Final Action Report

Hydrogen Fueling Station (HFS) Permitting Workshop for Fire Safety and Building Code Officials

NYC-NY-NJ

May 15 & 16, 2008
Teaneck, NJ

Prepared by

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TABLE OF CONTENTS

Table of Contents

		Page
1.	Executive Summary	1
2.	Project Development	3
3.	The Workshop	8
4.	The Results	12
5.	Recommended Action for Participant Comments	18
6.	Summary	21

Appendices

A. List of Participants

B. NREL Presentation

C. Telecommunications Presentation

D. General Motors Presentation

E. Hydrogen Background Material/Breakout Session Presentation

F. Breakout Session Reporting PPT

G. I-Code Pathway

H.. Review Report Form

I. Individual Evaluation Form

J. Evaluation Results

Executive Summary

SECTION 1

1. Executive Summary

The overall objective of the workshop was to present “case studies” for a selected number of hydrogen motor-fueling station configurations and back-up power for telecommunication sites to an invited group of fire and building code officials that shows how existing codes and standards, or engineering solutions based on the latest codes (“alternative methods”), have been or can be applied to permit construction of a hydrogen motor-fueling station in a rigorous but timely manner. Additionally a goal was to have this group review and vet the permitting process, codes and standards, and engineering solutions exemplified by the case studies.

To summarize the project:

- The workshop would be hosted ias a stand alone activity.
- The workshop built on the previous workshops via teleconference coordination and discussion.
- Twenty-five building code, fire code and electrical code officials from New York City, New York State and New York City participated in the workshop.
- An overview of hydrogen as compared to other fuel gases was provided along with a logical path for applying codes and standards to hydrogen fuel projects.
- Participants were broken down into three teams.
- Each team was assigned a primary and a secondary plan involving a service station and a primary and a secondary plan involving telecommunications sites.
- Each team gave a verbal report on the results of their reviews which was followed by comments from any team that used the same plan for their review. General discussion followed.
- Several code issues were identified dealing with an understanding of how to apply the codes and standards and existing code language that presented roadblocks to effective application of the codes.
- Participants were overwhelmingly positive in their post workshop review comments.

The goals of the project were met. Participants were provided with a better understanding of how to apply the codes and referenced standards to a hydrogen motor-fueling facility permit application and they indicated they had an increased level of comfort with the topic. In addition, feed back from the participants provided guidance on content to include in future workshops along with areas within the existing code language that may need modification to clarify technical requirements.

Workshop Sponsors

The National Association of State Fire Marshals

Shell Hydrogen, LLC

General Motors

Plug Power, Inc.

ReliOn, Inc.

National Renewable Energy Laboratory

Workshop Facilitators

Davidson Code Concepts, LLC

The DiCristina Group, Inc.

Project Development

SECTION 2

2. Project Development

The success of any project rests on establishing clear goals, assigning responsibilities, setting timelines for completion of assignments, and verifying follow through.

The development phase of the project presents its own challenges through the involvement of agencies and firms with office locations scattered around the country and individuals that are highly mobile on a day to day basis. Face to face meetings during the planning and development phase would be limited and alternate means of communications was a necessity.

Project development was accomplished via teleconferences and effective use of electronic communications such as e-mail exchange of messages and documents.

The initial project meeting was held on March 13th after completion of the California workshop. Representatives of NREL, NASFM and industry discussed the workshop that had just completed, participation for the next workshop to be held in the NYC-NY-NJ area and chose the target dates of May 15 & 16.

The initial project teleconference occurred on March 27th, 2008 involving representatives of NREL, NASFM and industry. The discussion agenda was:

1. Date, location of workshop: May 15-16, Mahwah, NJ

2. Roles and responsibilities
   - NAFSM
   - Industry
   - USFCC/NHA
   - DOE/NREL

3. Preliminary Agenda Items
   - Plenary
   - H2/FC technologies, information sources
   - Pathway to Permitting via ICC codes (bone diagram)
   - H2 supply for FC backup power
   - Breakouts
   - Permitting Fueling Stations
   - Permitting H2FC Backup Power for WTF
   - Wrap-up
   - Follow-up w/i region

4. Next Steps, Action Items
   - List of Invitees
   - Save the date notice
   - Draft agenda

As a result of this teleconference the following parameters were identified and discussed.

- The overall objective of the workshop is to present “case studies” for a selected number of HRS and back-up power for telecommunication site configurations to an invited group of fire, building, and electrical code officials that shows how existing codes and standards or engineering solutions based on the latest codes (“alternative methods”) have been or can be applied to permit HRS in a rigorous but timely manner and to have this group review and vet the permitting process, codes and standards, and engineering solutions exemplified by the case studies. The targeted areas would be from the states of New York and New Jersey along with New York City.

- The fire and building code officials will be invited by NASFM. Criteria for invitation include previous experience permitting HFS, responsibility and authority within jurisdictions were HFS permit applications are likely, potential future location for an installation and “standing” within the community of fire and building code officials.

- The case studies can include existing, planned, and “hypothetical” installations. The case studies should demonstrate the logic and concept of the configurations and how safety is built into the design in relation to the existing site improvements.

- At the workshop, teams will be formed to review several case studies each. The teams will be asked to evaluate the application of codes and standards to the examples presented in each case study and reach a consensus on whether the codes and standards were selected and applied appropriately. Each team will review more than one type of case study to provide experience with both a HFS and a telecommunications site.

- Two keys issues to address with the workshop is how the codes and standards apply and in which order, (which will deal with the logic and design principals); and we also want the site plan dimensional issues dealt with because they are the 'make or break' issues when attempting to site a hydrogen motor fuel station or back up power for telecommunications sites on an existing lot in an urban or suburban environment.

As a result of the second teleconference on April 10th a draft agenda was created for the workshop

Workshop on Permitting Hydrogen Fueling Stations and
Hydrogen Fuel Cell Backup Power for Wireless Telecommunication Sites

Mahwah, NJ
May 15-16, 2008

May 15 (Thursday)

8:30	Continental breakfast	
9:00	Welcome	TBD
9:05	Background, objectives of workshop	Antonio Ruiz, U.S. DOE
9:30	Introductions, agenda, structure of workshop	Jim Narva, NASFM
9:45	Hydrogen Fuel	TBD
10:15	Break	
10:30	Fuel Cells	TBD
11:00	Permitting Pathway in ICC codes	Bob Davidson, Davidson Code Concepts
11:30	Hydrogen Fueling Stations	
	Case studies	Alex Keros, GM
	Codes and standards issues	Bob Davidson, Davidson Code Concepts
12:15	Lunch	
1:30	Hydrogen Fuel Cells for Back-up Power at Wireless Telecommunication Sites	
	Case studies	Paul Buehler, Plug Power Mike Maxwell, ReliOn
	Fueling Back-up Power Systems	TBD
	Codes and standards issues	Sal DiCristina, DiCristina Group
3:00	Q/A, discussion	Bob Davidson, Sal DiCristina
3:30	Breakout sessions, group assignments	Jim Narva
3:45	Break	
4:00	Breakout session 1	
5:30	Adjourn for Day 1	

May 16 (Friday)

8:00	Continental breakfast with screening of permitting website	
8:30	Breakout session 2	
10:30	Break	
10:45	Breakout session 3	
12:00	Lunch	
1:00	Plenary for report outs	Bob Davidson, Breakout team chairs
2:30	Summary, next steps	Jim Narva
3:00	Adjourn workshop	Antonio Ruiz

Workshop material and resource development to be accomplished included:

- Update of site plans for both HFS and telecommunication scenarios.
- Update of a Team Review Report Form.
- Update of a Participant Evaluation Form.
- Compilation of a list of code official invitees with a goal of thirty participants.
- Obtaining copies of electrical codes for use by the teams.
- Printing and delivery of workshop materials.
- Update of individual presenter Power Point presentations.

One additional teleconference occurred on April 25th, 2008 and all items were completed in a timely manner leading up to the day of the workshop.

The Workshop

SECTION 3

3. The Workshop

The agenda for the workshop was as follows:

Permitting Hydrogen Fueling Stations and Hydrogen Fuel Cell Backup Power for Wireless Telecommunication Sites Workshop

Teaneck Marriott at Glenpointe, Teaneck, NJ
May 15-16, 2008

DAY ONE: THURSDAY, MAY 15, 2008

10:30 a.m. – 11:00 a.m.	**Registration**
11:00 a.m. – 11:05 a.m.	**Welcome** *Honorable Elie Y. Katz, Mayor, Teaneck, NJ*
11:05 a.m. – 11:20 a.m.	**Workshop Background and Objectives** *Antonio Ruiz, U.S. Department of Energy*
11:20 a.m. – 11:30 a.m.	**Workshop Introductions, Agenda and Structure** *Jim Narva, National Association of State Fire Marshals (NASFM)*
11:30 a.m. – Noon	**Hydrogen Fuel** *Bob Davidson, Davidson Code Concepts*
Noon – 1:00 p.m.	**Working Lunch – Fuel Cells and Permitting Pathway in ICC Codes** *Bob Davidson, Davidson Code Concepts*
1:00 p.m. – 2:00 p.m.	**Hydrogen Fueling Stations** ▪ Case studies – *Michael Paritee, General Motors* ▪ Codes and standards issues - *Bob Davidson, Davidson Code Concepts*
2:00 p.m. – 3:00 p.m.	**Hydrogen Fuel Cells for Back-up Power at Wireless Telecommunication Sites** ▪ Case studies - *Paul Buehler, Plug Power and Mark Cohen, ReliOn* ▪ Fueling Back-up Power Systems – *Mark Cohen, ReliOn* ▪ Codes and standards issues - *Sal DiCristina, DiCristina Group*
3:00 p.m. – 3:30 p.m.	**Q/A and Discussion** *Bob Davidson, Davidson Code Concepts and Sal DiCristina, DiCristina Group*
3:30 p.m. – 3:45 p.m.	**Breakout Sessions and Group Assignments** *Sal DiCristina, DiCristina Group*
3:45 p.m. – 4:00 p.m.	**Break**
4:00 p.m. – 5:30 p.m.	**Breakout session 1**
5:30 p.m.	**Adjourn for Day 1**

DAY TWO: FRIDAY, MAY 16, 2008

8:00 a.m. – 8:30 a.m.	**Continental Breakfast with Screening of Permitting Website**
8:30 a.m. – 10:30 a.m.	**Breakout session 2**
10:30 a.m. – 10:45 a.m.	**Break**
10:45 a.m. – Noon	**Breakout session 3**
Noon – 1:00 p.m.	**Lunch**
1:00 p.m. – 2:30 p.m.	**Plenary Session for Report Outs** *Bob Davidson and Breakout Team Chairs*
2:30 p.m. – 3:00 p.m.	**Summary and Next Steps** *Jim Narva, NASFM*
3:00 p.m.	**Adjourn Workshop** *Antonio Ruiz, U.S. Department of Energy*

The primary goals of the workshop were

- Provide the participants with background on hydrogen such as its chemical properties and uses with comparisons to other flammable gases.

- Familiarize participants with examples of hydrogen motor fueling station projects and telecommunication back up power installations that have been implemented in the United States.

- Familiarize participants with the codes and standards and the processes that have been utilized by local/state officials to permit the projects.

- Provide workshop participants with the opportunity to conduct “Virtual Permittings” of projects that have already been permitted to get a handle on how they would do the permitting, given available information about the projects and available codes and standards.

- Identify critical issues associated with the permitting process that need to be addressed by the Department of Energy, in order to facilitate the permitting process (i.e., make it efficient, both in terms of time and expense).

