TEXAS HYDROGEN EDUCATION

FINAL SCIENTIFIC/TECHNICAL REPORT

Houston Advanced Research Center
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August 1, 2008 to February 28, 2011

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1.0 EXECUTIVE SUMMARY

The Texas Hydrogen Education project builds on past interest in hydrogen and fuel cells to help create better informed leaders and stakeholders and thereby improve decision making and planning for inclusion of hydrogen and fuel cell technologies as energy alternatives in Texas. In past years in Texas, there was considerable interest and activities about hydrogen and fuel cells (2000-2004). During that time, the Houston Advanced Research Center (HARC) created a fuel cell consortium and a fuel cell testing lab. Prior to 2008, interest and activities had declined substantially. In 2008, in cooperation with the Texas H2 Coalition and the State Energy Conservation Office, HARC conducted a planning process to create the Texas Hydrogen Roadmap. It was apparent from analysis conducted during the course of this process that while Texas has hydrogen and fuel cell advantages, there was little program and project activity as compared with other key states. Outreach and education through the provision of informational materials and organizing meetings was seen as an effective way of reaching decision makers in Texas. Previous hydrogen projects in Texas had identified the five major urban regions for program and project development. This geographic targeting approach was adopted for this project.

The project successfully conducted the five proposed workshops in four of the target metropolitan areas: San Antonio, Houston, Austin, and the Dallas-Ft. Worth area. In addition, eight outreach events were included to further inform state and local government leaders on the basics of hydrogen and fuel cell technologies. The project achieved its primary objectives of developing communication with target audiences and assembling credible and consistent outreach and education materials.

The major lessons learned include: (1) DOE's Clean Cities programs are a key conduit to target transportation audiences, (2) real-world fuel cell applications (fuel cell buses, fuel cell fork lifts, and hydrogen fueling) are effective for engaging target audiences, and (3) a clear path forward is needed for state and local agencies interested in project implementation (funding, financing, preliminary design, technical assistance, etc.).

2.0 BACKGROUND

This project began in August 2008 as an outgrowth of the planning process for the Texas Hydrogen Roadmap. The Roadmap set forth the following Texas goals:

GOAL1: Increase hydrogen production capabilities in anticipation of hydrogen demand and market growth within and outside Texas
GOAL 2: Increase hydrogen demand in new markets, particularly the transportation sector
GOAL 3: Eliminate existing barriers that may reduce Texas participation as hydrogen production and demand increase
GOAL 4: Develop and deploy hydrogen applications including production, storage, distribution, and use, as part of paving the way for new markets
GOAL 5: Create a responsive organizational setting that is positioned to meet these goals

The Hydrogen Roadmap focused mainly on (1) hydrogen production, since Texas has been one of the largest hydrogen producers in the U.S., and (2) transportation applications for fuel cells, which represented prominent proposals at that time in Texas (heavy duty applications as well as vehicle manufacturer interest). Achieving those goals would establish hydrogen production and demand as a larger part of a Texas energy portfolio, as well as address the State's environmental improvement and economic development goals.

The Roadmap started with four basic premises: (1) Texas is already a large hydrogen producer and market with high levels of knowledge and capabilities; (2) the first hydrogen transportation markets will take hold in states and municipalities that are proactive (Texas has not been among these), (3) in the longer term, Texas will need additional hydrogen infrastructure, including storage and distribution; and (4) Texas can act now to reduce barriers and support near-term hydrogen projects. The Roadmap identified three routes toward State hydrogen "destinations", with different speeds, complexity, and challenges.

The Hydrogen Education Project addressed a major action item in the HR2 route that set forth a set of actions: "support public outreach and education for state and local government officials and for greater public awareness about hydrogen and hydrogen technologies."[1]

Concurrent with the education project, HARC participated in the Texas Hydrogen Highway Fuel Cell Hybrid Bus and Fueling Infrastructure Technology Showcase project that addressed the HR2 route action: "encourage and support demonstration and deployment projects". This project was completed and has achieved funding support to proceed to its next stage of deployment.

