

**APPLYING LOCAL BUILDING AND FIRE  
SAFETY CODES TO HYDROGEN  
TECHNOLOGY APPLICATIONS  
IN NEW YORK STATE**

**FINAL REPORT 06-18  
DECEMBER 2006**

**NEW YORK STATE  
ENERGY RESEARCH AND  
DEVELOPMENT AUTHORITY**





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- Conducting a multifaceted energy and environmental research and development program to meet New York State's diverse economic needs.
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- Helping industries, schools, hospitals, municipalities, not-for-profits, and the residential sector, including low-income residents, implement energy-efficiency measures.
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Prepared for the  
**NEW YORK STATE  
ENERGY RESEARCH AND  
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## **Section 1 – Executive Summary**

Local building and fire safety codes will play a key role in the safe installation of new hydrogen fueled technologies. This study examines how existing building and fire safety codes in New York State apply to hydrogen-fueled technologies, focusing on two key hydrogen applications: stationary fuel cells and hydrogen fueling stations.

Ideally, building and fire safety codes will provide the tools local government needs to ensure that hydrogen technologies will be built properly, safely achieving their energy delivery purpose. Because hydrogen fuel cells and hydrogen fueling stations are relatively new applications, there is a need to assess whether the existing system of building and fire safety codes is equipped to effectively deal with these new technologies.

Plans for economically meeting New York State’s long-term energy needs, and for protecting the State’s environment, place great importance on developing the full potential of hydrogen as an energy carrier. In October 2005, the New York State Energy Research and Development Authority (NYSERDA) published the New York State Hydrogen Energy Roadmap (Roadmap), which sets forth goals for making New York State a leader nationwide in the move away from fossil fuel dependency toward a hydrogen-based economy. The Roadmap examined strategies and immediate work priorities for accomplishing this goal. This Roadmap recognizes the potential importance of local building and fire safety codes in deploying new hydrogen technologies. The Roadmap also acknowledges the importance of ensuring that the local code regulation works well to both protect public safety and allow the construction of new hydrogen facilities without unnecessary delays and financial burdens.

This study investigates the steps being taken by New York’s state and local governments to adapt building and fire safety codes to address specific hydrogen technologies, the hydrogen fuel cell powered distributed generation and hydrogen fueling stations for vehicles. The study focuses on these two areas because they represent the major new applications for hydrogen technology that local code officials are likely to encounter in project proposals during the next few years. Greater deployment of hydrogen for on-site power needs and infrastructure development for hydrogen-based transportation alternatives also represent two important steps toward the long-term goal of switching from carbon-based fossil fuels to a hydrogen economy.

Hydrogen can pose certain safety hazards if improperly managed. Properly managing these risks, and ultimately gaining the public acceptance of hydrogen fuel cell and fueling station facilities, will require the effective development and enforcement of local building and fire safety codes. At the same time, if codes are excessively conservative, the administration of these codes can pose a major barrier to siting of hydrogen facilities in the State.

The insurance industry's *COSPE* framework<sup>1</sup> provides a convenient way to view the risks hydrogen technology applications may pose. For the two applications being considered in this study, the following identifies the major code issues for hydrogen using the *COSPE* framework.

**C = Construction**

Construction of any building is important in terms of its fire rating. Because hydrogen is lighter than air, it is desirable to avoid any pocketing of hydrogen in roof areas. Accordingly, the design of roofs and cabinet enclosures is important. Sufficient natural and/or mechanical ventilation are a primary concern.

Materials used for piping, valve, welds, etc. must be suitable for hydrogen. Properly designed electrical systems are required to avoid possible ignition sources.

**O = Occupancy**

For most DG sites, the fuel cell power plant is unmanned and remotely monitored. When abnormalities materialize, the system typically shuts itself down safely or adjustments are made through the control systems. If the incident requires one, a maintenance service call is made to correct the situation. In general, therefore, personnel are not directly exposed to any risks from the use of hydrogen.

Hydrogen fueling stations, by the very nature of their intended operation, expose people to hydrogen risks. This element of public interface distinguishes hydrogen fueling stations from hydrogen storage and distribution applications that are “inside the fence” at commercial and industrial hydrogen storage facilities, where the people exposed to facility risks are under the direct control of hydrogen gas suppliers and traditional industrial users. Trained personnel are needed on site all of the time, 24 hours a day, seven days a week.

**S = Special Hazards**

The special hazards associated with hydrogen involve the potential for fires and explosions under certain adverse conditions.

For the refueling station application, the hydrogen storage infrastructure represents a major hazard because of the quantity of energy stored, possible vulnerability to weather events, and deliberate efforts to damage or destroy the facility, such as terrorism and sabotage.

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<sup>1</sup> COPSE is an acronym representing the terms:

- Construction
- Occupancy
- Special Hazards
- Protection
- Exposure

See Section 4.2.4 Practical Use of Codes and Standards [infra](#) for further explanation

The fact that a hydrogen flame is invisible makes it difficult to detect without an ultra-violet (UV) scan device. It is, therefore, difficult to warn people of its presence. Leaks during the refueling process – dispensed to vehicles – could have effects not visible to the naked eye, and, therefore, they are not detectable without special equipment.

Because hydrogen has a low energy density, it typically is pressurized in storage facilities and vehicles carrying hydrogen fuel. The operating pressures to fill a vehicle with hydrogen are typically in excess of 3000 psig and as high as 5000 psig. These high storage pressures represent another hazard. These high pressures may also affect the compressor design and operations because such pressures increase the potential for compressor leaks.

Fuel cells for DG facilities operate at much lower pressures (50 psig to 200 psig) because the hydrogen fuel typically is produced on site (i.e., by electrolysis or a hydrogen reformer).

#### ***P*** = Protection

Various codes recommend various protection schemes. For example, both the International Code Council (ICC) and National Fire Protection Association (NFPA) have tables that recommend separation distances from the hydrogen source to various objects based upon hydrogen quantities. There are a litany of other devices and design features such as adequate ventilation, hydrogen sensors / detectors, and fire suppression system. Proper training of operating and maintenance personnel is also essential as is a comprehensive emergency plan that is kept current.

#### ***E*** = Exposures

The principal exposure is public safety and welfare. Codes and standards are concerned about those who may be directly involved at the site but also those who may become involved as a consequence of an accidental release of a hydrogen cloud or suffer consequential damages from a fire or explosion. Because hydrogen is often stored and transported at very low temperatures, in a liquid state, the risks of exposure to hydrogen also include severe frostbite.

Although there are risk factors attributed to the physical and chemical characteristics that make hydrogen unique, they are essentially controllable with proper awareness and design. The purposes of the codes and standards are to define the guidelines for proper design, operations, and maintenance.

This study examines:

- how existing building and fire safety codes address hydrogen fuel cell and hydrogen fueling station technologies
- how these codes are evolving to address these new technologies
- how building and fire safety codes are administered in New York State
- what steps are needed to ensure that building and fire safety codes will continue to function well as changes in hydrogen technologies take place

In addressing each of these points, the report provides an overview of how in New York State Building and Fire Safety Codes and the administration of these codes relates to hydrogen technologies. The report then recommends steps to remove potential roadblocks to project implementation and public acceptance that may be posed by these codes.

Several important facts emerge from this assessment:

- Under New York State law, all municipalities, with the exception of New York City, are required to adopt State building and fire codes; New York City is authorized to develop its own set of codes.
- New York State and the City of New York have undertaken the work required to replace their building and fire codes with new codes based on the model codes of the ICC. These are important actions that will, in the long run, ensure that local codes in New York State remain in sync with global efforts to revise codes to keep up with technical progress and new hydrogen safety research findings. This will enable New York State and New York City to leverage the considerable technical expertise and consensus building work being committed by the ICC to building these model codes.
  - New York State will soon complete the changes necessary to implement a new building and fire safety code based on the International Code Council model code framework.
  - New York City has made significant progress with changing its building code but has made much less progress with changing its fire safety code to incorporate the International Code Council model codes.
- The New York City fire safety code does not yet offer a code framework for the safe installation of hydrogen fueling stations within New York City.
- Because the enforcement of building and fire safety codes involves thousands of local government officials, training, is and will remain, a major requirement of plans to ensure that New York's building and fire safety codes function effectively to ensure the safe installation of hydrogen facilities.

Building on these findings, the report offers three major recommendations:

- New York State should continue to support the transition to the ICC model code framework throughout New York State.
- New York City should organize a hydrogen codes and standards initiative that will draw upon the Fire Department and the Buildings Department of the City.
- The New York State Energy Research and Development Authority (NYSERDA) in collaboration with the New York State Department of State should develop and implement a continuing hydrogen technology training program for code officials throughout New York State, including New York City.

The report identifies several important steps that New York State and New York City should take to implement these recommendations:

- Maintain active involvement with the national codes and standards working groups that are addressing the relationship of model codes and standards to emerging hydrogen technologies.
- Endorse the commitment of the New York State Building Codes Council and the Council of the City of New York to complete and implement the transformation of New York State and New York City building and fire safety codes to a codes structure based on the ICC model codes in each case.
- Develop a permanent hydrogen safety education program for public officials. Expand existing code official training programs managed by the New York State Department of State to provide initial, and later continuing, education of public officials on hydrogen technology. This training should target code enforcement officers and other public officials who will be called on to evaluate and approve new hydrogen technologies in communities throughout New York State. This is a need that will increase as deployment of hydrogen technology accelerates in sync with milestone objectives of the New York State Hydrogen Energy Roadmap.
- For the benefit of developers of hydrogen fuel cell projects to be located in New York City, communicate clearly the code enforcement process and the specific requirements applicable to these facilities.
- Place a priority on developing fire safety code permit criteria that will allow the safe installation of hydrogen fueling station facilities in New York City. The New York City fire safety code governs the installation of hydrogen refueling stations but does not explicitly identify the permit criteria against which such facilities will be evaluated. The absence of permit criteria effectively prevents the location of hydrogen fueling stations in New York City.

## **Section 2 – Introduction**

Hydrogen is emerging as a potential energy resource to power our economy at a time when concerns about the climate change effects of fossil fuel combustion and the economic implications of dependence on foreign oil supplies are increasing. The federal government has placed a high priority on, and indicated a long-term commitment to, developing hydrogen as a major new fuel source for our economy. New York State energy policy is aimed at taking advantage of this major new fuel source and capturing the full potential hydrogen may offer to strengthen the New York State economy and protect its environment.

A recently completed New York State Hydrogen Energy Roadmap has examined the potential of hydrogen and proposed a strategy for capturing this potential:

New York State has the potential to assume a leadership role in the national and global transition to a hydrogen energy economy. Significant benefits would result from achieving this role: a cleaner environment and an increase in high-tech businesses and high-paying jobs.

The goal is for hydrogen to serve as a fuel in the transportation and stationary power markets in New York. By serving as an energy carrier from clean sources of energy, hydrogen will displace polluting, often-imported energy sources. The hydrogen energy infrastructure will be well-integrated into regional systems and will complement various energy sources and other energy carriers.

To achieve this, there will need to be a well-coordinated, integrated statewide effort that includes the establishment of a business and regulatory climate that attracts public and private investment in hydrogen energy.<sup>2</sup>

This Roadmap identifies developing uniform codes and standard as among the key steps required to achieve the leadership in hydrogen development and deployment New York seeks.<sup>3</sup>

### **Section 2.1 -- Project Objectives**

This project addresses how local building and fire safety regulation will apply to key components of the hydrogen energy infrastructure in New York State.

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<sup>2</sup> page iii. New York State Hydrogen Energy Roadmap. New York State Energy Research and Development Authority Report No. 05-10. October 2005.

<sup>3</sup> Ibid. p .9

The recently completed New York State Hydrogen Energy Roadmap calls for “a well-coordinated, integrated, statewide effort that includes the establishment of a business and regulatory climate that attracts public and private investment in hydrogen energy.”<sup>4</sup> This project takes an important step forward on this path.

This report examines the impact of New York's building and fire safety codes and standards on two important hydrogen technology applications. These codes are in place in New York State to protect citizens, workers, and emergency personnel called upon to respond to fires and other public safety threats and incidents. The two important hydrogen technologies this report focuses on are (1) hydrogen fueled stationary fuel cells for distributed generation, and (2) hydrogen fueling stations for transportation technology. These applications were selected because they represent major new applications for hydrogen technology that local code officials are likely to encounter in project proposals.

The primary goals of this project are:

1. to describe how building and fire safety code regulation will apply to these two promising hydrogen energy applications;
2. to identify existing and prospective barriers to the accelerated deployment of these new hydrogen economy technologies;
3. to recommend policies and programs to address these barriers; and
4. in the short-term, to provide hydrogen project developers with guidance on how to navigate existing code compliance processes in New York State.

Although literally billions of cubic feet of hydrogen are consumed globally each year by industry in so-called “behind-the-fence” applications, such as in refineries, the use of hydrogen in a more public domain is a recent development. These “new” applications primarily involve the use of fuel cell technology, which has been available since before the space program, but has only recently seen significant technology advancements.

Despite the public’s common misperceptions of equating hydrogen with exploding blimps (Hindenburg) and bombs (the H-Bomb), hydrogen can be safely used. However, its particular physical characteristics warrant proper attention.

“Codes and Standards” are, fundamentally, the means to ensure equipment and processes are properly designed and operated to assure the public’s safety. Just as the newer technologies associated with hydrogen are evolving, so are the codes and standards. The very difficult challenge is keeping codes and standards up to date and in sync with progress in new hydrogen technology deployment. How a jurisdiction responds to that challenge will dictate how hydrogen friendly it is for promoting the emerging hydrogen economy.

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<sup>4</sup> Page i. New York State Hydrogen Energy Roadmap. New York State Energy Research and Development Authority Report No. 05-10. October 2005

The distinction between a “code” and a “standard” should be noted. Model building codes are guidelines for the design of the built environment (i.e., buildings and facilities). When model codes are adopted by state and local jurisdictions, they achieve the force of law. Codes often incorporate standards for the equipment used within the built environment. Standards are rules, guidelines, conditions, or characteristics for products or related processes and generally apply to equipment or components. Standards have no regulatory standing unless they are referred to in codes adopted by state and local jurisdictions or when incorporated in government regulations.

This distinction is important when sorting through the specific requirements to be imposed on specific projects that are in deliberations with code enforcement officials.

## **Section 2.2 -- Why does hydrogen pose health and safety concerns?**

Although hydrogen has been used in industrial applications for some time, it is not widely used and not yet widely deployed for residential, commercial building, and transportation system uses. Hydrogen poses some unique issues in assuring its safe use as an energy carrier in the still-developing applications of fuel cell and hydrogen combustion engines and others, which are technically similar to issues raised by other fuels.

The U.S Department of Energy Hydrogen, Fuel Cells, & Infrastructure Technologies Program’s Multiyear Program Plan for Hydrogen Codes and Standards offers an observation that sets this in perspective:

Like all fuels, hydrogen can be handled and used safely with appropriate sensing, handling, and engineering measures. Hydrogen is a potentially dangerous substance because its low-volumetric energy density requires high pressure and liquid storage to provide the same customer qualities, such as vehicle range and power density. However, its risk level as a fuel at atmospheric pressure is similar to that of fuels such as natural gas and propane. Hydrogen has unique properties because of its size and buoyancy.<sup>5</sup>

Depending on its state, hydrogen is similar in many ways to several gaseous and liquid fuels that are widely adopted and safely used. Building and fire safety codes already address and have extensive experience with natural and compressed gas, gasoline, and other flammable liquids. The following Table 1 identifies some of the key parameters that differentiate hydrogen from other fuels such as natural gas, propane, and gasoline.

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<sup>5</sup> page 3-133. US Department of Energy, Energy Efficiency and Renewable Energy. Hydrogen, Fuel Cells & Infrastructure Technologies Program: Multi-Year Research, Development and Demonstration Plan. Planned program activities for 2003-2010. FOE/GO-102 003-1741. January 2005

Table 1. Comparison of Hydrogen Properties With Other Gases

Gas	Hydrogen	Natural Gas	Propane	Gasoline Vapor
<b>Buoyancy (Density Relative to Air)</b>	0.07	0.55	1.52	3.0
<b>Molecular Weight</b>	2	16	44	107
<b>Density (kg / m<sup>3</sup>) at NTP</b>	0.084	0.651	1.87	4.4
<b>Auto-ignition Temperature ( °F)</b>	918 - 1018	960-1170	842	50
<b>Diffusion Coefficient in still air at NTP (cm<sup>2</sup>/s) (see note below)</b>	0.61	0.16	0.12	0.05
<b>Theoretical Explosive Energy (kg TNT/cubic meter of gas volume)</b>	2	7	18	44
<b>Flammability Range (% by volume in air)</b>	4 to 75	5 to 17	2 to 10	1 to 8
<b>Detonation Range (% by volume)</b>	18 to 59	6 to 14	3 to 7	1 to 3
<b>Minimum Ignition Energy (mJ)</b>	0.02	0.29	0.26	0.24
<b>Maximum Burning Velocity in Air (cm /s)</b>	346	43	47	42

Note: NTP = Normal Temperature & Pressure (70° F/21°C and 14.7 psia absolute pressure of 101 kPa )

**Sources:**

[1] Fire Protection Guide to Hazardous Materials –13<sup>th</sup> Edition, NFPA

[2] Avoiding Static Ignition Hazards in Chemical Operations – L.G. Britton, American Institute of Chemical Engineers, 1999

[3] Safety Standard for Hydrogen and Hydrogen Systems, NSS 1740.16, National Aeronautics and Space Administration, 1997

[4] Bureau of Mines, Bulletin 680, page 35 (Hydrogen’s auto-ignition temperature range in 200cc vessel)

[5] Stuart Energy Systems, G. Howard, “Comparison of Gaseous Hydrogen Properties with Natural Gas”, February 2004

Several key safety issues emerge from Table 1:

1. Hydrogen’s flammability range is significantly broader than for the other fuels. This makes hydrogen easier to ignite over a much wider range of concentrations in a given space.