- Provide participants with the opportunity to articulate codes and standards gaps or conflicts (if any) that need to be addressed.

- Raise the comfort level of the code official should they be presented with an application to construct a hydrogen motor fueling station in their jurisdiction.

As an opening introduction to issues that can develop when applying codes and standards to projects utilizing hydrogen as an energy source, presentations were done on the use of stationary hydrogen fuel cells as a back up power supply at telecommunications equipment sites and on hydrogen as a motor fuel. The presentations were used as an avenue to identify the path a code official should take when applying the 2006 edition of the International Building Codes along with related codes and standards and as an introduction to the properties of hydrogen as compared to other fuel gases commonly in use.

For the breakout sessions the participants were broken down into 3 Teams. Each team was assigned a primary motor fueling station and a primary telecommunications site review projects and additional scenarios as a secondary review project. This ensured that there would be sufficient work for the allotted times and that the participants would be exposed to plans covering both HFS and telecommunication installations.

A. The Teams were:

Team 1 Tamara Sakian
Chris Afuwa
Craig Lucas
Brain Grant
George Selah
David Peach
Thomas Kelly

Team 2 Shaji Joseph
Salvatore Garafalo
John Palcher
Michael Whalen
Raymond R Meyer
George M Roberts
Tim Fisher

Team 3 David Kahn
Leonard Splain
Theodore Horishny
Michael E Razzoli
Steven M Gluck
Joseph Rischak
William Pfeiffer

B. The resources provided to each team included the following:

A set each of:

- International Code Council I-Codes
  - International Building Code
  - International Fire Code
  - International Fuel Gas Code
  - International Mechanical Code

- National Fire Protection Association
  - NFPA 853 Stationary Hydrogen Fuel Cells
  - NFPA 55 Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks 2006 edition
  - NFPA 70 National Electrical Code

Along with:

- A set of Site Layout Plans
- Note Pad Easel, Review Report Forms, Evaluation Forms, Pens and Scales

C. The teams were instructed to address the following questions:

- Which codes and standards did you apply during your review and why were they applied?
- What codes or standards were needed but not supplied?
- What items shown on the plan were determined to be acceptable?
- What items shown on the plans were not found to be acceptable?
- What items or information, if any, was not provided on or with the plan and is needed to complete your review?

(The teams were instructed to list relevant code references)

And were advised that for the afternoon:

- When the plan review portion is completed everyone will return to this room and the team leaders will present their primary assignment reviews.
- The team assigned the same plan for the secondary review will be asked if they have anything to add.
- General discussion will then occur.

D. The Plans included various scenarios

- Combined Gasoline-Hydrogen Retail Station with Below-Grade Liquid H2 Storage

- Combined Gasoline-Hydrogen Retail Station with Canopy-Top Electrolyzer and Above-Ground H2 Storage

- Two roof top telecommunication site installations.

- Two at grade telecommunication site installations.

The Results

SECTION 4

4. The Results

The manner in which the teams were selected ensured that individuals had diverse qualifications and were diverse from the standpoint of regional influences on application of codes and standards. The workshop would be the first time they had worked with each other applying the code.

Each of the teams began with a slightly disorganized or a shotgun approach to the plans with team's members picking up the different codes and standards and identifying issues to be addressed. It is a fairly common approach to dealing with hydrogen installations because most guidance documents simply list all of the codes and standards that may apply without providing a matrix of the path that should be followed to properly apply the technical requirements of the codes and standards. This approach also occurs because it is not uncommon to have a building code, fire code, mechanical code and/or electrical code official simultaneously reviewing their portions of an application to complete a review process. Several code officials from specific disciplines moved off by themselves to do a review until they were encouraged to return to the assigned group.

However, within a short time team leaders and team members coalesced and agreed that the codes and standards needed to be applied in an orderly manner starting with the building code and followed by the fire code. The fuel gas code and referenced standards would be applied subsequent to these two documents. Once this decision was made the teams progressed through each applicable section of the building and fire code and followed paths to other referenced sections, codes and standards. This process was helped by the availability of the I-Code Path matrix that visual depicts the path through the various codes.

The structured approach ultimately applied by the separate teams wherein sections of the building code were noted with a path to a reference led all of the teams to identify loop backs wherein the code language pointed to another code section, only to find the referenced code section pointed back to the starting point. Some of these issues were pointed out in the introductory presentations.

Ultimately the teams did an excellent job of reviewing the assigned plans in a collaborative manner. Only minimal guidance was provided by the workshop facilitators. Reporting of results was thorough and well documented by all five teams.

Each team's final analysis and presentation began with the International Building Code followed by the International Fire Code, and referenced standards. Explanations were provided on how they made their decisions, why they made the decisions they did, and what path took them to the next section of the code or to a referenced standard.

At the end of the workshop each participant was asked to complete an evaluation form. The evaluation asked the participants to rank their responses to four questions concerning expectations, increase in comfort level, increased understanding and whether or not they would recommend others to attend a similar workshop. In addition they were asked to share what they liked or disliked about the workshop and to provide recommendations for improvements. (*A full listing of the responses and comments provided by the participants is in Appendix J.*)

The rankings provided by the participants were overwhelmingly positive and all those that commented responded that they would recommend participation in similar workshops to their peers.

Recommended Action for Participant Comments

SECTION 5

5. Recommended Action for Participant Comments

The recommended improvements suggested by participants are summarized below with similar topics grouped. Some of the changes are reasonable and will increase the positive experience of participants at future workshops.

A. Introductions

- Have all attendees introduce themselves at the beginning of the workshop; provide an attendee list/affiliation/email at the workshop itself; start 1st day earlier; print size in handouts could be larger.

This comment can easily be accommodated by doing introductions at the start. Depending on how close to the start of the workshop we are still working on the finalized attendance list will determine if it can be provided at the start or by the end of the workshop.

B. Local permit process

- Each jurisdiction should explain their permit process; the planning department will create most delays; local civic leaders need to be involved from the beginning.

We don't believe this will add to the workshop. The focus is the application of the codes, something we can address on a global manner. How each jurisdiction handles the permit process does not provide a tangible benefit. In NY State, once you reach the construction permit phase the process is fairly similar statewide with the only difference being the location of the Fire Marshal's Office, (i.e., is it in the building department or a separate agency). In NJ the construction permit process is the same statewide. The difference would be in the prior approvals (zoning/planning) which cannot be addressed at our level.

C. Presenter response to audience.

- Presenters seemed reluctant to challenge opinions of some in audience (NYC). This seemed to create a feeling that the presenters were not confident with some responses.

There is an art in dealing with "aggressive" participants during presentations. A presenter cannot appear to be attacking a commenter in the audience, to do so will turn off the entire audience. The skill is to attempt to address the comments in a positive fashion and wait for the audience in general to fatigue. Once the audience as a whole grows tired of the "aggressive" comments a stronger

response can be employed. In the case at hand the “aggressive” commenter’s supervisor reach a level of uncomfortably and quietly whispered to the individual causing him to quiet down.

D. Introduction of ‘bad H2 occurrences’

- Didn’t discuss bad H2 ‘incidents’ except for ‘Hindenburg’.
- More discussion of “bad stuff”.
- The workshop should indicate some dangers associated with hydrogen & fuel cells, nothing is perfect.

It should be noted that all three of these comments came from the same agency and the comment in item C dealt with this same agency. This particular jurisdiction initially adopted the 2003 ICC International Series of codes and forbid the storage of hydrogen associated with the use of stationary fuel cells and deleted the language in the International Fuel Gas Code that provided for the installation of gaseous hydrogen fuel gas systems. That position has recently changed and the local adoption has been modified to allow the installations and an installation had already been approved and was used in the workshop.

Certainly a quick mention of where to go to view information on H2 incidents can be included in the presentation. But we caution against focusing on any one incident unless we can show how that incident can be solved by applying a relevant code, or resulted in a positive change to the codes. Relating an incident that is not related to the code language will send the wrong message and may result in applications being denied unless guarantees are provided that an incident will not occur.

E. Vehicle fuel comparison

- In the video presentation with the two vehicles burning there was a lot of discussion on the burning of the gasoline; I suspect that this was done to indicate that the hydrogen fueled vehicle was safer than a vehicle with an accepted fuel (gasoline). I think a comparison to LPG or CNG (which is also accepted now) would be a better comparison.

A search can be done to assess if there is information available concerning the risks posed by LPG or CNG fueled motor vehicles that would be able to be used for comparison purposes during future workshops.

F. Industry participation

- Industry professionals could have been more involved in breakout sessions.

Industry participation has been encouraged during the presentations, discussions and as a resource. However, we caution against to heavy participation during the breakout sessions. Certainly we would expect an industry representative to answer a direct question concerning one of their installations, but caution must be used to avoid the response from morphing into a 'sale' of the installation or from providing too much information. The goal of the workshop is to have the code officials work through the codes in the manner they normally do to build a comfort level with the topics, to indentify areas of misapplication and to identify code language that might need to be cleared up. If industry provides too much information during this process it reverts to a lecture and the code officials are no longer active participants, they are now audience members.

G. Number of breaks

- Need more breaks.

Only one person made this comment. We believe the breaks were sufficient.

H. Steam reforming fuel cells

- Maybe cover the use of fuel cells for co-generation, they are widely used in NYC.

We believe this refers to the installation of steam reformation of natural gas stationary fuel cell installations. We did mention these types of installations and we can expand a little on them. However, since they are the easiest hydrogen fueled installation to site due to minimal code requirements we do not believe we need to spend a lot of time on them.

I. Hands on equipment access

- Would like to see the actual equipment such as a fuel cell.

We were fortunate that GM offered to bring a hydrogen fuel cell powered vehicle to the workshop to allow the attendees to get a "hands on" look at one. It is hoped that if a vehicle is available for future workshops that this addition to the workshop continue. It is a decision of the fuel cell industry participants as to whether or not they can provide a stationary hydrogen fuel cell for a "hands on" look at future workshops.

J. Reference materials supplied

- Didn’t supply enough materials such as copies of the CGA regulation and referenced standards.

Certainly we can add a copy of the CGA standard P-1 to the next workshop as an addition to the codes and standards provided to each breakout group at a cost of $90.00 each, of a total of $450, (if we remain at only 5 groups). It would serve as a benefit since we do refer to this standard when introducing the topic of transferring gas from one cylinder to another. However, beyond that we believe an appropriate amount of code references have been provided to serve the purposes of the workshop. To go deeper involves ASME standards such as B31.3 and the cost would be significant with minimal benefit. (*B31.3 costs $320 per copy*)

K. Information for plan reviews

- Improve the information provided during the breakout sessions.
- Add more documentation for plan review sessions on fuel cell sites.
- Add additional information into the plan review packages including equipment cut sheets.
- The lack of detail on the breakout drawings.
- A better integration of hydrogen and gasoline fueling operations into the review process.

We have consistently added more information, the plans we use now are the most detailed of any workshop. We can give the break out teams as much information as the industry participants are willing to provide us for duplication.

L. Knowledge levels

- I wasn’t knowledgeable enough to contribute to any breakout, but tried to use the time productively.

By their nature the participants will have various levels of knowledge. There is not much we can do to change the ability of attendees to participate during the breakouts other than to point out at the beginning of the workshop that there are varying levels of knowledge present and that we expect some participants will end up providing instruction as others continue to learn during the breakouts.

M. Breakout group size/make up

- Smaller breakout groups, it was hard for everyone to see plans on table provided at the same time.
- Code officials of the same discipline should review together and then split into mixed groups.

