New Jersey Hydrogen Learning Center
Year One Report

May 15, 2007

CENTER FOR ENERGY, ECONOMIC & ENVIRONMENTAL POLICY

Edward J. Bloustein School of Planning and Public Policy

THE STATE UNIVERSITY OF NEW JERSEY
RUTGERS

New Jersey Hydrogen Learning Center
Year One Report

Table of Contents

History of the New Jersey Hydrogen Learning Center

State energy policymakers in New Jersey began to think about hydrogen and fuel cell technology in the late 1990s. At this time, New Jersey deregulated its electric industry and concerns mounted about feasible means of promoting energy efficiency and renewable energy technologies under the new market structure. The State formed the Office of Clean Energy and created the Societal Benefits Fund to support non-conventional energy development in the state. A number of hydrogen demonstration projects were supported by this fund. These projects were collaborative efforts with universities, colleges, and fuel cell companies located in the state and region; some of the projects still exist today.

In 1998 the state contracted with the New Jersey-based firm H-Power[1] to upgrade 65 solar powered highway variable messaging signs with hydrogen fuel cells to serve as backup power. This project was followed with the state's sponsorship of the New Jersey *Project Venturer* in 1999. A collaboration of several New Jersey universities, technology companies, and state departments, *Project Venturer* was a demonstration car using on-board compressed hydrogen gas tanks to provide fuel to an H-Power fuel cell. The vehicle was tested in the 1999 Tour de Sol organized by the Northeast Sustainable Energy Association[2], an annual event highlighting innovative low and zero emission vehicle technologies. In 2000 a second vehicle, the *Genesis*, was entered into the contest using a new fueling technology developed by Millennium Cell of Eatontown, New Jersey.

These initial activities set the stage for New Jersey's interest in exploring the value of hydrogen gas and fuel cell technology. Moving away from supporting transportation applications, the next four years of the state's involvement with hydrogen and fuel cell demonstration projects was in the realm of stationary power applications. In 2000, Ramapo College of New Jersey purchased two 200kW fuel cells to provide a portion of the heat and power to a computer lab and adjacent parking area. This was followed by similar purchases by Richard Stockton College, Ocean County College and, finally in 2004, the College of New Jersey. Each used a combination of governmental subsidies, either federal or state, to make the fuel cell's purchase financially viable. All of these, with the exception of Ocean County College, were phosphoric acid fuel cells purchased from UTC Power. Ocean County College purchased a molten carbonate fuel cell from Fuel Cell Energy, which uses high heat to process natural gas into hydrogen.

By 2003, the fuel cell purchase rebate program was placed within the state's combined heat and power program under the Clean Energy Program. Since most current stationary fuel cells are powered by natural gas, policymakers deemed fuel cells as "non-renewable" energy technology. As such, fuel cells are not eligible for the state's renewable portfolio standard. This approach is different than other states, including Connecticut, which is home to a number of major fuel cell manufacturers. It includes fuel cells in its renewable standards for economic development purposes and in recognition of their high efficiency.

[1] H-Power was purchased by Plug Power of New York in 2003.
[2] For more information, visit http://www.nesea.org/.

In the national context, hydrogen and fuel cells have garnered a lot of attention as the preferred future energy technology by a number of high profile stakeholders and policymakers. The automobile and oil industries have begun investing large amounts in R&D related to hydrogen production and fuel cell technologies. In the 2001 National Energy Policy Report strongly favored hydrogen and fuel cells as its long-term answer to a secure and sustainable energy future for the United States. By 2003, states such as California, Michigan, Connecticut, and New York were all developing their own hydrogen and fuel cell policies and roadmaps to attempt to gain an early advantage in this emerging sector.

New Jersey's early experience with hydrogen and fuel cells and its strong support of renewable and clean energy policies led policy makers to want to learn more about the role hydrogen could play in the state's energy portfolio. In 2003, the New Jersey Board of Public Utilities (NJ BPU) and the Fund for New Jersey, a non-profit foundation, sponsored a study by the Center for Energy, Economic & Environmental Policy (CEEEP) entitled, "New Jersey: Opportunities and Options in the Hydrogen Economy" (Hydrogen Report). This study examined potential state policies to facilitate the commercialization of hydrogen fuel and to build out related infrastructure in New Jersey. This report provided the initial discussion of the issues facing hydrogen commercialization and set out a number of policy recommendations to guide the state towards making a decision.

The Hydrogen Report made five specific recommendations:

1. The NJ BPU, Office of Clean Energy, should establish a Hydrogen Learning Center to act as a focal point for education and outreach for all New Jersey's stakeholders regarding the state's consideration of policies related to hydrogen fuel.

2. The state should initiate a New Jersey Hydrogen Vision and Roadmap process, similar to the federal government's efforts to create a framework for the state's overall goals and activity for hydrogen and fuel cells.

3. The Governor should consider establishing a Hydrogen Policy Working Group across key state departments and agencies to coordinate and collaborate on these efforts.

4. The Office of Clean Energy should continue to encourage the deployment of fuel cell applications in the state through its clean energy programs.

5. The state should expand on the research programs in basic and applied research at New Jersey universities to assist in solving the technical barriers to hydrogen fuel and infrastructure deployment.

Through a $200,000 grant to CEEEP as administrator, the New Jersey Hydrogen Learning Center (Learning Center) was established in 2005 as the next step in the state's consideration of hydrogen energy. The Learning Center was a "virtual center" based geographically around the colleges with fuel cell or hydrogen fuel production facilities. Besides establishing the Learning Center, the project sought to accomplish four tasks:

1. Creation of Hydrogen and Fuel Cell educational modules to be implemented by the University Partners in on-campus courses or demonstrations;

2. Development of a Stakeholder Network of companies, educational institutions, governmental entities, non-profits and individuals interested in hydrogen as an alternative fuel and fuel cell technology;

3. Hosting of a New Jersey hydrogen web-portal to disseminate information about hydrogen and fuel cells as well as to publicize and organize information about the activities of the Learning Center; and

4. Implementation of a workshop for local officials about the current and future development of codes and standards applicable to the implementation of hydrogen and fuel cell technology.

The initial $200,000 grant covered activities that established the center from February 2005 to its launch in September 2005 and through the conclusion in April 2007. This report examines the activities and outcomes of the Learning Center in its first year and provides findings and recommendations based on the collaboration and discussion of university partners and stakeholder members throughout the first year. In addition, the report explores potential future activities for the Learning Center in the next few years.

Center Goals and Approach

There are many challenges inherent in encouraging movement toward a hydrogen economy. From technological barriers in hydrogen production, storage and delivery mechanisms to policy and funding issues, these challenges emphasize the importance of targeting collaboration among the private, public, academic, and non-profit sectors to help build consensus about next steps. Furthermore, education of New Jersey's students and outreach to a broad network of stakeholders will be a key component in achieving this vision.