3.0 SUMMARY OF PROJECT ACTIVITIES

This section summarizes the project activities, including: communication and outreach, content development, and workshops and events. Section 4.0 discusses specific project outputs.

3.1 COMMUNICATION AND OUTREACH

HARC built upon target audience contacts developed during the Texas Hydrogen Roadmap project. This e-mail and contact list was expanded to more closely focus on the five target regions. The list was updated throughout the project period through communications with other organizations and requests from individuals to be included in announcements and invitations. In addition, coordination with the four major Clean Cities programs provided excellent outreach and communication to the target audiences to enlist their participants in hydrogen workshops. Workshop flyers were designed for web download and printed copies were used at outreach events and related meetings during the project. The only challenge with communication was the need to continuously update and expand the contact and email lists.

[1] 2009. "Texas Hydrogen Roadmap." Houston Advanced Research Center, with the support of Texas H2 Coalition, National Renewable Energy Laboratory, U.S. Department of Energy. January. http://files.harc.edu/Projects/TexasHydrogen/TexasHydrogenRoadmap.pdf Accessed June 22, 2011.

HARC staff participated in five workshop and eight outreach events in the target areas, including Dallas-Ft. Worth (2), San Antonio (2), Houston (7), and Austin (2). The initial work plan was to organize workshops or webinars only. For example, a webinar was planned for San Antonio, rather than a face-to-face workshop. These plans were changed after discussion with other state hydrogen education projects. The work plan was revised to emphasize participation in outreach events such as those described below. The initial workshop format was revised from a full day event to shorter sessions of 2.5 to 3 hours (webinar issues are discussed below). This revision allowed the project to hold five face-to-face workshops rather than three as originally planned. The eight outreach events and their activities include:

- Clean Air Through Energy Efficiency (CATEE) conference, an annual event by the Energy Systems Laboratory/Texas A&M University, held in Dallas, Texas. A booth featuring hydrogen activities and programs was provided by HARC. Individuals were invited to sign up for Texas Hydrogen 101 information (December 15-17, 2008).

- A briefing for State leaders held April 9, 2009 in Austin, Texas to help ensure that hydrogen and fuel cell information was available during the Texas legislative session. The briefing covered key topics and basic knowledge about hydrogen and fuel cells.

- The 2009 Houston Clean Cities conference, *Advancing the Choice,* on June 24, 2009. HARC hosted a Hydrogen 101 education booth, which included a hydrogen quiz, a model fuel cell car, and sign up for outreach activities.

- Dallas-Ft.Worth Alternative Fuels and Vehicles Workshop. Participated in Clean Cities workshop and distributed information on Texas Hydrogen Education workshops (August 18, 2009).

- San Antonio Community Development Summit. Attended event, distributed information on Texas Hydrogen 101 Workshops in San Antonio and Houston (September 16 and 17, 2009), and participated in energy panel presentations.

- Provided interview for special broadcast for Houston public television channel (KUHT) on alternative transportation fuels and vehicles – electric, hydrogen, and biofuels.

- Distributed hydrogen education materials at the Houston Auto Show (January 29-31, 2010) as part of the University of Houston School of Technology display at this large event.

- Provided a display booth for Austin Climate Protection Conference and Expo on January 15 and 16, 2010, including a presentation as part of an alternative transportation fuels panel. The hydrogen fuel cell bus from the University of Texas at Austin was available during this event for riders.

- Organized a tour for stakeholders of Sysco Food's new Houston distribution warehouse on March 24, 2010, where 100+ fuel cell forklifts and pallet trucks have been deployed.

- Participated as team sponsor for the University of Houston's Team Element1 fuel cell prototype vehicle as part of the Shell Eco-Marathon competition on March 26 to 28, 2010.
- Presentation to Houston Engineers Without Borders meeting, June 17, 2010.
- Provided a display booth at the Houston area Clean Cities' Advancing the Choice workshop, Pasadena, Texas July 13, 2010.
- Participated in outreach activities with organizers of the 2010 Fuel Cell Seminar to be held in San Antonio, Texas October 18-21, 2010.