We have been using groups with anywhere from 8 to 10 team members based upon the number of participants. We can decrease individuals on a team by increasing the number of teams, the impact would be on break out room availability and an increase in the number of code book sets we will need.

We do not support the second comment wherein it is suggested that attendees are broken into disciplines, (i.e., electrical with electrical, building with building, fire with fire). The reason for the mix disciplines during breakout groups is to provide increased knowledge of how each discipline relates/effects the other disciplines. In some jurisdictions a single code official handles multiple if not all jurisdictions. The commenter in this is from an NJ jurisdiction. For the past three years the State of NJ has been working to breakdown the separation of disciplines by sponsoring cross-discipline training programs.

N. Group assignments

- The breakout sessions were too long, this could be a one day workshop. Each team could work/focus on a different project.
- Drop down to two scenarios, four is a little much when dealing with a new concept.

Only one participant felt the workshop could be done in a day and that comment conflicts with comments we have received from others seeking more time at past workshops. Only one commenter asked for a reduction in scenarios.

Both comments suggest limiting the number of scenarios, one suggest a single per group and the other suggesting just two scenarios. This past workshop we only focused on 4 scenarios, a canopy top hydrogen motor fueling station, a remote grade level storage motor fueling station, a grade level telecommunications site installation and a roof top installation. The choices were to ensure all attendees got a look at the common types of installations that they might be confronted with.

These comments must be balanced with that of many others that consistently ask for more detail to review to enhance the experience. We have done three workshops and we find that the level of performance of teams will fluctuate based upon the personalities if the individual team members, something that cannot be predicted, but which we can continue to manage during the process by providing active guidance.

O. Code training

- Based upon the fact that this is a new area effort should be made to evaluate a simple hydrogen plan examination with the audience participation.
- Include a plan review with an installation correctly shown on the plan and give the appropriate codes.
- More concentrated code specifics with relation to hydrogen installations; better clarification of fire protection system requirements.
- Should review the code sections of the I-Codes before the breakouts.
- After initial exposure to concept a more in depth study of code issues for each discipline would benefit individual code officials.
- Subject matter requires a more intense study into application of codes.

Collectively these comments are seeking a code application lecture and/or for the presenters to do a group plan review while teaching the specific code sections. Most of these comments came from NJ participants and can be the result of the NJ mandatory CEU program for licensed code officials. Most of such offerings are done in a manner where the code official sits back and is lectured.

Our workshops are intentionally hands on to have the code officials apply their knowledge to a set of plans. In this way we can gauge how easy or how difficult it is to apply the codes, where the codes need to be improved, and what kind of guidance needs to be developed. This occurs while the participants increase their knowledge level. If we follow these suggestions and do a section by section lecture on application of the various codes & standards we will require several hours of additional lecture time and when we break the groups out to do the reviews they will simply mimic our code lecture back to us.

All of the suggestions we supported can be accomplished with reasonable effort and any increased costs are negligible when compared to the benefits of the increased knowledge and comfort of code officials when dealing with the permitting of hydrogen motor-fuel stations. As we move forward with additional workshops we can continue to improve the offerings by inclusion of some of these recommendations.

Summary

SECTION 6

6. Summary

The workshop was a success both from the standpoint of providing code officials with an understanding of how to apply the various codes and standards to an application to build a hydrogen motor-fuel station or a back up power installation for a telecommunications site, and in having the codes and standards methodically applied to a project in a manner that identified areas of concern that needed to be addressed. For code officials to feel comfortable dealing with these types of applications they need to believe they have an adequate knowledge of the issues involved and they need to be assured that the existing codes and standards adequately address safety in an effective manner.

For the workshop to have been the success it was, all involved in the preparation had to perform their functions in an effective and timely manner. The management of the invitations, travel and accommodations for those attending, and scheduling of the facility for meeting rooms and refreshments are as important as the information gathering, material preparation and presentation of the workshop itself.

A failure of any one component, whether it was the lack of a room, missing or inaccurate piece of information, or the functioning of the workshop itself affects the experience of the participant and their assessment of the workshop as a whole.

When a team is assembled and contracted to develop and present a workshop it must include and agency or organization that has a proven track record organizing an event that includes travel, accommodations and leasing of conference space. When the participants arrive for the workshop everything must be organized and ready to go. Technical assistance must be available before and during the activity to address any audio visual equipment issues that come up.

The team must include firms, individuals or agencies familiar with the targeted topic to provide valid information and resources for use in the workshop. To be effective the information must be current, technically accurate and in a form that allows it to be understood and have a professional appearance.

And the team must include experienced educational presenters to develop the material and present or facilitate the workshop. Many otherwise well prepared presentations have failed when the presenter did not have the ability to communicate effectively with the audience.

The code officials that were invited to attend this workshop were all experienced in their field of endeavor. All are knowledgeable about codes and standards. Because of their backgrounds they were a challenging audience; one that requires a high content level and a high level of accuracy. They have the ability to

immediately pick up on flaws, incorrect information or if a presenter is not being entirely open with their information.

Because the participants had such a high level of knowledge and experience, their positive response to the workshop and the information provided documents the quality and value of the workshop for the purpose of educating code officials on the topic of hydrogen motor-fuel stations and the safe use of hydrogen in general.

With implementation of the changes suggested by the participants the workshop will be an effective education tool that should be expanded to include presentation at the regional level in each state, starting with those that either have hydrogen motor-fuel station construction activities or will have those activities in the near future.

List of Participants

APPENDIX A

Permitting Hydrogen Fueling Stations and the use of Stationary Hydrogen Fuel Cells as Back-up Power for Telecommunications Antenna Sites Workshop

Teaneck, NJ
May 15 – 16, 2008

FINAL ATTENDANCE LIST

First Name	Last Name	Title	Agency
Chris	Afuwah	Fire Alarm Consultant	NYC Fire Department
Anthony	Androsky	Deputy Executive Director	US Fuel Cell Council
Chad	Blake	Senior Project Leader	NREL
Paul	Buehler	Tech Consultant	Plug Power Inc.
Melanie	Caton	Project Leader	NREL
Michael	Ciotti	Project Manager – Hydrogen Solutions	LINDE North America, Inc.
Mark	Cohen	Product Manager	ReliOn
Allison	Crowley		NASFM
Chris	Daetwyler	Program Specialist	South Carolina Hydrogen and fuel Cell Alliance
Robert	Davidson	Consultant	Davidson Code Concepts, LLC
Timmy	Fisher	Building Inspector	Township of West Milford
Salvatore	Garafalo	Chief Fire Marshal	Town of Brookhaven
Kyle	Gibeault	Project Coordinator	National Hydrogen Association
Steven M.	Gluck	Construction Official	Township of Teaneck
Brian	Grant	City Engineer	City of Asbury Park
Fred	Hettenbach	Plumbing Subcode/Inspector	City of Ashbury Park

Russ	Hewett	Senior Systems Analyst II	NREL
Theodore	Horishny	Supervising Fire Marshal	Nassau County Fire Marshal's Office
Bruce	Johnson	Regional Manager, Fire Service	International Code Council
Shaji	Joseph	Deputy Chief Inspector, Technology Management	Bureau of Fire Prevention, NYC Fire Department
David	Kahn	Project Manager	Bureau of Fire Prevention, NYC Fire Department
Elie	Katz	Mayor	Teaneck, NJ
Kevin	Keddy	Fire Chief	City of Ashbury Park
Thomas	Kelly	Building Subcode Official	Woodbridge Twsp Municipal Bldg
Lisa	Larue	Building Subcode Official	Township of South Brunswick
Craig	Lucas	Principal Building Inspector	Town of Brookhaven
Raymond R.	Meyer	Construction Official	City of New Jersey
Chrishawn	Morgan-Price		NASFM
Jim	Narva		NASFM
Dharam	Pal	Chief Mechanical Engineer	Port Authority of NY and NJ
John	Palcher	Captain/Fire Prevention Officer	Arlington Fire District
Michael	Paritee		General Motors - Fuel Call Activities
David A.	Peach	Fire Subcode Official	Teaneck Building Department
William	Pfeiffer	Building Inspector	Township of Franklin
Michael E.	Razzoli	Fire Protection Subcode Official	Jersey City Building Department & Fire Department
Terence	Reidy	City Manager	City of Ashbury Park
Joseph	Rischak	Fire Protection Subcode Official	Woodbridge Township Municipal Building

Carl	Rivkin	Senior Project Leader II	NREL
George M.	Roberts	Electric Subcode Official	Township of Teaneck
Antonio	Ruiz		US Department of Energy
Tamara	Saakian, P.E.	Director of Engineering, Technology Management	Bureau of Fire Prevention, NYC Fire Department
Robert	Schroeder, P.E.	Network Engineer II	Sprint Nextel
George	Selah	Electric Subcode Official	City of Ausbury Park Construction Dept.
Leonard	Splain	Fire Inspector	Town of Poughkeepsie
Ron	Vigliotti	Building Inspector	City of Ashbury Park
Steven	Weiner	Program Manager, Hydrogen Safety	Pacific Northwest National Laboratory
Michael	Whalen	Construction Official	NJ DCA, Division of Codes & Standards

First Name	Last Name	Title	Company Name
Joe	McElveney	Fire Protection Engineer	Phoenix Fire Department
Jeffrey	Miller	Fire Prevention Inspector	Iowa State Fire Marshal's Office
Jim	Muir, C.B.O.	Building Official	Washington State - Clark County Community Development/Building
Jonathan	Munetz	Research Analyst	Sentech, Inc.
Daniel	Nichols		NYS Department of State Codes
Tim	Nogler	Managing Director	Washington State Building Code Council
Jim	Ohi		NREL
Eddy	Prince, AIA, Esq.	Director	County of Mecklenburg, NC
Jon	Roberts	Fire Protection Engineer, Investigations & Code Enforcement	Oklahoma State Fire Marshals Office
Antonio	Ruiz		U.S. Department of Energy
Marc	Sampson	Fire Protection Engineer	Longmont Fire Department, Colorado
Joseph	Sauerwein	Building Code Enforcement	Town of Brookhaven, NY
Patrick	Serfass		National Hydrogen Association
Brad	Smith		Shell-Hydrogen
Jack	Taddeo	Battalion Chief, Technology Management- FDNY	New York City Fire Department

NREL Presentation

APPENDIX B

Permitting Hydrogen Fueling Stations and Hydrogen Fuel Cells for Backup Power at Wireless Telecommunication Facilities

DOE/NASFM Workshop
Teaneck, NJ
May 15 & 16, 2008

Antonio Ruiz
Technology Development Manager
U.S. Department of Energy
Hydrogen Program

DOE Hydrogen Safety, Codes and Standards Program Objectives

- Establish requirements for hydrogen codes and standards based on scientific data, modeling, and analysis
- Implement consensus national agenda on domestic and international codes and standards for hydrogen systems in commercial, residential, and transportation applications
- Facilitate permitting of retail hydrogen fueling stations and fuel cell installations for backup power in the US through education and outreach to state/local code officials
  - priority for FreedomCAR and Fuel Partnership and Hydrogen Technical Advisory Committee
  - need efficient, cost-effective permitting process based on collaboration among code officials, industry, and other key stakeholders

Jonathan4

Background: HFS Permitting Workshop

(Sacramento, February 1, 2007)