2. All the other fuels have a greater density compared to air than hydrogen. This allows hydrogen to be quickly dispersed in the air and reduces the explosive potential.
3. Contrary to public perceptions, the explosive energy of hydrogen is about a third of that of natural gas, one tenth of propane, and 5% of gasoline. For the same volumetric quantity, gasoline has over 20 times more energy release than hydrogen.
4. Hydrogen's minimum ignition energy, which is approximately a tenth of that for the other comparative fuels at stoichiometric mixtures, but at the minimum flammability limit, is about the same as natural gas. Furthermore, static electricity from a human body will produce about 10mJ of energy and contains enough energy to ignite any of the fuels included in Table 1.
5. Hydrogen flame speed is ten times faster than that for the other fuels, which makes detection more difficult.
6. Compared to gasoline's 50<sup>0</sup>F auto-ignition temperature where no flame or spark is needed to self-ignite the vapors, hydrogen requires 918<sup>0</sup>F or a temperature 18 times higher to self-ignite. This adds to the safer handling of hydrogen when a fuel leak is present.

Once hydrogen's unique chemical properties are understood, they can be safely addressed for its intended application in stationary power and transportation modes. As explained later, in Section 3, considerable research, development, and demonstration activity is underway in the United States and in other countries to understand the risks and the most effective ways to manage those risks. The US DOE Hydrogen Program Plan, cited earlier, states its commitment:

The aim of this program element activity is to verify the physical and chemical properties of hydrogen, outline the factors that must be considered to minimize the safety hazards related to the use of hydrogen as a fuel, and provide a comprehensive database on hydrogen and hydrogen safety.<sup>6</sup>

The challenge to building and fire safety codes is to make sure that they address the risks posed by hydrogen facilities, providing for public safety while also providing the guidance to project developers needed to allow the safe deployment of these potentially beneficial hydrogen applications at the minimally necessary incremental cost.

### **Why building and fire safety codes are important to the development of the hydrogen economy?**

Compliance with building and fire safety codes is a necessary and important part of developing new hydrogen fuel based projects in New York State. The codes guide project developers by defining the minimum design features needed to adequately ensure a successful project and protect their personnel and the public at large, while, at the same time, providing the public with assurance that new installations will be safe additions to the community.

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<sup>6</sup> Ibid.

Codes function most effectively for established, widely deployed technologies because the risks of these technologies are widely understood, and the methods of managing those risks also are well understood. In such cases, the code compliance process can be predictable and fairly easy to navigate. Communities can administer codes routinely, and developers can develop their project with confidence that code compliance can be achieved quickly and predictably, if the projects meet clearly prescribed design requirements.

In the case of new technology, the existing building and fire safety codes may not address such new technology, specifically. In such cases, a code administrator often uses existing performance standards that apply safety principles and concepts to some of the specific characteristics of the new technology. Such use of requirements not specific to the technology tends to increase the time and cost of demonstrating compliance with codes and obtaining the necessary certifications required by law to permit a project to be constructed. Such project specific reviews also burden the often very busy local code inspectors.

The effective administration of codes and standards will protect the public from exposure to hazards resulting from unsafe applications of hydrogen technology and will help project developers by communicating clearly what will be required to meet regulatory requirements. The long term goal of increased use of hydrogen technology to meet our energy needs is also served by preventing public relations setbacks caused by accidents resulting from poorly installed hydrogen facilities.

Existing codes and standards may act as a barrier to the development of key sectors of the hydrogen economy if they do not relate well to hydrogen technology characteristics. Just as importantly, the absence of codes can have a material effect on market development. Without proper guidelines, local code officials will discharge their responsibility to protect the public by assessing hydrogen technologies in the most conservative and risk-averse manner. While this protects the health and welfare of the public, it does not necessarily serve the commercialization interests of new hydrogen technologies. Moreover, the lack of accepted safety standards requires the code official to undertake costly and time-consuming case-by-case review. In addition, decisions will tend to be inconsistent across regulatory jurisdictions. Consequently, barriers that exist in outdated code systems can and will impede development of new industries and construction activity related to these industries throughout the State. New York may be placed at a competitive disadvantage relative to states that act swiftly to amend and update their building and fire codes in an aggressive effort to accommodate and support the growth of the hydrogen economy while preserving safety.

Hydrogen fueled technologies are relatively new, and accordingly, there is relatively little operating experience with many aspects of these technologies. There can be widely divergent views on the scale and characteristics of the risks hydrogen facilities pose to public safety. Fortunately, a great deal of study and testing is underway to define the risks and to define the appropriate design standards needed to protect the public.

## Project Approach

The Project team investigated how national and international work on developing and deploying hydrogen technology is addressing the need for that new technology to comply with local codes and standards. The project team investigated how codes and standards in New York State would apply to hydrogen technology and looked for lessons in the experience so far with developing and constructing new hydrogen projects in New York State. The project team tapped the knowledge and experience of code experts in New York State government, local government, public authorities, the federal government, and national organizations.

Key personnel at the New York State Department of State Division of Code Enforcement and Administration, the New York City Department of Buildings, and the National Renewable Energy Laboratory have been instrumental in providing information and advice to the project study team. The following individuals served as technical advisors for this project, and provided information about their agencies' operations and comments on the draft report:

- Michael P. Burnetter, P.E., Senior Mechanical Engineer, Energy Services Unit, the Division of Codes Enforcement and Administration, New York Department of State, Albany, New York
- James Hansen, Director of Code Revision, New York City Fire Department. New York, New York
- Sam Marcovici, MS, Senior Electrical Engineer, Code Development and Implementation Unit, New York City Department of Buildings, New York, New York.
- James M. Ohi, PhD., Senior Projects Leader, Hydrogen Technologies and Systems, National Renewable Energy Laboratory, Golden, Colorado (principal contact with federal programs)

### **Section 2.3 -- What hydrogen energy technologies must codes address?**

Two hydrogen energy technologies are the focus of current efforts to expand the role of hydrogen in meeting New York's energy needs. These two technologies are the centerpieces of efforts to use hydrogen for power/stationary applications and for hydrogen refueling for passenger, bus, and truck vehicles.

In the case of both the stationary fuel cell and the hydrogen refueling station, the facilities include components that are common to many existing commercial and residential facilities and components that are not strictly related to hydrogen delivery and storage. The common technology components offer no particular challenge and may be dealt with using established code requirements and established code compliance practices. It is the hydrogen-related components that pose the challenge for building and fire safety codes because they involve risks and risk management methods that have not yet become widely used, are not codified in rule, and have not been observed in the field.

Two diagrams below portray each of these two technologies and identify the components this investigation addresses.

## Section 2.4 -- Fuel Cell Distributed Generation (DG)

In simple terms, a fuel cell converts chemical energy from hydrogen and oxygen into electrical energy. It is similar to a battery in that it has an anode and a cathode. However, a battery is only capable of storing power, whereas the fuel cell can generate it, as long as hydrogen, the fuel, is being supplied. In the process of electrochemical conversion to create electricity, the by-products of the fuel cell are water and heat.

A fuel cell system generally includes three major functions – see Diagram 1 below.

1. A fuel processor – typically either converts a gaseous fuel such as natural gas or methane into hydrogen through a reforming process or uses electrolysis to generate hydrogen from water and electricity.
2. The fuel cell stack – chemically converts hydrogen into DC power, and for some designs waste heat is produced.
3. An inverter – an electronic device that converts DC power into AC power. For the purposes of this study, the inverter is excluded from this analysis because it is a common and acceptable component that has numerous established uses.



Diagram 1

Key Components and Function of a Stationary Hydrogen Fuel Cell  
(From Fuel Cell Demonstration Project at CT Dinosaur State Park written by Hydrogen Safety)

## **Fuel Cell Technologies**

There are five fuel cell technologies:

***Solid Polymer / Proton Exchange Membrane (PEM) Systems*** – Ballard, Plug Power, UTC Fuel Cell, Proton Energy Systems

This is the fastest growing fuel cell technology being developed with 250 KW and smaller systems being a typical size for land-based applications. Smaller sizes are being developed for transportation and residential uses.

***Molten Carbonate*** – Fuel Cell Energy

Some industry observers believe that this technology, because of its costs and reliability, will eventually be proven as the technology of choice. Since the fuel cell operates at 650 °C, it is well suited for some co-generation applications. Although its highly corrosive nature limits the useful life of the electrolyte, Fuel Cell Energy announced in a press release on June 20, 2000 that their 250 KW fuel cell, connected to the grid, successfully passed a one-year (8,660 hour) endurance test.

***Phosphoric Acid*** – UTC Fuel Cells (formerly known as ONSI)

This is currently the most commercially developed fuel cells with approximately 140 installations. Their track record is generally high reliability, but it has a low power density and therefore high costs.

***Solid-Oxide*** – Accumentrics, Ztek, Siemens-Westinghouse Power, McDermott Technology, Allied Signal

DOE is investing nearly \$13 million in research to develop an all-solid state ceramic form of this technology. It operates at extremely high temperatures allowing the waste heat to be used. Accumentrics and Ztek are the only manufacturers that claim to have working fuel cells.

***Alkaline*** – UTC, International Fuel Cells

This is currently restricted to space applications because the design is easily contaminated by CO<sub>2</sub> and CO.

For this Study, alkaline technology is not considered because the electrical output is typically too small for DG applications.

## Section 2.5 – Hydrogen Refueling Stations

The New York State Hydrogen Energy Roadmap observes that “The vision for hydrogen energy in New York State calls for a significant fueling infrastructure to be in place by 2020.” While the number and location of fueling stations will depend on the timing and characteristics of hydrogen vehicle deployment, it is clear that the development of a network of hydrogen fueling stations will be a necessary component of any hydrogen-fueled transportation system in New York State.

There are some basic components for refueling stations, but there are also some variations. Since there are only 114 refueling stations in operation and another 52 in the planning stage in the world at this time<sup>7</sup>, the designs have not been universally standardized. For the purposes of this study, the components considered include:

1. The dispenser – the equipment that physically fills the on-vehicle hydrogen storage tank.
2. The compressor – equipment that increases the pressure of the hydrogen to the desired storage pressure for the container on the vehicle. This pressure is determined by the operating characteristics and the desired driving range of the vehicle.
3. Hydrogen storage – this may vary for each application. Typically, some storage is furnished on site to have a reservoir of supply.

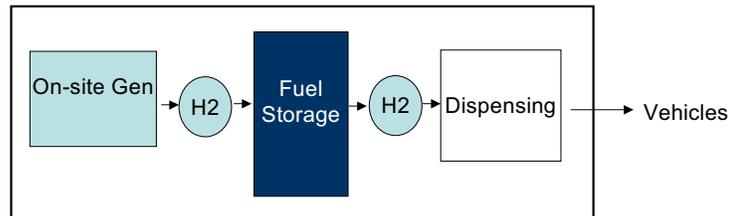


Photo 1 – Typical Hydrogen Refueling Station  
Courtesy of FTI International Inc.

Diagram 2 shows the key hydrogen components of a hydrogen fueling station facility. The vehicles are not the focus of local building codes but may be the subject of transportation regulations, which is another important regulatory issue but one that is not a part of building and fire code regulation.

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<sup>7</sup> Listing of refueling stations from Fuel Cells 2000, updated July 2006, and found at [www.fuelcells.org/info/charts/h2fuelingstations.pdf](http://www.fuelcells.org/info/charts/h2fuelingstations.pdf)



## Notes

- 1) On-Site Generation considers Reformer & Electrolysis only
- 2) On-road considerations only for vehicles (cars & buses)

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## Diagram 2

## Key Components of a Hydrogen Fueling Station for Transportation Vehicles

## Section 2.6 -- How is this report organized?

The remainder of this report is organized in three major sections.

**Section 3** of the report describes how the building and fire safety code framework in New York State addresses hydrogen-fueled stationary fuel cell installations and hydrogen fueling station facilities. Section 3.1 describes how work at the national and international level strengthens the foundation of knowledge and code practice for New York and other states. Section 3.2 describes the building and fire safety code framework for New York State, explaining the general code framework for all areas outside New York City and then focusing on how New York City codes address these hydrogen technologies.

**Section 4** builds on Section 3’s general discussion of the building and fire safety code framework in New York by focusing on how codes and standards address hydrogen technology, specifically. Section 4 describes the characteristics of hydrogen technologies that distinguish these technologies from other technologies that local building and fire codes already handle routinely. The section explains how local codes and standards apply to both hydrogen fueled stationary fuel cells for distributed generation and hydrogen fueling stations for transportation technology. Section 4 introduces a codes and standards matrix, developed for this report and presented in its entirety in Appendix A-1. Referring to the matrix, the section describes the key building and fire safety code provisions that apply to each major hydrogen technology component. Section 4 uses the

matrix to identify the key code provisions that drive the code compliance issues confronting hydrogen technology in New York.

The third and final major section of this report, **Section 5**, summarizes barriers to the development of hydrogen technologies that exist in the current code system identified in Section 3 and recaps the detailed set of recommendations, also presented earlier in Section 3, for action that may be required to mitigate those barriers.

## **Section 3 -- The Emerging Code Framework for Hydrogen Technologies**

### **Section 3.1 -- National and International Code Programs**

This Section of the report observes the extensive work underway at the national and international level to develop new code provisions and strengthen existing code treatment of hydrogen technology. The existence of the significant investments at this level by the United States government, other nations, and international organizations not only reduces the burden on state and local government to determine how to accommodate this new technology but also promises to standardize the way codes are written and enforced. This, in turn, greatly helps developers who may be trying to deploy hydrogen-based-technology in many different states and localities.

This Section summarizes the federal activity that is underway, identifies the institutions that bear upon national code standardization, and addresses the obstacles and uncertainties that influence the hydrogen codes development enterprise. It focuses on the federal agencies and activities that affect the administration of building and fire safety codes in New York State and provides general context about national and international activities. Appendix A-3 lists information resources on the overall federal and international efforts to address hydrogen technology through codes and standards.

The federal government has recognized that codes and standards are a potential critical barrier to the commercial development of hydrogen as an energy carrier, and has established several initiatives to clarify and work toward the management or elimination of that risk.<sup>8</sup> Federal action regarding codes and standards issues is driven by a number of interests, and it is directed toward achieving several strategic objectives. They include, broadly:

- rationalization of codes according to underlying science and engineering factors;
- education about and management of risk;
- clarity and ease of use;
- uniformity of standards to facilitate economies of scale;
- encouraging cooperation among states; and
- facilitating the commercialization of new technologies.

These objectives are bound within a general goal of fostering a safe and competitive domestic hydrogen industry. This, it is assumed, will create jobs, deliver clean energy, provide energy security, help improve electric reliability, and reduce U.S. dependence on oil and gas imports.

The national effort recognizes the value of individual state efforts to adopt uniform model codes and standards. The National Renewable Energy Laboratory

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<sup>8</sup> Of course there are many technical, legal and other issues to overcome in the pursuit of a viable hydrogen infrastructure; that this Report focuses on codes and standards in no way implies that the many other needs and efforts are unimportant.

(NREL) is the lead agency for the DOE to coordinate this effort. Greater uniformity of codes among states would facilitate the deployment of hydrogen application nationwide.

This description of national and international programs will show that, despite significant challenges, the US DOE has effectively rallied the means at its disposal, in conjunction with many other significant actors.

### **Section 3.1.1 - Federal Role and Strategy**

Having identified the development of a hydrogen economy as a national interest and codes and standards uncertainty as an obstacle to that interest, the federal government has assumed a leadership role, despite its limited direct authority to promulgate and enforce such standards.

Several obstacles must be overcome in order to create the standardized and rational code structure that will both ensure safety and meet the hydrogen energy industry needs for clear and consistent code guidance. Some general technical, institutional, and legal factors slowing the federal government's effort to standardize code requirements for hydrogen technologies include the following:<sup>9</sup>

**Technical Issues** -- The federal government's ability to resolve the codes and standards issues related to hydrogen is constrained by an amalgam of technical issues including technical uncertainty regarding aspects of the codes, lack of basic research on topics such as the physical properties of hydrogen and its interaction with materials and equipment, and availability and reliability of relevant technical data.

- **Lack of Federal Authority** – Broadly, the federal government has limited power to impose a standard solution to the codes problem. It is unable to unilaterally create international consensus, and it has not attempted to mandate uniform domestic implementation without statutory authorization. Although the federal government has some power to establish certain codes and standards for health, safety, and other reasons, most observers of the current effort do not seem to believe that building and other codes affecting hydrogen could be so imposed, even if a federal agency wanted to do so. This lack of authority imposes obvious costs in terms of certainty, consistency, and timeliness in developing necessary codes. This said, the federal government controls substantial resources that amount, in practical terms, to significant power, which it appears to wield effectively, and a decentralized development process offers some advantages.
- **Local Implementation** – Most codes typically are enacted at the state and local levels as an exercise of the power to promote health safety and welfare. States generally select codes published by established code development organizations (“CDOs”) (in whole, in part or with changes), which are then

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<sup>9</sup> This list represents the synthesis and judgment of the study team. The DOE's Hydrogen, Fuel Cells and Infrastructure Technologies (HFCIT) Program identified a detailed list of challenges facing its mission of code development. (See: Hydrogen, Fuel Cells & Infrastructure Technologies Program, “Technical Plan – Hydrogen Codes and Standards DRAFT (6/3/03)”, P. 3-115 (§3.6.4.2 “Barriers”).) The HFCIT implementation plan strives to address, and is addressing, these issues, as described below.

codified as law by municipalities (again, in whole, in part, or with changes). These several steps, multiplied by up to 44,000 local jurisdictions, impose obvious obstacles to national coordination and consistency. States may make broadly different choices<sup>10</sup>, or important differences may emerge via many minor changes made during the adoption processes. The ICC reports that:

- 47 states plus the District of Columbia use the International Building Code
- 45 states plus the District of Columbia use the International Residential Code
- 42 states plus the District of Columbia use the International Fire Code

To address the possibility of conflicting state and local code approaches, the DOE effort encourages communication between and among the states that are embarking upon hydrogen development, and it emphasizes the underlying scientific basis of codes in the hope and expectation that apparently different code regimes will rest upon underlying requirements that are substantively similar.

- **International Factors** – Hydrogen energy is an international industry, and the codes and standards of other nations necessarily influence domestic manufacturers. Codes and standards development in international organizations are influenced by many diverse stakeholders and inform domestic code making. Some standards are being developed concurrently with no certainty as to which will prevail. Economic politics also plays a role. For example, there is a strategic concern that the Global Regulation on Pollution and Energy (GRPE) process underway in Europe could become a binding international standard prematurely, which would harm U.S. producers.
- **Competition Among CDOs** – CDOs profitably publish codebooks, and therefore they compete to develop and market their documents to the exclusion of others. When New York City decided after a lengthy process to base standardized codes on ICC documents, the National Fire Protection Association (NFPA) launched a lobbying effort to reverse the decision in favor of its own standards.