At its core, the New Jersey Hydrogen Learning Center strives to act as the focal point for education and outreach for all of New Jersey's stakeholders regarding the state's consideration of policies related to hydrogen fuel. More specifically, the Learning Center's goals are to:

- Involve and integrate New Jersey's colleges and universities in hydrogen activities and the development of a hydrogen economy;
- Leverage existing hydrogen fuel cell assets deployed as demonstrations at various New Jersey colleges and universities;
- Educate and train New Jersey's students in the basics of hydrogen and fuel cell concepts;
- Build capacity among hydrogen, fuel cell and related businesses and other hydrogen stakeholders to have a New Jersey identity and involvement in state energy, economic and environmental policy;
- Increase the dissemination and exchange of ideas and information among stakeholders; and
- Develop greater understanding of hydrogen and fuel cell issues among local government officials.

The following sections describe in detail the main elements of the Hydrogen Learning Center and the accomplishments of the first year.

University Partners

University Partners were required to have either a fuel cell facility on campus providing heat and/or power to campus buildings, or would need to have fueling research facilities on site that would further the implementation of hydrogen as a fuel. Four New Jersey colleges and universities met the first description: The College of New Jersey, Ocean County College, Ramapo College of New Jersey and Richard Stockton College. The Rutgers EcoComplex fit the second description with their research work on purifying landfill gas to be used in fuel cells.

Involving multiple colleges and universities is an important way the Hydrogen Learning Center reached a significant student population. The geographic locations of these schools encouraged stakeholder involvement in the communities closest to them. In exchange for the active participation of the university partners, CEEEP provided mini-grants in the amount of $8,000 as part of its overall project grant to offset the costs of the require activities.

CEEEP and representatives from each of the five identified potential university partners met on August 16, 2005. The purpose of the meeting was to review the requirements for receiving the mini-grant and the paperwork for moving the process forward. In order to receive the mini-grants, the University Partners were required to complete a Statement of Work to be submitted along with a budget to the Rutgers Office of Research and Sponsored Programs (ORSP). The duration of the SOW activities and the requirements of the grant were set at twelve months.

CEEEP worked with the Rutgers EcoComplex to have them establish an educational module for elementary and middle school students that take tours of their facility. They were also chosen to host the final symposium held in September 2006, wrapping up the first year of activity from the Center. Instead of an SOW, the EcoComplex submitted their plans for the creation of an educational kiosk targeting students touring their facility, including their plans for hosting the symposium to CEEEP for approval prior to encumbering these expenses. As a part of Rutgers University, the EcoComplex did not need to have a separate subcontract with CEEEP generated by the ORSP.

Educational Modules

The four colleges and universities targeted their educational modules at their undergraduate students in various classes. The EcoComplex's module was aimed at elementary school students participating in fieldtrips at their facility. In addition, a PowerPoint presentation on hydrogen and fuel cells was developed for the K-12 student audience for teachers to include in their classes. This presentation and the other modules are on the Learning Center's website. Through partnerships with science and technical high schools that joined the stakeholder network, the Learning Center also provided educational opportunities at the secondary school level.

Each university partner took a different approach to implementing their educational module. The Learning Center received outlines of modules from four distinct disciplines and embedded in a range of classroom settings and approaches. Together they combined examination of the social, political and technical aspects of hydrogen energy systems in the classroom with hands-on experience through hydrogen demonstrations to provide students with necessary knowledge to prepare them for further studies or work in a future hydrogen economy.

Altogether the schools offered these modules to more than 100 undergraduate students who learned about the basics of hydrogen and fuel cell technology through this program. All of the professors agreed that they would continue teaching these modules in their classes. Some of the courses included online discussions, lab activities with model fuel cells, and design/redesign projects.

More details about each of the educational modules given below:

Ocean County College

Ocean County College's educational module was implemented in the 2006 Fall Semester Physics-171, a course taught by Mr. Neil Schiller, MSE, PE. The class first broadly explored why alternative sources of energy are being sought. Then more specifically, the role that hydrogen may play in the state's energy portfolio was discussed, especially when used with fuel cells. In addition, the instructor examined the purchase of the on-campus molten carbonate fuel cell at Ocean County College and explained the school's experiences with its use. Throughout the lecture, the instructor provided facts about hydrogen, its sources, its uses and fuel cells. The lecture portion of the class was followed by a lab in which students used an electrical charge or a solar cell to electrolyze water into hydrogen and oxygen. The hydrogen collected was then run through a fuel cell to operate a small motorized fan. At each stage in the process the students collected data, calculated efficiencies, and performed other calculations to learn the physical properties of hydrogen and fuel cells.

Ramapo College of New Jersey

The educational module implemented at Ramapo was included in a course titled Energy and Society (SENV-223) offered in the Spring 2006 semester by Dr. William Makofske. The students in the class were given a background paper reading assignment. An in-class lecture

covered two-days and was followed by a class assignment and tour of the fuel cell facility on campus.

Richard Stockton College of New Jersey

The Stockton educational module was offered by Dr. Tait Chirenje in two of his courses: Introduction to Pollution, GNM-2261 and Environmental Issues, ENVL-2300. Introduction to Pollution offered in Fall 2005 was the first course to implement an educational module and was used to test the survey instrument before full implementation in the Spring 2006 semester of courses. The overall goal of the module was to give students an understanding of the hydrogen economy and the concept of energy storage. Further objectives of the course were to introduce students to the possibility of using hydrogen to replace common fossil fuels and to give students a real world example through a tour of the campus fuel cell facility. Students were introduced to the history and science of fuel cells and issues between hydrogen produced from renewable versus fossil fuel sources. Further discussion was aided by Web CT's online discussion technology. Students discussed four alternative energy sources including geothermal, solar, wind, and fuel cells as part of the exercise.

The College of New Jersey

Two professors worked together to offer the educational module in their courses at TCNJ. Dr. Matthew McGarry and Dr. Lisa Grega offered their educational module in Thermodynamics II, ME 371 and Thermal System Design, ME 461. In addition to labs working with small fuel cells, an in-class lecture covered two to three days and was followed by a class assignment and tour of the fuel cell on campus. The classes were much more technical in nature than the other modules. Students in the class were given background reading assignments. Fuel cells were compared to combustion engines and concepts of combined heat and power and system efficiencies were explored.

Each module included an introductory lesson entitled "An Introduction to Fuel Cell Technology" to provide sufficient background information on hydrogen and fuel cells in order for the students to more fully explore the technical aspects in the course topics.

Measuring Outcomes

Each faculty member administered to the students a survey of prior knowledge about hydrogen and fuel cell and followed the module with a post-survey to measure what the students had learned. The Learning Center collected the results of these surveys and processed the answers. Some of the results are presented below.

Figure 1 below shows the pre and post-module answers to the question "Do you agree or disagree with the following statement? Hydrogen is the most abundant element in the universe." The large jump in the agree column after participating in the module shows that the vast majority of the students have learned this hydrogen fact.