- Invited fire/building code officials, HFS developers from states where HFS located or likely to be located
- Perspectives of hydrogen fueling station (HFS) developers and code officials on permitting experience (case studies)
  - Shared lessons learned
    - Shell Benning Road HFS (Washington, DC, Office of Fire Marshall)
    - NextEnergy energy station (Michigan Dept. Environmental Quality)
    - Chevron AC Transit HFS (Oakland Fire Prevention Bureau)
- Key issues and barriers to timely and cost-effective permitting of HFS identified
- Recommendations to DOE on how it can facilitate permitting process for HFS
- Feedback on proposed DOE initiative

Background: HFS Permitting

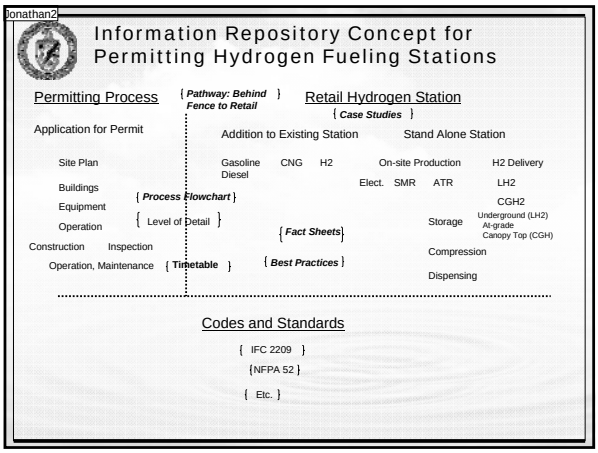
- Key Recommendations to DOE
  - Develop Information Repository for HFS with validated,"3rd party" data and information
  - Identify applicable codes & standards (specific safety requirements) and make them more accessible to permitting officials
  - Develop detailed Process Flowchart for permitting HFS
  - Develop Template for code officials to navigate permitting process
  - Note best practices for application of codes and standards for HFS
  - Develop fact sheets on hydrogen technologies/HFS equipment for permitting officials
  - Develop permitting pathway from "behind the fence" stations to retail stations
- Proceedings/presentations posted on NHA website (www.hydrogenandfuelcellsafety.info)

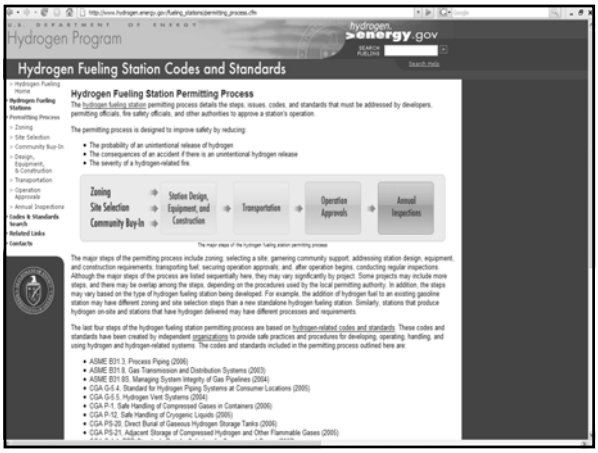
Permitting H2 Fueling Stations and Fuel Cell Installations: DOE Initiative

- Information Toolkit
  - Fact sheet(s)
    - basic information on hydrogen and FC installations (examples, codes/standards typically used, information sources)
  - Network chart
    - contact list of code officials whose jurisdictions have issued permits for hydrogen and FC installations
  - Flowchart of permitting requirements
    - web-based map to "navigate" requirements with database of key standards and codes
  - Permitting Compendium
    - web-based information source and database
- Education-outreach workshops for code officials
  - National workshops with NASFM and NCSBCS (planned)
    - vet case studies, C&S permitting process, information tools
  - Workshops in key regions
    - locations where industry will focus H_2 infrastructure development and hydrogen vehicle and fuel cell deployment

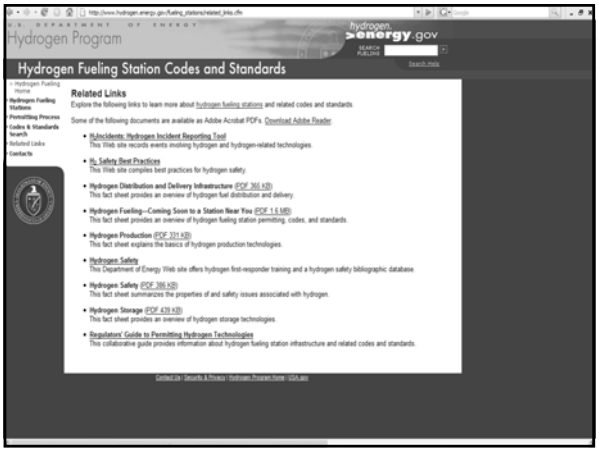
DOE/NASFM/CFPI Workshop

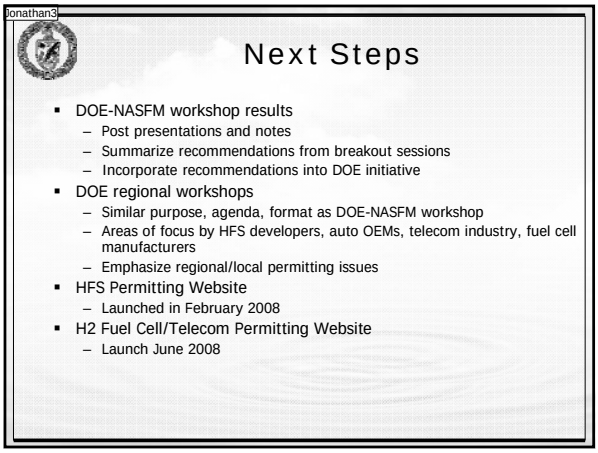
- Objectives
  - Invite key fire and building code officials
    - present case studies
      - H2 stations and fuel cell installations permitted/permitting underway
      - codes/standards applied
    - review and discussion by permitting officials of case studies
    - recommendations to DOE on facilitating permitting process
  - Show information repository concept
    - web-based tools to "navigate" requirements with database of key standards and codes
    - recommendations to DOE on initiative and other steps
- Acknowledgements
  - NASFM, Shell, GM, Sprint, Plug Power, ReliOn, Idatech, Black and Veatch
  - Bob Davidson, Sal DiCristina, Lisa LaRue, Jim Narva, Chrishawn Morgan-Price, Allison Crowley



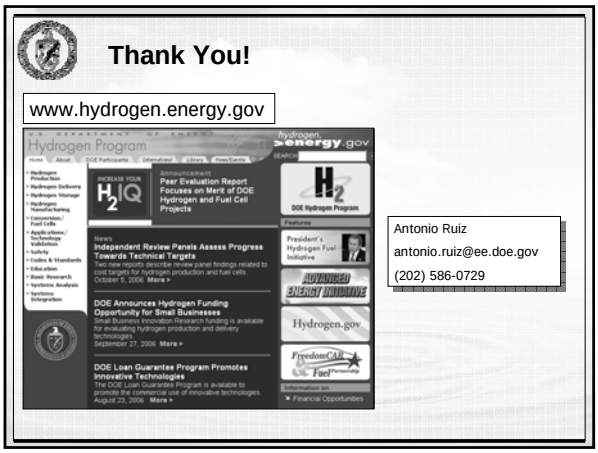


Antonio Ruiz
Technology Development Manager
U.S. Department of Energy Hydrogen Program





Antonio Ruiz
Technology Development Manager
U.S. Department of Energy Hydrogen Program



Antonio Ruiz
Technology Development Manager
U.S. Department of Energy Hydrogen Program

Telecommunications Presentation

APPENDIX C

Applying Codes and Standards Systematically

P.J. Buehler – Plug Power
Mark Cohen - ReliOn
16 May 2008

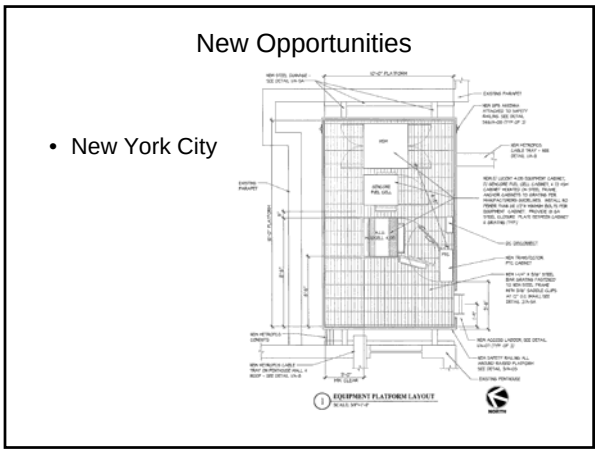
Where We Stand Today

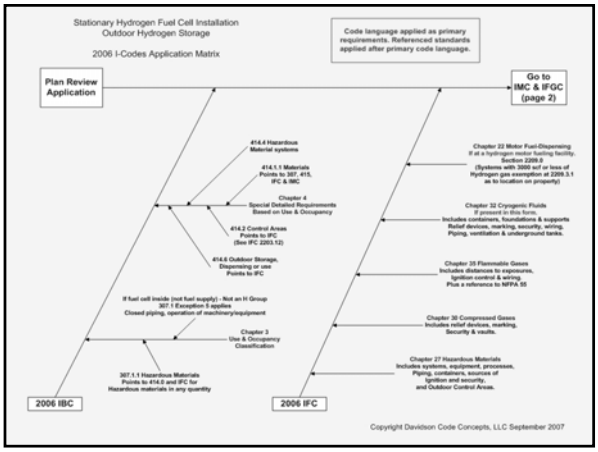
- We now have a path through the I-Codes.
  - Available to all.
  - Endorsed by HELP and SBCC.
  - Linked on Plug Power, HELP and SBCC websites.
    - http://www.nasfmhydrogen.com/documents/I-CodePathFuelCell.pdf
    - http://www.saferbuildings.org/docs/training/I-CodePathFuelCell.pdf

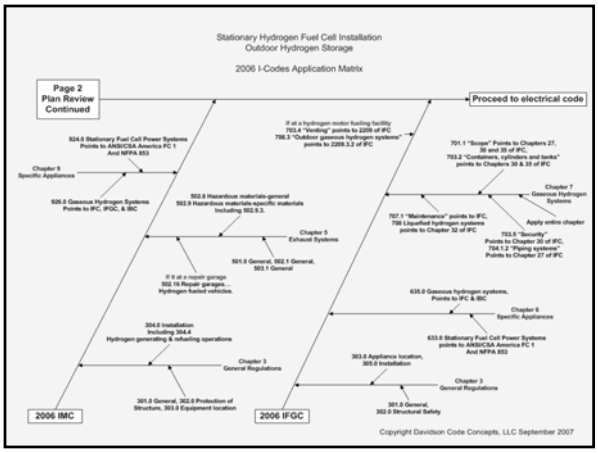
Progress with AHJs

- Clear and concise rules have allowed for painless permitting since June 2007.
  - Massachusetts
  - New York
  - California
  - Rhode Island
  - New Hampshire
  - New Mexico
  - North Carolina
  - Houston, Texas

Applying Codes and Standards Systematically







Applying Codes and Standards Systematically

Referenced Standards?

- NFPA 853 Standard for the Installation of Stationary Fuel Cell Power Systems
- NFPA 55 Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks
- ANSI/CSA America FC 1

Others

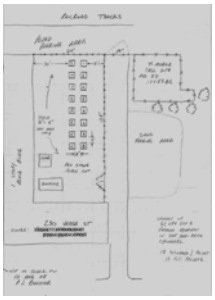
- NFPA 70 NEC
- NFPA 54 ANSI Z223.1–2006 National Fuel Gas Code

How It's Done

- Engineer follows published codes in the design process.
  - Then applies referenced standards.
- Engineer submits plans which meet the setback distances relevant to that jurisdiction.
- AHJ has an easier time reviewing the permit.
  - Has path through the codes showing relevant distances.
  - Can easily match design with codes.
- Permit is issued quickly or on the spot!

