided to direct any Hydrogen being purged or released from the piping system of a fuelling station to a safe outdoor location, not less than 3 m (10 ft) above grade using piping that does not obstruct the flow.	comply

CLAUSE	COMMENTS
8.18 Electrical Classification of Space Surrounding Relief Valves Except for devices covered under Clauses 8.5 and 8.6, the space surrounding a relief valve vent shall be electrically classified according to the following: (a) The distance 100 vent orifice diameters, within 15° of the line of discharge of a vent, shall be electrically classified as Class I, Zone 1 (Division 1, Group B). (b) The distance 1.8 m (6 ft) in all directions from the vent opening (excluding the Zone 1 space) shall be classified electrically as Class I, Zone 2 (Division 2, Group B).	Comply
8.19 Reference Pressure and Bleed Valve A suitable means shall be used to set the pressure of the fuel delivered to a motor vehicle in accordance with CSA B51 Part 1 or 2. This control shall be designed to fail safe so that there is no possibility fuel will be supplied in excess of the limit specified in Clause 4.6.1.	comply
9 Emergency Shutdown Systems **9.1 General** Any emergency shutdown system shall comply with all of the following: (a) It shall fail in a safe manner. (b) It shall be installed at each fuelling facility to promptly shut down part or all of the facility in the event of a hazardous condition occurring. (c) It shall be approved by the authority having jurisdiction.	comply
9.2 Control Circuits Control circuits shall be arranged such that when an ESD switch is activated, the electrical power is cut off, or the low Hydrogen supply pressure circuit is activated, systems that shut down shall remain shut down until they are manually reset after it has been verified that a safe situation has been restored.	comply
9.3 Location of Manual ESD Switches **9.3.1 General** Manual ESD switches shall be provided such that they are readily visible and accessible to persons filling vehicles or performing other operations at a fuelling facility and in accordance with Clauses 9.3.2, 9.3.3, and 9.3.4 as applicable. A manual ESD switch shall be installed within 10 m (33 ft) of the Hydrogen compressor. A manual ESD switch shall be installed within 3 m (10 ft) of any dispensing point and in the operator's kiosk or the sales office at public stations. More than one ESD switch may be required to satisfy this condition.	

CLAUSE	COMMENTS
9.4 Function of Manual ESD Switches **9.4.1 General** Manual ESD switches shall be provided as required in accordance with Clauses 9.4.2, 9.4.3. Multiple ESD switches performing different functions shall not be permitted at the same location at a fuelling facility.	comply
9.4.2 A manual ESD switch that performs both of the following operations shall be provided: **(a)** shuts off power to the Hydrogen compressor; and **(b)** closes the valve on the supply line to the Hydrogen compressor.	comply
9.4.3 A manual ESD switch shall be provided that performs both of the following operations: **(a)** de-activates the dispensing system; and **(b)** closes the valve(s) on the line(s) supplying Hydrogen to the dispensing system. .	comply

CLAUSE	COMMENTS
9.5 Automatic Compressor Hydrogen Supply Shutoff The self-closing valve on the Hydrogen inlet to the compressor shall close automatically when any of the following occur: (a) a manual ESD switch is activated; (b) a power failure occurs; (c) the power to the compressor is switched off; or (d) the Hydrogen supply pressure falls below the minimum requirements.	comply
9.6 Automatic Compressor Shutdown The compressor shall shut down when any of the following occurs: (a) a manual ESD switch is activated; (b) a power failure occurs; or (c) the hydrogen supply pressure falls below the minimum requirements	comply
9.7 Signs for Manual ESD Switches Prominently displayed signs shall be provided to indicate the location of the ESD switches referred to in Clause 9. These signs shall comply with all of the following: (a) have red letters on a white background; (b) have letters not less than 25 mm (1 in) in height; and (c) be located where readily visible adjacent to every ESD switch.	comply
10 Dispatch and Receiving of Hydrogen **10.1 Transportation of Bulk Hydrogen Containers** When a bulk hydrogen container is transported from one station to another, an isolated parking bay shall be provided at both the dispatching and receiving stations.	comply
10.2 Isolated Parking Bays for Vehicles Transporting Bulk Hydrogen Containers An isolated parking bay for a vehicle transporting bulk hydrogen containers shall allow easy ingress and egress of the vehicle and shall meet the requirements of Clause 7.	comply
10.3 Bulk Transport of hydrogen Bulk transport of hydrogen shall conform to the provisions of the Transportation of Dangerous Goods Act and Regulations**.**	comply