Increasingly, code development and adoption is following a “top down” approach. International and national organizations develop model standards and codes, which are typically endorsed by states and enacted into legal requirements by states and municipalities. States can exert considerable influence on the standard development

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<sup>10</sup> According to the ICC web site, California and Hawaii are currently the only states with no ICC code adoptions at all (<http://www.iccsafe.org/government/adoption.html>). However, on March 16, 2005, the California Building Standards Commission (CBSC) rescinded its July 29, 2003 decision to use the NFPA 5000 Building Code as the basis for the next California Building Code, and decided to move toward ICC codes. (<http://www.nema.org/stds/fieldreps/codealerts/20050325ca.cfm>)

organizations (“SDOs”) and other institutions, Municipalities frequently modify codes at the time they adopt them.

In New York, State law requires all municipalities outside New York City to adopt and enforce the State code (with limited room for revision). The municipality must either enforce these codes or allow the county or state government to conduct enforcement. New York City is an important exception to this policy: it develops its fire, building, and other codes. New York City and other very large, densely populated cities face unique problems providing public safety.

Both New York State and New York City are changing their building and fire safety codes from the established, locally developed code framework to ones based on an international model, the International Code Council’s family of model codes. In each case, changes in the model code are being made to address New York State/New York City conditions.

This top-down approach to codes leaves the job of applying codes in the hands of state and local government but lifts much of the burden for code design from the shoulders of individual states and local governments. States and local government retain the authority to adapt model codes to local conditions but do not have to address problems of developing codes for new technologies, such as the hydrogen applications considered here, on their own.

The federal authorities interviewed for this report are keenly aware of the critical role that states will have to assume in the near future, and they are seeking strategies to promote cooperation and standardization as quickly as possible. States bear responsibility for the implementation of code changes, and if all works well, they will use model codes and studies supported and guided by the federal work with state and industry input.

The U.S. Department of Energy (US DOE) encourages coordination and sharing of information among relevant state agencies and welcomes input into the various codes and standards activities. Interviews with New York State code administration staff indicate they have well established links with federal officials.<sup>11</sup> By participating in the code development committees, the NYS Department of State staff is able to proactively communicate its concerns or new ideas. Model code decisions and developments occur outside the jurisdiction of any given state. It is important that New York remain an active participant in the national/international code development committees.<sup>12</sup> Only by doing so can New York ensure that model codes will address its needs.

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<sup>11</sup> Interview with Michael Burnetter, NY State Department of State, Division of Code Enforcement and Administration. April 12, 2005.

<sup>12</sup> The New York State Department of State Division of Code Enforcement and Administration currently represent New York in code development committees within the ICC framework. Ibid.

### **Section 3.1.2 – Involved Agencies and Roles**

Several federal agencies are at work on hydrogen safety code issues and research, most prominently the US DOE. Appendix A-3 provides a list of federal agencies involved in this work. The official federal role involves coordinating key players, providing technical support, and in general, facilitating a constructive resolution of the numerous code development processes underway. Federal agencies have sponsored research, helped identify conflicts and discrepancies, and participated directly in codes and standards development negotiations.

The Office of Energy Efficiency and Renewable Energy (EERE), in conjunction with the National Renewable Energy Laboratory (NREL) and other national laboratories, lead hydrogen research at the US DOE. NREL is the US DOE's designated lead entity for coordinating national hydrogen codes and standards activities, and NREL provides the bulk of technical support, in addition to coordinating the collaborative codes project. Within EERE, the Hydrogen, Fuel Cells and Infrastructure Technologies Program (HFCIT) manages hydrogen and fuel cell technology issues. Other US DOE Offices carrying out programs within the Initiative are Fossil Energy, Nuclear Energy, and Science. Hybrid and other advanced vehicle technologies are being developed within the Office of Freedom CAR and Vehicle Technologies.<sup>13</sup>

Currently, the HFCIT<sup>14</sup> has assumed leadership and coordination roles for codes and standards issues and has taken significant steps toward identifying, resolving, and coordinating action on many of them. Other code and standards efforts are underway within different agencies and sub-agencies, particularly the US Department of Transportation ("DOT"), but the DOE's role is most prominent.<sup>15</sup> The HFCIT, in particular, engages industry and CDOs, helps connect various processes and concerns, directs research to meet needs and fill identified gaps in knowledge, defines meeting agendas, helps provide a consistent posture in international forums, and works to coordinate the efforts of the various states.

With respect to technical research, the HFCIT stresses the importance of "getting the underlying science right." A comprehensive body of factual information is critical for the development of any functioning code system, regardless of the details, or which company organizes and presents them. The HFCIT does not envision its role as deciding which code system should prevail, but rather, based on the realistic recognition that

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<sup>13</sup> EERE FY 2003 Progress Report.

<sup>14</sup> The HFCIT is managed by the US DOE Office of Energy Efficiency and Renewable Energy (EERE). The HFCIT Program's "Multi-Year Research, Development and Demonstration Plan" is available at <http://www.eere.energy.gov/hydrogenandfuelcells/mypp/>; it describes the planned research, development and demonstration activities for hydrogen and fuel cell technologies through 2010.

<sup>15</sup> The NREL Hydrogen Project objectives are listed as:

- Facilitate creation and adoption of model building codes and equipment standards for hydrogen systems in commercial, residential, and transportation applications. [Emphasis added]
- Provide technical resources to harmonize development of international standards among the International Organization for Standardization (ISO), International Electro-technical Commission (IEC), and Working Party on Pollution and Energy (GRPE).

competing CDOs exist, as ensuring that requirements incorporated in codes and standards are based on sound, objective science and engineering knowledge.

Additionally, the federal government works closely with national and international SDOs to promote code development and standardization and to protect domestic economic interests. These non-federal institutions (identified in Appendix A-3) include the entities primarily responsible for developing the actual text of codes and standards relating to hydrogen. Agencies and institutions such as the International Standards Organization (ISO), NFPA, ICC, and other SDOs and CDOs have their own internal organizational structures, institutional mandates, and objectives.<sup>16</sup> They should be considered in conjunction with the federal government because, from a state's perspective, their respective influences are, in many respects, bundled together.

International organizations and networks are important. International standards provide a reference framework, or a common technological language, between suppliers and their customers. They are neither codes, nor law. Rather, they are voluntary, but because they are based on consensus among the interested parties they have widespread applicability. For example, although ISO is a non-governmental organization, it occupies a special position between the public and private sectors. Many of its member institutes are part of the governmental structure of their countries or are mandated by their government. Conversely, other members have their roots uniquely in the private sector, having been set up by national partnerships of industry associations.

### **Section 3.1.3 -- Ongoing Federal Activities**

The DOE and other national level entities are conducting a wide range of activities to facilitate code and standard development. These activities range from information sharing, such as supporting the American National Standards Institute (ANSI) web portal that provides information to code officials and other interested parties,<sup>17</sup> to basic research into the scientific and engineering issues that lie at the foundation of rational code development. The following lists some of the important activities now underway.

#### **1) Support an ANSI web portal that provides information to code officials.<sup>18</sup>**

NREL has established a project with the ANSI called the Hydrogen Codes and Standards Portal (the "Portal"). The objective of the project is to provide a web-based capability in order to allow code and fire safety officials to access hydrogen codes and standards documents (e.g., NFPA, ICC and other codes and standards) via the ANSI web site. The Home page for the Portal is: <http://HCSP.ANSI.ORG>

Visitors to the site can search for and browse codes and standards documents of the participating CDOs and SDOs, by subject, as well as download codes and standards documents (i.e., documents of the participating CDOs and SDOs).

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<sup>16</sup> NOTE: this list does not include organizations that primary focus on equipment standards.

<sup>17</sup> New York State participated in a pilot program at one stage of this portal's development. See <http://hcsps.ansi.org/>.

<sup>18</sup> EMAIL TEXT FROM Russell Hewitt, National Renewable Energy Laboratory referred by Jim Ohi

During the 2004 fiscal year, ANSI completed development of the Portal and conducted two mini trials, including one in New York State. The ANSI site has been integrated with the Fuel Cell/Hydrogen Infrastructure Codes and Standards matrix at [www.fuelcellstandards.com](http://www.fuelcellstandards.com), which provides another example of how the federal efforts are well coordinated.

**2) The US DOE and NREL allocate funding for basic research.**

Sound codes depend on a thorough understanding of hydrogen's physical properties, how it interacts with various metals, experience with and testing of storage and detection mechanisms, and other experimental knowledge. Thus, research lays the foundation for understanding the fundamental risks of hydrogen use. This, in turn, allows a rational assessment of risks, which can be codified. A number of federal agencies are sponsoring and conducting fundamental research related to hydrogen technology development, including NREL and many of the national laboratories. For example, there remains significant controversy around defining minimum separation distance requirements for hydrogen storage facilities in codes; the outcome of this research may have significant implications for the feasibility and cost of siting hydrogen storage facilities in urban settings.

**3) The DOE provides staff that are working on hydrogen code issues.**

DOE national laboratory staff attend and participate actively in numerous industry and stakeholder organizations and in public forums. Staff give presentations, attend conferences, and, in general, create an active presence in the field. This presence promotes "real world" solutions to codes issues. Activity includes addressing industry interests, facilitating agreement among parties that may not necessarily agree, and performing a more general, and essential, communication function on codes issues. Internationally, government staffers also represent the U.S. hydrogen industry in some SDOs and other bodies.

These three examples illustrate some of the ways that federal officials are helping accomplish the complicated codes development mission. By promoting research, federal agencies help develop the underlying risk factors and rational basis for codes. By leveraging their high profile and position as a clearinghouse of information, federal officials can balance the goals of promoting consistency and state experimentation. Through their efforts with industrial and national interests at heart (as opposed to narrower commercial interests for one company), federal agencies help steer the many ongoing processes toward consensus solutions.

**Section 3.1.4 – Key Findings and Recommendation – Interaction with Federal Programs**

Extensive work, funded by the federal government and international codes and standards organizations, is underway to develop effective model building and fire safety codes for new hydrogen technology applications, especially for stationary fuel cell and hydrogen refueling stations.

- This work addresses the underlying science and risk engineering knowledge base effective codes require.
- This work will provide a base of knowledge and experience that can offer state and local code officials confidence in the effectiveness of model codes.
- There are significant ongoing efforts to develop model codes pertaining to hydrogen storage and use that draw support from federal programs, international code development organizations, state and local code officials. This makes it clear that New York needs to pursue a stand-alone hydrogen code, standard research agenda, and code development process. The national and international code development studies/programs provide state and local code officials the opportunity to represent local needs and concerns in the code development process, as demonstrated by New York City and the New York State Department of State code officials' active participation in these efforts.

The federal government programs recognize there is an important opportunity to learn from different approaches to code design and administration implemented by the 50 states and their municipalities. To capture the benefits of such diverse experience requires communication and coordination among the states.

The federal government has identified a lead contact for their efforts to build effective building and fire safety code requirements for new hydrogen technology applications.

The federal government officials believe communication and coordination among states and municipalities will be enhanced if each state and major municipality identifies a lead contact for addressing the application of state and local code to new hydrogen technology applications.

➤ Recommendations:

- New York State should continue to monitor federal hydrogen C&S development activities and stay constructively engaged where state input is sought. Similarly, NYS should continue to be actively involved in ICC technical committees bearing on hydrogen storage and use.
- New York State and New York City should each maintain a central coordinator to interface with NREL and other hydrogen technology codes and standards efforts on an interstate, national, and international level.
- NY State should work with other states, such as California, that are actively promoting hydrogen technology deployment, to share information and lessons learned.
- NYSERDA should maintain the point of contact channel of communication between the NYSERDA hydrogen program and the Federal programs led by the NREL. Such regular communication, a regular feature of NYSERDA program planning, will coordinate NYS hydrogen code program priorities with national programs.

- NYSERDA should establish regular communication links among the NYS Department of State Division of Code Enforcement and Administration, the New York City Department of Buildings, and the NYSERDA hydrogen program to nurture coordination in addressing hydrogen technology issues affecting building and fire safety codes. It may be appropriate to create a hydrogen working group for codes and standards as an outgrowth of the New York State Hydrogen Energy Roadmap activities sponsored by the NYSERDA, the Long Island Power Authority, and the New York Power Authority.

## **Section 3.2 -- New York State**

The administration of codes and standards in New York State is governed by State law, which has created an overall state framework within which local governments are generally responsible for code compliance. This Section outlines the statewide framework, addresses the special case of New York City, and then describes how local, state and federal authority overlaps.

### **Section 3.2.1 -- New York State Framework**

#### **3.2.1.1 Overview**

New York State law requires that state government develop and implement an integrated fire and building code for the entire state, except New York City, which is allowed to maintain its own code.<sup>19</sup>

The New York State Uniform Fire Prevention and Building Code provides minimum requirements to safeguard the public safety, health, and general welfare through structural strength, means of egress facilities, stability, sanitation, adequate light and ventilation, energy conservation, and safety to life and property from fire and other hazards attributed to the built environment.<sup>20</sup>

State law<sup>21</sup> assigns responsibility for enforcing the Uniform Fire Prevention and Building Code (Uniform Code) to New York's cities, towns, and villages (i.e., municipalities). Responsibility for code enforcement will shift to a county or the NYS Department of State (i.e., the Department's Division of Code Enforcement and Administration) if the municipality or county decides not to accept code enforcement responsibility.

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<sup>19</sup> For additional background see the New York State Department of State publication: Administration and Enforcement of the Uniform Fire Prevention and Building Code and the Energy Conservation Construction Code. (March 2004).

<sup>20</sup> Ibid.

<sup>21</sup> Section 381 of the Executive Law.

In the case of federal or state government projects, including projects of an independent state authority, those governmental entities may have the authority to administer building and fire safety code compliance. An analysis of the specific statutory authority for the particular entity as well as consideration of other facts is required to determine if the State’s Uniform Code can be enforced against a federal or state entity. Federal governmental instrumentalities are only subject to state or local regulation when Congress has authorized such regulation in clear and unambiguous language.<sup>22</sup> For New York State, the State Court of Appeals has established a “balancing of public interest test” to determine if the land use requirements of one political subdivision are applicable to the proposed activities of another.<sup>23</sup> Generally, a project’s sponsor agency will be responsible for addressing issues of code compliance.

Overall responsibility for maintaining and updating the Uniform Code is the responsibility of a seventeen member State Fire Prevention and Building Code Council (“Code Council”), composed of State officials, local government officials, and members of the private sector. The NYS Department of State Division of Code Enforcement and Administration (NYS DOS DCEA) provides technical and other staff advisory support to this Council.

The NYS DOS DCEA supports the local code enforcement program in New York by providing several support services and by providing interpretations of the Uniform Code when requested to do so. This role may be important for new technologies such as hydrogen fueled technologies, which pose new or poorly understood risks. The NYS DOS web site provides extensive information about New York State Building and Fire Safety Codes and available support services – see [www.dos.state.ny.us/about/codes.htm](http://www.dos.state.ny.us/about/codes.htm)

In 2002, the State Fire Prevention and Building Code Council began a wholesale revision of the Uniform Code to bring it into conformity with the International Code Council (“ICC”) model code framework. A completely revised Uniform Code, based on the ICC model, is expected to supersede the current Uniform Code sometime in 2006. This new Uniform Code is expected to include new provisions from the ICC model that are specifically designed to address the technology characteristics of hydrogen fuel storage and use in fuel cells, transportation fueling facilities, and other new applications of hydrogen.

### 3.2.1.2 Hydrogen Technology and the Uniform Code

By developing a new Uniform Code based on the ICC model code framework, New York State effectively taps the resources of the United States’ and international community programs underway to assess the adequacy of existing codes and to respond to deficiencies with new code provisions and compliance practices.

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<sup>22</sup> U.S. Postal Service v. Town of Greenwich, 901 F.Supp. 500 (D.Conn. 1995).

<sup>23</sup> Matter of County of Monroe v. City of Rochester, 72 NY2d 338, 530 NE2d 202, 533 NYS2d 702 (1988).

NYS DOS DCEA staff are members of ICC technical committees assessing the existing codes and developing new code practices. The Code Council has the benefit of these channels of communication; participation on these committees strengthens the Code Council's ability to respond to new challenges with the benefit of high-quality technical advice.

NYS DOS DCEA Code Development staff anticipates that this framework will assure that New York State's Uniform Code keeps pace with the needs of a developing hydrogen economy in New York, and we concur.

### 3.2.1.3 Obtaining a Permit for a Hydrogen Facility in New York State (except New York City)

The following outlines the building and fire safety code compliance path for a hydrogen fuel cell or refueling station project developer, from project design to project construction and operation.

- Step One: Analyze the applicability of the Uniform Code to the Hydrogen Project (see Appendices A-1 and A-2 for an assessment of key code provisions to hydrogen technologies)
- Step Two: Determine the code enforcement jurisdiction for the project. Will the project be the code enforcement responsibility of:
  - The city, town, or village in which the project is located;
  - The county in which the project is located, because the municipality has declined responsibility;
  - The NYS Department of State because the municipality and county have declined code enforcement responsibility;
  - A state agency or an independent state authority, e.g., New York Power Authority; or
  - A federal government agency
- Step Three: Prepare code compliance documents demonstrating how the project will comply with the applicable provisions of the Uniform Code.
- Step Four: Contact local code officials and potentially interested political leaders (e.g., town supervisor, mayor's staff) to inform them of your plans and desire to obtain permit approvals. If the contact is effective this will start a process of consultation involving both technical code officers and political leaders whose support or interest may ensure fair and responsive handling of the code compliance applications. Because hydrogen technology is new to many local government leaders, it is likely that senior officials will take an interest. The subsequent consultations will require addressing the formal code process and public education.

- Step Five: Consult with appropriate code officials, and provide detailed descriptions of the project in a form required by the local code compliance process. This and subsequent steps are likely to involve an iterative process of presentation of plans and confirming their implementation up until the facility is authorized to operate.
- Step Six: Begin construction after receiving signed building permits.
- Step Seven: After the local code authority issues a building permit for a project, the process shifts to verifying compliance with the specific provisions of the building permit, often an iterative process of demonstrating that approved plans have been implemented.