Figure 1. Do you agree or disagree with the following statements: Hydrogen is the most abundant element in the universe

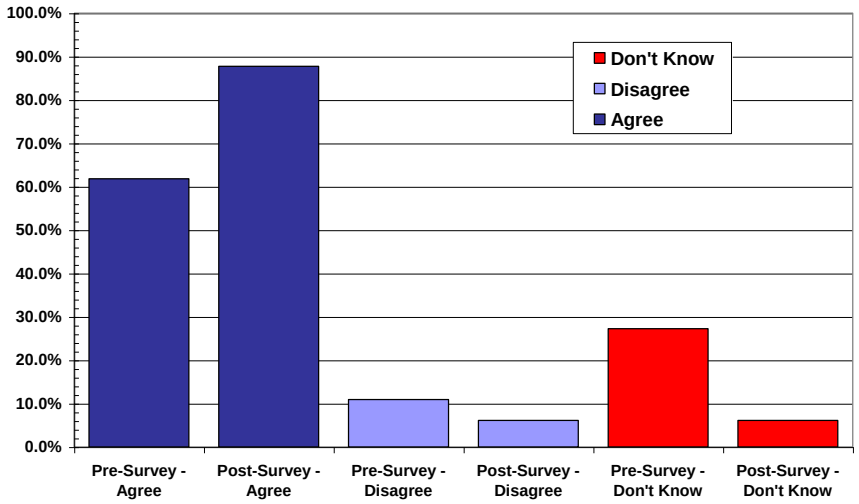

Figure 2 below shows the answers to the question "Do you agree or disagree with the following statement? Hydrogen gas has the most energy content by weight of any type of fuel." Again, there was a sizable increase in the correct answer by those who agreed and a drop in the number of students who answered that they did not know.

Figure 2. Do you agree or disagree with the following statements: Hydrogen gas has the most energy content by weight of any fuel

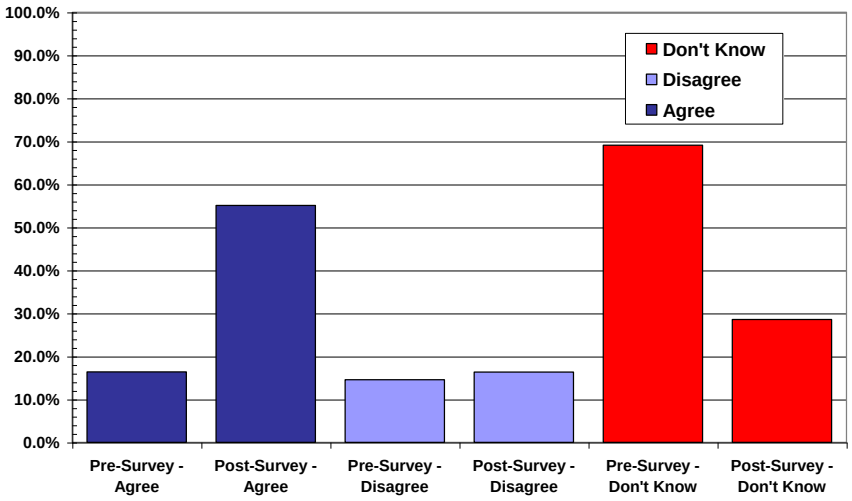

Figure 3. Do you agree or disagree with the following statements: There are multiple ways to separate hydrogen from its sources

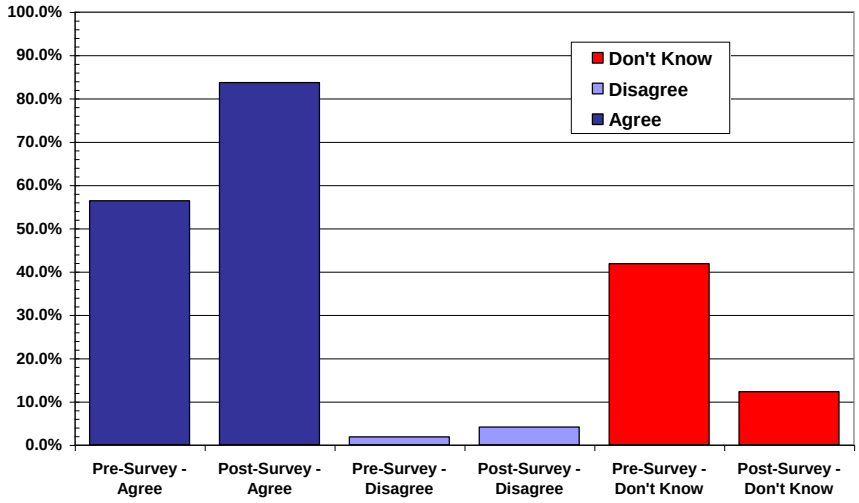

Figure 3 above examines whether students had understood the concept that there were a number of ways to separate hydrogen from other elements. The question read, "Do you agree or disagree with the statement that there are multiple ways to separate hydrogen from its sources?" Again, there was significant improvement in the number of correct answers after the module.

Figure 4. Can you Identify One or More Sources of Hydrogen

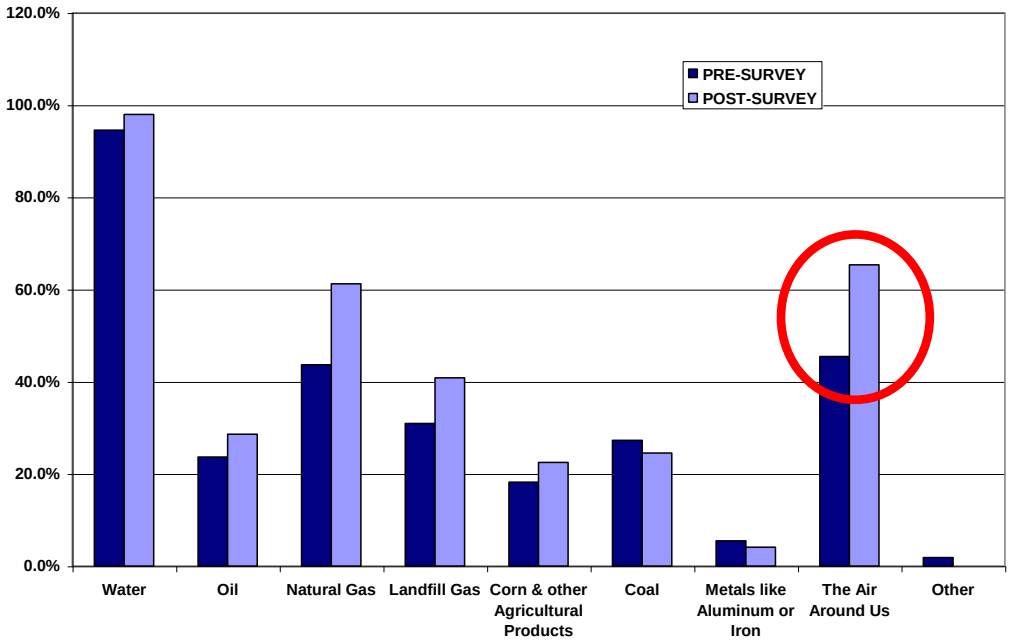

Figure 4 above provides a good example of where misconceptions about hydrogen can be hard to break. The pre- and post-surveys found that in answering a question about the sources of hydrogen, more people agreed in the post-test than in the pre-test that hydrogen can be found

naturally in "the air around us." The emphasis of hydrogen being the most abundant element in the universe and being a light gas may have lead students to understand that hydrogen is so abundant that it can be found in the air. While this could be a matter of phrasing the question, it is an area in which future monitoring will be important. The goal should be to clarify that while hydrogen exists as part of all sorts of organic matter, it almost never is found on its own naturally in the environment.