Designs Which Were Approved Quickly

No permit required. Electrical inspection at completion of work for power and grounding.



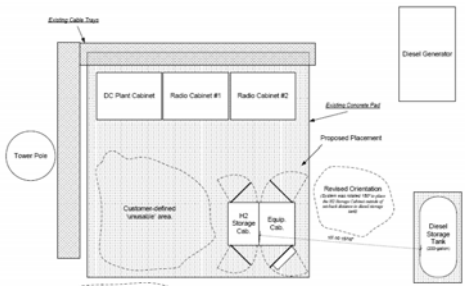
Permit issued "on-the-spot".

Applying Codes and Standards Systematically

How It's Done (the hard way)

- Original site plan oriented the fuel cell cabinet and fuel storage cabinet to so the fuel cell front panels faced the outside of the pad
- This plan was rejected by the AHJ because the fuel storage cabinet violated the setback distance to an existing diesel storage tank
- The plan was modified by simply re-orienting the cabinets by 180°, placing the fuel storage cabinet outside of the required setback
- The plan was approved.
- Knowledge of setbacks would have saved 1 week off the siting schedule with a trivial re-orientation

Minor change in orientation solves siting restriction

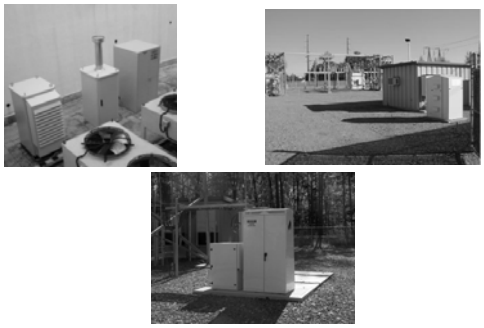


Don't Even Think About it Here!
(Yes, this is a real proposed location)

Applying Codes and Standards Systematically

Listed and approved fuel consuming appliances

A stationary hydrogen fuel cell is a listed and approved fuel consuming appliance



Questions?

General Motors Presentation

APPENDIX D

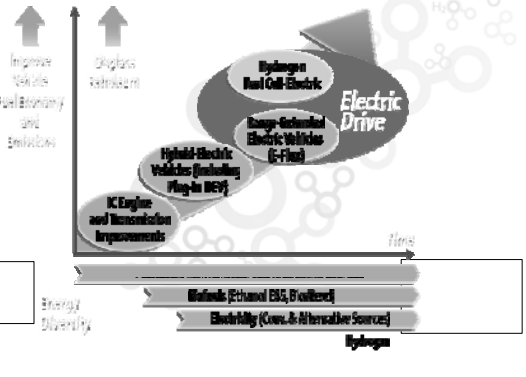
Chevrolet Equinox Fuel Cell Electric Vehicle and Project Driveway

Chevrolet Equinox Fuel Cell Electric Vehicle and Project Driveway

EQUINOX FUEL CELL

Mike Paritee
Fuel Cell Activities- Eastern Region

GM's Advanced Propulsion Technology Strategy



Project Driveway Program Overview

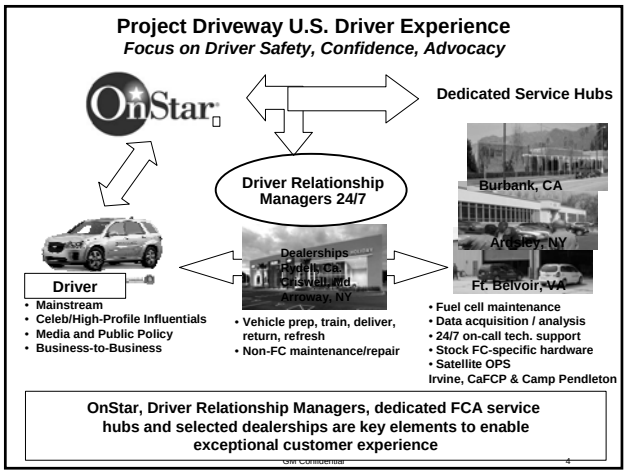
Equinox Fuel Cell is a fully-functional, distinctively-styled, 4-passenger crossover, with all the safety features of the 5-star production Equinox

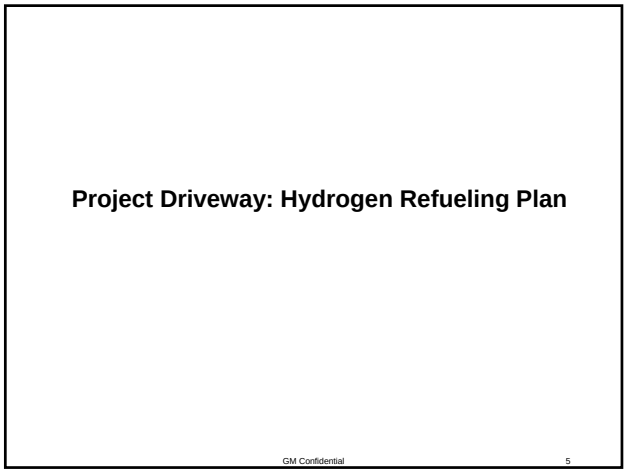
- 110 Equinox Fuel Cell Vehicles fielded globally
  - Deployment plan based on 110 vehicles globally
- U.S. deployments in three locations
  - California (LA, Sacramento)
  - Greater New York City metro area
  - Washington D.C.
  - Other global deployments planned for Germany, China, Korea, Japan
- Deployment began in Sept. 2007 & runs through end of 2011
- U.S. deployment includes five target driver groups
  - Media, Public Policy, Celebrities/Influentials, B2B and mainstream driver
  - 3 to 30-month deployments, depending on driver group
- Comprehensive feedback on all elements of customer experience

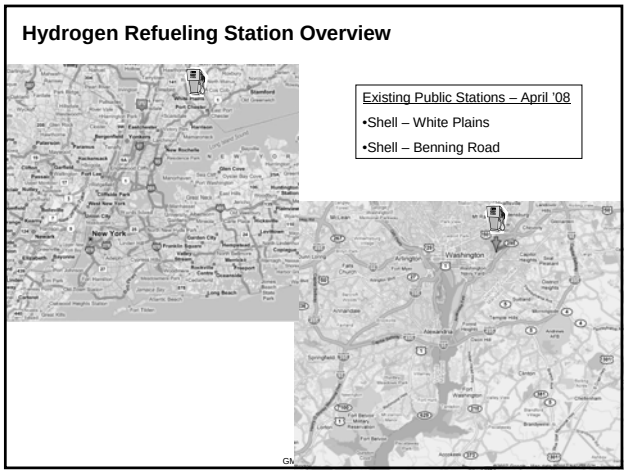
GM Confidential 3

Mike Paritee
Fuel Cell Activities- Eastern Region

Chevrolet Equinox Fuel Cell Electric Vehicle and Project Driveway







Mike Paritee
Fuel Cell Activities- Eastern Region

Chevrolet Equinox Fuel Cell Electric Vehicle and Project Driveway

Project Driveway: Hydrogen Refueling Plan

We currently face…

- **Limited network of stations, mostly behind-the-fence applications**
- **Various access arrangements**
  - Few locations publicly accessible 24/7
- **Time-consuming and unpredictable station approval procedures**
  - Varying methodologies for application of codes and standards to hydrogen infrastructure
  - Continuing need to educate local authorities on hydrogen and fuel cell vehicles. Starting from scratch each time.

Hydrogen Infrastructure continues to be challenging.
Technical and commercial details must be addressed.

GM Confidential 7

Project Driveway: Hydrogen Refueling Plan

We need…

- **Retail-like refueling stations**
  - Geographically targeted regions where automakers want to put vehicles
  - 700bar fast-fill refueling
- **Expedient station approval and permitting process**
  - State-wide consistency and local adherence
  - Community support
- **Funding Support and Incentives**
  - Stations and upgrades
  - Liability coverage (funded liability pool, liability cap) or…
    - Full-service attendants to mitigate liability issues
  - Station operating costs/refueling costs

Vehicles will be in customer's hands.
Goal must be to promote a normal sense of driving / refueling.

GM Confidential 8

Project Driveway: Hydrogen Refueling Plan

Current Strategy Update

- Underestimated infrastructure hurdles
  - Current gap between existing and required fueling experience
  - Lead time required to execute infrastructure
  - Inability to keep pace with requirements of evolving vehicle programs
- GM has purchased and plans to site temporary refuelers to supplement existing hydrogen refueling network in order to meet program needs
  - Strategically selected locations in LA and NYC metro areas
  - GM owned and operated equipment
  - Permitting will be difficult and timing unpredictable
    - Working with Public Policy, local municipalities and Fire Marshalls
  - Goal is to provide more comfortable/convenient access
    - No PPE, safe surroundings, 24/7, simple training, etc.
- Working with Shell Hydrogen and partners in LA and NYC areas to facilitate permitting, siting and operation of additional 700-bar sites

GM Confidential 9

Chevrolet Equinox Fuel Cell Electric Vehicle and Project Driveway

Hydrogen Background Material Breakout Session Presentation

APPENDIX E

What is Hydrogen?

1

Hydrogen Facts

US Fuel Cell Council

- Hydrogen (H) is the first element in the periodic table of elements. It consists of one proton and one electron.
- Molecular hydrogen (H_2) is a small, simple molecule consisting of two protons and two electrons.
- Hydrogen is not commonly found in its pure form on Earth since it readily combines with other elements.

2

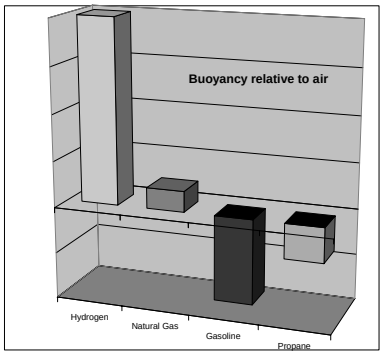
Hydrogen is the lightest and most abundant element in the universe. It is present in water, nearly all organic compounds and in all living organisms. Hydrogen is able to react chemically with most other elements.

3

Hydrogen is a flammable gas. It is the lightest gas known, having a specific gravity of 0.0695 (air = 1.0). Hydrogen diffuses rapidly in air and through porous materials.