#### 3.2.1.4 Problems and Special Conditions

The NYS DOS DCEA maintains Technical Services to assist local code officials, design professionals, and the public by addressing new technologies, unusual site conditions, or other special problems of code enforcement/compliance. Communications from the unit come in many forms and a request can come from any person or group. “The unit renders opinions via telephone, electronic mail, and advisory letters, on request. Also, the unit periodically issues technical bulletins that clarify a group of related Code issues or advise the public of newly developed conditions or practices that affect the Code.”<sup>24</sup> These services may be useful to developers seeking building and fire safety permits for hydrogen fuel cells or hydrogen fueling stations.

### **Section 3.2.2 -- New York City Framework**

#### 3.2.2.1 Overview

Local fire prevention and building codes are handled differently for New York City than for other municipalities in New York State (see Section 3.2.1 supra). Under New York State law, the City of New York is allowed to maintain its own codes whereas other municipalities are subject to the New York State Uniform Fire Prevention and Building Code.<sup>25</sup>

The New York City Council is responsible for establishing New York City’s fire prevention and building codes. The current building code was enacted by the City Council and approved by the Mayor in 1968.<sup>26</sup> Fire safety permits and requirements and the New York City Fire Prevention Code are the responsibility of the New York City Fire Department and are compiled in Title 3 of the Rules of the City of New York.

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<sup>24</sup> See website of the NY DOS at [www.dos.state.ny.us/code/technical\\_services.htm](http://www.dos.state.ny.us/code/technical_services.htm)

<sup>25</sup> see New York State Department of State, Administration and Enforcement of the Uniform Fire Prevention and Building Code and the Energy Conservation Construction Code. Op cit supra.

<sup>26</sup> Building Code of the City of New York (Internet version) available at [http://www.nyc.gov/html/dob/html/reference/code\\_internet.shtml](http://www.nyc.gov/html/dob/html/reference/code_internet.shtml)

New York City has embarked on a process of code reform. Work is underway to adapt the ICC model building and fire codes for use in New York City. Staff at the New York City Department of Buildings (DOB) anticipates enactment of a new code in 2007 with an effective date one year thereafter.<sup>27</sup>

While Building Codes and fire safety rules based on the ICC model codes may eventually be enacted by the City of New York, current project developers should expect to comply with the existing New York City Building Code and Fire Prevention Code.

The New York City DOB has the responsibility for the administration and enforcement of the New York City Building Code and Zoning Resolution.

The DOB is generally responsible for administering compliance with the New York City Building Code for projects on property that is on the New York City tax rolls. Projects located on property of other agencies of the City of New York (e.g., the Parks Department, the Department of Transportation, and the Police Department) may be handled independently without DOB involvement.

Projects located on property of the New York Power Authority, other state authorities, and state agencies are handled by the State authority's or agency's code compliance certification process, not a New York City administered process (see discussion of state and federal authority in Section 3.2.1 supra).

Scale of activity, density of population, commercial activity, highways, and electric and gas systems in the five boroughs of New York City are orders of magnitude greater than other parts of New York State and are only experienced on a similar scale in the largest cities of the US and world. This poses difficult challenges for introducing new technology with operating characteristics and risks that are new to the diverse community officials who must address code enforcement in New York City.

### 3.2.2.2 Hydrogen Technology and the NY City Building and Fire Code

In New York City, the DOB has general responsibility, through the Building Code, for the permit process associated with installation of stationary hydrogen fuel cells. In the case of a hydrogen fueling station, the construction of any associated buildings will be subject to the New York City Building Code, but the fueling station will also require a Fire Code permit obtained from the New York City Fire Department for the installation of the hydrogen fuel storage facility.

Generally, the local Borough office where the project is located handles projects subject to DOB jurisdiction.

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<sup>27</sup> Sam Marcovici, Code Coordinator, New York City Buildings Department, June 2006.

Because stationary fuel cell projects involve new technology, or technology not previously subjected to detailed engineering review, projects seeking Building Code compliance certification must apply for Material Equipment and Acceptance (MEA) approval.

In accordance with [Section 27-131](#) of the New York City Building Code, certain materials and equipment require Department of Buildings acceptance. These manufactured items affect public safety, health, and welfare (including structural stability and fire safety) and they are usually a permanent part of a building. They include such items as boilers, air-conditioning equipment, commercial cooking equipment, fire-rated assemblies, fire alarm and suppression equipment, wheelchair lifts, etc. The actual list of accepted products to date is known as the [MEA Index](#) (see below for further information).<sup>28</sup>

#### New York City Experience Permitting Stationary Fuel Cells

Only a few fuel cell models have received MEA approval. Therefore, most fuel cells and fuel cell reformers will eventually require MEA approval.<sup>29</sup> When required by NY City Building Code, MEA approval is applied for and obtained by equipment manufacturers for their particular equipment. The MEA approval is provided to specific models and is based on minimum performance standards as indicated by the New York City Building Code. The MEA approval process for new technologies such as hydrogen fuel cells may take a significant amount of time and require extensive product performance data filings and discussions with appropriate City agencies. The list of products requiring MEA approval is published in the City's MEA Index.<sup>30</sup>

There is accumulating experience with siting and permitting stationary fuel cell installations in New York City. Several fuel cell facilities have obtained permits and have been constructed in New York City. Recently, the Sheraton New York Hotel in Manhattan obtained a building permit for a fuel cell power plant installation furnished by Fuel Cell Energy. Earlier, a fuel cell installation developed by UTC Fuel Cells, Inc. obtained permits and was constructed at Two Time Square (this product received MEA approval in 1998 under the "International Fuel Cells" company name). A case study of the Two Times Square project code compliance experience is provided in Section 4.2.5 below. With each new installation, the accumulating code review process builds experience that may facilitate the processing of future project reviews. However, any design changes to the model or equipment would force the manufacturer to reapply under MEA for a new resolution.

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<sup>28</sup> The New York City Department of Building website offers a full explanation of the MEA process at [www.nyc.gov/html/dob/html/applications\\_and\\_permits/mea\\_home.shtml](http://www.nyc.gov/html/dob/html/applications_and_permits/mea_home.shtml)

<sup>29</sup> Hydrogen storage and dispensing facility, major components of hydrogen fueling stations, are the jurisdiction of the NY City Fire Department.

<sup>30</sup> The New York City Building Code requires that certain materials and equipment be accepted by the Department of Buildings. Accepted products are given an MEA Number; MEA Numbers are recorded in the MEA Index. The MEA Index is available on the NYC Department of Buildings website at [www.nyc.gov/html/dob/html/reference/mea\\_index.shtml](http://www.nyc.gov/html/dob/html/reference/mea_index.shtml)

Stationary fuel cells do not qualify as emergency power supplies, limiting the potential usefulness as on-site electric power supplies.<sup>31</sup> They do not qualify as emergency power supplies for two reasons: first, their primary fuel supply (natural gas) is not stored on-site and is therefore potentially interruptible, and, second, emergency power supplies must be available on a near instantaneous start-up, a barrier for fuel cells because the hydrogen reformer takes some time to launch operation. While fuel cells do not qualify as emergency power sources, they are being sited as primary power supplies in New York City locations.

Despite the accumulating experience with hydrogen fuel cell siting and construction within New York City, there appears to be no single place where a project developer or a code official can go to find out how code issues have been addressed by the several different entities (e.g., NY City Department of Buildings, NY Power Authority, other City agencies) who have separately addressed code compliance for hydrogen fuel cell installations.

#### New York City Experience Permitting Hydrogen Fueling Stations

In contrast to stationary fuel cell installations, no hydrogen fueling stations have obtained fire safety and building permits in New York City.

While a hydrogen fueling station would be subject to the DOB administered Building Code, the features of the fueling station associated with the hydrogen storage and dispensing are subject to provisions of the Fire Code, administered by the NY City Fire Department, not the Building Code.

Under the existing New York City Fire Code, it is not permissible to fill a gas storage cylinder with a flammable gas until the Fire Commissioner writes a rule addressing the conditions under which this would be permitted. The use of hydrogen is addressed under Subchapter 17 (Gases Under Pressure) of the New York City Fire Prevention Code. Because the Fire Commissioner has not written such a rule for hydrogen, such facilities, which would fill storage cylinders with hydrogen, are now prohibited in New York City.<sup>32</sup> There is no indication that any work is underway to develop and issue the needed rule. The Fire Department is in the process of adapting the ICC's International Fire Code (IFC) that addresses use and storage of hydrogen for various applications.<sup>33</sup> We understand, though, that the section dealing with hydrogen and other hazardous materials (Chapter 22 of the IFC) has been set aside for further consideration at a later date, effectively foreclosing the permitting of such facilities until a rule is developed and adopted.<sup>34</sup>

While a state agency, an independent state authority, and federal agencies may not be required to obtain building and fire permits from the City of New York, the New York City fire code barrier may influence the willingness of these agencies to proceed with

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<sup>31</sup> Telephone and email communication from Sam Marcovici, NYC DOB, on October 10, 2006. See footnote 44 *infra*.

<sup>32</sup> Telephone conversation between Sam Swanson, Pace Energy Project and James Hansen, PE, Director of Code Revision, NY City Fire Department on May 10, 2005

<sup>33</sup> E-mail communication from Tamara Saakian, Director of Engineering, Bureau of Fire Prevention, NY City Fire Department. April 28, 2005.

<sup>34</sup> James Hansen telephone conversation. *Op cit supra*.

hydrogen fueling station projects in the face of New York City Fire Department opposition.

It is reasonable to conclude that it will not be possible to site a hydrogen fueling station in New York City until the Fire Department is satisfied that this can be done safely and issues the necessary rules to allow this to happen.

### 3.2.2.3 Obtaining a Permit for a Hydrogen Facility in New York City

The Application filing and permit process is outlined in Diagram 3 below:

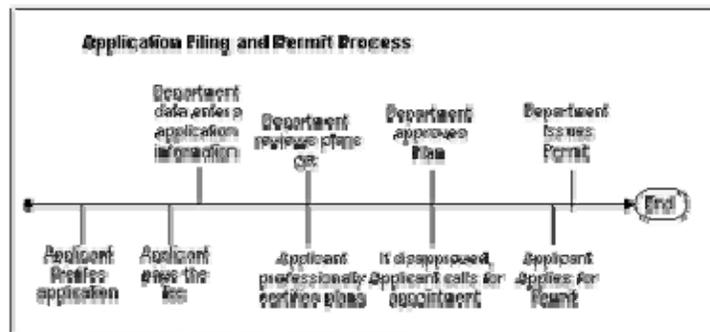


Diagram 3

From NYC Department of Buildings Fact Sheet:  
"Application Filing and Permit Process Fact Sheet"  
(see Appendix C)

- Step One: Determine the code enforcement jurisdiction for the project for those code provisions that apply. Will the project be the code enforcement responsibility of:
  - The New York City DOB
  - A New York City agency/department on whose property the project will be sited
  - An independent state authority, e.g., New York Power Authority, or a New York State agency
  - A federal agency
- Step Two: If subject to New York City DOB jurisdiction, analyze the applicability of the New York City Building and Fire Codes to the Hydrogen Project.
- Step Three: Prepare code compliance documents demonstrating how the project will comply with the applicable City Building and Fire Code provisions.
  - The NY City DOB has published a two page Fact Sheet outlining the steps involved in applying for and obtaining Building Permits. This Application and Filing Permit Process fact sheet (April 2005) is presented in Appendix YY.
  - See Section 3.2.3 for information on addressing code compliance when the project is located on State, State Authority, or Federal property.

- Step Four: Contact code officials, and potentially interested political leaders (e.g., Borough President), in the Borough in which the project is located to inform them of your plans and your desire to obtain permit approvals. If the contact is effective, this will start a process of consultation involving both technical code officers and political leaders whose support or interest may ensure fair and responsive handling of the code compliance applications. Because hydrogen technology is new to many local government leaders, it is likely that senior officials will take an interest. The subsequent consultations will require addressing the formal code process and public education.
- Step Five: Consult with appropriate code officials, providing detailed descriptions of the project in a form required by the local code compliance process.
- Step Six: Begin construction after receiving signed building permits.
- Step Seven: After the local code authority issues a building permit for a project, the process shifts to verifying compliance with the specific provisions of the building permit, a process of demonstrating that approved plans have been implemented.

### **Section 3.2.3 – Hydrogen Based Projects And Environmental Review Processes**

As noted elsewhere in this report, the installation of hydrogen projects – whether an on-site fuel cell generation application or hydrogen refueling station for transportation alternatives – will require local review and approval by a permitting authority for conformance with applicable building and fire codes. Similarly, such projects could potentially involve other state and local government agencies, such as would be the case where a portion of the upfront cost of the system is underwritten by a state authority through programs to incentivize deployment of hydrogen-based technologies.

As such, it is worth considering if such agency interactions would trigger environmental review requirements pursuant to the New York State Environmental Quality Review Act (SEQRA) or, for projects located in New York City, the City Environmental Quality Review (CEQR). The SEQRA/CEQR's overarching purpose is to require the review and mitigation of environmental impacts associated with discretionary actions that may be considered by state and local agencies.

### 3.2.3.1 Applicability

The threshold question is if the review and approval of a hydrogen project for conformance with applicable building and fire codes would generally be regarded as an agency “action” triggering SEQRA/CEQR’s<sup>35</sup> environmental review procedures.

SEQRA/CEQR is generally structured to require different levels of environmental analysis based on the nature, scope, and extent of the anticipated environmental impacts. “Type II” actions are those specifically listed actions that are categorically deemed to have no significant impact on the environment or that are otherwise precluded from environmental review under SEQRA. In contrast, “Type I” actions are those that meet or exceed specified thresholds and, therefore, are presumed to have an adverse affect on the environment such that a full Environmental Impact Statement will be required. Actions that are not classified as either Type I or Type II actions, “Unlisted” actions in SEQRA parlance, require the developer to undertake further environmental analysis. This may range from the completion of an Environmental Assessment Form (EAF) (short form or long form) to a full EIS where the potential exists for at least one significant adverse environmental impact as a result of the project. The SEQRA sets forth a non-exhaustive list of significant adverse impacts.

Although it is not possible to state a universal rule regarding the applicability of CEQR/SEQRA to hydrogen projects, the following observations can be made:

- Where the hydrogen project involves the routine issuance of a building permit, the project will not fall under the purview of SEQRA. Indeed, SEQRA explicitly exempts such routine building permits as a Type II action:
  - (19) official acts of a ministerial nature involving no exercise of discretion, including building permits and historic preservation permits *where issuance is predicated solely on the applicant's compliance or noncompliance with the relevant local building or preservation code(s)*;
  - 6 NYCRR 617.5(c)(19) (italics added)<sup>36</sup>.

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35 Unless otherwise specifically noted, the remainder of this discussion focuses on the text and intent of the SEQRA process. CEQR procedures are specified in the Rules of the City of New York (RCNY), Title 62, Chapter 5 and are substantially similar to SEQRA procedures.

<sup>36</sup> See *Incorporated Village of Atlantic Beach v. Gavalas*, 81 N.Y.2d 322, 324 (1993) (held that the Village Ordinance did not entrust the Building Inspector with the type of discretion which would allow a permit grant or denial to be based on environmental concerns detailed in an EIS). A decision on the application can only be predicated on the applicant’s compliance or noncompliance with the Building Code, therefore the determination constitutes a SEQRA-exempt ministerial act. *Id.* at 325.

- CEQR provides a similar exemption for ministerial, as opposed to discretionary, actions undertaken by City agencies. According to the Office of Environmental Coordination website, “Ministerial actions, such as the routine issuance of building permits, are not subject to CEQR.”  
<http://www.ci.nyc.ny.us/html/oec/html/ceqr/ceqr.shtml><sup>37</sup> The Department of Buildings confirms that it would generally regard the review of a permit application for a hydrogen project as the routine enforcement of existing codes<sup>38</sup> and, as such, would constitute “non-discretionary” approval exempt under CEQR. The same holds true for recognition under the Materials, Equipment and Acceptance (MEA) procedures for new hydrogen technologies.<sup>39</sup>
- Agency decisions to fund hydrogen projects may or may not be subject to environmental analysis under SEQRA depending upon the scope of the project.
- NYSERDA lists the “design, laboratory testing, construction, installation, or demonstration of ... engines or fuel cells producing no more than 200 kilowatts that either use existing fuel supplies or involve new fuel storage supplies of not more than 500 liters” as a Type II action. 21 NY ADC 503.3 (a) (19)
- Funding of larger-scale stationary fuel cell applications and hydrogen refueling stations to service transportation applications will be classified as Unlisted action, thus requiring the completion of an EAF or EIS.
- The project developer is advised to consider whether other agency approvals will be required for the hydrogen project and if so, whether the agency with jurisdiction retains some discretion in granting approval. For example, a large-scale hydrogen project may require a variance from the local zoning commission as a non-conforming use. Alternatively, the hydrogen project may be part of a more comprehensive development scheme with broader environmental implications. If the issuing agency is permitted to exercise “site plan approval powers” and “the authority to make certain case-by-case judgments on site plan design” the permit

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<sup>37</sup> See City Environmental Quality Review Technical Manual (October 2001) at 1-2 through 1-3. “Actions that are subject to CEQR include proposed actions...(3) for which the City issues permits or approvals *at its discretion.*” (*italics added*). Examples given of the granting of discretionary permits “may include approvals of construction projects, such as building a bridge, or adoption of regulations, such as a decision to rezone an area.” See also *Vestry Tenants Association v. Raab*, 658 N.Y.S.2d 804, 809 (1997).

<sup>38</sup> Phone conference with Sam Marcovici and Helen Gittleston, Department of Buildings, June 27, 2006.

<sup>39</sup> *Ibid.*

issuance is no longer exempt from SEQRA's provisions. *Incorporated Village of Atlantic Beach v. Gavalas*, 81 N.Y.2d 322, 324 (1993) at 326. The developer will need to consider these and other examples on a case-by-case basis.

### 3.2.3.2 Scope of Review

The permitting of a large-scale fuel cell or a hydrogen refueling station is somewhat new terrain insofar as SEQRA is concerned, although the need for, and content of, an EIS or EAF will be highly case specific. Co-location of hydrogen fueling at a pre-existing fleet garage or refueling station will result in a different set of environmental issues than development of a hydrogen refueling station on a green-field site and, depending upon the precise scope, scale, and nature of the project, a more thorough environmental review may be required. The project will have to be reviewed in light of the criteria set forth in 6 NYCRR Part 617.7(c), particularly the two that are most relevant to the unique energy, environmental, and public health issues posed by a hydrogen infrastructure project, namely, if the agency approval of the project will constitute:

- a major change in the use of either the quantity or type of energy (See 6 NYCRR Part 617.7(c)(1)(vi); or
- the creation of a hazard to human health (See 6 NYCRR Part 617.7(c)(1)(vii).