CLAUSE	COMMENTS
11. On Site Storage of Hydrogen Pressure vessels for the storage of Hydrogen shall be designed and manufactured in accordance with all the requirements of CSA B 51 Part 1 or Part 2. Clearances to electrical parts and to property limits shall be in accordance with Tables 1 to 7. Clearances to populated areas shall be in accordance with the Location Classification as addressed in **Part 2** of this document.	comply
12. System Maintenance **12.1 Maintenance Program** **12.1.1 General** The following maintenance program shall be established for each fuelling facility. The details of the maintenance program shall reflect the equipment that is installed and the layout on the site and shall be designed to mitigate the possibility of any of the following: (a) a mechanical or electrical failure that could cause injury to persons; (b) a failure that could result in an unplanned release of hydrogen; (c) a failure that could cause a safety system to malfunction; or (d) a failure that could result in damage to property owned by other parties.	comply
12.1.2 Personnel Maintenance shall be undertaken by a certificate holder for the purpose, who is familiar with the requirements of this Code and the manufacturer’s instructions for the installed equipment. The manufacturer’s instructions should be consulted for details on how to perform any specific maintenance operation. Personnel working on the maintenance of the stations should be trained and familiar with Workers Compensation Board requirements and procedures.	comply
12.1.3 Minimum Maintenance The maintenance items listed in Table 8 shall be mandatory. Inspections that are to be undertaken by the facility operator and their frequency shall be specified in the operator’s manual. Manufacturers and suppliers can recommend additional maintenance tasks	comply

CLAUSE	COMMENTS
12.1.4 Permanent Records A permanent, bound maintenance logbook for each refuelling station shall be kept available for inspection. On a fully automated refuelling station, some maintenance items may be fulfilled remotely. If this is done, the notification and recordkeeping systems should be agreed upon by the authority having jurisdiction.	comply
12.1.5 Control System Software Any control system software shall be stored in a nonvolatile medium and shall only be accessible to authorized personnel.	comply
12.1.6 Dome-Load System Check Where the dispensing pressure is controlled by a dome-load system, the licensee shall ensure that the dispensing pressure is checked at least once every 2 weeks by means approved for the purpose and shall: (a) record the date of the check, the ambient temperature, the dispensing pressure, and the temperature-compensated dispensing pressure; (b) maintain the record at the site for at least 2 years after it is made; and (c) produce the record, upon request, for examination by an inspector.	N/A
12.1.7 Electronic System Check Where the dispensing pressure is controlled by an electronic temperature-compensating, pressure limiting device, the licensee shall ensure that the system is checked at least once every 6 months and shall (a) record the date of the check, the ambient temperature, the dispensing pressure, and the temperature-compensated dispensing pressure; (b) maintain the record at the site for at least 2 years after it is made; and (c) produce the record, upon request, for examination by ~~an inspector~~a Safety Officer. ~~.~~	comply
12.3 Records Retention Records of the verification and maintenance required by Clause 12.2, other than ventilation, shall be kept by the operator of the facility for 2 years. Records of verification and maintenance for ventilation shall be kept for 4 years.	

Tables and Appendixes

TABLE 1

Electrical Classification of Space Surrounding Compressors

	Electrical classification distance **Class I, Zone 1** (Division 1, Group B), m (ft)	 **Class I, Zone 2** (Division 2, Group B), m (ft)
Not enclosed	Up to and including 1.5 (5) measured from the compressor package.	1.5 (5) all around Zone I
A compressor that is sheltered by a building or enclosure having four sides, a roof, and limited ventilation	All the enclosed space	Up to and including 3 (10) from a non-Hydrogen-tight seams in the enclosure
An enclosed compressor that is provided with an exhaust fan interlocked with a Hydrogen detection system that functions to shut down the compressor and activate the exhaust fan when the concentration of Hydrogen within the building or enclosure reaches 20% of the LEL. The exhaust fan shall also incorporate controls for manual activation.		All the enclosed space

TABLE 2

Distance of hydrogen storage Systems from Property Lines

(See Clause 7.1.1)

Aggregate water capacity of storage system, L	**Distance from property line, m(ft)**
Up to and including 10 000 with a 4hour fire resistant wall	1(3) or electrically classified area whichever is greater
Over 10 000 with a 4 hour fire resistant wall	1.5 (5) or electrically classified area whichever is greater

Any volume without a 4 hour fire resistant wall	3 (10) or electrically classified area whichever is greater

TABLE 3

Sample Calculations*
(See Clause 7.4.2.)