The Texas Hydrogen 101 website was launched (http://hydrogen.harc.edu) in August 2009 with information on workshops and basic content material on hydrogen and fuel cells. Participants could register for the five workshops as part of this site. Registration was simplified to include only the provision of basic information via email (name, position, organization, email address). Workshop presentations were posted at the project website along with basic education links and links to other sites. The website was intentionally designed to avoid replicating more extensive information available on the Internet. The intent was to focus on the education workshops and the provision of summary hydrogen information. The website will be maintained for two years after project completion.

3.2 Content Development

Staff assembled informational materials on hydrogen and fuel cell topics for use and adaptation in this project, particularly materials already developed by DOE. These materials were reviewed as they applied to the project goals of bringing basic hydrogen and fuel cell information to the target audiences. Texas-focused materials were also assembled, such as the state energy report issued in 2008 by the Texas State Comptroller's Office, and a companion report on Texas renewable energy resources. In 2009, HARC had completed the Texas Hydrogen Roadmap, which included a substantial amount of background research on hydrogen as it relates to Texas.

Following the content review for this project, nine one-page, two-sided flyers were selected for use as printed materials that would be made available at outreach events and workshops. All of these were up-to-date products from the U.S. Department of Energy (eight flyers) and the National Hydrogen Association (one flyer on hydrogen safety). In addition, information was distributed at outreach events and workshops recommending that participants who wanted more detailed knowledge about hydrogen and fuel cells take online training developed by DOE for first responders (http://www.hydrogen.energy.gov/firstresponders). This site was also mentioned as part of presentations at workshops.

The primary challenge in identifying and selecting content was limiting the information to that which would be suited to the project's target audience, while being somewhat consistent in style and appearance. The information needed to be accurate, credible, relatively short and somewhat non-technical.

The lesson learned in content development for this type of outreach and education project was to avoid "reinventing the wheel" when addressing a topic intended for basic information and

education. Governmental agencies and environmental or energy organizations often seek the same goal of providing basic accurate and readable information on similar topics. These are also intended for wider distribution in either print form or posted online.

3.3 WORKSHOPS AND EVENTS

HARC had initially planned on conducting six events, three of which would be face-to-face workshops in Austin, Houston, and the Dallas-Ft.Wort metropolitan areas. Three webinars were planned to focus on San Antonio, El Paso, and state-wide. The work plan was modified early in the project to include face-to-face workshops supplemented with participation in relevant outreach events. This decision led to implementing more face-to-face workshops, fewer webinars, and more direct contact through outreach events.

Following the October 2008 workshop in Golden, CO, HARC staff revisited its initial approach. This was based on suggestions from other grant recipients and DOE staff. The initial approach envisioned five to six hour workshops, but this approach was seen as a barrier to reaching project participation goals due to the likelihood that the target audience would be reticent to devote an entire day to this topic. Instead, a two- to three-hour agenda was developed to cover basic materials. This approach also allowed the possibility of project workshops to parallel other related events (such as a Clean Cities conference or an air quality event). Having shorter workshops and participating in related events was also viewed as providing a better opportunity to follow-up with those interested or who wanted additional information.

As part of this approach, HARC organized two briefings, one in 2009 with the Houston Clean Cities Stakeholders committee, and another in 2009 for Texas legislative staff in Austin, Texas. Due to early interest expressed in the San Antonio area, a face-to-face workshop was scheduled first in San Antonio replacing the proposed webinar. Staff discussed the possibility of paralleling this event with an NREL hydrogen code workshop, but the schedule could not be coordinated at that time. NREL staff participated in the San Antonio workshop in September 2009, and again at a briefing following the 2010 Fuel Cell Seminar in San Antonio.