If the risk of at least one significant adverse effect is present, an EIS must be prepared. The EIS will have to document the full range of the potential environmental impacts at a level of detail that reflects the severity of the impacts and the reasonable likelihood of their occurrence. This may include, but not be limited to, such diverse issues as:

- the risk of explosion accompanying on-site storage of hydrogen;
- surface disturbance resulting from placement of underground storage tanks;
- visual impacts;
- increased traffic to and from the refueling station.

Additionally, the EIS must address any mitigation measures considered appropriate to mitigate the environmental impact, and the range of reasonable alternatives to the proposed action, including a "no action" alternative. It is important to note that SEQRA mandates the *procedures* that must be undertaken by government agencies in reviewing environmental effects – it does not mandate specific *outcomes*. As the statute provides:

When an agency decides to carry out or approve an action that has been the subject of an environmental statement, it shall make an explicit finding that the requirements of the section have been met and that, consistent with social, economic, and other essential considerations, to the maximum extent practicable, adverse environmental effects revealed in the environmental impact statement process will be minimized or avoided.

The SEQRA leaves how to appropriately balance economic and environmental questions to agency discretion, “if the agency has followed all necessary procedures and made a formal finding as to the reasons for its decision.”<sup>40</sup>

### **Section 3.2.4 – Key Findings and Recommendations – New York State and New York City Code Administration**

As a practical matter, this framework of local code administration, state statutory and administrative leadership and federal coordination and research provides a complete framework that, if administered effectively, can serve the emergence of these new hydrogen energy technologies in New York State.

In the case of New York State, the framework appears to be a solid one, well coordinated with the ICC model codes and the supporting research and code development underway at the national and international level. The NYS DOS DCEA estimates the new ICC based code system is likely to be integrated into New York State’s Uniform Code within a year. The biggest problem for New York State is likely to be meeting the challenge of educating all the involved local code officials in the 1,447 cities, towns, and villages throughout New York State. The NYS DOS DCEA has an education program in place to address this challenge, but the resources are not yet committed to hydrogen related code and technology education.

In the case of New York City, the city has made a policy commitment to link up with the ICC model code framework, but the process of making this happen, especially for new hydrogen fueling station technology, appears to be a long way from implementation. Considering the risks and challenges of locating new technology in New York City, one of the most densely settled places in the world, the difficulty of implementing these changes is easy to understand but important to address.

#### **3.2.4.1 Implementation of the International Code Council model code framework improves treatment of hydrogen technology by local codes in New York State.**

The treatment of hydrogen technologies by local building and fire safety codes will be significantly strengthened by the recent decisions to transition from the established code framework to a new code framework based on the International Code Council (ICC) model code framework.

- The Uniform Code includes provisions recently added to the ICC model code to address hydrogen fuel cells, hydrogen fueling stations, and other gaseous hydrogen system facilities (see Section 4.2 below).
  - New York State administrative process implementing this change started in March 2005 and probably will be completed in 2006. A new State

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<sup>40</sup> See Gerrard, Municipal Powers Under SEQRA, 1997 New York State Bar Journal.

Uniform Fire Prevention and Building Code was proposed by a vote of the State Building Code Council and released for public comment in March 2005. This administrative process may result in the final adoption of the new Uniform Code in 2006.

- By an Executive Order of the Office of the Mayor in cooperation with the City Council's Housing and Buildings Committee, a special Commission was formed in November 2002 to study the feasibility of adopting a model building code in New York City. In May 2003, Mayor Michael R. Bloomberg accepted the Commission's recommendation of adopting the International Building Code, with modifications to address New York City's needs. Work on this transition is underway but no specific replacement code has yet been formulated. New York City has adopted changes to the plumbing code and seeks to complete changes in the rest of the building code which may take effect in 2007 or soon thereafter.<sup>41</sup> The existing code remains in effect until a new ICC based building code is enacted.
- Not long after announcing plans to revise the Building Code, New York City announced plans to review the fire code. The Fire Department is reviewing and revising the International Fire Code (IFC) for New York City, aiming to eventually present a modified IFC for adoption by City government. A schedule for completing this has not been announced. The existing New York City fire code will remain in effect until a new ICC base fire code is enacted.<sup>42</sup>
- The decisions to link local building and fire safety codes to the ICC model code framework enables New York State to tap the very large national and international research and engineering design effort underway to define the most effective ways to address real safety risks and to standardize code compliance practice.

➤ Recommendation

- Publically endorse publicly the decisions by the New York City Council and the New York State Building Code Council to reform local building and fire safety codes to implement the ICC system of model building and fire safety. The progress toward addressing the New York City fire code is difficult to observe and should be monitored. It may be appropriate for NYSERDA to examine ways to support and encourage New York City progress with fire code revisions.

3.2.4.2 An effective hydrogen safety education program for public officials may significantly reduce barriers to hydrogen technology deployment caused by public distrust of hydrogen technology.

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41 See: <http://home2.nyc.gov/html/dob/html/model/ibc.shtml>

42 The Council of the City of New York. Committee on Fire & Criminal Justice Services. "Oversight: Modernizing the Fire Code." December 6, 2004. and interview of James Hansen, Director of Code Revision, New York City Fire Department, May 10, 2005.

Code official education is extremely important when new technologies involving new building and fire safety issues are introduced. Because code compliance responsibility is dispersed widely, potentially involving thousands of officials across New York State, it is extremely important that these code officials and other public officials responsible for overseeing local code enforcement have access to information they can trust on appropriate ways to ensure public safety.

The effective administration of building and fire safety codes requires that those with enforcement responsibility have access to technical information and training to support their work. Because hydrogen technology is new and not widely understood the siting of new hydrogen facilities in local communities may encounter public apprehension about the risks such facilities pose for the community. On such occasions, elected officials may be drawn into public debates with code officials over hydrogen project proposals. Local public discussions around plans to site hydrogen technology facilities will be improved, if local officials have ready access to training and to objective information explaining the unique properties of hydrogen, how hydrogen can be safely use, and the safety characteristics of the technologies using hydrogen as a fuel.

Code officials appropriately approach the unknown cautiously, acting carefully to ensure their permits will adequately protect public safety. Nonetheless, taken to the extreme, such caution may slow the permit review process and impose excessively stringent safety requirements, slowing the deployment of new technology applications, such as the ones considered here.

National and international programs to develop appropriate risk management strategies for new technologies may have limited benefits unless the resulting knowledge reaches the local officials responsible for evaluating project code compliance.

Administering new code provisions relating to new hydrogen fuel cell and hydrogen fueling station facilities will require education, and effective communication with the code officials across New York State who may address code compliance for such new facilities.

New York State Department of State and New York City Department of Buildings officials responsible for administration of codes and their application to new hydrogen fuel technology applications place a high priority on the need to educate officials responsible for issuing building and fire safety permits pursuant to City and State code regulations.

The New York Department of State has a well-developed code official training program designed to keep code officials up to date on code issues and new provisions in the Uniform Code. This education program can address the new Uniform Code as well as the requirements of new technologies. Resources for

training are limited and must address a wide range of pressing code administration issues.

➤ Recommendations

- New York State code officials should be sufficiently trained to understand the unique properties of hydrogen, how it can be safely used, and the safety characteristics of the technologies using hydrogen as a fuel.
- New York State and New York City should develop the means to educate local code officials on emerging hydrogen technologies and to provide training to code officials on how to effectively evaluate such applications for code compliance.
- New York’s hydrogen technology industry needs to be fully engaged, not only in the codes and standards deliberations, but also in the outreach programs to educate the code officials, first responders, and general public.
- New York State should immediately develop and implement a continuing hydrogen technology-training program for code officials throughout the state to address the application of best practices for building and fire safety code enforcement.

3.2.4.3 New York City faces difficult code development, enforcement, and administration challenges that pose large potential barriers to deploying hydrogen technology.

New York City is the nation’s largest and most densely settled urban environment. The urban geography of New York City exposes great numbers of people and high value building and city infrastructure (streets, water supply, communication, power, and transportation systems) to the risks of fire and explosions. Public officials responsible for defining building and fire safety codes and enforcing such codes necessarily reflect appropriate caution when modifying codes to address new technology, especially hydrogen technology with its fire and safety risks.

Although New York City has committed to a transition from the existing, locally developed, building and fire safety codes to a new code framework based on the ICC model codes, this transition is progressing slowly. No implementation date is yet in sight, although scores of people are at work on addressing the changes needed to accomplish the switch to the new ICC framework.

Responsibility for administering and enforcing building and fire safety codes in New York City is distributed between the New York City Department of Buildings and the New York City Fire Department. Other City agencies may contact the DOB and the FDNY for guidance when planning their own facilities.

- The New York City Fire Department has responsibility for the design and administration of the New York City Fire Safety Code.
- The New York City DOB has responsibility for the administration and enforcement of the New York City Building Code and Zoning Resolution.

- State agencies, independent state authorities, and federal agencies have the authority to design and construct their facilities within New York City to state or federal standards without consulting with City code officials.<sup>43</sup>
- Despite the accumulating experience with hydrogen fuel cell siting and construction within New York City, there appears to be no single place where a project developer or a code official can go to find out how code issues have been addressed by the different entities (e.g., NY City Department of Buildings and other City agencies, as well as State entities, such as the New York Power Authority) that have separately addressed code compliance for hydrogen fuel cell installations.
- During the period this study has been underway, the DOB has taken steps to communicate how to navigate the code compliance process. The DOB Internet web site now offers information briefs on permit application and MEA administration, which important steps toward making code compliance easier to address.

The New York City Building Code and the NYS Fire Code do not yet include provisions addressing the design and installation of stationary hydrogen fuel cells or hydrogen fueling stations. Hydrogen fuel cells are required to follow the City's Material Equipment and Acceptance (MEA) review process.

- Separate Borough offices and City agencies administer MEA approval independently.

The New York City Fire Department has decided to postpone indefinitely changes in the New York City Fire Code needed to address the installation of compressed hydrogen storage, which is a key component of a hydrogen fuel station.

- Until this omission is addressed it will not be possible to obtain approval from the New York City Fire Department for the construction of a hydrogen fueling station in New York City.
- This poses a major barrier to the deployment of hydrogen refueling station facilities anywhere in New York City, New York State's largest commercial center.

- Recommendations addressing existing barriers to hydrogen technology deployment in New York City:
  - Develop a process within the system of Building and Fire Code administration in New York City to ensure that similar hydrogen technologies are treated similarly among agencies handling code enforcement and issuing building and fire safety permits. Suggestions for specific steps to include in such a process are:
    - Develop a publically available list of all New York City sited hydrogen projects that are approved or in process, organized by application (refueling station/stationary power), permitting authority, and borough location. The availability of such a list may

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<sup>43</sup> Section 3.2.1.1 *supra* addresses the “balancing of public interest” called for by the NY State of Court of Appeals decision in Matter of County of Monroe v. City of Rochester. (footnote 23)

give the other reviewers contacts to discuss how to proceed with permit approvals, conditions, or rejections.

- Develop a uniform compliance practice for each hydrogen technology application that may be adopted by the diverse agencies responsible for code enforcement in New York City. For example, the Port Authority should not grant permits under one set of rules, while the NY City Department of Buildings is developing its own guidelines.
  - Agencies, such as a Borough Office of the Department of Buildings, should not grant permits for fuel cells without the knowledge and consent of the central office. Take steps to improve communications, sharing of data, and consistency among project evaluation processes of different agencies in NY City.
- Develop fire safety codes and standards for facilities dispensing hydrogen fuel in New York City. No such facilities may be developed for any location in New York City until the Fire Department develops the appropriate codes and standards. The absence of such fire safety codes and standards is a major impediment to the development of a delivery network within the City.

## Section 4 – The Code Framework

### Section 4.1 -- Focus

As explained earlier, this report focuses on the two most promising applications for using hydrogen: the stationary fuel cell for distributed generation and the hydrogen refueling station for transportation vehicles.

In the case of the stationary fuel cell electric generators, this assessment of the application of building and fire safety codes addresses the components that involve the processing of hydrogen, i.e., the fuel processor and the fuel cell stack. The inverter, an electronic component that converts the electric output from the fuel cell stack from direct current (DC) to alternating current (AC), is not addressed here because it does not involve any processes or other attributes uniquely connected with hydrogen-based technology. Diagram 4 shows these boundaries.

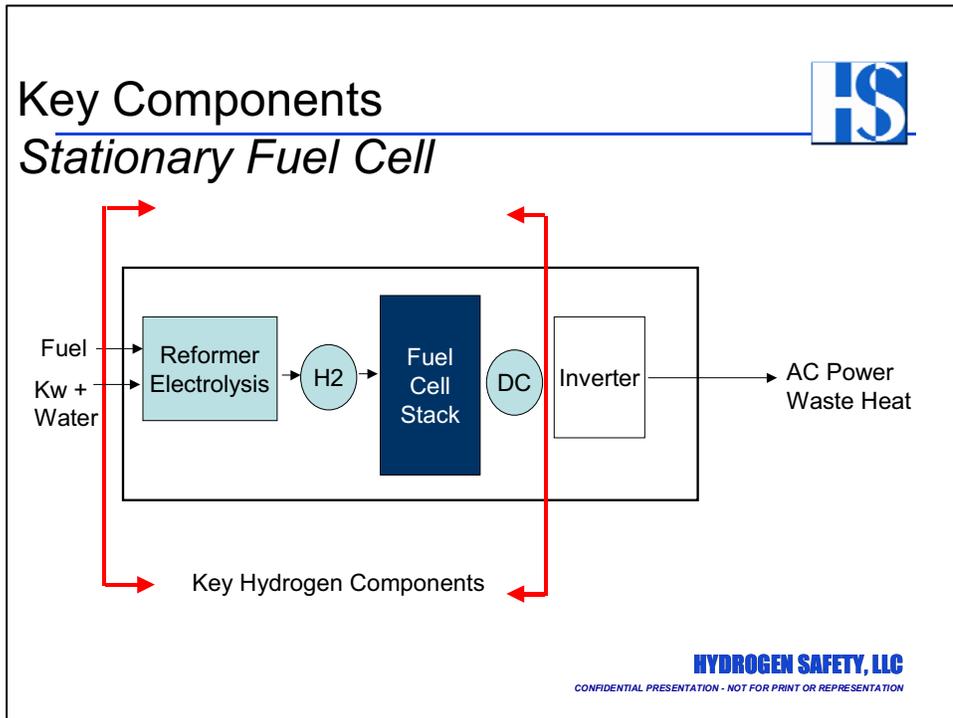


DIAGRAM 4  
Key Components of a  
Stationary Hydrogen Fuel Cell Addressed by this Study

In the case of hydrogen refueling stations, this assessment of the application of building and fire safety codes addresses the components of the stationery facility that involve the storage, compression and dispensing of hydrogen. This study does not address the transportation vehicles into which hydrogen will be dispensed from such a facility. Vehicle design and safety is the subject of national and international transportation codes and standards, not the subject of local building and fire safety codes over which New York has jurisdiction. Diagram 5 shows these boundaries.

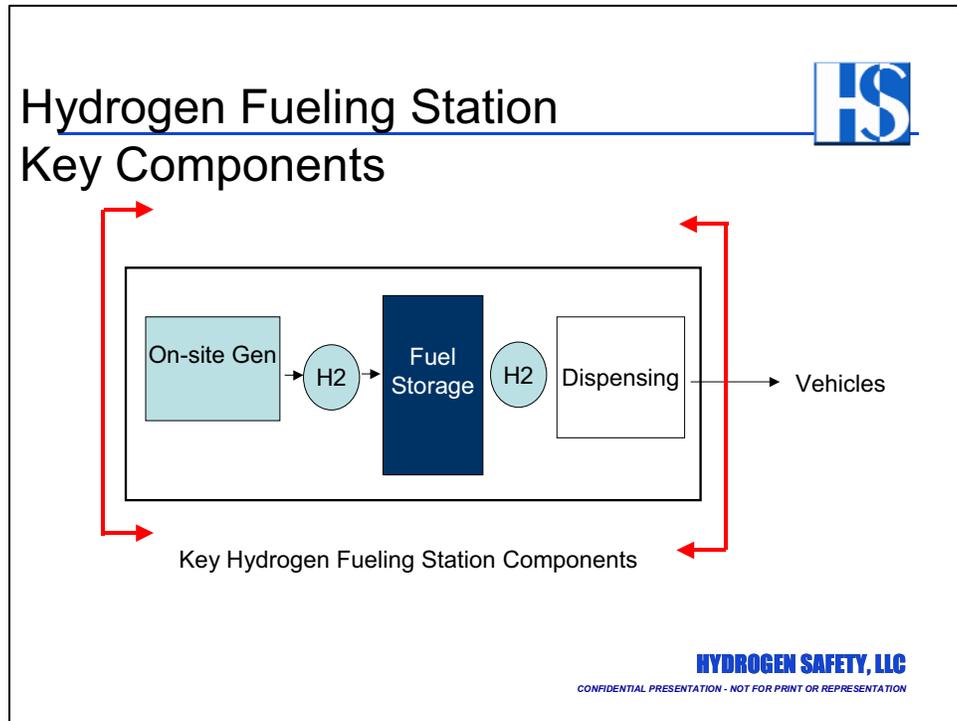


Diagram 5  
Key Components of a  
Hydrogen Fueling Station for Transportation Vehicles Addressed by this Study

## Section 4.2 -- A Matrix of Applicable Building, Fire and Electric Codes

### Section 4.2.1 The Code Matrix Tool

There are many state, federal, international, industry associations, and private companies working on developing a set of cohesive and consistent codes and standard for hydrogen. This is an enormous task, since there are at least forty-eight (48) separate codes and standards from eight (8) or more standards associations. To makes matters more confusing, as reported in this study, the ICC and NFPA are developing hydrogen standards that are designed as “all encompassing” guidelines, yet, these guidelines, in turn, reference other codes and standards for specific components and applications. The ICC and NFPA, with the National Hydrogen Association, have formed the Hydrogen

Industry Panel on Codes (HIPCO) to harmonize requirements in ICC and NFPA model codes and to coordinate future code development.

**Appendix A-1** to this report sets forth a comprehensive matrix of codes and standards for the stationary fuel cell and hydrogen fueling station technologies. This matrix shows how codes and standards address the technology components of each of these two hydrogen applications.