Nominal tubing size, In	Orifice diameter, mm	Class I, Zone 1 (Division 1, Group B) mm	Class I, Zone 2 (Division 2, Group B) m
1/2	9.4	950	1.8
3/8	7.0	750	1.8
¼	4.6	500	1.8

**This Table provides examples of calculations and is for information only.*

TABLE 4

Electrical Classification Distances
(See Clause 7.4.3.)

Aggregate water capacity of Hydrogen storage system, L	Class I, Zone 1 (Division 1, Group B), m (ft)	Class I, Zone 2 (Division 2, Group D), m (ft)
Up to and including 4000	1.8 (6) measured from the opening in the Hydrogen container	0.7 (2) all around Zone 1
Between 4001 L and 10 000	3 (10) measured from the opening in the hydrogen container	1 (3) all around Zone 1
Over 10 000	9 (3) measured from the opening in the hydrogen container	1 (3) all around Zone 1

TABLE 5

Distances Required from Combustible Materials

(See Clause 7.5.2.)

Aggregate water capacity of Hydrogen storage system, L	Distance from combustible material, m (ft)
Up to and including 10 000 with a 4 h fire resistant wall	1 (3)
Over 10 000 with a 4 h fire resistant wall	1.5 (5)
Any volume without a 4 h fire resistant wall	3 (10)

TABLE 6

Distances Required from a Hydrogen Dispensing Point

(See Clause 8.1.)

Object	Distances required from a Hydrogen dispensing point m (ft)
Property line	3.0 (10)
Opening into a building	2.0 (7)
Hydrogen storage up to and including 4000 L	2.5 (8)
Hydrogen storage over 4000 L up to and including 10 000 L	4.0 (13)
Hydrogen storage over 10 000 L	10.0 (33)

TABLE 7

Electrical Classification of the Space Surrounding a Dispenser
(See Clause 8.3.)

	Distance*
Class I, Zone1,(Division 1, Group B)	**Class I, Zone2,(Division 2, Group B)** **m (ft)**
Enclosed areas in direct communication with Hydrogen-carrying fittings and components	A radius of 3.0 (10) beyond the perimeter of the Zone 1 area or the dispensing point, as applicable

*The space inside the dispenser enclosure may be classified as Zone 2 if adequate ventilation is provided as approved by the authority having jurisdiction.

TABLE 8

Mandatory Maintenance Items

(See Clause 12.1.3.)

Area	Maintenance requirement	Record values	Monthly	Quarterly	Annually	Longer term
General	Verify that system pressures and temperatures are within the design values.	Yes	X			
Compressor package	Verify that the pressures and levels of the compressor oil and any other liquid lubricated equipment is within specifications.	Yes	X			
Compressor package	Visually inspect the general condition of compressor package. Check condition of hoses, drive belts, etc.		X			
General	Visually inspect valves, tubing, and piping connections for leaks and abnormalities.	Yes	X*			
Compressor package	Drain recovery tank and filter bowls. Record if unexpected volumes of liquid are present.		X			

Area	Maintenance requirement	Record values	Monthly	Quarterly	Annually	Longer term
Compressor package	Verify compressor shuts down at the correct output pressure.		X			
General	Visually inspect all pressure-relief devices, ensuring that all tags are in place.			X		
Dispensing system	Inspect and lubricate dispenser breakaways.			X		
Dispensing system	Observe a fuelling process for each dispenser hose to ensure Code compliance.			X		
General	Verify correct functioning of ESD system.			X		
Instrumentation and controls	Check set points of all instrumentation (pressure and temperature switches, oil level switches, etc.)	Yes			X	
General	Soap test all piping and tubing and verify the absence of leaks.				X	
General	Visually inspect general site including all barriers, fences, walls, doors, and other items to verify site compliance with Code				X	

	requirements.					
Hydrogen storage system	Retest and/or re-qualify Hydrogen storage containers.					†
General	Recertify all pressure relief device set points.	Yes				5 years

*This shall be performed in accordance with Clause 14.1.6.
†The frequency of inspection for storage containers may vary with the Standard to which they are registered.