Workshops in the Houston and the Dallas-Ft. Worth areas were conducted in late 2009. The Houston workshop was held in parallel with a related conference, but this event failed to attract many participants. However, the highlight of the workshop was a presentation by Sysco Foods, that had recently begun acquiring fuel cell forklifts for their newest warehouse. Staff also organized a display booth and that activity succeeded in reaching most of those attending the related energy/air quality conference. However, based on the lack of workshop participation, the workshops that followed were planned as stand-alone events. The Dallas-Ft. Worth (DFW) workshop involved bringing the fuel cell bus being operated in the Austin area by the University of Texas to Arlington, Texas where the meeting was being held. Most of the participants were from governmental agencies, including cities, school districts, federal agencies, and counties. Representatives from the auto industry also attended the DFW event

The Austin hydrogen workshop was held in early 2010 at the Pickle Research Center where the hydrogen fueling station and fuel bus are located. The availability of the fuel cell bus and fueling station at this workshop was a distinct advantage in terms of the level of interest of participation

and the degree of audience participation. The first part of the workshop included riding the bus and seeing a refueling demonstration. Attendees also included individuals and organizations that had participated in the San Antonio workshop.

Project staff worked with conference organizers for the 2010 Fuel Cell Seminar being held in San Antonio by providing them with contact lists from the Texas Hydrogen Education project, and making recommendations for local and state participants. The Texas Hydrogen Briefing was organized to be co-located at the same convention center as the Seminar, and it was scheduled to be held immediately following the Seminar's conclusion. The hydrogen event was furthered by coordinating with an electric vehicle conference organized by the Alamo Area Clean Cities Coalition. This event began immediately following the hydrogen workshop and continued on the following day. This provided the opportunity to continue outreach at this event and to highlight that fuel cell vehicles were electric vehicles as well.

During the final quarter of the project the website was updated with all presentations given at previous workshops posted, and the short quiz used at the workshops added to the website. All proposed tasks on this project were completed by the project end date of February 28, 2011.

The major challenge for the workshops and related outreach events was achieving the initial participation goals for individual workshops. With the exception of Houston, participation averaged 35 to 40 participants, while planned attendance was for 50 to 100 participants. The Houston workshop was held in parallel to a related conference, and failed to achieve the intended focus level. As mentioned, many more people were reached through the display booth provided as a part of the overall conference. It was concluded that the concept of parallel workshops was not fruitful and, hence, this was not pursued at other events. Instead, the project focused on outreach events that included a display booth and/or presentations. The final San Antonio workshop was somewhat parallel to the Fuel Cell Seminar, but this schedule was due to the level of interest in San Antonio and the direct connection between this project and topics at the Seminar.

In summary, the workshop approach was changed early in the project to include shorter face-to-face workshops and the addition of outreach events. This revised approach was more successful in reaching a larger audience, although with less intensive exposure to hydrogen education materials. During the project period, awareness of hydrogen and fuel cells was increased as several fuel cell applications were launched. These include three materials handling (fuel cell forklift) projects implemented partially with ARRA funds, and two state funded hydrogen projects for heavy duty fuel cell vehicles. These examples were extremely helpful to the hydrogen education project in communicating at workshops and in outreach events.

4.0 PROJECT OUTPUTS

4.1 PAPERS

Hydrogen Education in Texas: DOE Annual Merit Review, presentation and paper, May 21, 2009.