4

Hydrogen Characteristics



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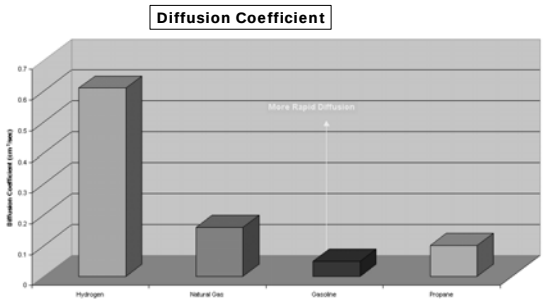
Hydrogen Characteristics



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Hydrogen Properties

US Fuel Cell Council

Hydrogen has some interesting physical properties:

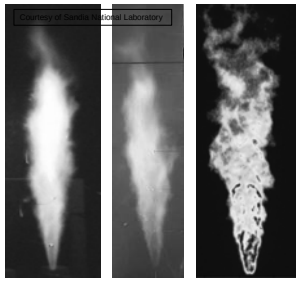
- Non-toxic
- Asphyxiant
- Odorless and Tasteless
- *Burns with a pale-blue, almost-invisible flame (DOE)*
- Burning hydrogen produces no carbon dioxide, particulate, or sulfur emissions. It can produce nitrous oxide (NOX) emissions under some conditions. (DOE)

7

Hydrogen Properties

US Fuel Cell Council

- A pure hydrogen flame is a pale blue color and is difficult to see in sunlight.
- Impurities in the air reacting with the hydrogen may make the flame more visible



30 msec exposures 100 μsec exposure

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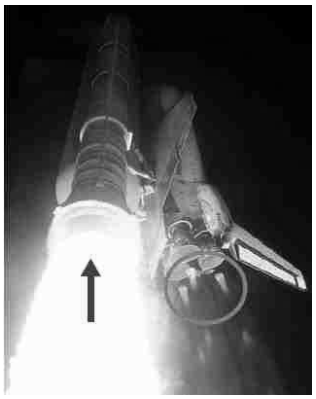

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10

- The flammable limits of hydrogen-air mixtures depend on pressure, temperature, and water vapor-content.
- At atmospheric pressure the flammable range is approximately 4 percent to 74 percent by volume of hydrogen in air.

11

Hydrogen remains as a gas at high pressures. It is liquefied when it is cooled to its boiling point of -423°F (-253°C).

12

- Hydrogen fires are not normally extinguished until the supply of hydrogen has been shut off because of the danger of reignition or explosion.
- In the event of fire, large quantities of water have been sprayed on adjacent equipment to cool the equipment and prevent involvement in the fire.

13

Hydrogen Properties

US Fuel Cell Council

	Hydrogen (4 / 0 / 0)	Natural Gas (4 / 1 / 0)	Gasoline (3 / 1 / 0)
Color	No	No	Yes
Toxicity	None	Some	High
Odor	Odorless	Mercaptan	Yes
Buoyancy Relative to Air	14X Lighter	2X Lighter	3.75X **Heavier**
Diffusivity Relative to Gasoline	~20X Gasoline	~5x Gasoline	0.2cm3/sec
Energy by Weight	2.8X **>** Gasoline	~1.2X **>** Gasoline	43 MJ/kg
Energy by Volume	4X to 10X**<** Gasoline	1.5X **<** Gasoline	120 MJ/Gallon

Hydrogen Properties

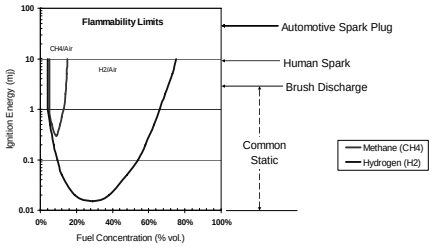
US Fuel Cell Council

	Hydrogen (4 / 0 / 0)	Natural Gas (4 / 1 / 0)	Gasoline (3 / 1 / 0)
Flammability in air (LFL – UFL)	4.1% - 74%	5.3% - 15%	1.4% - 7.6%
Explosive limits in air (LEL – UEL)	18.3% - 59%	5.7% - 14%	1.4% - 3.3%
Fuel/Air Stoichiometry (complete combustion)	29%	9%	2%
Auto Ignition Temperature (F)	968	1166	437
Flame temperature (F)	3700	3400	4000
Radiant Heat Transfer From Flame	1/10 Gasoline	~ Gasoline	Gasoline

Hydrogen Properties

US Fuel Cell Council

Ignition Energy as a function of Mixture



Air Products Presentation dates 1998 June 12, p. 12

16

Hydrogen Generation

US Fuel Cell Council

- Hydrogen can be generated at a central plant or locally at the point of use. It can be generated by a number of methods. Some of these methods include:
  - Reforming of Hydrocarbon Fuels
  - Splitting of water using electricity (electrolysis)
  - Gasification of fossil fuels (e.g. coal)
- The most common method of generating hydrogen is steam methane reforming (SMR) of natural gas. Steam methane reforming accounts for 95% of the hydrogen produced in the U.S. (DOE).
- The most common methods for the local point-of-use generation of hydrogen are:
  - Steam methane reforming
  - Electrolysis

17

Transport to Site

US Fuel Cell Council

Hydrogen can be generated on-site (distributed generation) or at a remote location (central generation) and transported.

- Hydrogen generated on-site for use on-site is typically stored as a compressed gas since liquefaction is not needed and liquefaction is costly.
- Hydrogen generated off-site may be delivered as a liquid or as a gas depending upon the economies of transportation and liquefaction. Delivery is typically based on the method of storage.

18

History Lesson

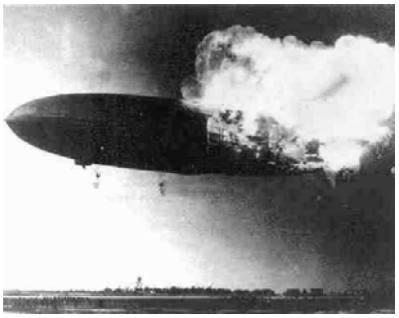
19

20

The New York Times.

HINDENBURG BURNS IN LAKEHURST CRASH;
21 KNOWN DEAD, 12 MISSING; 64 ESCAPE

21



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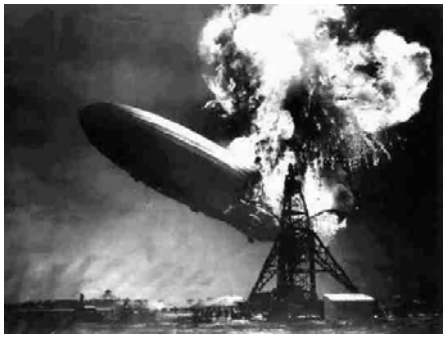
Hindenburg



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Hindenburg

The explosion of the luxury airship Hindenburg at Lakehurst, NJ, on May 6, 1937, serves as one of the most spectacular moments recorded by the media. Until very recently, it has aided in paralyzing the development of widespread hydrogen use as a fuel, due to concerns for safety (and viewing the fiery picture on prior slides, understandably so). But knowing the actual nature of the Hindenburg disaster, as well as knowing the behavior of hydrogen allows us to dispel this stigma associated with hydrogen.

24

The Facts

The bags of hydrogen that provided the lifting force for the Hindenburg were NOT the main contributor to the fire. The surface of the ship was coated with a combination of dark iron oxide and reflective aluminum paint. These components are extremely flammable and burn at a tremendously energetic rate once ignited. The skin of the airship was ignited by electrical discharge from the clouds while docking during an electrical storm. This reaction has been proven chemically for years, and was demonstrated with actual remnants of the Hindenburg sixty years later, which burned as vigorously as on the day of the disaster.

25

The hydrogen burned quickly, safely, above the occupants. When the escaping hydrogen was ignited by the burning skin of the airship, it burned far above the airship, and was completely consumed within 60 seconds of the ignition. During this period of time, the airship descended to the ground from the 150-foot docking tower.

26

Almost all deaths were caused by jumping or falling from the airship. Of the 35 deaths from the disaster, 33 were caused by jumping or falling. Only two deaths were caused by burning, and it is likely that those two were from proximity to the burning skin of the airship, or from the stores of diesel fuel that were ignited by the covering. Whereas the hydrogen burned within one minute of ignition, the diesel fires burned for up to ten hours after the ignition.

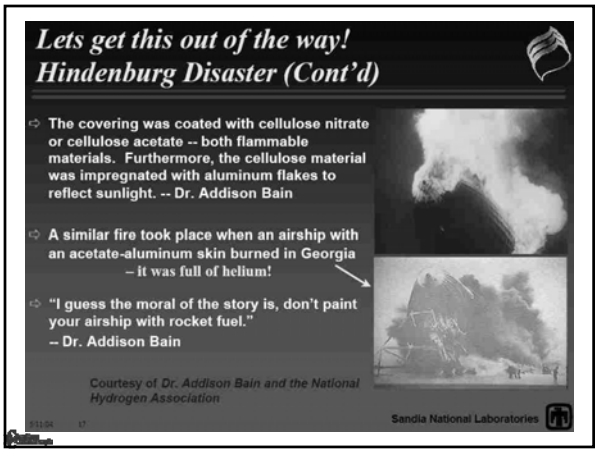
27

Files examined at the Zeppelin Archive in Friedrichshafen, Germany, yielded final confirmation of Bain's theory. Several handwritten letters, when finally translated from German, corroborate what Bain uncovered. Wrote electrical engineer Otto Beyersdorff on 28 June 1937, "The actual cause of the fire was the extreme easy flammability of the covering material brought about by discharges of an electrostatic nature."

28

The Hindenburg would have burned if it had been filled with inert helium gas. Even if the Hindenburg had not been lifted by hydrogen, the ignition of the covering would still have happened, and would then have set ablaze the diesel stores, resulting in the same disaster.

29



H_2 - LPG Comparison

Hydrogen - specific gravity of 0.0695
LPG – vapor specific gravity of 1.5

Air = 1.0

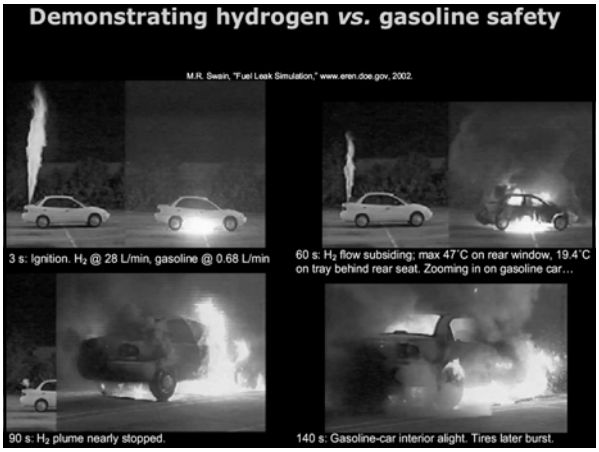
Hydrogen – lighter than air
LPG – heavier than air

32

33

Hydrogen Vehicle Fire

34



Uses

36

- Large quantities of H2 are needed in the petroleum and chemical industries. By far the largest application of H2 is for the processing ("upgrading") of fossil fuels.
- The key consumers of H2 in the petrochemical plant include hydrodealkylation, hydrodesulfurization, and hydrocracking.

37

- Used in the hydrogenation of fats and oils (found in items such as margarine), and in the production of methanol.
- H2 is used in the manufacture of hydrochloric acid
- H2 is used in certain welding methods
- H2 is used in the reduction of metallic ores.
- H2 is an ingredient in some rocket fuels.

38

- H2 is used as the rotor coolant in electrical generators at power stations, because it has the highest thermal conductivity of any gas.
- Liquid H2 is used in cryogenic research, including superconductivity studies.

39

- Deuterium, an isotope of hydrogen (hydrogen-2), is used in nuclear fission applications as a moderator to slow neutrons, and in nuclear fusion reactions. Deuterium compounds have applications in chemistry and biology in studies of reaction isotope effects.
- Tritium (hydrogen-3), produced in nuclear reactors, is used in the production of hydrogen bombs, as an isotopic label in the biosciences, and as a radiation source in luminous paints.

40

What is a Fuel Cell (FC)?

41

Fuel Cells

US Fuel Cell Council

What is a fuel cell?

A fuel cell generates electricity efficiently and cleanly without combustion. A chemical reaction between a fuel supply and oxygen produces direct current electricity inside the fuel cell. The fuel cell will stop running when the fuel supply is depleted or shut off.