The matrices are organized by application. The diagram at the beginning defines the study's scope boundary, showing what technology components are addressed. Horizontal column headings list the major technology components that involve the use of hydrogen in some manner. The matrix row headings set forth relevant codes and standards. The codes and standards are assigned to categories of importance and relevance to indicate their relative impact on hydrogen issues, i.e.,

- Codes & Standards of primary importance (shown in *New Times Roman Bold Italics* font)
- Codes & Standards of secondary importance (shown in *New Times Roman Italics* font)
- Codes & Standards for informational purposes (shown in New Times Roman font)
- Codes & Standards with tangential impacts (shown in Franklin Gothic Book font)

**Appendix A-2** supports the matrix in Appendix A-1, providing a brief explanation of each code and standard addressed in the matrix

Of primary importance are those codes and standards that directly influence the design and use of hydrogen. This is contrasted to those of secondary importance, which should be prudently considered because of their possible impact but are not deemed to have significant or primary importance.

The “X” in each column indicates that the specific code and standard has some bearing upon the component under which it is listed. For example the ICC Fire Code specifically defines the minimum separation distances for gaseous hydrogen from various situations, which is critical in designing a project's equipment arrangement. Similarly, piping designers need to consider CGA's G 5.4 “Standard for Hydrogen Piping at Sites.”

### **Section 4.2.2 ICC vs. NFPA**

Both organizations are concerned with safety issues but use different approaches. An effective code framework would ideally be based on a single authoritative source for assessing the safe installation of a project involved with hydrogen. The two major CDOs, the ICC and the NFPA, are competing for code preeminence. Both have similar missions to serve the public at large regarding safety issues. The ICC framework has been adopted as a model for the New York State Uniform Fire Prevention and Building Code and the New York City Building and Fire Codes. Nevertheless, the NFPA code framework remains influential and is likely to affect the way codes are defined in New York.

The following subsections briefly explain the similarities and differences in the ICC and NFPA frameworks. These code systems will be the foundation for codes applicable to emerging hydrogen technologies, such as the fuel cell and fueling station technologies this report addresses.

#### 4.2.2.1 International Code Council (ICC)

The ICC was established in 1994 as a nonprofit organization dedicated to developing a single set of comprehensive and coordinated national model construction codes. The founders of the ICC are Building Officials and Code Administrators International, Inc. (BOCA), International Conference of Building Officials (ICBO), and Southern Building Code Congress International, Inc. (SBCCI). Since the early part of the last century, these nonprofit organizations developed the three separate sets of model codes used throughout the United States. Although regional code development has been effective and responsive to our country's needs, the time came for a single set of codes. The nation's three model code groups responded by creating the ICC and by developing a uniform system of codes that could be applied in all regions.

#### Purpose of the ICC

There are substantial advantages in combining the efforts of the existing code organizations to produce a single set of codes. Code enforcement officials, architects, engineers, designers and contractors can now work with a consistent set of requirements throughout the United States. Manufacturers can put their efforts into research and development rather than designing to three different sets of standards, and they can focus on being more competitive in worldwide markets. Uniform education and certification programs can be used internationally. A single set of codes may encourage states and localities that currently write their own codes or amend the model codes to begin adopting the International Codes without technical amendments. This uniform adoption would lead to consistent code enforcement and higher quality construction. The code organizations can now direct their collective energies toward wider code adoption, better code enforcement, and enhanced membership services. All issues and concerns of a regulatory nature now have a single forum for discussion, consideration, and resolution. Whether the concern is disaster mitigation, energy conservation, accessibility, innovative technology, or fire protection, the ICC provides a single forum for national and international attention and focus to address these concerns.

#### ICC Publications

- The ICC has developed and made available an impressive inventory of International Codes that are comprehensive and coordinated with each other to provide the appropriate package for adoption and use. Among the family of ICC codes, those pertinent to hydrogen are the International Building Code, International Fire Code, International Electric Code, International Mechanical Code, and the International Fuel Gas Code.

## ICC Code Development

Any interested individual or group may submit a code change proposal and participate in the proceedings in which it and all other proposals are considered. This open debate and broad participation before a committee comprised of representatives from across the construction industry, including code regulators and construction industry representatives, ensures a consensus in the construction community in the decision making process. A major advantage of the ICC's consensus-based private-sector code development process is that it allows both the ICC code development committees and eligible voting members at the code change hearings to participate in establishing the results of each proposal. Voting members may either ratify the committee's recommendations or make their own recommendation. The results of all votes are published in the report of the ICC code development hearings.

Eligible voting members of each of the three model code groups review the recommendations of the ICC code development committee at their annual conference and determine the final action. Following consideration of all public comments, eligible voters are individually polled on each proposal. The final action is based on the aggregate count of all votes cast. This important process ensures that the International Codes will reflect the latest technical advances and address the concerns of those throughout the industry in a fair and equitable manner.

### 4.2.2.2 National Fire Protection Association (NFPA)

The mission of the international nonprofit NFPA is to reduce the worldwide burden of fire and other hazards on the quality of life by providing and advocating scientifically-based consensus codes and standards, research, training, and education. NFPA is an international nonprofit membership organization founded in 1896 as the National Fire Protection Association. Today, it has more than 75,000 members representing nearly 100 nations and 320 employees around the world. In fact, NFPA's 300 codes and standards influence every building, process, service, design, and installation in the United States, as well as many of those used in other countries.

#### Commitment to consensus

NFPA codes and standards have helped save lives and protect property around the world. The volunteers and staff of NFPA are dedicated to the single mission of continually enhancing public safety. That dedication can be seen in the codes and standards that are adopted – documents developed through NFPA's commitment to creating a true consensus among those interested in safety.

NFPA encourages the broadest possible participation in code development. The process is driven by more than 6,000 volunteers from diverse professional backgrounds who serve on 230 technical code standards development committees. Throughout the entire process, interested parties are encouraged to provide NFPA technical committees with input. All NFPA members then have the opportunity to vote on proposed and

revised codes and standards. NFPA's focus on consensus has helped the association's code-development process earn accreditation from the American National Standards Institute (ANSI).

NFPA 70 – National Electric Code is one of the NFPA’s more widely used standards. It sets the requirements for the design and installations of all electrical devices in numerous applications ranging from residential homes to power utilities.

### NFPA's Role in the World of Codes and Standards

NFPA is a consensus standard, code, or guideline, depending on the designation given by the Standards Council at the time the project is authorized. A committee is formed by advertisement in the monthly NFPA newsletter. It must contain a balance representation of Manufacturer [M], Special Expert [SE], Installer/Maintainer [IM], User [U], Insurance [I], Consumer [C], Enforcer [E], Labor [L], and Research/Testing [RT]. Usually there is a federal representative assigned to define and represent the federal government's interests.

A NFPA staff liaison who has background in the committee's intent is assigned. The Standards Council defines the scope of work for the committee, stating that the committee will have primary responsibility for any code, standard, or guide. The committee then works through a two to three-year peer review process, which is open to the general public. At this stage in the review process, the resulting code is referred to as a "Model Code" that can be then adopted by state legislatures. Nevertheless, many states may continue to work with prior versions of the code, not the newest Model Code.

### Section 4.2.3 Summary of Applicable Codes

As a further guide to better understand the relevance of each of the codes and standards, a brief description of each is provided in **Appendix A-2**. Although the codes and standards may address other issues besides hydrogen, its importance to hydrogen specifics are described in Appendix A-2 under “H2 Issues Addressed.” The intention is to focus the attention upon the critical applications for hydrogen use.

### Section 4.2.4 - Practical Use Of Codes and Standards

The following summarizes generally the key features of the risks and related design requirements codes and standard address for hydrogen facilities.

Considering all the possible codes and standards that can apply to various processes and equipment is, as practical matter, quite difficult. The insurance industry uses the acronym *COSPE* as a framework to assess the risk exposures. Project developers and bank engineers providing due diligence project assessments follow a similar analysis. We use this framework here to summarize the major considerations codes and standards address for hydrogen facilities, including stationary fuel cell facilities and hydrogen fueling stations.

For the two applications being considered in this study, the following identifies the major code issues for hydrogen using the *COSPE* framework.

**C = Construction**

Construction of any building is important in terms of its fire rating. Because hydrogen is lighter than air, it is desirable to avoid any pocketing of hydrogen in roof areas. Accordingly, the design of roofs and cabinet enclosures is important. Sufficient natural and/or mechanical ventilation are a primary concern.

Materials used for piping, valve, welds, etc must be suitable for hydrogen. Properly designed electrical systems are required to avoid possible ignition sources.

**O = Occupancy**

For most DG sites, the fuel cell power plant is unmanned and remotely monitored. When abnormalities materialize, the system typically shuts itself down safely or adjustments are made through the control systems. If the incident requires one, a maintenance service call is made to correct the situation. In general, therefore, personnel are not directly exposed to any risks from the use of hydrogen.

Hydrogen fueling stations, by the very nature of its intended operation, expose people to hydrogen risks. This element of public interface distinguishes hydrogen fueling stations from hydrogen storage and distribution applications that are “inside the fence” at commercial and industrial hydrogen storage facilities, where the people exposed to facility risks are under the direct control of hydrogen gas suppliers and traditional industrial users. Trained personnel are needed on site all of the time, 24 hours a day, seven days a week.

**S = Special Hazards**

The special hazards associated with hydrogen involve the potential for fires and explosions under certain adverse conditions.

For the refueling station application, the hydrogen storage infrastructure represents a major hazard because of the quantity of energy stored, possible vulnerability to weather events, and deliberate efforts to damage or destroy the facility, such as terrorism and sabotage.

The fact that a hydrogen flame is invisible makes it difficult to detect, without an ultra-violet (UV) scan device. It is, therefore, difficult to warn people of its presence. Leaks during the refueling process – dispensed to vehicles – could have effects not visible to the naked eye, and therefore they are not detectable without special equipment.

Because hydrogen has a low energy density, it typically is pressurized in storage facilities and vehicles carrying hydrogen fuel. The operating pressures to fill a vehicle with hydrogen are typically in excess of 3000 psig and as high as 5000 psig. These high storage pressures represent another hazard. These high pressures may

also affect the compressor design and operations because such pressures increase the potential for compressor leaks.

Fuel cells for DG facilities operate at much lower pressures (50 psig to 200 psig) because the hydrogen fuel typically is produced on site (i.e., by electrolysis or a hydrogen reformer).

***P*** = Protection

Various codes recommend various protection schemes. For example, both the ICC and NFPA have tables that recommend separation distances from the hydrogen source to various objects based upon hydrogen quantities. There are a litany of other devices and design features such as adequate ventilation, hydrogen sensors/detectors, and fire suppression systems. Proper training of operating and maintenance personnel is also essential as is a comprehensive emergency plan that is kept current.

***E*** = Exposures

The principal exposure is public safety and welfare. Codes and standards are concerned about those who may be directly involved at the site but also those who may become involved as a consequence of an accidental release of a hydrogen cloud or consequential damages from a fire or explosion. Because hydrogen is often stored and transported at very low temperatures, in a liquid state, the risks of exposure to hydrogen also include severe frostbite.

Although there are risk factors attributed to the physical and chemical characteristics that make hydrogen unique, they are essentially controllable with proper awareness and design. The purposes of the codes and standards are to define the guidelines for proper design, operations, and maintenance.

**Section 4.2.5 Case Study of a Distributed Generation Project in New York City**

The design and construction of the Four Times Square Building, which includes a 200 kW fuel cell power plant, provides an example of the process of obtaining the necessary codes and standards in a highly visible location in Manhattan. The following case study details how that project was completed.

**4.2.5.1 Case Study: Siting 200 kW Fuel Cell Power Plants In New York City**

**Background**

This case study describes the five month process undertaken by International Fuel Cells, a division of United Technologies Corporation, now known as ONSI, to obtain a permit to install two fuel cell power plants in a new building being constructed at Four Times Square in Manhattan.

This activity took place between November 1997 and April 1998, and although several of United Technology's fuel cells had been installed in New

York City over the previous twenty-five years, this was the first installation that received the full attention of the NYC DOB. The previous installations were operated by utilities or on industrial sites including:

- Early 1970s – A 40 kW demonstration power plant operated by Brooklyn Union Gas at Kennedy International Airport.
- 1978-1980 – A 4.8 MW power plant at Con Edison's 14<sup>th</sup> Street facility in Manhattan. The power plant successfully demonstrated the production of hydrogen but required a permit from the Fire Department before it could generate power. A local politician made the site a political issue because of the use of hydrogen and the close proximity of a playground and a housing project. The Fire Department ordered additional pressure tests of the power plant's pressure vessels and pressure piping beyond those already conducted according to the ASME Boiler and Pressure Vessel Code and ASME B31.1 Power Piping Code. Water used in this testing, and not fully drained, froze in the piping, causing damage and essentially ended the project. A sister power plant was installed in Tokyo and ran successfully for many years.
- 1992 – A 200 kW commercial power plant (PC25A) operated by Brooklyn Union Gas at a hospital on Staten Island. The power plant provided electricity for the general hospital load and waste heat for its laundry.
- 1996 – Two 200 kW commercial power plants (PC25C) operated at a Sun Chemical facility on Staten Island.

### Introduction

Two PC25C 200 kW fuel cell power plants were to be installed in a new 48-story office tower being developed by the Durst Group. The site at Four Times Square, known today as the Conde Nest Building, was advertised as a "Green Building" using the latest in environmental friendly technologies.

The two power plants were to be located in a fourth floor mechanical room and could provide enough electricity to cover the building's base load during night time hours. (Eventually they were used to power the building's exterior neon signs. In the event of a "black out", the NASDAQ sign would continue to operate.)

These power plants were approved by an independent testing agency, the American Gas Association Laboratories, as safe. That approval process included:

1. Approval of design
2. Selection of components
3. Witnessing of tests
4. Demonstration of safety features
5. Review of Operating and Maintenance Manuals

## 6. Review of Quality Program

### Permit

Because the power plants were a new product, they required a Material, Equipment & Acceptance (MEA) number from the DOB before they could be sited in a commercial building. This was pursuant to the City of New York, DOB Administrative Code Section 27-131. This process required three approvals including the DOB's Material and Equipment Division, the Bureau of Fire Prevention, and the Bureau of Electrical Control.

Two approvals were possible. 1. An MEA number that would be applicable for all New York City site installations. 2. A "J" number designation that was specific to that site only. The MEA approval from the three involved city agencies took from two weeks to three months to complete. The process involved responding to detailed questions from agency personnel involved in the review of the MEA submission and face-to-face meetings to provide further detail.

Along with the acceptance to install, came the following stipulations:

- Installation and use shall meet all conditions and limitations of the Bureau of Electrical Control Advisory Board approval dated January 28, 1998.
- All requirements of American Gas Association laboratories Appliance Certificate #C2551002, Standard AGA 8-90, shall be adhered to with reference to construction, performance, and quality assurance.
- Installation and use of the unit, including fluid system and electrical interfaces, shall comply with all requirements of the NYC Building Code and all other agencies having jurisdiction.
- Under no circumstances shall the unit be allowed as the sole source of power to a building, based, in part, upon documented operating histories submitted in support of this MEA application.
- In accordance with DOB PPN#1/96, the unit shall not be used to supply emergency power to fire safety devices.
- The conventional building electric supply shall be designed in such a manner as to be sufficient to handle all building loads without the PC25C.
- The unit shall be installed in such a manner that in the event of PC25C shutdown, conventional utility power shall instantaneously and automatically pick up all building electric loads.
- Under no circumstances shall the unit be installed to supplement an existing conventional electric service that has, over the course of time, become insufficient to meet the building's normal (non-emergency) power requirements.
- In the event of a fire emergency in the building, it may become necessary to shut down electric power to the building via the main utility disconnect. A disconnect for the PC25c shall be provided in a

manner and location acceptable to the Department of Buildings and the Fire Department.

- In the event of a fire emergency in the building, it may be necessary to shut down the natural gas supply to the building. Means shall be provided to shut down the natural gas supply to the PC25C in a manner and location acceptable to the Department of Buildings and the Fire Department.
- All manufacturer's recommendations regarding site preparation, installation, plumbing requirements and interface connections, electrical requirements and interface connections, as described in the Installation Manual, shall be strictly adhered to.
- Manufacturer's routine scheduled maintenance requirements shall be strictly adhered to.
- Protection functions, as described in PC25C Installation Manual, Section B.2.7., shall be tested during routine scheduled maintenance annual two-day shutdown.
- The following Electrical/Motor Compartment safety features shall be checked during the routine scheduled annual two-day shutdown: ventilation air fan, flow verification and alarm, smoke detector, thermal fuses used for fire detection.
- The following Fuel Compartment safety features shall be checked during scheduled maintenance annual two-day shutdown: ventilation fan, thermal fuses used for fire detection.
- Safety valves installed in the following systems shall be checked during routine scheduled maintenance annual two-day shutdown: cell stack cooling water loop, ancillary loop, and nitrogen system.

## Prologue

The following codes and standards activities have occurred since this case study, which should make the siting of current fuel cell power plants easier.

- Fuel Cell Standard  
During this process, the document that AGA Labs used to test these power plants was an internal document: AGA Requirement for Fuel Cell Power Plants, No. 8-90. On June 9, 1998, the American National Standards Institute (ANSI) approved the first edition of the American National Standard for Fuel Cell Power Plants as ANSI Z21.83. On January 20, 2004, a new edition of the American National Standard/ CSA America Standard For Stationary Fuel Cell Power Plants was approved by ANSI as ANSI/CSA America FC 1-2004. (CSA America – formerly American Gas Association Laboratories)
- Fuel Cell Installation Standard  
During this process, there was no standard for installing fuel cell power plants. On August 18, 2000, the NFPA published Standard for the Installation of Stationary Fuel Cell Power Plants, and it was

approved by ANSI as ANSI/NFPA 853. This standard was for power plants above 50 kW. In 2003, the standard was updated to include power plants below 50 kW.

- Emergency Power  
In 1999, the NFPA Standard for Emergency and Standby Power Systems, NFPA 110, was amended to allow fuel cells to be used as part of emergency power systems.
- Electrical Interface  
The 1992 edition of the National Electrical Code, NFPA 70, includes a new section, Article 692 Fuel Cell Systems, which deals with the electrical installation of fuel cell power plants. The 2005 edition of the National Electric Code introduces a new section, 700.12(E), allowing the use of Fuel Cells for Emergency Systems. It should be noted that the 2007 edition of the NY City Electrical Code will not allow the use of fuel cells for Emergency Systems.<sup>44</sup>
- National Building Codes  
The National Building Codes published by the ICC provide local building inspectors with instructions on which standards should be invoked: The 2000 edition of the ICC National Building Codes reference ANSI Z21.83 for fuel cell power plants, and the 2003 edition references ANSI NFPA 853 for installing fuel cell power plants.