4.2 PROJECT WEBSITE

http://hydrogen.harc.edu

4.3 PRESENTATIONS: WORKSHOPS AND MEETINGS

- Texas and Hydrogen: Hydrogen 101; Houston Clean Cities Stakeholders Meeting; Houston-Galveston Area Council; presentation, March 18, 2009.
- Workshop Presentations (presentations varied in content somewhat from workshop to workshop and are posted individually on the project website)
    - Texas Hydrogen 101, San Antonio, Houston, Dallas/Ft. Worth, and Austin
    - Infrastructure 101 for a Growing Hydrogen Market, B. Weeks, Gas Technology Institute, San Antonio, Houston, Dallas/Ft. Worth, and Austin
    - There is a Hydrogen Fuel Cell Bus Operating in Texas, R. Thompson, University of Texas Center for Electromechanics, San Antonio, Houston, Dallas/Ft. Worth, and Austin
- Codes, Standards, and Permitting, C. Rivkin, National Renewable Energy Laboratory, San Antonio presentation, September 28, 2009.
- Hydrogen 101, D. Hitchcock, Houston Engineers Without Borders, June 17, 2010.
- San Antonio Hydrogen Briefing, October 21, 2010
    - Texas Hydrogen Progress, D. Hitchcock.
    - National Hydrogen and Fuel Cell Validation Activities, K. Wipke, National Renewable Energy Laboratory.
    - Fuel Cell Vehicle Projects in Texas, R. Thompson, University of Texas Center for Electromechanics.
    - Infrastructure 101 for a Growing Hydrogen Market, B. Weeks, Gas Technology Institute.

4.4 NETWORKS/COLLABORATIONS

- Major Texas Clean Cities Programs: Houston, Austin (Central Texas), San Antonio (Alamo Area), and Dallas-Ft. Worth.
- Texas H2 Coalition

- University of Texas/Center for Electromechanics
- Gas Technology Institute
- Texas State Energy Conservation Office
- NREL
- Sysco Foods
- Port of Houston staff
- Austin Energy staff
- University of Houston School of Technology

5.0 ACCOMPLISHMENTS, GOALS, OBJECTIVES

This section discusses the project accomplishments versus the stated project goals and objectives, and the current state of hydrogen knowledge and awareness in the State of Texas. Tables 1 and 2 summarize barriers, accomplishments, and performance measures for the project. The diversity of participants is illustrated in Figure 1.

5.1 GOALS AND OBJECTIVES

The overall aim of the project was to increase basic knowledge and awareness of Texas state and local government leaders about hydrogen and fuel cell technologies. To reach this goal, the project set the following objectives:

- Establish communications to reach the target audience
- Assemble consistent and accurate materials for education and outreach
- Conduct workshops and webinars for the five major Texas cities/regions

Although no rigorous method was proposed to assess increases in basic knowledge and awareness the teaching process included quzzing on basic features of hydrogen and fuel cells. This was included in all workshops; and at outreach events where this was feasible. This "hydrogen pop quiz" was roughly based on DOE's H2 IQ national survey. The intent was to engage participants, rather than assessment of knowledge levels. The quiz results were tabulated, and participants were found to be somewhat better informed than the larger DOE survey population.[2] This was not unexpected since participants likely had an existing interest or their occupation included alternative energy and technologies considerations. While basic knowledge levels were not measured, several individuals and organizations attended more than one workshop, suggesting that

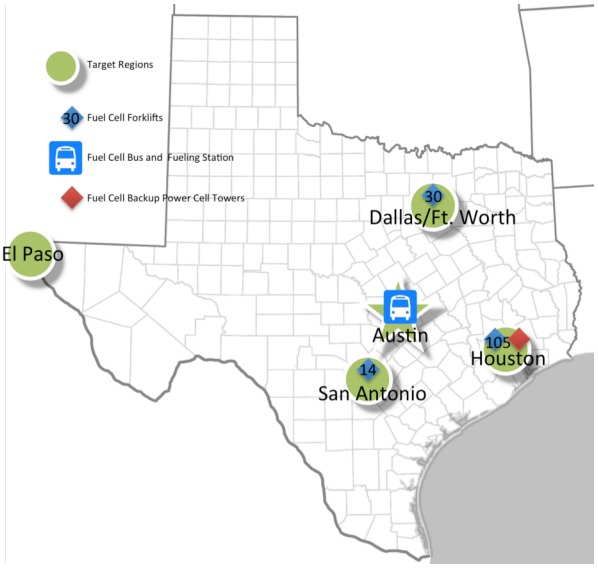
[2] From 2006 DOE report on 2004 survey. http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/survey_2004.pdf

the level of interest may have increased. In addition, Clean Cities programs have requested additional workshops on hydrogen in the future.