Part 2

General This section outlines the BC Safety Authority's requirements for the registration of the design and the approval of the installation of Hydrogen refuelling stations installed in BC.	
1 List of approvals required	
1. Approval of the Municipality and Fire Department in which the Hydrogen refuelling station will be installed. The Municipality respectively the fire Department is responsible for approving the site and the clearances for the installation. In case some technical requirements need to be clarified, this approval can be given as a conditional approval depending on the later approval by the BCSA. All the requirements of the provincial or local building Code and Fire protection shall be fulfilled .	- Victoria building permit - Local Fire Chief
2. Registration of pressure vessels pressure piping and fittings Boiler and Pressure Vessel Safety Program of the BCSA. The pressure retaining components for which the Boiler and Pressure Vessel Program has jurisdiction and for which design registration is required are defined in Part 1, section5.1	- gas inspector approval - CRNs for all componets
3. Approval in principle from the BCSA, Engineering and Standards, for the proposed installation design.	Approval in principle by BCSA
4.Satisfactory site inspection of the installed pressure vessels by a BCSA Boiler Safety officer as well as the complete fuelling station by a BCSA Gas Safety officer.	completed
To avoid confusion and delays in processing, requests for approval will be submitted in the above order. At each successive stage proof of approval from the previous stage will be supplied.	
2. Documentation required in support of an application	
2.0 General requirements The submission of all required documentation, for the registration of a hydrogen refuelling station shall be co-ordinated by the owner of the station or a designated agent so that the registration submission is a complete package. Owners of Hydrogen refuelling stations must be aware that after an approved installation has been completed, development to the surrounding area may require the revaluation of the installation by the approving authorities and accordingly modifications to the installation may be required to improve safety and enhance emergency response procedures.	see drawings
2.1 Municipality and Fire Department As a minimum, the following documentation and information will be submitted in support for each application.	
2.1.1 Site plans A site plan shall be submitted showing the location of the hydrogen storage and dispensing equipment, clearances to roadways and surrounding structures. A prefire plan showing location of buildings storge and dispensing points of Hydrogen should be submitted to the local Fire Department where the station is installed. The site plan will provide the clearance distances to the different buildings and facilities in the vicinity of the contemplated station. Population densities will be taken into account as per the class location defined further in this paragraph. The quantity distances relationship is based on the concept that the effects of fire, explosion, and detonation are dependent on the amount of material stored on site. By adopting reasonable clearances to	

people and facilities the effects of an accidental release of hydrogen and the resulting consequences can be controlled to a tolerable level. Tests, analyses, and experience are employed to determine the relationship between the effects of an accident and the quantity of material involved in the accident. From knowledge of the tolerance levels of people and structures, safe distances are determined. These distances are based entirely on the estimated damage that could result from an incident, without considering probabilities or frequency of occurrence.	
2.1.2 Class locations Class locations shall be determined by applying the criteria set forth in these requirements. The class location is enclosed by a line that extends 100 meters from any external surface of a hydrogen container within the station. The class location is determined by the population density within this perimeter; each unit in a multiple unit building will be considered a separate unit. The population density of a dwelling unit will be calculated as 3 people per dwelling. A population density of 100% of the licensed occupancy will be assumed for hotels, motels, and restaurants. Only that portion of the population contained in the portion of the building included in the location perimeter will be considered. Class locations are defined as per Appendix A In unincorporated areas or where there is no fire department, the zoning shall be determined by the Provincial Gas Inspector.	Class 1 Industrial Parks and open areas 1000 kg hydrogen permitted
2.1.3 Resolution of disagreement If agreement is not reached between the submitter and the fire department final arbitration will lie with the Provincial Gas Safety Manager. As a minimum, the documentation required for such arbitration will be an ordinance map provided by the municipality in which approval is requested.	
2.2 Registration of pressure vessels and pressure piping	
2.2.1 Application for Registration A completed BCSA CRN application shall be submitted (See attached Appendix B)	see Bill of Materials
2.2.2 Pressure Vessels Drawings and calculations demonstrating that the pressure vessel design conforms to CSA B 51 Part 2, or any of the equivalent standards defined as such by that Code, shall be submitted to the BCSA, Engineering and Standards department. The registration submission will be reviewed to verify that all applicable code requirements have been considered in the design and the calculations made. Upon satisfactory review the vessel design shall be assigned a Canadian Registration Number (CRN). A stamped design registration letter indicating the CRN, date of registration, manufacturer’s name, description of the vessel, drawing numbers, registration fee and any other pertinent information will be sent to the applicant. The submitted documents will not be stamped or returned to the applicant.	comply
2.2.3 Pressure Piping Schematic drawings of pressure piping within the limitations prescribed in Sec 1.2 of Part 1 will be submitted if required by the Power Engineers Boilers Pressure Vessel and Refrigeration Safety Regulations.	comply