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<sup>44</sup> The reasons that the Fuel Cells are not acceptable (yet) for Emergency Systems in NY City are (1) Section 700.12(E) of the NEC allows a minimum of 2 hours operation capability. In NY City, power devices that supply Emergency Systems are required to have a minimum of 6 hours operation capability. (2) The Fuel Cells used so far, are connected to a natural gas line. This type of fuel source has proven to be unreliable during emergency situations. (3) There is no additional storage of fuel available. (4) Fuel Cells do not have a quick start up, required by Emergency Systems. They usually need about 10-15 min to get the reformer going, and that requires a 3rd source of electric power. So, for now, Fuel Cells can be used as regular sources of power, but not for emergency systems.

## **Section 5 – Summary of Conclusions and Recommendations**

The project team set out to assess how New York's system of building and fire safety codes may affect the deployment of hydrogen technologies in New York State. The work first aimed to identify needed changes in the system of codes of standards in New York State and then to consider what changes may be needed in specific codes and standards and/or the process of administering building and fire safety codes. The report focused on two types of hydrogen technology: stationary hydrogen fuel cells and hydrogen fueling stations.

The Project team examined work underway in the federal government and internationally and then investigated codes and standards in effect throughout New York State, including the special situation in New York City, the one municipality in this State with sole responsibility for developing and administering its own codes. Section 3 describes the results of this work. Section 4 summarizes how building and fire safety code framework applies to the hydrogen technologies. Section 5 summarizes specific findings and recommendations developed in previous sections, providing an overview of the conclusions of this report with the supporting findings and recommended actions related to these findings.

### **5.1 Implementation of ICC Model Code Framework**

In general, two sets of building fire safety codes and standards apply in New York, one for all areas of New York State except New York City and one for New York City specifically. This report addressed New York State framework of codes and standards in Section 3.2.1 and the New York City framework in Section 3.2.2. At the moment this report is being written, both New York State and New York City have committed to replacing the codes and standards that have been developed over several decades by New York State and New York City, separately, to codes and standards that reflect the International Codes Council (ICC) model codes and standards. New York State expects to complete the transition to ICC framework sometime in 2006. New York City, although committed to such a change, offers no estimate of when this transition will be achieved and the new process will be complete. The change will benefit installation and use of hydrogen technology in New York State because there is extensive work underway nationally and internationally to make sure that the ICC model codes effectively address hydrogen technologies. This work is supported by large resource commitments by the US DOE, commitments that derive from this nation's energy policy.

The commitments by New York State and New York City to adopt the ICC model code framework are important. When fulfilled, these commitments will serve the goal of providing an effective system of codes and standards that addresses both the needs to protect public health and safety and to ensure a regulatory environment conducive to the deployment of emerging new hydrogen fueled technologies throughout New York State. It is important that the transition already underway be completed as quickly as possible to remove the uncertainty about what criteria and permit conditions will be applied to

proposals to deploy hydrogen fuel cells, hydrogen fueling stations, and other hydrogen technologies. New York State has nearly completed the regulatory changes that will accomplish the transition. New York City appears to be a long way from completing this important work.

**Accordingly, the first major conclusion and recommendation of this study is:**

**Support the transition to the ICC model code framework throughout New York State.**

The first critical step is for New York City and New York State to move expeditiously to implement the ICC framework. It is important that New York City and New York State commit resources needed to sustain an effective and ongoing relationship with the codes and standards development organizations that continue to assess changes needed to effectively address the safe deployment of existing and new hydrogen technologies. The national and international work can relieve New York State of the burden of developing its own hydrogen technology related codes and standards. There are opportunities to make a substantive impact on codes and standards, but only if New York State and New York City each are able to observe progress and contribute information identifying New York's specific needs or concerns that the continuing development of codes and standards should address.

## **5.2 Educating Local Officials about the Role and Real Risks of Hydrogen Technology**

The introduction of new technology poses a challenge to the administration of building and fire safety codes because local building inspectors are called upon to decide whether to allow the installation of such technology and to decide what, if any, conditions should appropriately be included in any building or fire safety permits for such facilities in the absence of a long track record of experience. These challenges are exacerbated if that technology faces public apprehension about the dangers posed by the operation of such facilities. Hydrogen often faces such public concerns.

One of the primary functions of the building and fire safety code law and administration is to provide an orderly process to determine an adequate level of protection for the public. The application of good engineering practice embodied in codes and standards will achieve this. Local code officials are expected to proceed cautiously, making sure that any facility sited in their community is properly designed and constructed before they issue building and operating/occupation permits for such facilities. With new, unfamiliar, and potentially hazardous technology, the building permit and fire safety regulation process may move very slowly. While public safety remains paramount, it must be recognized that protracted permitting processes will potentially inhibit commercial development. To enhance the prospects that permit review will timely fulfill its intended objectives, it is extremely important that local building and fire safety be kept informed of new hydrogen technology for which they may be called upon to issue permits.

New York State recognizes the importance of continuing education for local permit officials. New York State requires that local permit officials seek out and acquire continuing education on the administration of codes and code enforcement. The NYS DOS DCEA maintains a Training Unit dedicated to administering the training requirements and providing certified training opportunities for code officials throughout New York State. Because the Training Unit must address the full gamut of code official responsibilities, the resources available to address hydrogen technology specifically are and will likely remain quite limited. The DOS DCEA training program for Building Officials provides an excellent means to reach code officials with training opportunities, but others must assume responsibility for developing the training materials and events if a continuous hydrogen-training program is to be sustained over time.

**The second major recommendation of this study is:**

**Develop and implement a continuing hydrogen technology training program for code officials throughout New York State, including New York City.**

Ideally, this training will introduce code officials to hydrogen technology in the context of broad state energy policy and address the application of best practices for building and fire safety code enforcement for the hydrogen technologies currently being deployed.

### **5.3 Addressing the Special Needs of New York City**

New York City is unique among communities in New York State. It is more like other great cities in the US and the world, such as Los Angeles and London, than it is like the other large cities in New York. Some parts of New York City are among the most densely populated of any city worldwide.

The scale, complexity, and vulnerability of the supporting communication, transportation, and other urban infrastructure require careful attention when introducing a new potentially hazardous technology such as hydrogen. There is evidence to demonstrate that hydrogen poses quite manageable risks, ones similar to potentially hazardous natural gas and gasoline fuel infrastructure already well integrated into New York City.

The fact that other technologies, some of which may pose greater risks than hydrogen, have been deployed, now fairly routinely, is a testament to the efficacy of the system of building and fire safety codes. The codes work because a great deal of care goes into code design and compliance practice.

Currently, the New York City fire code does not address the siting of hydrogen storage equipment required by hydrogen fueling stations. Until such provisions are established it will not be possible to site hydrogen fueling stations for vehicles within the boundaries of New York City. We recommend that steps be taken to address this

obstacle, drawing upon the resources of federal government efforts as well as NYSERDA.

The New York State Hydrogen Energy Roadmap contemplates a sustained period of introducing new and changing hydrogen technology. Success in these efforts will be made easier if a focused effort is made to assist New York City with the development of new code requirements when needed, to educate the City's code administration officials about the new technologies and best code practice, and to increase coordination and communication among the code officials throughout New York City government who will be addressing these technologies.

This study recommends several steps to improve coordination and communication in New York City regarding the application of codes and standards to new hydrogen facilities in New York City.

**Accordingly, the third, and final, major recommendation of this study is:**

**Call upon New York City to organize a hydrogen codes and standards initiative that will draw upon the Fire Department and the Buildings Department of the City.**

The purpose of this initiative would be to identify and to undertake necessary steps to ensure that hydrogen fuel cell facilities and hydrogen fueling stations can be sited on a timely basis in appropriate locations in New York City. The knowledge and skill of New York City code professionals is among the best anywhere, but they are also burdened by many competing demands. Without a programmatic focus on hydrogen safety, we anticipate that progress will be slow in integrating hydrogen technology in the new system of building and fire safety codes being implemented in New York. There are many different ways to elevate the priority given to hydrogen technology; we defer to New York City officials to decide the steps they know will be effective.

## **5.4 Other Findings and Observations**

In the course of the investigation of how building and fire safety codes and standards addressed hydrogen fuel cells and hydrogen fueling stations, potentially important issues appeared, which, though clearly beyond the scope of this investigation, deserve mention, lest they be ignored and remain untended. We identify two such issues, so that others may decide what, if any, additional steps may be appropriate.

Homeland security concerns may result in rules regarding the transportation of hydrogen over bridges and through tunnels. Such rules may pose barriers to the deployment of hydrogen transportation, a problem for New York City and other major metropolitan areas nationwide. Such issues arise from concerns that bridges and tunnels may be vulnerable to sabotage when hydrogen is transported in large volumes in tanker trucks. The homeland security issues addressed by such issues are handled by programs and authorities entirely separate from the

system of building and fire safety code regulation addressed by this study. This topic requires further study but is beyond the scope of this report.

Local government may need assistance with adapting emergency preparedness plans to address hydrogen related accidents. The information used for the development of building and fire safety codes will support such efforts. This will address how to communicate with the public about risk exposure when hydrogen accidents occur. This will involve preparedness but also will involve the prevention of undue alarm based in unsubstantiated fears about hydrogen risks.

# **Appendix A-1 – Applying Codes and Standards to Hydrogen Technology: A Matrix Tool**







## Appendix A-2 – Interpreting the Matrix Tool in Appendix A-1

### Note:

Each Code Regulation, Standard, is assigned to a category of relative impact on hydrogen issues, corresponding the categories shown in Appendix A-1.

**Primary** Importance (shown in *Times New Roman Bold Italics*)

**Secondary** Importance (shown in *Times New Roman Italics*)

**Informational** (shown Times New Roman)

### A-2 Section 1 – References for Fuel Cell Considerations

#### A-2 Section 1.1 – REGULATIONS

**29 CFR**; OSHA code influences hydrogen practice through how hydrogen is classified as a flammable gas (Part 1910.1000) and through requirements for siting of storage (1910.103), control on processes that use more than 10,000-lbs, training and labeling. (Category = Primary)

**29 CFR 1910.103**: This is the portion of OSHA code that pertains specifically to gaseous and liquid hydrogen systems. Its primary purpose is to codify hydrogen-siting requirements and to call out acceptable practice for storage systems. It is based almost completely upon NFPA 50 A and 50 B, which are referenced. (Category = Primary)

#### A-2 Section 1.2 - CODES

**International Code Council** - The Family of International Codes consists of the following that specifically address hydrogen issues: (Category = Primary)

**International Fire Code-2006** -- This portion of the ICC established minimum regulations for fire prevention and fire protection systems using prescriptive and performance-related provisions. (Category = Primary)

#### H2 Issues Addressed:

Chapter 22, Section 2209 defines the requirements for hydrogen motor-fuel-dispensing facilities and repair garages. Table 2209.3.1 provides a listing of separation distances. Also, venting system requirements are defined. Chapter 30 established the requirements for compressed gas storage in containers, cylinders, tanks, and gas cabinets and for the use and handling of compressed gases. Chapter 25 has a new section under the 2004 Supplement that addresses metal hydride storage systems.

**International Mechanical Code – 2003**-- This portion of the ICC established minimum regulations for mechanical systems using prescriptive and performance-related provisions. (Category = Primary)

H2 Issues Addressed:

Chapter 5, which is also updated by the 2004 Supplement to the International Codes, defines exhaust system requirements, specifically hydrogen limits, in rooms and in cabinets as an acceptable concentration percentage of the total volume. Section 502 defines the ventilation requirements for repair garages, while Section 510 describes the needs for hazardous exhaust systems. Chapter 9, Section 924 talks about the installation and testing of stationary fuel cells.

***Supplement to the International Codes -2004--*** This document identifies all the approved changes to the family of ICC codes that were released in 2003. (Category = Primary)

H2 Issues Addressed:

In addition to the changes noted above, this Supplement also identifies these references to hydrogen:

- ***International Building Code*** – Section 406.5.2.1 – canopies used as weather protection for gaseous hydrogen systems (Category = Primary)
- ***International Electric Code*** – Section 1202.12 – notes that stationary fuel cells power systems having a power output not exceeding 10 MW, shall be tested in accordance with ANSI, CSA, American FCQ and the installed in accordance with the manufacturer’s installation instructions and NFPA 853. (Category = Primary)
- ***International Fire Code*** – Section 2209 – Provides updates on emergency controls, venting, valving, and flow rates. (Category = Primary)
- ***International Fuel Gas Code*** – Section 633 restates the directives for stationary fuel cells as provided in the Electric Code. Chapter 7 provides requirements for inspecting and testing gaseous hydrogen systems. (Category = Primary)

National Fire Protection Association-NFPA 2 – (Hydrogen Technologies). This document, under development, will consolidate NFPA requirements for hydrogen. (Category = Tangential)

*NFPA 70 - 2005 Edition; National Electric Code.* (Category = Secondary)

Issued as an American National Standard on 8/5/04; Revision est. to be 2007. This edition is a NFPA Code.

H2 Issues Addressed:

Electrical classifications that apply to hydrogen as a gas and hydrogen as a liquid are in Chapter 5's special occupancies. Hydrogen is a Class I, Group B material per this code.

Article 250 covers grounding and bonding. The requirements for Class I, Divisions 1 and 2 locations are covered in Articles 500 and 501. Article 504 covers the installations of intrinsically safe apparatus, wiring, and systems. Article 505, zone classification system, is the alternative to division classification systems. Articles 511 through 517 cover occupancies that may be hazardous due to atmospheric concentrations of flammable liquids, gases, or vapors. In Article 692, the requirements of fuel cell power systems include circuit requirements, disconnecting means, wiring, grounding, and marking.

*NFPA 72 - 2002 Edition; National Fire Alarm Code (Category = Secondary)*

Issued as an American National Standard on 7/19/02, this document dates back to 1898. revision is estimated to be completed in 2005. This edition is a NFPA Code.

H2 Issues Addressed:

Requirements for signaling components and signaling systems are covered. The primary function is to provide notification of a fire (hydrogen gas that has ignited), and to provide supervisory and trouble signals, to alert occupants, to summon aid, and to control fire safety functions.

*NFPA 101 - 2006 Edition; Life Safety Code (Category = Secondary)*

Issued as an American National Standard on 1/17/03 19/02. This edition is a NFPA Code.

H2 Issues Addressed:

Hydrogen is a high hazard occupancy and is likely to burn with extreme rapidity. Thus, it requires special provisions in egress, fire protection, interior finishes, and building services.

A-2 Section 1.3 - STANDARDS

*NFPA 55 – 2005 Edition; Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks (Category = Secondary)*

This was issued as an American National Standard on 2/07/05. It incorporates two other documents in Chapters 10 and 11, respectfully, 50A (Gaseous Hydrogen Systems at Consumer Sites) and 50B (Liquefied Hydrogen Systems at Consumer Sites) that have been withdrawn from publication. This edition is a NFPA Standard not a Code. This is a guidance document.

H2 Issues Addressed:

Requirements are on the storage, transfer, location, and use of industrial hydrogen either as a gas or as a liquid. Included are the requirements for the installation of associated storage, piping, and distribution equipment; operating practices; installation of aboveground & fire-resistant tanks; dispensing & required building construction; electric classifications; and operational requirements.

This standard does not apply to portable gas containers having a total liquefied hydrogen content of less than 11 cubic meters (400scf), if separated by 5 ft or to liquefied portable hydrogen containers of less than 39.7 gallons (150 Liters).

*NFPA 496* - - 2003 Edition; Standard for Purged and Pressurized Enclosures for Electrical Equipment (Category = Secondary)

Issued as an American National Standard on 7/18/03; Revision is estimated to be in 2007. This is a guidance document.

H2 Issues Addressed:

Purging and pressurizing of electrical equipment in classified high hazard area as defined by NFPA 70's Article 500 or 505 apply to hydrogen as a gas and as a liquid are covered. Requirements for pressurized control rooms, enclosures, and analyzer rooms are included.

*NFPA 853* -- 2003 Edition; Standard for the Installation of Stationary Fuel Cell Power Systems (Category = Secondary)

American National Standard on 7/18/03. Revision is estimated to be completed in 2006. This edition is a NFPA Standard not a Code but is a guidance document.

H2 Issues Addressed:

Fuel cell design, construction and installation requirements of a singular or any combination of self-contained pre-packaged power systems, two or more factory-matched modular components, and engineered field-constructed power systems. Fuel systems would be hydrogen, CNG, or LPG.

*NFPA 10* - 2002 Edition; Standard for Portable Fire Extinguishers (Category = Secondary)

Issued as an American National Standard on 7/19/02. Revision is estimated to be completed in 2006. This edition is a NFPA Standard not a Code.

H2 Issues Addressed:

Requirements to select, install, and maintain portable fire extinguishing equipment based on the classification of hazards. Class B fire extinguishers are used for pressurized flammable liquids and pressurized gas fires only if there is reasonable assurance that the source of fuel can be turned off.

*NFPA 13* - - 2002 Edition; Standard for the Installation of Sprinkler Systems (Category = Secondary)

Issued as an American National Standard on 7/19/02. Revision is estimated to be finalized in 2006. This edition is a NFPA Standard not a Code and should be considered a guidance document.

H2 Issues Addressed:

Requirements to classify an occupancy, design, and install automatic sprinkler systems. Article 13.11 provides the design requirements when required by NFPA 55.

NFPA 45 -- 2004 Edition; Standard on Fire Protection for Laboratories Using Chemicals (Category = Information)

Issued as an American National Standard on 8/5/04; Revision is estimated to be completed in 2008. This edition is a NFPA Standard not a Code and should be considered a guidance document.

H2 Issues Addressed:

Laboratory unit fire hazard classification is based on the quantities of flammable gases present and NFPA 704's rating of the material hazard. Chapter 11 covers compressed and liquefied gases. The design, fire protection, and ventilation requirements are covered.

*NFPA 69* -- 2002 Edition; Explosion Prevention System (Category = Secondary)

Issued as an American National Standard on 7/19/02; Revision estimated to be completed in 2006. This edition is a NFPA Standard not a Code and should be considered a guidance document.