Rutgers EcoComplex

Each year the Rutgers EcoComplex hosts several hundred elementary and middle school students on class field trips. As part of their educational module, the EcoComplex developed an informational kiosk to convey information about hydrogen and fuel cells with a particular emphasis on the challenges and opportunities for renewable hydrogen generation. As a research center with facilities concentrating on landfill gas reformation, it is fitting that the EcoComplex targeted this aspect of a potential future hydrogen economy. The kiosk was combined with hands-on demonstrations for the students to further engage them about hydrogen and fuel cells. In addition to the students on field trips, numerous visitors and conference attendees to the EcoComplex will be able to visit the kiosk and take information sheets about hydrogen and fuel cells targeted to a more general audience. By having the kiosk prominently displayed in the main foyer of the EcoComplex it will serve as an important information distribution point for the New Jersey Hydrogen Learning Center.

Other Educational Materials

The Learning Center also developed a PowerPoint presentation geared toward elementary and middle-school classes and available for download on its website. In addition to the basic information about hydrogen and fuel cells, the presentation includes information about the predominant methods of extracting hydrogen, hydrogen's uses in transportation, and barriers to wide-spread use of hydrogen fuel cell vehicles. The website also provides links to other existing educational sources hosted by other universities, associations and the U.S. Department of Energy.

Stakeholder Network

Besides the educational modules, the majority of the effort of the Learning Center has been to engage a broad group of stakeholders in a discussion about the possible role of hydrogen and fuel cells in New Jersey. This network began by identifying companies, organizations, and government departments & agencies that participate directly or indirectly in hydrogen, fuel cells or alternative energy. Working with university partners, the Learning Center provided networking opportunities to share ideas and build a New Jersey identity by hosting four stakeholder meetings over the course of the first year. During these meetings, the Learning Center encouraged dialogue and collaboration, while obtaining feedback on existing policies and discussion of current barriers facing hydrogen as an alternative fuel and fuel cell technology

The Stakeholder Network was formally established at the September 20, 2005 kick-off event. This event helped to provide the foundation for stakeholder involvement. Interested parties were able to sign up to be part of the network at the event and later through the New Jersey Hydrogen Learning Center website.

Over the first year of operation, the Learning Center's Stakeholder Network continued to grow and attract a broader range of stakeholders. New members joined throughout the year by attending a quarterly networking event or by signing up through the Hydrogen Learning Center's website. The stakeholder network consists of over 102 members representing 75 companies, organizations and other entities. There are 45 private sector members, 9 non-university partner educational members, 13 non-profit members, 2 individuals and 6 non-NJ BPU government stakeholder members. The following sections describe the stakeholder events sponsored by the Hydrogen Learning Center.

Learning Center Launch Event

The launch event of the New Jersey Hydrogen Learning Center took place on September 20, 2005 in the Special Events Forum of the Bloustein School of Planning and Public Policy. The welcome address was given by Dean James Hughes, who spoke about the potential for New Jersey to use alternative and renewable energy industries as an economic development strategy for the state. President Jeanne Fox of the NJ BPU gave the keynote address, sharing her thoughts about the need to consider the state's policy on hydrogen energy to be prepared for the future.

Nora Lovrien of the Learning Center presented the purpose and design of the Learning Center and the events planned for the first year. Finally, a panel of experts presented four different perspectives on hydrogen and fuel cell technology in New Jersey. The panelists were: Stephen Poniatowicz, Assistant Vice President, Marina Energy, LLC; James Sherman, Vice President, American Wind Power & Hydrogen; Joseph Sullivan, Director of Facilities, the College of New Jersey; and Michael Winka, Director, NJ Board of Public Utilities, Office of Clean Energy. There were approximately 50 people in attendance, and the event gained subsequent press in the Star Ledger and WMBC television.

First Quarterly Meeting

The first quarterly meeting took place on Tuesday, November 16, 2005 at Ocean County College in Toms River. The keynote address by Patricia Passarella, Director of Clean Cities Program, U.S. DOE Mid-Atlantic Regional Office was cancelled due to illness. Her presentation entitled "Federal rationales and programs supporting hydrogen energy and how state policies and activities may fit into this picture" was posted on the Center Website. As an alternative to the keynote address, Lyle Rawlings of Advanced Solar Products, Inc. and James Sherman of American Wind Power & Hydrogen discussed issues facing hydrogen and fuel cell businesses regionally and particularly in New Jersey. An open discussion session followed their presentations. The topics discussed focused on the approaches New Jersey could take, if it so chooses, to establishing a hydrogen energy infrastructure in the state. This was followed by a tour of the fuel cell facility and a networking lunch. The event was covered by the Asbury Park Press, a local radio station, and WMBC television.

Second Quarterly Meeting

Ramapo College hosted the second networking meeting on February 7, 2006, with a keynote address provided by John Love, Project Manager at the New York State Energy Research and Development Authority. The topic of his address was New York's experience envisioning and commissioning a hydrogen energy roadmap and the steps following its establishment. A hydrogen and fuel cell short-course was given by Professor Bill Makofske prior to the start of the official program for those interested in learning basic facts. He also provided a response to John Love's address and spoke about challenges and barriers facing adoption of hydrogen and fuel cell technology. Filling out the discussion, Mike McGowan of BOC Gases provided an industry perspective and Mona Mosser of the NJ Board of Public Utilities provided the government perspective on these issues. The tour of the fuel cell on campus was followed by a discussion with the Ramapo facilities director, Bill Alagna, about his operational experience with Ramapo's 200kW phosphoric acid fuel cell.

In addition to the speakers and the tour, a variety of small-scale hydrogen and fuel cell models were set up by the registration desk. These demonstrations included a small solar cell that provided electrolysis of water and then the use of the hydrogen generated to power a small motor. The highlight of the demonstrations was a remote controlled car powered by a hydrogen fuel cell.