The following piping systems do not require registration: i. A pressure piping system operating at and with a relief valve or valves set at 103kPa or less ii.Pressure piping that is NPS 3 or less Pressure piping systems other than those under i) and II) have to be designed as per the requirements of CSA B 51 Part 3, and the standards adopted by that Code. The following documentation is required in order to register a piping system: a. A completed British Columbia CRN application form b. Design data such as code of design, material specifications, pressure and temperature ratings, CRN's for components and fittings. c. PI & D or schematic drawings showing the specific lines to be registered, diameters, line lists and approximate lengths of the piping system d. Code calculations for expansion, flexibility and supports in the system	
2.2.4 Pressure Fittings 2.2.4.1 Proof of Registration A list of fittings to be used in the pressure system will be submitted to the BCSA, Engineering and Standards department. Proof of registration of pressure retaining fittings with the BCSA or through the Central registration of Fittings system will be submitted to the BCSA or documentation as required in the BCSA circulars will be submitted.	comply
2.2.4.2 Requirements for Registration of Fittings In case all or some fittings have not been previously registered, documentation for their registration shall be submitted to the BCSA, Engineering and Standards department. For the registration of fittings to be installed in a pressure piping system, the following documentation is required: a. A completed British Columbia CRN application form. b. A completed statutory declaration form. c. Drawings or catalogues detailing dimensions, material specifications, pressure/temperature ratings and markings. d. Documentation from a regulatory authority or authorized inspection agency verifying that the manufacturer's quality control program conforms to the minimum requirements of CSA B51 Annex F. e. Proof of registration from original province of registration if the fitting has been previously registered. Submissions for fittings conforming to a code other than the ASME/ANSI Boiler, Pressure Vessel or Piping Codes, require a copy of the applicable code or standard. The code or standard must be translated into English if necessary. The code or standard must detail requirements for materials, dimensions, pressure/temperature ratings and markings. Detailed calculations or proof tests results, witnessed by an authorized inspector, may be required to demonstrate that the fitting design is suitable for the pressure and temperature ratings. The fittings shall be registered in a category listed in Table 1 of CSA B51. Fittings of the same category may be registered collectively. Separate registration of each fitting design in a category is not required.	comply
2.3 Approval in principle for the Fuelling Station Design and Installation	
2.3.1 Drawings and Specifications Specifications, drawings and details demonstrating that the installation complies with the technical requirements contained in Part 1, Technical	completed