H2 Issues Addressed:

Requirements for installing systems to prevent explosions by prevention or control of deflagrations in enclosures that contain flammable concentrations of gases.

*NFPA 704* -- 2001 Edition; Standard System for the Identification of the Hazards of Materials for Emergency Response (Category = Secondary)

This standard system identifies material hazards for emergency response personnel since 1961. Issued as an American National Standard on 8/2/01; Revision is estimated to be completed in 2006. This is a guidance document.

H2 Issues Addressed:

Hydrogen is a 3-4-0 [Health-Flammability-Instability ratings where 4 is the highest degree of hazard] with a required DOT shipping label "Class 2.1, Flammable Gas" and an ID NO.: UN 1966 refrigerated liquid. [This chemical's entry in DOT's Hazardous Materials Table for recommended emergency action procedure.]

ISO 14687 Hydrogen fuel – Product specification (1999, Cor 1 - 2001) under revision (Cor 2 and FDTS 14687-2) (Category = Information)

This International Standard specifies the quality characteristics of hydrogen fuel in order to assure uniformity of the hydrogen product as produced and distributed for vehicular, appliance, or other fueling applications uses.. It delineates hydrogen fuel grades and purity specifications.

*CGA G-5.3* Commodity Specification for Hydrogen, Edition: 5  
Published: 8/3/2004 (Category = Secondary)

This document describes the current commodity specification for gaseous and liquid hydrogen product. The document also provides pertinent information on methods of analysis and sampling technique, quality verifications, typical-use tables, as well as supplemental graphs and data tables.

*CGA G-5.4* Standard for Hydrogen Piping at Sites (2001) (Category = Secondary)

This standard describes the specifications and general principles recommended for piping systems for either gaseous (Type I) or liquid (Type II) hydrogen on premises, beginning at the point where hydrogen enters the distribution piping (the battery limits of the hydrogen storage system) at service pressure to the use point of the hydrogen.

#### A-2 Section 1.4 -- RECOMMENDED PRACTICES

*NFPA 68* - 2002 Edition; Guide for Venting of Deflagration (Category = Secondary)

Issued as an American National Standard on 1/31/02; Revision is estimated to be completed in 2007. This edition is a design guide(not a code or a standard).

##### H2 Issues Addressed:

Applies to explosion protection systems for all types of equipment and for buildings but not to pressure venting devices such as pressure relief valves and rupture discs. Table C shows hydrogen's fundamental burning velocity is 312 cm/sec compared to gasoline's 40 and propane's 46. Table D has the maximum pressure developed in a 0.005 cubic foot test sphere of 6.8 bars compared to gasoline's 7.9 – this data is used for design calculations for deflagration vents.

*NFPA 497* - 2004 Edition; Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous materials (Classified Locations for Electrical Installations in Chemical Process Areas (Category = Secondary)

Issued as an American National Standard on 1/16/04; Revision is estimated to be completed in 2008. This edition is a NFPA Recommended Practice (Not a Code or a Standard).

##### H2 Issues Addressed:

Electrical classifications apply to hydrogen (Class I, Group B) as a gas and hydrogen as a liquid where release could be ignited. Procedure and extent of the classified location, diagrams, and basis for recommendations are covered.

*CGA G-5.5* 2004 (Second Edition) Hydrogen Vent Systems (Category = Secondary)

This document presents design guidelines for hydrogen vent systems for gaseous and liquid hydrogen systems at consumer site and provides recommendations for their safe operation.

*AIAA G-095-2004*; Safety of Hydrogen and Hydrogen Systems (Category = Secondary)

This AIAA Guide is an ANSI approved industry consensus document based on the National Aeronautics and Space Administration (NASA) document “Safety Standard for Hydrogen and Hydrogen Systems”, NASA Safety Standard (NSS) 1740.16. The guide provides a practical and comprehensive set of guidelines for safe hydrogen use.

NFPA 77 - 2000 Edition; Recommended Practice on Static Electricity (Category = Information)

Issued as an American National Standard on 8/18/00. Revision is estimated to be completed in 2007.

H2 Issues Addressed:

Requirements for reducing the fire hazard from static electricity. Its nature and origin, mitigation methods, and ways to dissipate the charge are discussed.

NFPA 901 - 2006 Edition; Standard Classifications for Incident Reporting and Fire Protection Data (Category = Information)

Issued as an American National Standard on 2/9/01; Revision is estimated to be completed in 2007.

H2 Issues Addressed:

Feedback information would be available based on the reporting and fire protection data resulting from other facilities where a hydrogen fire occurred.

ISO/TR 15916 Basic consideration for the safety of hydrogen systems (2004)  
(Category = Information)

This Technical Report provides guidelines for the use of hydrogen in its gaseous and liquid forms. It identifies the basic safety concerns and risks, and describes the properties of hydrogen that are relevant to safety. This document was prepared as the “cornerstone” for general hydrogen safety considerations. Detailed safety requirements associated with specific hydrogen applications are treated in separate International Standards.

ISO/CD 22734 Hydrogen generators using water electrolysis process  
In progress: ISO/TC 197 WG 8 (Category = Information)

This draft International Standard will address the safe design and use of hydrogen generators for the purpose of water electrolysis.

ISO/WD 16110 Hydrogen generators using fuel-processing technologies  
In progress: ISO/TC 197 WG 9 (Category = Information)

This draft international standard applies to packaged, self-contained, or factory matched hydrogen generation appliances, referred to as hydrogen generators, that convert a hydrocarbon fuel to a hydrogen rich stream of composition and conditions suitable for the type of device (e.g. fuel cells) using the hydrogen.

ISO/WD 16111                      Transportable gas storage devices — Hydrogen absorbed in reversible metal hydrides  
In progress: ISO/TC 197 WG 10 (Category = Information)

This standard addresses the safe design and use of transportable hydrogen gas storage canisters including all necessary valves, relief devices, and appurtenances, intended for use with reversible metal hydride, hydrogen storage systems. This standard only applies to refillable devices where hydrogen is the only transferred media. Transportable gas storage devices do not include devices intended as fixed on-board fuel storage for hydrogen fueled vehicles.

The requirements of this standard are not intended to constrain innovation. The manufacturer may consider materials, designs, or constructions not specifically dealt with in this document. Components used in transportable hydrogen gas storage devices may not be within the size limitations of the standards referenced in this document. These alternatives shall be evaluated as to their ability to yield levels of safety and performance equivalent to those prescribed by this standard.

CGA G-5: Hydrogen, Edition: 5 Published: 10/2/2002 (Category = Information)

A complete monograph with physical properties is included, as well as how hydrogen is made, used, contained, and transported. This publication complements G-5.4 and G-5.5 to ensure safe and effective hydrogen installations.

CGA H-1 Edition: 1 Title: Service Conditions for Portable, Reversible Metal Hydride Systems Published: 8/24/2004 (Category = Information)

This publication outlines the service conditions expected for the system and various system components in a portable, reversible metal hydride system. These systems do not include metal hydride battery systems.

CGA H-2 - 2004 (First Edition 2004): Title: Guidelines for the Classification and Labeling of Hydrogen Storage Systems with Hydrogen Absorbed in Reversible Metal Hydrides Published: 8/24/2004 (Category = Information)

Hydrogen storage systems based on reversible metal hydride technology are being introduced for consumer use. Due to the lack of appropriate regulations, codes and standards, and experience for this emerging technology, there is the potential for inconsistency in their classification, labeling, and treatment for shipping and installation. This document gives guidance to regulators, manufacturers, and users of these systems to

establish a consistent and uniform basis for the classification, labeling, and treatment of such products.

CGA PS-17 Edition: 2 Title: CGA Position Statement on Underground Installation of Liquid Hydrogen Storage Tanks Published: 9/29/2004 (Category = Information)

This publication clarifies statements within CGA P-12 and CGA G-5.4 that are viewed as prohibitions to below grade installation of liquid hydrogen. In addition to industry's position based on experience, it also provides general design and installation minimum criteria for such installations.

CGA P-6 Edition: 5 Title: Standard Density Data, Atmospheric Gases and Hydrogen Published: 3/8/2000 (Category = Information)

Density data recommended in this publication were developed by the Compressed Gas Association to provide uniform values of liquid and gas density for atmospheric gases and hydrogen for the benefit of suppliers and users of these commodities. Tables present standard density data and volumetric conversion factors.

CGA P-12 Edition: 3 Title: Safe Handling of Cryogenic Liquids Published: 1/1/1993 (Category = Information)

A general guide to the safe handling of cryogenic liquids commonly used in industry, including their properties, safety standards, general safety practices and first aid procedures, fire prevention and fire fighting procedures, and recommendations for safe handling of these liquids in containers and storage systems. Intended for use by consumers, shippers, carriers, distributors, and others who want an introduction to cryogenic liquids.

CGA P-28 Edition: 2 Title: Risk Management Plan Guidance Document for Bulk Liquid Hydrogen Systems Published: 12/8/2003 (Category = Information)

The EPA Risk Management Plan (RMP) rule applies to the storage and use of listed substances including liquid hydrogen when the inventory of the process equals or exceeds 10,000 lbs. This publication provides information and expert guidance to help liquid hydrogen users comply with the RMP rule. It includes a typical system flow diagram; a typical hazard and operability (HAZOP) study; and information, tables, and charts to help users of liquid hydrogen carry out the required hazard assessment efficiently. The tables and charts allow the user to look up worst-case and alternative-case distances directly.

## A-2 Section 2 - Additional References for Refueling Station Considerations

### A-2 Section 2.1 - REGULATIONS

**49 CFR;** The transportation code (DOT) has specific requirements for the transportation of hydrogen as a compressed gas or cryogenic liquid and for the mode of transportation (by road, rail, sea, or air). (Category = Primary)

### A-2 Section 2.2 - CODES

**NFPA 30A - 2003 Edition;** Code for Motor Fuel Dispensing Facilities and Repair Garages (Category = Information)

Issued as an American National Standard on 7/18/03; Revision estimated to be completed in 2007.

#### H2 Issues Addressed:

Applies to liquid motor fuels and 3 gases. H2 is not mentioned, but other gases are in new Chapter 12: CNG, LNG, &LP-Gas. Requirements are on above ground and fire-resistant tanks, dispensing piping and required building construction, electric classifications, and operational requirements.

### A-2 Section 2.3 - STANDARDS

**NFPA 52-- 2006 Edition;** Vehicular Fuel Systems Code applies to the design, installation, operation, and maintenance of compressed natural gas (CNG) and liquefied natural gas (LNG) engine fuel systems on vehicles of all types and for fueling vehicle (dispensing) systems and associated storage. Revisions is estimated to be completed in 2010. This is a NFPA code. (Category = Secondary)

This was issued as an American National Standard on August 18, 2005. It now incorporates NFPA 57, LNG Fuel System Code, in this edition with new chapters addressing hydrogen topics that relate to vehicular fuel systems.

#### H2 Issues Addressed:

NFPA 52 addresses requirements on general gaseous hydrogen and equipment qualifications; service and maintenance of gaseous hydrogen engine fuel systems; gaseous hydrogen compression; gas processing, storage, and dispensing systems; and liquefied hydrogen fueling facilities.

**SAE J2600;** Compressed Hydrogen Surface Vehicle Refueling Connection Devices  
Published: October 2002 (Category = Secondary)

SAE J2600 applies to design, safety, and operation verification of Compressed Hydrogen Surface Vehicle (CHSV) refueling connection devices hereinafter referred to as nozzle

and receptacle. CHSV Refueling nozzles and receptacles shall consist of the following components, as applicable. This document applies to devices that have working pressures of 25 MPa, 35 MPa, 50 MPa or 70 MPa. For the purposes of this document, compressed hydrogen gas should meet the requirements of ISO 14687 Hydrogen fuel - Product specification.

ISO 13984 Liquid hydrogen – Land vehicle fueling system interface (1999)  
(Category = Information)

This International Standard specifies the requirements for the fueling system interface for refillable tanks for liquid hydrogen used as fuel in land vehicles.

ISO 13985 Liquid hydrogen—Land vehicle fuel tanks (2006) (Category = Information)

This International Standard specifies the construction requirements for refillable fuel tanks for liquid hydrogen used in land vehicles. It also identifies the testing methods required to provide a reasonable level of protection from loss of life and property resulting from fire and explosion.

ISO/PAS 15594 Airport hydrogen fueling facility operations (2004) (Category = Information)

This standard specifies the fueling procedures, hydrogen boil-off management procedures, hydrogen storage requirements, and characteristics of the ground support equipment required to operate an airport hydrogen fueling facility.

## **A-2 Section 2.4 - RECOMMENDED PRACTICES**

ISO/DIS 17268 Gaseous hydrogen — Land vehicle filling connectors  
In progress: ISO/TC 197 WG 5 (Category = Information)

SAE J2600 applies to design, safety and operation verification of Compressed Hydrogen Surface Vehicle (CHSV) refueling connection devices.

ISO/CD 15869 Gaseous hydrogen and hydrogen blends —Land vehicle fuel tanks (5 part standard)  
In progress: ISO/TC 197 WG 6 (Category = Information)

This International Standard specifies minimum requirements for serially produced light-weight refillable gas tanks intended only for the on-board storage of high-pressure, compressed gaseous hydrogen or hydrogen blends as fuels for land vehicles to which the tanks are to be fixed.

This International Standard covers tanks of any steel, aluminum, or non-metallic material construction, using any design or method of manufacture suitable for the specified

service conditions. This part of ISO 15869 defines the common aspects of all tanks covered in ISO 15869. Specific aspects, which may modify or supplement the common aspects and therefore cannot stand alone, are given in the following individual parts:

- . Type 1 - Metal tanks in ISO 15869-2;
- . Type 2 - Hoop wrapped composite tanks with a metal liner in ISO 15869-3;
- . Type 3 - Fully wrapped composite tanks with a metal liner in ISO 15869-4;
- . Type 4 - Fully wrapped composite tanks with non-metallic liner in ISO 15869-5.

ISO/NP 20012

Gaseous hydrogen - Service Stations

In progress: ISO/TC 197 WG 11 (Category = Tangential)

This draft International Standard will address design and safety issues for gaseous hydrogen service stations.

## **Appendix A-3 – U.S. Government and International Agencies Involved in Hydrogen Code Development**

### **U.S. Government Agencies**

#### **U.S. DOE – Hydrogen, Fuel Cells and Infrastructure Technologies Program**

Serves as the lead institution at the national level. This program coordinates (or attempts to coordinate) national participation in the international code development processes, coordinates code submissions to the NFPA, and facilitates ICC code adoption.

#### **U.S. DOT – Research and Special Programs Administration**

Safety testing for hydrogen fuel cell and combustion fueled vehicles. Other DOT departments regulate transport of Hydrogen, and local authorities may have jurisdiction over particular locations via hazardous materials authority.

#### **U.S. Coast Guard**

Develops and authorizes standards for marine uses.

### **International and Other Organizations**

#### **ANSI (American National Standards Institute)**

ANSI administrators and coordinates the United States private sector voluntary standardization system. ANSI specifies methodologies for codes/standards development. ANSI also coordinates U.S. participation in ISO activities. According to its web site, “ANSI Federation’s primary goal is to enhance the global competitiveness of U.S. business and the American quality of life by promoting and facilitating voluntary consensus standards and ensuring their integrity.”

#### **NFPA (National Fire Protection Association)**

Develops suites of building, fire, and other codes for adoption by states and municipalities. NFRA has taken up Hydrogen. (Competes with ICC.)

#### **ICC (International Code Council)**

Develops suites of building, fire, and other codes for adoption by states and municipalities. ICC is addressing Hydrogen. (Competes with NFPA.)

#### **ASME (American Society of Mechanical Engineers)**

Equipment design and performance standards.

#### **CSA (Canadian Standards Association International of America)**

The primary Canadian SDO: a non-profit, consensus-based organizational approach to develop standards, generally in harmony with international standards.

#### **CGA (Compressed Gas Association)**

A voluntary industrial gas industry association that develops technical information, standards and practices, to help maintain the industry’s status as self-regulating.

#### **NGI (Natural Gas Institute)**

#### **SAE (Society of Automotive Engineers)**

**ISO (International Organization for Standardization)**

The ISO is a network of the national standards institutes of 150 countries, with one member per country. It has several hydrogen codes activities underway, including Technical Committee 197 – Hydrogen Technologies, and at last count thirteen working groups on hydrogen issues. The ISO acts as a bridging organization to address both the requirements of business and the broader needs of society. A Central Secretariat in Geneva, Switzerland coordinates the system.

## **Appendix A- 4 -- Glossary of Abbreviations**

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
BOCA	Building Officials and Code Administrators International, Inc.
CDO	Code Development Organization
COSPE	Construction, Occupancy, Special Hazards, Personnel, Exposure (see Section 4.2.1)
DG	Distributed Generation
DOB	(see NYC DOB)
DOS	(see NYS DOS)
EERE	Office of Energy Efficiency and Renewable Energy (at US DOE)
FDNY	Fire Department of the City of New York
HFCIT	Hydrogen, Fuel Cells and Infrastructure Technologies Program (at US DOE EERE)
ICBO	International Conference of Building Officials
ICC	International Codes Council
ISO	International Standards Organization
LPG	Liquid Petroleum Gas
MEA	Material Equipment and Acceptance (at NYC DOB)
MW	mega-watt = 1000 watts
NASA	National Aeronautic and Space Administration
NFPA	National Fire Protection Association
NREL	National Renewable Energy Laboratory
NYC DOB	New York City Department of Buildings

NYS Codes Council	New York State Fire Prevention and Building Code Council
NYS DOS	New York State Department of State
NYS DOS DCEA	New York State Department of State Division of Code Enforcement and administration
NYSERDA	New York State Energy Research and Development Authority
SBCCI	Southern Building Code Congress International, Inc.
SDO	Standards Development Organization
Uniform Code	New York State Uniform Fire Prevention and Building Code
US DOE	United States Department of Energy

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**APPLYING LOCAL BUILDING AND FIRE SAFETY CODES TO  
HYDROGEN TECHNOLOGY APPLICATIONS IN NEW YORK STATE**

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**FINAL REPORT 06-18**

**STATE OF NEW YORK  
GEORGE E. PATAKI, GOVERNOR**

**NEW YORK STATE ENERGY RESEARCH AND DEVELOPMENT AUTHORITY  
VINCENT A. DEIORIO, ESQ., CHAIRMAN  
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