Third Quarterly Meeting

Stockton College hosted the third networking meeting on April 3, 2006. Continuing education credit for Architects was available based on the content of the course and arranged through Stockton. The main address for the stakeholder meeting was given by Robert Davidson of Davidson Code Concepts who spoke about the role of codes and standards in shaping hydrogen and fuel cell deployment in New Jersey and in the United States. The second address was by Rick Dovey from the Atlantic County Utilities Authorities (ACUA) who spoke about their experience of installing the Atlantic Wind Farm, the first onshore wind farm on the East Coast. In addition, Lynn Styles, Professor of Physics at Stockton, spoke about Stockton's experience installing several new energy technologies on campus, including their fuel cell, photovoltaic cells, and a large geothermal installation. In addition to the speakers and the tour, students from the courses in which the Hydrogen Education Module was taught provided poster presentations of their work from the course.

A tour of the fuel cell at Stockton College was given by Alice Gitchell, from the Facilities Planning & Construction Department at Stockton. Due to Stockton's extensive geothermal system, the heat from the fuel cell has not been utilized as efficiently as possible, thus reducing the overall efficiency of the unit. Construction on campus may result in the fuel cell unit being moved to a new location and shut down during this period. The high cost of natural gas has also reduced the financial payback of the fuel cell.

One of the main handouts for the stakeholder meeting was a draft discussion paper on the role of codes and standards in New Jersey's adoption of fuel cell technology.

Fourth Quarterly Meeting

The College of New Jersey hosted the fourth networking meeting on June 14, 2006. The topic of the two keynote presentations was exploring options for large-scale hydrogen production. This topic was selected because the success of a future "hydrogen economy" will rely on large amounts of hydrogen to fuel stationary, transportation and micro/small applications. The first presentation was given by Luke O'Keefe, Director of Energy Technology, from Burns and Roe Enterprises Inc. Mr. O'Keefe talked about coal gasification technology and developments. This was followed by a presentation by Dr. Serpil Guran from the New Jersey Department of Environmental Protection's Bureau of Sustainable Communities and Innovative Technologies who spoke about biomass reformation and its potential for mass production of hydrogen.

Breakout sessions by interest area were held in order to build on the discussion from the previous stakeholder meetings and to construct a list of issues, barriers and possible solutions for hydrogen and fuel cell technology deployment in New Jersey. The groups divided into two main categories: stakeholders interested in renewable hydrogen and those representing utilities, installers, energy service companies and fuel cell end users.

During the tour of TCNJ's three 250 kW fuel cell installation, Joe Sullivan, TCNJ's facilities director provided information about his experiences operating the fuel cells. The system is

designed to provide power and hot water for a new set of dormitories on the campus that are still under construction.

Learning Center Year-End Symposium

The Rutgers EcoComplex in Bordentown hosted the year-end symposium on September 15, 2006. The keynote address was given by NJ BPU Commissioner Fred Butler. The afternoon speaker was Valri Lightner, Fuel Cell Team Leader, U.S. Department of Energy Hydrogen Program. Also in the day-long agenda was a panel including: Mike Winka, New Jersey Office of Clean Energy; Lyle Rawlings, Advanced Solar Products; Mike Schweizer, Mercedes Benz; and Robert Kudrick, New Jersey Natural Gas. The title of the symposium was "Powering the NJ Hydrogen Economy: Next Steps for Hydrogen & Fuel Cell Technology in New Jersey."

This event capped the first year of the Hydrogen Learning Center's operations. Nora Lovrien and Dan Benson from the Learning Center discussed the center's activities since September 2005. They explained the purpose of the Center and its goals of furthering policy discussion of hydrogen and fuel cell technology with key stakeholders, encouraging students to learn about hydrogen and fuel cells in the classroom, and providing education and outreach to local officials and the general public. In addition, the Learning Center's speakers explored the future of hydrogen and fuel cells in New Jersey and presented the findings and recommendations.

Local Code Officials

Another key element of the Learning Center was engaging local code and zoning officials in an educational workshop about safe handling and installation of hydrogen and fuel cell technology. On the national level, comprehensive codes and standards have been identified[3] as one of the areas most in need of attention. Where the general public's safety is concerned, the adoption of new and potentially dangerous technology is often approached with great skepticism. Educating officials about the necessary safety precautions for handling hydrogen will help alleviate concerns and ease the process of installing hydrogen and fuel cell technologies in communities. This is especially relevant for residential and small commercial sites.

Working with the Rutgers Center for Government Services (CGS) at the Bloustein School and Robert Davidson of Davidson Code Concepts, the Hydrogen Learning Center hosted a full day session and offered continuing education credits through the Department of Community Affairs, Division of Codes and Standards. There were about 50 local code officials in attendance. In addition to the day-long workshop, Mr. Davidson and CGS offered a similar shorter workshop for code officials. Altogether about 150 code officials around the state were educated in the handling requirements for hydrogen and fuel cells and will be prepared if a building application includes these technologies in its design in the future.

The goals of the local code officials' module and workshop developed by the Learning Center were to:

- Examine current codes and standards affecting hydrogen and fuel cell technology
- Develop a training guide to disseminate recent changes to NJ codes and standards
- Provide opportunities for local code, zoning, planning and elected officials to get information on hydrogen and fuel cells

Prior to the codes and standards workshop, the Learning Center also prepared a discussion paper, which provided background and context for how codes and standards for new technology develop. The federal government is developing programs to encourage national codes and standards bodies to adopt language to address the potential uses of hydrogen and fuel cell technology.

[3] National Science and Technology Council. "Safety, Codes & Standards," Hydrogen.gov, http://www.hydrogen.gov/safety.html. Accessed on November 27, 2006.

Public Education and Outreach

The Learning Center's mission included a broader educational mission to the general public through outreach activities. The goals of the center's public education and outreach efforts included:

- Providing a general resource to the public about hydrogen and fuel cells
- Representing a New Jersey perspective at conferences such as the National Hydrogen Association's (NHA) annual conference
- Speaking to targeted audiences interested in hydrogen, fuel cells, or alternative energy
- Working with educators at the K-12 level to increase understanding of hydrogen and fuel cells

The primary vehicle to reach these goals was the Learning Center website at http://policy.rutgers.edu/ceeep/njh2lc.html. These public education and outreach activities are important because hydrogen is still relatively unknown in society and barriers may exist based on lack of knowledge about the safety and sources of hydrogen, the advantages and disadvantages of hydrogen as a fuel and fuel cell technology, or the important role of the New Jersey policy environment in helping to promote alternative energy resources like hydrogen.

New Jersey Hydrogen Learning Center Website

The website of the Learning Center is designed to be a single internet destination linking all the hydrogen related activities and research in New Jersey and the region. The website content spans the breadth of the target audiences, from basic information to links accessing more advanced or in-depth information.