The project objectives were achieved using approaches and metrics that were modified early in the course of the project. The following summarizes accomplishments for each major objective:

Objective 1: Establish communications with target audiences

- A project communication list for target audiences was developed, expanded, and improved throughout the project. Clean Cities programs in Texas' four major regions were engaged in planning and communicating workshop participation. A project website was designed and launched for use and update during the project. The primary communication channels were repeated email contacts and multiple announcements from the Clean Cities programs.



Target Regions and Applications

Objective 2: Develop basic education materials

- A set of handouts was developed for use throughout the project, including one-page DOE flyers on hydrogen and fuel cells, supplemented with other suitable materials. After review of many different sources, these were deemed to be the most consistent and credible summary materials available for covering the basic education topics. The materials were printed as one-page flyers for distribution at each workshop and outreach event. These materials were supplemented with posters displays that included educational materials and hydrogen applications.

Objective 3: Conduct workshops/webinars in target metro areas

- Five workshops were organized in major Texas metropolitan areas including Houston, Austin, San Antonio, and the Dallas-Ft. Worth area. Two workshops were held in San Antonio, the first workshop, and the last workshop that coincided with the 2010 Fuel Cell Seminar. Staff participated in eight outreach events to further the achievement of project goals and objectives.

The project approach was modified early to reflect additional viewpoints about reaching the target audience. First, the workshop format was designed for shorter workshops coupled with expanded staff participation in outreach events, including related conferences and workshops. Staff participation at outreach events included presentations on the program, display booths, and distribution of materials. No workshop was held in the El Paso area due to logistical and organizational barriers.

A second modification was the decision to focus on face-to-face workshops rather than webinars, which had become increasingly utilized in similar programs. This modification allowed the project to add two face-to-face workshops, as well as participation in many related outreach events. Other project experience at HARC suggested that it would essential to first establish a webinar track record if the webinars were to achieve sufficient audience participations. The number of webinars had been reduced to only one, and this was not believed sufficient to organize a separate structure and to attract participation. Follow-up projects on this topic will likely use webinars as a primary tool.

Finally, the project had the unique opportunity to work with and sponsor a university led vehicle development team as part of the 2010 Shell Eco-Marathon. The student team based at the University of Houston School of Technology designed and built a fuel cell prototype vehicle to meet the requirements of that competition. This was the first year this event was held in Houston for the Americas competitors. This activity allowed the project to distribute hydrogen education information at the Houston Auto Show, and to interact with engineering students and faculty as they learned about hydrogen and fuel cells. The students were able to interact with several hundred people at the Auto Show on these topics. They were provided with distribution materials and educational signage from the project.

Shell Eco-Marathon 2010, Houston, Texas

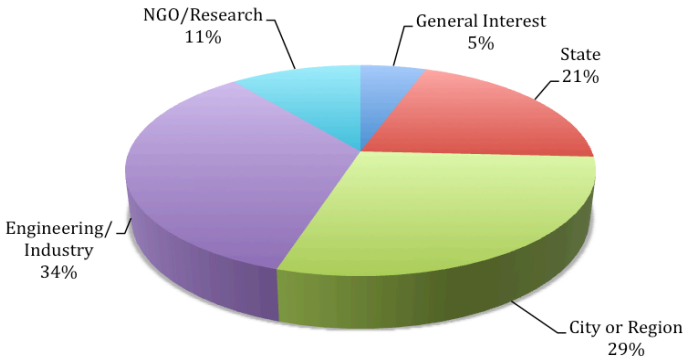
Table 1
Identified Barriers from DOE Hydrogen Plan and Project Accomplishments

Barriers	Accomplishments
Disconnect between hydrogen information and dissemination networks	• Created http://h2101.harc.edu/ • Hosted five workshops in four major metropolitan areas • Hosted a booth at eight coordinating events to disseminate information and conduct outreach • Speaker at four coordinating events to discuss hydrogen and fuel cells
Lack of readily available, objective, and technically accurate information	• Compiled existing DOE and other information for consistent, accurate content • Created educational posters • Expanded collaborators to include the University of Texas and the Gas Technology Institute for additional technical expertise
Regional Differences	• Hosted 5 regional workshops – San Antonio (2), Houston, Dallas/Fort Worth, and Austin – working with Clean Cities programs in each region.