Fuel cells on the space shuttle use bottled oxygen and hydrogen as fuel and make water for the astronauts to drink. For our systems, oxygen from the air is used.

42

Fuel Cells

US Fuel Cell Council

What parts make up a fuel cell?

A fuel cell, like a battery, is a string of cells. Each cell consists of:

- an anode electrode
- an anode fuel distributor
- an electrolyte
- a cathode electrode
- a cathode fuel distributor
- a heat removal device

A fuel cell needs fuel to run. Fuel can be provided in many ways, and is fed to the fuel cell in order for the chemical reaction to take place, which provides electricity.

43

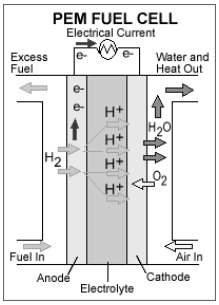
Fuel cells

44

PEM Fuel Cells

US Fuel Cell Council

PEM cells are being commercialized and typically operate between ambient room temperature and 250ºF (120ºC).



Courtesy of DOE

45

US Fuel Cell Council

Fuel Cell Vehicles

Courtesy of General Motors and US Postal Service

Courtesy of Ballard

Courtesy of Hydrogenics

Courtesy of DaimlerChrysler

46

US Fuel Cell Council

Light Commercial/Backup Utilizing H2 Storage

Outdoor installation of power plant and fuel supply

Courtesy of Plug Power

Indoor Rack mounted installation of power plant without fuel supply

Courtesy of UTC Power

Telecommunications backup power

Courtesy of ReliOn

Extended run backup power for telecommunications

Courtesy of IdaTech

47

US Fuel Cell Council

24 x 7 Reliable Large Industrial Scale Fuel Cell Power

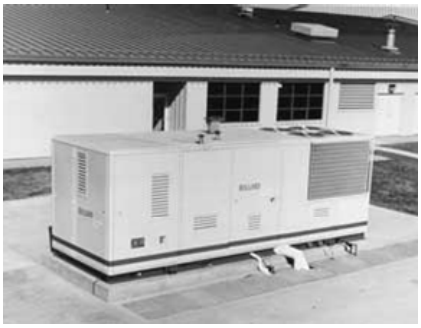
Sierra Nevada Brewery
Chico, California
Courtesy of FuelCell Energy

- 1MW (250kW x 4) Net Output
- Runs on a blend of digester gas and natural gas
- Connected in parallel with electric grid
- Provides 95% of the electrical requirements for the brewery
- Heat recovery provides about 65% of the hot water/steam requirements

48

Ballard Generation Systems

- 250 Kw fuel cell



US Fuel Cell Council

Micro / Portable Applications

Angstrom Power Cell Phones
Courtesy of Angstrom Power

Jadoo Power System
Courtesy of Jadoo Power

50

Container Safety

51

Hydrogen: The Matter of Safety

54

Hydrogen Properties

US Fuel Cell Council

Some Hydrogen properties present a challenge:

- Easily ignited
- Wide flammability and explosive ranges
- Permeable through many materials
- Hydrogen can cause embrittlement of some metals.
- Some polymers are not compatible with hydrogen.
- *Low energy content (by volume)*
- *Low emissivity ("almost invisible flame" and low radiant heat transfer)*

55

Hydrogen Properties

US Fuel Cell Council

Some Hydrogen properties make it easier to work with:

- *Low energy content (by volume)*
- *Low emissivity (low radiant heat transfer)*
- Highly diffusible (disperses quickly)
- Very buoyant
- Easily managed by ventilation

56

Hydrogen Properties

US Fuel Cell Council

One of the uses of hydrogen is as a fuel gas.

As with other fuel gases, *it is to be respected but not feared!*

Hydrogen is similar to but not identical with other fuel gases.

DOE maintains a source of hydrogen incident data at www.h2incidents.org .

Hydrogen Safety updates and information can be found at www.hydrogensafety.info .

The next few slides compare hydrogen to other common fuel gases.

57

Conversions — Units of Pressure

Unit	Accurately Multiply By	Roughly Multiply By	To Get
Standard to Standard			
psi	0.068 046	0.07	atm
psi	2.04	2	in Hg
Standard to Metric			
psi	6.894 757	7	kPa
psi	0.068 948	0.07	bar
atm	1.013 25	1	bar
Metric to Standard			
kPa	0.145 038	0.15	psi
bar	14.503 77	15	psi
Metric to Metric			
bar	1000		millibar
bar	100		kPa
kPa	1000		Pa
MPa	1000		kPa

58

59

Hydrogen Properties

US Fuel Cell Council

Sources for information on hydrogen properties used in slides:

- Bulletin 503, US Bureau of Mines, Limits of Flammability of Gases and Vapor; Coward and Jones 1952
- Bulletin 627, US Bureau of Mines, Flammability Characteristics of Combustible of Gases and Vapor; Zabetakis,1965
- CGA G-5, Hydrogen, 6th Edition, 2005
- Engineering Manual, 2nd Edition; Robert. H. Perry, 1967
- NFPA 497, Recommended Practice for the Classification of Flammable Liquids, Gases or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas; 1997
- NASA NSS 1740.16, Safety Standard for Hydrogen and Hydrogen Systems

60

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Permitting Hydrogen Fueling Stations

and the use of

Stationary Hydrogen Fuel Cells as Back-up Power for Telecommunications Antenna Sites Workshop

Teaneck, NJ
May 15 & 16, 2008

Davidson Code Concepts, LLC
&
The DiCristina Group

National Association of State Fire Marshals

Plan Review

3 Teams

4 scenarios

Resources provided…

2

Resources provided each team…

- International Code Council I-Codes
  - International Building Code
  - International Fire Code
  - International Fuel Gas Code
  - International Mechanical Code
- National Fire Protection Association
  - NFPA 54 ANSI Z223.1-2006 National Fuel Gas Code
  - NFPA 55 Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks 2006 edition
  - NFPA 853-2003 Standard for Stationary Hydrogen Fuel Cells
  - NFPA 70 National Electric Code
- Set of 4 Site Layout Plans
- Note Pad Easel, Review Report Forms, Evaluation Forms, and Scales

3

Questions to address

- **Which codes and standards did you apply during your review and why were they applied?**
- **What codes or standards were needed but not supplied?**
- **What items shown on the plan were determined to be acceptable?**
- **What items shown on the plans were <u>not</u> found to be acceptable?**
- **What items or information, if any, was not provided on or with the plan and is needed to complete your review?**

4

Tomorrow

- When the plan review portion is completed everyone will return to this room and the team leaders will present their assignment reviews.
- General discussion will then occur.

5

Teams

Select a Team Leader

The team leader will lead the discussion and will give an oral report of the results of the team review at the end of the workshop.

6

Team 1

- Tamara Sakian
- Chris Afuwa
- Craig Lucas
- Brain Grant
- George Selah
- David Peach
- Thomas Kelly

7

Team 2

- Shaji Joseph
- Salvatore Garafalo
- John Palcher
- Michael Whalen
- Raymond R Meyer
- George M Roberts
- Tim Fisher

8

Team 3

- David Kahn
- Leonard Splain
- Theodore Horishny
- Michael E Razzoli
- Steven M Gluck
- Joseph Rischak
- William Pfeiffer

9

Breakout Session

10

Breakout Session Reporting

APPENDIX F

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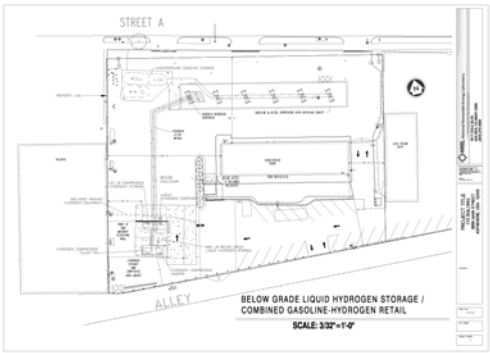
National Association of State Fire Marshals

Plan 1 Review

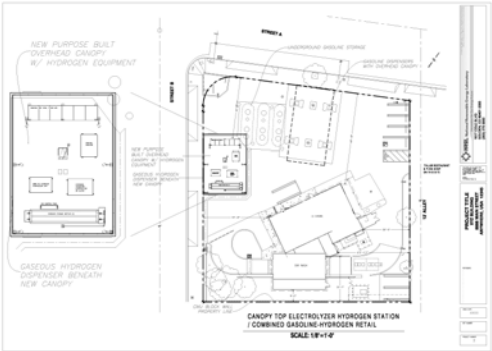
2



3

Plan 2 Review

4



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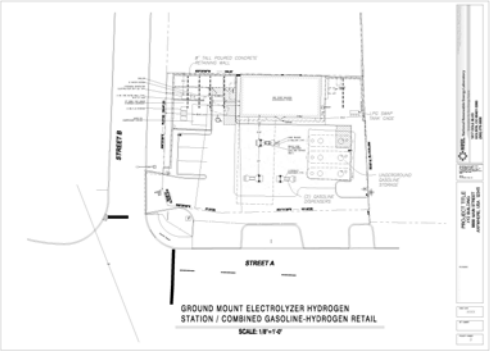
Plan 3 Review

6



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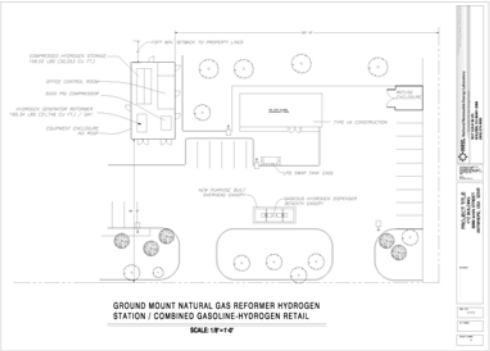
Plan 4 Review

8



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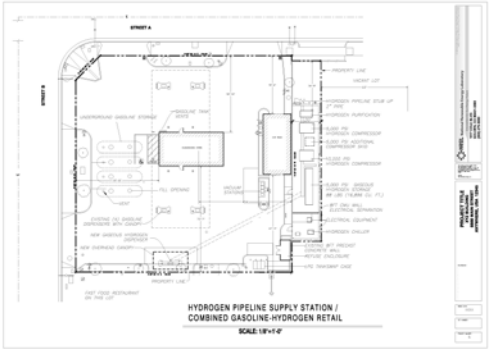
Plan 5 Review

10



11

The Review Process Used

12

Hydrogen Jack Video

http://www.youtube.com/watch?v=YT5uE5XfNA8

13

Fuel Cell Fire Service Vehicle Video

http://www.youtube.com/watch?v=yHVCpAVMJd0

14

Questions?

15

Thank-you for your attention and participation

16

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17

The DiCristina Group
Construction Code Consultants
108 Kino Boulevard
Hamilton, New Jersey 08619
(609) 890-4256
Sal@CodeSolutions-Inc.com

18

I-Code Pathway

APPENDIX G

Stationary Hydrogen Fuel Cell/Motor Fuel Installation
Outdoor Hydrogen Storage
Rev.2
2006 I-Codes Application Matrix

Code language applied as primary requirements. Referenced standards applied after primary code language.