The New Jersey Hydrogen Learning Center website went live on September 20, 2005. The goals of the site were to:

- Design a website to provide basic information for the public and policymakers on hydrogen and fuel cells;
- Provide links to NJ, regional, and federal hydrogen and fuel cell information; and
- Post information about the Stakeholder Network and Education Modules for wider consumption.

The website contains links to the university partner websites, information about the stakeholder network, news and events related to the Hydrogen Learning Center, as well as general information about hydrogen and fuel cell technology, state and federal policy. Since its launch, the site has been updated regularly as new stakeholders have signed up to be part of the network or hydrogen and fuel-cell related news or events were planned. The search engines Google™ and Yahoo!® yield several related hits (the number and accuracy of hits are related to the visits to the site and the volume of related searches as well as the length of time the webpage exists).

Important additions since the website's initial launch have been the *Educational Resources* web page with information for elementary and secondary school teachers and the *Networking Forum* web page for the stakeholder networking participants to post information about their activities or

to discuss issues facing the hydrogen and fuel cell community. Also added at a later date were pages dedicated to information on *Hydrogen Safety*, *Hydrogen Links*, *Hydrogen FAQs* and a *Hydrogen Codes and Standards* web page. The Learning Center also continued to update the other pages to include the educational modules of each university partner and posting the presentations and other materials from each networking meeting.

Other Outreach Efforts

In addition to the website, the Learning Center has been involved with various energy events and activities through attendance, providing literature, or giving presentations. The following describes some of the various events that Learning Center staff has participated in over the course of its first year of operation.

National Hydrogen Association Conference
March 16-20, 2006 – Long Beach, California

Nora Lovrien, Research Project Coordinator at CEEEP, represented the Learning Center at the conference. The Learning Center participated in the *State and Local Initiatives* and the *University Members* working group. The Learning Center has continued to be involved with NHA activities through phone conferencing and their email listserv to ensure that New Jersey input is provided on activities occurring in the state and region.

Warshauer Electric Training Seminars
March 6 and 20, 2006 – Parsippany, New Jersey

Dan Benson, Research Project Manager at CEEEP, gave two lectures on the installation of hydrogen fuel cells and on the basics of the technology at a seminar series held by Warshauer Electric for electric supply wholesalers and vendors. These companies were interested in learning more about advanced energy technology and opportunities for their companies to be wholesalers and integrators of key electrical supply parts needed for advanced energy technology installations.

NJ Higher Education Partnership for Sustainability – Spring Energy Workshop
May 5, 2006 – Rutgers EcoComplex - Burlington, New Jersey

Nora Lovrien, Research Project Coordinator at CEEEP, represented the Learning Center at the workshop. Besides providing a forum for networking and for identifying other stakeholders that may be interested in joining the Center's Stakeholder Network, the workshop was an opportunity for the Center to update existing stakeholders on the progress of the Center's mission. In addition, the Center was able to provide education and outreach information to targeted stakeholders in the higher education arena about hydrogen and fuel cells.

New Jersey Citizen Action's Clean Energy Leadership Forum
June 22, 2006 – Mount Laurel, New Jersey

Dan Benson, Research Project Manager at CEEEP, gave the welcoming address to leaders of various communities interested in learning more about cutting edge technologies and programs for their constituents. The NJ Hydrogen Learning Center was also asked to provide a high level overview of its activities and the long-term role that alternative fuels like hydrogen may play in creating a more sustainable energy future.

Association of Energy Engineers Annual Conference
April 4-5, 2007 – Atlantic City, New Jersey

Nora Lovrien, Research Project Coordinator at CEEEP, gave a presentation and wrote a conference paper discussing the results and recommendations that emerged in the first year of the NJ Hydrogen Learning Center. The 30-minute presentation included a review of the major components of the Learning Center, the main findings and challenges identified by the university partners and the stakeholder network, and suggested policy recommendations for encouraging the development of the hydrogen economy in New Jersey.

Findings and Recommendations

Based on networking meetings, outreach events, fuel cell case studies, and working group breakout sessions, the Learning Center was able to identify a number of issues that stakeholders deemed important for the growth of hydrogen and fuel cell technology in New Jersey.

Findings

1. First among the issues identified by stakeholders was expanding understanding of and awareness about basic information regarding hydrogen as a fuel and its use in fuel cells. Stakeholders found that there was a broad lack of awareness of hydrogen and fuel cells in the general public. More specifically, many people have concerns about hydrogen's safety compared to natural gas or propane. Lack of substantial operational data and widespread demonstrations makes the knowledge gap challenging to address.

2. Fuel and maintenance costs are a major concern for fuel cell operators in New Jersey. The recent trend of rising natural gas costs have created short-term disincentives and reduced potential savings that owners estimated they would receive over the life of the fuel cell. This has been especially true for lower temperature phosphoric acid fuel cells. Having maintenance agreements for the life of the fuel cell may help owners minimize rising operating and maintenance costs.

3. The largest maintenance cost for a fuel cell owner, regardless of type of fuel cell, is the replacement of the stack after 5-7 years of operation. The fuel cell stacks are the most expensive part of the fuel cell, making up approximately two-thirds of the original cost of the system. Whereas the initial purchase price of the fuel cell can be reduced by rebates and manufacturer incentives, rebuilding the stack is not eligible for incentives. The lack of support can be cost prohibitive for prolonging the life of the fuel cell.

4. Using the fuel cells to the maximum of their combined heat and power capacity is the best way to operate the units efficiently. The molten carbonate fuel cell at Ocean County College has resulted in significant savings because the high temperature steam can displace the use of one or more boilers during portions of Ocean County College's academic year. Other sites have had less ability to use the steam heat and therefore could not maximize the cogeneration power of the unit, thus making it less valuable over its life.

5. In addition to the operational issues faced by stationary fuel cell owners, the fuel cell industry is still developing. In order for fuel cells to become commercially viable, consensus on the type or types of technology best suited for stationary, transportation, and portable uses must be achieved. Without such consensus, manufacturers cannot achieve benefit from economies of scale in mass production of a single product. The need for cost reducing breakthroughs is most important for transportation applications in the areas of storage and production/generation of hydrogen and in cost of fuel cell engines.

6. State policy and regulatory treatment of fuel cells can have an impact on the number of stationary fuel cells purchased in New Jersey. New Jersey does not allow fuel cells powered by natural gas to be included in its Renewable Portfolio Standard (RPS) rules. Only fuel cells powered by renewable fuels are eligible. Other states in the region do include natural gas powered fuel cells in their RPS policies. Fuel cell manufacturers and installers argue different incentive structures limit their ability to have a consistent sales strategy in the region.

New Jersey's Combined Heat & Power Program currently supports fuel cell installations in the state. Fuel cell installers and owners noted that the current rebate level is smaller than the previous combined state and federal incentive that supported most of the current installations. The program also has fuel cells and microturbines competing for the same funding. Even though the rebate is much higher per kilowatt for fuel cells over microturbines, companies that sell both say that the return on investment for microturbines is more competitive. The Combined Heat & Power Program also limits the use of a fuel cell for emergency backup power. Since fuel cells operate off the natural gas infrastructure, they could potentially provide a source of emergency generation during electricity power interruptions. The lack of support for rebuilding the fuel cell stack has also created a costly investment every 5-7 years as the stack reaches the end of its life.