Table 2
Performances Measures

Performance Measures	Achievements
Number of people reached (face to face – workshops and events)	700+
Number of workshops and events presented	5 Workshops 8 Events
Number of workshop participants	165
Number of webinars provided	None
Number and kind of collaborators	Thirteen Clean Cities, COGs, utility, industry, non-profits, and universities
Type of Audience Reached	Diverse Primarily state (21%), local/regional government (29%), and engineering/industry (34%)
Number of fuel cell project implemented during project period in Texas	Three sites with over 130 pieces of material handling equipment being deployed and fueling; new fuel cell bus (Austin); and fuel cell hybrid electric off road truck (drayage vehicle).
Number of Attendees actively looking for fuel cell opportunities	Three who identified funding as being a primary hurdle
Response of project partners /collaborators	Very positive with two cities requesting additional workshops; additional workshop conducted in San Antonio; requests for participation in other Clean Cities programs.
Preparation of a project summary/lessons learned that can be used by people interested in replication the program –	See Section 6 of this report.
Places the program has been replicated	While HARC's program has not been replicated, other entities performed similar work as awardees of the same DOE Funding Opportunity Announcement. See http://hydrogen.harc.edu

Figure 1
Diversity of Participants



5.2 Outcomes and Current Environment for Hydrogen in Texas

People encountered in the course of this project were increasingly aware of hydrogen and hydrogen technologies. This is perhaps particularly true in recent markets such as hydrogen forklifts (three separate companies in Texas) and the backup power in cell towers (Sprint investment in Texas network hurricane preparedness, including fuel cell units). The possibility of fuel cell use in smaller applications instead of batteries was also of interest (for laptops and high end cameras). Since 2008 in Texas, more than 130 fuel cell forklifts came into operation, notably at prominent companies that included Nestle Waters in the Dallas-Ft. Worth area; at HEB in San Antonio, a major Texas supermarket chain based in San Antonio that has tested fuel cell forklifts in the past; and at Sysco, a global food distributor based in Houston that had the opportunity to embed fuel cells as a key component of its newest warehouse, creating a much more efficient warehouse operation.

This project contributed to short term interest and awareness of hydrogen and fuel cells in Texas, and there is continuity for including them in future fuel and energy policies. For example, following the 2011 Texas legislative session, Senate Bill 385, Refueling Stations for Alternative-Fuel Fleets, was signed into law. Funded through the Texas Emissions Reduction Plan (TERP) Fund this legislation sets aside a portion of TERP funds for alternative fuel refueling stations. Hydrogen is specifically mentioned as an "alternative fuel" under this statute. The funding is limited to two percent of the available TERP funds, which could amount to as much as $4 million over a two-year period. Financing was one of the issues identified by participants in the Texas Hydrogen Education project.

In addition, a project funded by the Energy Foundation is focusing on low carbon fuels that could be part of the Texas fuel portfolio in the future. This project specifically identifies hydrogen as one of the four fuel options of interest for Texas' future portfolio. This project helps continue interest in hydrogen as a transportation fuel, building upon the Texas Hydrogen Roadmap and the Texas Hydrogen Education project.

There has been expansion of hydrogen production in Texas during this project period, which is the primary aspect of Texas' strength in the hydrogen market. Praxair began installing a new 135

million scfd hydrogen plant at Valero's Port Arthur, Texas refinery. Plant start-up is scheduled to begin the first quarter of 2013. The hydrogen will be used to process ultra-low-sulfur diesel fuels. In addition, Air Products acquired a new hydrogen production facility in Corpus Christi, Texas to expand its market. This facility is projected to produce 30 million scfd of hydrogen for delivery to local refineries. Hydrogen pipelines were also being expanded. Air Products began construction of an additional 180-miles of pipeline from their Louisiana plant to tie into the Texas hydrogen pipeline. Hydrogen production remains a principle characteristic of Texas circumstances that may be of value for expanded fuel cell applications.