Plan Review Application

Go to IMC & IFGC (page 2)

406.0 Motor-Vehicle Related Occupancies
If at a hydrogen motor fueling facility.

414.4 Hazardous Material systems

414.1.1 Materials Points to 307, 415, IFC & IMC

Chapter 4
Special Detailed Requirements Based on Use & Occupancy

414.2 Control Areas Points to IFC (See IFC 2203.12)

414.6 Outdoor Storage, Dispensing or use Points to IFC

If fuel cell inside (not fuel supply) - Not an H Group
307.1 Exception 5 applies
Closed piping, operation of machinery/equipment

Chapter 3
Use & Occupancy Classification

307.1.1 Hazardous Materials Points to 414.0 and IFC for Hazardous materials in any quantity

2006 IBC

Chapter 22 Motor Fuel-Dispensing
If at a hydrogen motor fueling facility.
Section 2209.0
(Systems with 3000 scf or less of Hydrogen gas exemption at 2209.3.1 as to location on property)

Chapter 32 Cryogenic Fluids
If present in this form.
Includes containers, foundations & supports Relief devices, marking, security, wiring, Piping, ventilation & underground tanks.

Chapter 35 Flammable Gases
Includes distances to exposures, Ignition control & wiring. Plus a reference to NFPA 55

Chapter 30 Compressed Gases
Includes relief devices, marking, Security & vaults.

Chapter 27 Hazardous Materials
Includes systems, equipment, processes, Piping, containers, sources of Ignition and security, and Outdoor Control Areas.

2006 IFC

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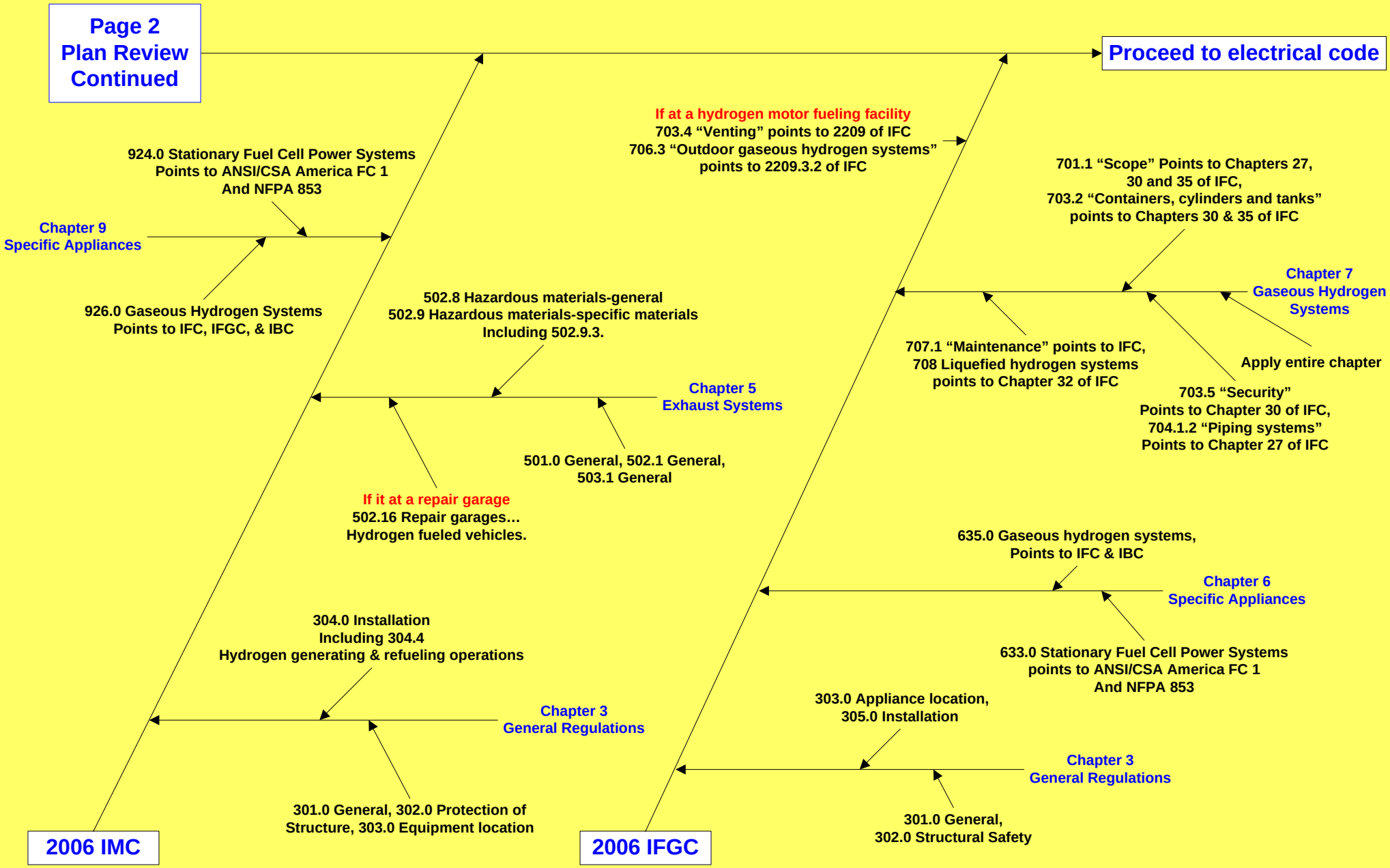
Stationary Hydrogen Fuel Cell/Motor Fuel Installation
Outdoor Hydrogen Storage
Rev.2
2006 I-Codes Application Matrix



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Review Report Form

APPENDIX H

A national laboratory of the U.S. Department of Energy
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NREL National Renewable Energy Laboratory

Innovation for Our Energy Future

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Permitting Hydrogen Fueling Stations

and the use of

Stationary Hydrogen Fuel Cells as Back-up Power for Telecommunications Antenna Sites Workshop

May 15 & 16 2008

Team Plan Review Reporting Form

Team #: _____ Plan #: _____

Which codes and standards did you apply during your review and why were they applied?

_____

_____

_____

_____

_____

_____

_____

What codes or standards were needed but not supplied?
(Explain why they were needed.)

_____

_____

_____

What items shown on the plan were determined to be acceptable?
(List code sections referenced)

What items shown on the plans were not found to be acceptable?
(*List code sections referenced*)

What items or information, if any, was not provided on or with the plan and is needed to complete your review?
(List code sections referenced)

Individual Evaluation Form

APPENDIX I

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Permitting Hydrogen Fueling Stations

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May 15 & 16, 2008

Evaluation Form

Rating: 1 being the lowest, 5 being the highest

The workshop was what you expected?

❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

Participation in the workshop increased your comfort level should you have to review an application for a hydrogen fueling station?

❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

The workshop increased your understanding of how to apply the various codes and standards when reviewing a hydrogen fueling station?

❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

Would you recommend that your peers attend a similar workshop?

❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

What did you like about the workshop?

_____

_____

_____

_____

What didn't you like about the workshop?

_____

_____

_____

_____

What improvements, if any, would you recommend to the workshop?

_____

_____

_____

_____

What target audience do you believe should be included in a future workshops?

_____

_____

If a similar workshop was offered in your state, would you be willing to assist as a facilitator?

❑ Yes ❑ No

Optional

Name: _____

Phone #: _____

Evaluation Results

APPENDIX J

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Permitting Hydrogen Fueling Stations

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May 15 & 16, 2008

Evaluation Form

Rating: 1 being the lowest, 5 being the highest

The workshop was what you expected?

1	2	3	4	5
		15%	40%	45%

Participation in the workshop increased your comfort level should you have to review an application for a hydrogen fueling station?

1	2	3	4	5
		15%	30%	55%

The workshop increased your understanding of how to apply the various codes and standards when reviewing a hydrogen fueling station?

1	2	3	4	5
		10%	40%	50%

Would you recommend that your peers attend a similar workshop?

1	2	3	4	5
		10%	20%	70%

What did you like about the workshop?

- The references to all applicable codes.
- Included the basics of hydrogen and fuel cells; included industry professionals; and addressed misconceptions of hydrogen.
- Instructors knowledge of topic; very good presentation.
- I liked the working sessions, we were able to express our opinions and discuss them with representatives of different jurisdictions.
- Very interesting, timely subject matter.
- It was very educational to hear all of the review comments from the various code officials.
- The varied background of the instructors.
- The multiple instructors on the different aspects of hydrogen and group work.
- Working lunch; breakout groups; materials provided; professionals attending from various levels of code enforcement; the speakers; accommodations & food.
- Very informative about the use and understanding of hydrogen.
- The information provided about the fuel cells; the review process; safety; DOE participation.
- The back and forth discussions.
- Introduction to new concept; new codes and involvement of building, fire & other authorities to formulate a common (at least) standard.
- It's continuity and having all interested parties commenting.
- The format was good.
- Provided great information about fuel cells and clarified the timeline for hydrogen auto fueling infrastructure and cell sites.
- It was very instructive for learning about codes & standards, issues and needs.

What didn't you like about the workshop?

- Didn't supply enough materials such as copies of the CGA regulation and referenced standards.
- Industry professionals could have been more involved in breakout sessions.
- Subject matter requires a more intense study into application of codes.
- Need more breaks.
- Presenters seemed reluctant to challenge opinions of some in audience (NYC). This seemed to create a feeling that the presenters were not confident with some responses.

- The lack of detail on the breakout drawings.
- The workshop should indicate some dangers associated with hydrogen & fuel cells, nothing is perfect.
- Didn't discuss bad H2 'incidents' except for 'Hindenburg'.
- The breakout sessions were too long, this could be a one day workshop. Each team could work/focus on a different project.
- I wasn't knowledgeable enough to contribute to any breakout, but tried to use the time productively.

What improvements, if any, would you recommend to the workshop?

- Should review the code sections of the I-Codes before the breakouts.
- Maybe cover the use of fuel cells for co-generation, they are widely used in NYC.
- After initial exposure to concept a more in depth study of code issues for each discipline would benefit individual code officials.
- Add additional information into the plan review packages including equipment cut sheets.
- More concentrated code specifics with relation to hydrogen installations; better clarification of fire protection system requirements.
- Smaller breakout groups, it was hard for everyone to see plans on table provided at the same time.
- Each jurisdiction should explain their permit process; the planning department will create most delays; local civic leaders need to be involved from the beginning.
- Would like to see the actual equipment such as a fuel cell.
- Improve the information provided during the breakout sessions.
- Add more documentation for plan review sessions on fuel cell sites.
- More discussion of "bad stuff".
- Drop down to two scenarios, four is a little much when dealing with a new concept.
- Include a plan review with an installation correctly shown on the plan and give the appropriate codes.
- In the video presentation with the two vehicles burning there was a lot of discussion on the burning of the gasoline, I suspect that this was done to indicate that the hydrogen fueled vehicle was safer than a vehicle with an accepted fuel (gasoline). I think a comparison to LPG or CNG (which is also accepted now) would be a better comparison.
- A better integration of hydrogen and gasoline fueling operations into the review process.

- Code officials of the same discipline should review together and then split into mixed groups.
- Based upon the fact that this is a new area effort should be made to evaluate a simple hydrogen plan examination with the audience participation.
- Have all attendees introduce themselves at the beginning of the workshop; provide an attendee list/affiliation/email at the workshop itself; start 1st day earlier; print size in handouts could be larger.

What target audience do you believe should be included in a future workshops?

- Engineers and Architects.
- Planning and zoning officials.
- All code officials.
- Design professionals.
- Community leaders.
- Fire Marshals
- Politicians
- Mechanical and electrical engineers.
- You have the right target; Put emphasis on getting larger attendance.

If a similar workshop was offered in your state, would you be willing to assist as a facilitator?

❑ Yes

George Selah
Salvatore Garafalo
William Pfeiffer
Craig Lucas
John Palcher
Rob Schroeder
Steven Gluck
Chris Daetwyler