Finally, since fuel cells are supported only in combined heat and power configurations, this may limit fuel cell deployment to current phosphoric acid, molten carbonate, and other fuel cells that generate high enough heat. Low temperature proton exchange membrane (PEM) fuel cells may have niche markets in areas where there is not a need for the waste heat and could still benefit from the efficiency and distributed power benefits of the fuel cell. Under the current policy, PEM fuel cells would not qualify for financial support.

7. In the area of codes and standards, New Jersey is one of the first states to adopt the latest International Building Codes, which explicitly addresses safe handling of hydrogen and fuel cells. The role of the New Jersey Department of Community Affairs, Division of Codes and Standards as top code enforcer and interpreter is an important benefit for the state, as it may act as arbiter between an installer and local code enforcement officials if either feels that enforcement is not being applied correctly. New Jersey is also on track to be the first state to adopt the new National Fire Safety Standards that contain key updates for fuel cell installations.

Recommendations

Based on the findings and concerns by fuel cell stakeholders, the Learning Center identified six recommendations for policymakers to consider, which will be described in detail in the following pages:

1. Define a state hydrogen and fuel cell policy

New Jersey has different vehicles to define a state policy for hydrogen and fuel cells. Individual departments can adopt their own policy through the regulatory process. The state can set goals and metrics for hydrogen and fuel cells in New Jersey's energy portfolio through the current Energy Master Plan process. The Governor can set the state's policy by issuing an Executive Order. Regardless of the approach, New Jersey should define its policy towards fuel cells and

hydrogen as an alternative fuel in a way that complements existing state energy goals. At a minimum, adopting a vision for hydrogen and fuel cells in New Jersey is an important first step in establishing an explicit policy for the state.

2. Invest resources to complement renewable energy

The state should develop a policy that complements existing energy efficiency and renewable energy policies and investments. Given New Jersey's leadership position in solar energy, the state should look for opportunities for innovative renewable to hydrogen demonstrations. New Jersey has already made headlines in hydrogen leadership due to its support of a PV solar to hydrogen powered home. The state should explore whether similar opportunities exist for a wind to hydrogen demonstration that could be supported at the Atlantic County Utility Authority's wind system. New Jersey's research and development community also has the potential for hydrogen and fuel cell technology breakthroughs in a number of areas. New Jersey can play a leading role in research and development through state support of research in photoelectrochemical hydrogen generation, nanotechnology storage, and landfill/bio-gas purification.

The following is an example vision statement that encompasses the view of hydrogen and fuel cells as a fuel and technology that can aid New Jersey in meeting its energy goals:

> *Hydrogen and fuel cell technology will be commercially competitive and available as a key component of New Jersey's energy portfolio as a complementary technology whose deployment complements existing state goals of encouraging distributed generation, increasing reliability, reducing congestion, expanding renewable energy growth and management, and increasing clean base-load, backup, and prime power production while reducing negative environmental emissions.*

Additionally, the potential retirement of older coal power plants in New Jersey will present the need to think about new large-scale electric generating policies and projects. New power plants provide an opportunity for choosing a site for a newer clean coal gasification plant that could become more integrated with a hydrogen economy. A integrated gasification combine cycled (IGCC) pilot plant can not only produce power with fewer emissions than traditional coal plant technology, but the syngas produced to generate electricity is mostly hydrogen and can easily be designed to co-generate hydrogen and electricity. IGCC plants are being encouraged by the Federal Government in the National Hydrogen Roadmap. Neighboring states, New York, Connecticut and Delaware, are currently seeking pilot projects for IGCC plants.

3. Review current fuel cell economic incentives

In order to ensure that fuel cells continue on a path towards competitive commercialization, New Jersey should review its economic incentives for hydrogen fuel and fuel cell technology on a regular basis, at least every two years. This review should include an examination of current capital costs for fuel cell technology. Incentives should be established in relation to a baseline for natural gas and electricity price forecasts for the life of the average fuel cell stack. This will help

to avoid a drop in fuel cell deployment when natural gas prices are expected to rise faster than electricity prices. State incentives should be tied, when possible, to the availability of federal incentives to increase savings for end users. At a minimum, incentives should be reviewed to ensure that they establish an appropriate rebate level that allows for a return-on-investment over the life of stack.

Other suggestions by stakeholders to improve incentives include reducing the competitive friction between fuel cells and micro-turbines by creating a separate fund for fuel cells within the CHP program. Also, in order to encourage its distributed generation goals, the State should consider bonus incentives for fuel cell deployment in load congested areas.

4. Build Regional Cooperation

To help gain acceptance of hydrogen and fuel cell technology, potential users need to understand both its benefits and limitations. Activities that broaden education and outreach will be vital to expanding the public's acceptance. This can be achieved by partnering with national and regional organizations to use common educational materials. Also, opportunities should be identified where regional educational campaigns for the general public can be created. New Jersey should continue its efforts to target students, educators, and local officials. The Learning Center should create a state speakers list of experts from stakeholders and university partners so that organizations and other groups that are interested in learning about hydrogen and fuel cells can seek a speaker near their community. The Learning Center should also seek to expand its hydrogen website by adding more interactive information.

Potential partners for building regional cooperation include:

- National Hydrogen Association,
- Mid-Atlantic Hydrogen Coalition,
- Neighboring states that are active in fuel cell development such as NY/CT/PA/DE/MD, and
- Clean Energy States Alliance's Public Fuel Cell Alliance

5. Broaden education and outreach activities and coordinate research and development

The state should encourage collaboration and coordination of relevant hydrogen and fuel cell research and development. The Learning Center can further this goal by expanding its University Partners to any college and university with hydrogen and fuel cell facilities or research on campus. To track the research that is being undertaken in New Jersey, the state through the Learning Center should develop a database of research and development related to hydrogen and fuel cells at NJ colleges and universities. Finally, through events tied to the Stakeholder Network, the Learning Center should identify companies performing hydrogen and fuel cell industrial and applied research that may benefit from collaboration with New Jersey's university research community.

6. Encourage fuel cells in state transportation alternative fuel policies

Since the State's collaboration on Project Venturer and NJ Genesis fuel cell vehicles over five years ago, New Jersey's investment in fuel cell technology has been strictly in the stationary power sector. The state's density and experience with transportation infrastructure provides an opportunity for it to play an important role in the commercialization of hydrogen fuel cell vehicles. As with the Venturer and Genesis projects, New Jersey should consider creating a standing collaboration through an inter-department and agency working group.