Requirements, of this document shall be submitted to the BCSA, Engineering and Standards department.	
2.3.2 Components All components used in the gas system shall be certified by one of the Certification Organizations acceptable to the BCSA through the BC Safety Standards Act and Regulations, or registered fittings as applicable.	comply
2.3.3 Permits A valid Installation Permit and an Operating Permit issued by the BCSA must be in place before start of construction. The owner of the station or his designated agent shall be responsible for this application.	comply applied by Powertech
2.3.4. Assessment of final designs Reviews of the final drawings, designs, structures, and containment systems shall include a safety assessment to identify potential system hazards and areas of compliance required by local and provincial agencies	completed
3 INSPECTIONS	
Following the registration acceptance, of the pressure vessel and piping design, the vessel installation and its piping shall be inspected by a Safety Officer for compliance with the Power Engineers, Boiler, Pressure Vessel and Refrigeration Safety Regulation. After Approval in Principle is granted for the fuelling station design, its installation shall be inspected by a Safety Officer for compliance with the Gas Safety Regulation as well with the requirements in Part 1, Technical Requirements, of this document, before the installation is being placed in service.	completed
4 OPERATION	
4.1 Evaluation of operational procedures Operational procedures, along with instrumentation and control systems, shall be evaluated for their capacity to provide the required safety. It may be necessary to develop special procedures to counter hazardous conditions. Analysis or certification testing should verify equipment performance and prove to be satisfactory for the authority having jurisdiction Standard operating procedures (SOP's), with checklists as required, shall be developed for common operations. The SOP's should be set by individuals directly involved with the operation of the Hydrogen refuelling station operation and shall be approved during the final safety review before starting up the station. These procedures should be reviewed and updated periodically. Repairs, alterations, cleaning, or other operations in confined spaces in which hydrogen vapors or gases are likely to exist are not permitted until a detailed safety procedure is established.	on-going
4.2 Development of emergency procedures The safety of personnel at and near hydrogen systems shall be carefully reviewed, and emergency procedures shall be developed in the earliest planning and design stages. The emergency procedure should be submitted and approved by the fire department responsible for the area. Advance planning for a variety of emergencies, such as fires and explosions, should be undertaken. The first priority is to reduce any risk to life.	
4.3 Reporting Spills shall be reported to the Fire Department and jurisdictional	

authorities. Any incident involving a pressure retaining part shall be reported to the Provincial Boiler and Pressure Vessel Safety Manager. Any incident involving a gas installation shall be reported to the Provincial Gas Safety Manager.	
5 TRAINING	
5.1 Personnel training Personnel who handle/use liquid and gaseous hydrogen or who design equipment for hydrogen systems must be familiar with its physical, chemical, and hazardous properties. In addition, the following requirements apply: Personnel must know which materials are most compatible with hydrogen, what the cleanliness requirements of hydrogen systems are, how to recognize system limitations, and how to respond to failures. Designated operators shall be familiar with procedures for handling spills and with the actions to be taken in case of fire. Also, knowledge of TDG and WHMIS requirements should be included. Training should include detailed safety programs for recognizing human capabilities and limitations. Personnel must constantly re-examine procedures and equipment to be sure safety has not been compromised by changes in test methods, equipment deterioration, over-familiarity with the work, or work-related stress.	completed
5.2 Operator certification Operators shall be adequately trained and certified prior to operations. Training courses and examinations must be acceptable to the BCSA, Engineering and Standards Department. Operators shall be certified and qualified for handling liquid and gaseous hydrogen and qualified in the emergency procedures for handling leaks and spills. Operators must be thoroughly trained in facility operations and safety procedures and any changes to either the installation or the procedures. As a minimum, training shall familiarize personnel with the physical, chemical, and hazardous properties of hydrogen and with the operation of the specific Hydrogen refueling station. (i.e., loading and storage; purge gas piping; control, alarm and warning signals; ventilation; and fire and personnel protection).	completed
6 RECORDS KEEPING	
Station owners and operators are required to keep the following records. 6.1 Records of all mandatory and periodical maintenance items required in Table 8, Part 1 of this document 6.2 Records of all repairs and unscheduled maintenance work that became necessary during the operation of the refueling station. 6.3 Records of all personnel performing the repairs and their qualifications. 6.4 Records of all and any accident and incident relative to the equipment installed in the station be that it was caused by operators or users of the station. 6.5 Any damage to equipment installed in the station 6.6 Any leak of Hydrogen 6.7 Any equipment malfunction 6.8 Any other unusual or unexpected event	

Records will be kept in a temper safe manner for a minimum of 7 years. At the request of a Safety Officer of an authority having jurisdiction, the records have to be presented.	

APPENDIX A: CLASS LOCATIONS

A1. Class 1 – Industrial Parks and open areas

A Class 1 location is any area that includes in the 100 m location perimeter a maximum of 10 buildings or dwelling units and is not inhabited by more than 30 people, or maximum 100 people if they are not in dwelling units.