Another project that was initiated during the education project period is a series hybrid Pluggable Hybrid Electric Terminal Tractor (PHETT). This technology development project of the company Capacity of Texas was awarded a $872,000 Grant to develop a Hydrogen Fuel Cell Terminal Truck—the ZETT, or Zero Emission Terminal Truck—based on the PHETT platform. Equipment like this is used in port operations, and Texas has several ports where such equipment might be deployed, the largest being the Port of Houston.

Notable for Texas during this project are comparisons with other states. As described in the Texas Hydrogen Roadmap, Texas has not been as competitive as it might be with other states such as Ohio, Connecticut and South Carolina. While not among the top five, in the 2011 report entitled Fuel Cells in America from Fuel Cells 2000, Texas was described as one of the five "Up and Coming" states to watch (along with Delaware, Florida, Hawaii, and Maryland). Texas has many supportive policy initiatives that include, but do not emphasize hydrogen and fuel cells. In addition, there is a solid research community at major Texas universities who have included hydrogen and fuel cells in past research initiatives. And hydrogen production and its use is well-known by many industries located in Texas. All of these factors suggest that the Texas environment is well positioned for future hydrogen and fuel activities including education and outreach such as that accomplished during this project.

6.0 LESSONS LEARNED

Several lessons were learned during the course of this project that will be helpful in the future for shaping further efforts to accomplish hydrogen education goals. These include:

- Clean Cities programs provide a key conduit to target audiences interested in applications for transportation. Some of the participants in these programs are also interested in stationary and non-road applications.
- Real-world applications, such fuel cell buses, fuel cell forklifts, and associated hydrogen fueling, are effective in capturing interest and furthering understanding of these technologies. Many of those interested in hydrogen are unacquainted with current and past applications in Texas.
- Recipients of DOE technology demonstration grants (such as Sysco), upon working with hydrogen technologies, can become staunch advocates for new technology. They are willing to share their time to discuss experience with the technology, and they are appreciated by audiences for their "real world" experience.

- The most effective outreach and education experiences were those which included technical experts, hands-on application demonstrations, real world technology user-advocates, and an interested and engaged audience.
- Effective project planning needs to take into account the changing political climate to help ensure that promising technologies continue to receive attention.
- While the state of technology continues to advance, and cost effective applications are available today, there is a persistent general attitude that hydrogen technologies are too expensive, "the technology that is always 15 years away," and potentially dangerous. Funding needs to continue to raise awareness and create more technology user-champions who can help overcome misperceptions about hydrogen and the state of fuel cell development.

7.0 NEXT STEPS

The Houston Advanced Research Center is continuing to conduct education and outreach related to hydrogen, as well as other candidate low carbon fuels that are included in its Texas Future Fuels (TFF) project. TFF will continue through 2011, and is proposed to begin another phase in 2012. This Energy Foundation project is evaluating technical and policy issues for Texas low carbon fuels and has operated in parallel with a similarly funded NREL project.

The Texas Hydrogen Education project has worked hand-in-hand with the Texas Fuel Cell Hybrid Bus and Fueling Infrastructure Technology Showcase project, which will be continued and expanded under separate funding from the State of Texas (NTRD funds) and the U.S. Department of Transportation Federal Transit Administration. A new, larger transit bus (from Proterra) will be being placed in transit service at Capital Metro Transit in Austin, Texas. The Texas Hydrogen Highway project has helped increase the understanding of transit management and operation staff for utilization of a fuel cell bus and fueling infrastructure, making the transition to a new vehicle and improved station possible. The bus and station will continue to increase public awareness and understanding of hydrogen as a transportation fuel.

Finally, the Houston Advanced Research Center will continue to work with the partnerships built under this project (including the Gas Technology Institute, the University of Texas, and hopefully local government agencies and private industry participants) to continue to seek support for testing and demonstrating hydrogen applications. Such activities are needed to maintain awareness levels and to continually inform public decision makers on hydrogen and fuel cell technologies.