A 2. Class 2 – Low population density

A Class 2 location is any area that contains within the 100 m location perimeter more than 10 and less than 20 buildings, with a maximum of 60 people inhabiting the area, or more than 100 but less than 150 people located in non-dwelling areas.

Typically such locations would contain industrial, commercial and some residential buildings.

A 3. Class 3 – Medium population density

A Class 3 location is any area that contains within the 100 m location perimeter more than 20 and less than 50 buildings, with a maximum of 150 people inhabiting the area, or more than 150 but less than 300 people located in non-dwelling areas.

Typically such locations would contain light industrial, commercial, and some residential buildings, townhouses.

A 4. Class 4 – Heavy population density

A Class 4 location is any area that contains within the 100 m location perimeter more than 50 buildings, or more than 150 but less than 300 people located in non-dwelling areas.

Typically such locations would contain high-rises, offices, and hotels.

A 5. A.L.R.T. and Bridge Clearances

Hydrogen containers shall not be installed within 150 ft (45.72m) of the A.L.R.T. track bridge or any similar structure used to transport or travelled by public at large.

When classifying locations, due consideration shall be given to the development plans for the area. If a building permit has been issued for the location area, such development shall be given consideration in the design and classification of the installation.

Maximum Quantities of Hydrogen Stored on Site

Location Classification	Class 1 See par.	Class 2 See par.	Class 3 See par.	Class 4 See par.
Quantity permitted for storage on site	20,000 USWG or 1000 kg	15 000 USWG or 750kg	10 000U SWG or 500kg	7 000 USWG or 350kg

Special consideration will be required for the storage of additional quantities.

APPENDIX B: DESIGN REGISTRATION FORM

British Columbia Safety Authority
Engineering and Standards Department
Design Registration

Suite 400, 88 – 6th Street
New Westminster, BC
V3L 5B3

Phone: (604) 660-6254
Fax: (604) 660-3460
Web: www.safetyauthority.ca

APPLICATION FOR CANADIAN REGISTRATION NUMBER (CRN)

If information about this design was submitted subsequent to this application, please provide Journal No:______________

Design Application must include the following:

- For Reciprocal Registration – Verification of registration in another jurisdiction CRN: ______________
- For Fitting Registration – Statutory Declaration per CSA B51

Section A - Billing Customer: **Date of Application:** ______________

Company Name:		Contact Name:
Address:		City/Town:
Province/State:	Postal/Zip Code:	Billing Reference #:
Email:	Phone #:	Fax #:

Section B - Submitted By: ☐ same as Section A ☐ see below

Company Name:		Contact Name:
Address:		City/Town:
Province/State:	Postal/Zip Code:	
Email:	Phone #:	Fax #:

Section C - Register To: ☐ same as Section A ☐ see below

Company Name:		Contact Name:
Address:		City/Town:
Province/State:	Postal/Zip Code:	
Email:	Phone #:	Fax #:

Section D - Additional Information:

Drawing #:	Drawing Revision #:	Title:
Applicant's Reference (job#, file#, etc.)		

Registration Type : (please check one)
☐ New CRN ☐ CRN Revision ☐ New Reciprocal ☐ Reciprocal Revision ☐ Alteration ☐ Used Vessel ☐ Control System

Design Category : (please check one and indicate corresponding volume or heat transfer/surface area)
☐ **Pressure Vessel** (Volume)__________ cu. m. ☐ **Heat Exchanger** (Area) ________ sq . m.
☐ **Boiler** (Heating Surface)__________ sq. m. ☐ **Fitting** ☐ **Piping System** ☐ **Nuclear Component**

NOTES:

1. For more than one design, please complete a separate application and collate documents by design.
2. Only one set of drawings, calculations & application form is required for each design submittal except for piping registrations where 2 sets of drawings together with one set of calculations & application form are required.
3. Please provide documents in smallest, legible size.
4. Please make cheque or money order payable to: **BC Safety Authority**.

(For BCSA Office Use Only)

Office:	Entry Date: yyyy mm dd	Branch: **BP**	Tran Type: **B108**	Document #
Area: **635**	Amount:	Payment Method:	Tran Date: yyyy mm dd	