The state's current experience with stationary fuel cells could be expanded to include vehicle refueling. Newer stationary power fuel cells can create additional hydrogen beyond the electricity generation needs of the system and generate enough hydrogen to fuel a vehicle. Supporting this move is federal funding for energy stations that combine stationary and refueling capabilities. Part of including a transportation component in the state's hydrogen and fuel cell investments should be identifying a vehicle fleet or transportation cluster that could best support a hydrogen station. Collaboration with a business or university vehicle fleet may provide opportunities for such a demonstration.

Future Activities

The Learning Center's first year was marked by a solid development of New Jersey's identity among hydrogen and fuel cell stakeholders. Its future activities will seek to build upon its initial success to further the goals and recommendations discussed in the previous section.

The Learning Center will expand its university partnerships to invite any university that is conducting hydrogen and fuel cell research and development activities. These institutions may include, but are not limited to, Rutgers Center for Advanced Energy Systems, New Jersey Institute of Technology, Stevens Institute of Technology, and Princeton University. These new partners will host a quarterly networking event and help educate middle-, high school, and undergraduate students by hosting field trips or visits to their lab facilities to learn about the research being conducted. The quarterly networking events will allow opportunities to highlight stakeholder activities through the sponsorship of the luncheon and a chance to address the group about new ideas and technologies that may have a future in New Jersey.

Researchers from the engineering and natural science departments at Rutgers will act as a technical advisory board to help steer the activities of the Center to the most timely and cutting-edge issues for the state. This expanded academic participation will enhance the University Partnership and expand the distributed nature of the NJ Hydrogen Learning Center.

The Stakeholder Network will have the chance for more in-depth involvement in the examination of hydrogen and fuel cells as part of the state's energy portfolio. Topics that will be explored in targeted working groups include transportation, state support for research and development, interagency cooperation, and potential niche approaches for New Jersey in the hydrogen economy. This activity will result in a model policy or policies for state energy policy makers to consider.

Deliverables will include four quarterly reports, four networking meetings, field-trip activities hosted by each of the existing and new University Partners, regular updates to the NJ Hydrogen Learning Center Website, instructional materials for a semester-length course developed by a University Partner, on-going working group meetings of targeted stakeholders, and finally, a model hydrogen policy for consideration by energy and environmental policy makers and the Governor.

Appendices

University Partner Contacts

The College of New Jersey
Main Contact: Dr. Matthew McGarry – Faculty Coordinator
Telephone: 609-771-3071
E-Mail: mcgarry@tcnj.edu
Secondary Contact: Lisa Grega – Faculty Contact
Telephone: 609-771-2860
E-Mail: grega@tcnj.edu
Mailing Address: 2000 Pennington Road, P.O. Box 7718
Ewing, NJ 08628-0718

Ramapo College of New Jersey
Main Contact: Ms. Carmela Federico – Sustainability Center Coordinator
Telephone: 201-684-6227
E-Mail: cfederic@ramapo.edu
Secondary Contact: William (Bill) Makofske – Faculty Contact
Telephone: 201-684-7752
E-Mail: bmakofsk@ramapo.edu
Mailing Address: 505 Ramapo Valley Road
Mahwah, NJ 07430

Richard Stockton College of New Jersey
Main Contact: Diane Hulse-Hiller – Geothermal Project Coordinator
Telephone: 609-652-4677
Email: diane.hulse-hiller@stockton.edu
Secondary Contact: Lynn Stiles – Faculty Coordinator/Facilities
Telephone: 609-652-4299
Email: lynn.stiles@stockton.edu
Mailing Address: PO Box 195
Pomona, NJ 08620-0195

Ocean County College
Main Contact: Ken Olsen – Director of Facilities
Telephone: 732-255-0363
E-Mail: kolsen@ocean.edu
Secondary Contact: Dennis Kalichstein – Faculty Contact
Telephone: 732-255-0400 ext. 2267
E-Mail: dkalichstein@ocean.edu
Mailing Address: College Drive, P.O. Box 2001
Toms River, NJ 08754-2001

Rutgers EcoComplex
Main Contact: Ms. Nancy Belonzi – Program Manager
Mr. David Specca – Acting Director, Rutgers EcoComplex
Telephone: 609-499-3600
Mailing Address: 1200 Florence-Columbus Rd.
Bordentown, NJ 08505-4200

Fuel Cell Case Studies

Among the four universities with fuel cells, two types of fuel cell systems were used. Three of the partners had phosphoric acid fuel cells from UTC Power of Connecticut. The fourth had a high temperature molten carbonate fuel cell from FuelCell Energy, also of Connecticut. Each University Partner experienced unique issues based on their siting, model, and incorporation into the rest of the school's physical plant.

Ramapo College of New Jersey, Mahwah

Ramapo College operates two fuel cells, both installed in 2000. The college invested in the units with financial support from the federal government through a Department of Defense subsidy. In 2000, the school paid about $600,000 per unit, after a government rebate of $200,000; between that time and the next year, the price for a unit increased as much as $350,000, making the total over one million dollars. The total cost including installation was $2,150,000. The additional cost included labor and auxiliary equipment, design and project management. The federal grant was awarded in the 1998 program year, and the fuel cell was installed in 2000 as part of a new dormitory building project.

The fuel cell manufacturer is UTC Power, a United Technologies Company. The power capacity of each unit is 200 kW each for a total of 400 kW. The age of units is 6 years and both operate using natural gas. Fuel Cell #1 provides 80 percent of the energy for Oak Hall dormitory and surrounding parking areas and hot water to the dorm. Fuel Cell #1 provides electric power in parallel with the electric grid during normal operation. Upon grid failure, the fuel cell disconnects from the grid and awaits manual reset. Hot water from the fuel cell is pumped to the dorm's domestic and space heating systems. When the base load of the dorm was discovered to be less than 200 kW the fuel cell output was reduced to 100 kW to avoid feeding power into the grid. During the summers, the heat is not used in the buildings and is exhausted and vented outside the buildings.

Fuel Cell #2 provides electrical power and hot water to a core group of academic buildings, including power to communications and computer facilities. As with the dorm fuel cell, the academic fuel cell operates in parallel with the electric grid. Upon grid failure, the fuel cell automatically disconnects from the grid. Within 10 seconds of grid failure, the fuel cell will reconfigure itself and provide electrical power directly to individual electrical panels. The electrical panels provide power primarily to the college computer center, telephone system, and cable TV station. This ability to reconfigure and power individual loads is one of the primary benefits of the fuel cell. Both units produce variable DC power output and a power conditioning unit within the system housing turns this output into required stable AC voltage for onsite and grid use.

Ramapo discovered fuel cell technologies as they sought to upgrade their power facilities. The school's environmental philosophy and desire to be a technology leader added to its willingness to try this new technology. William Alagna, director of facilities, began the quest to find a new

uninterruptible power source (UPS) for the campus when the computer data department requested a backup system to ensure that important information would not be at risk in case of a blackout. Richard Roberts, associate vice president for administration and finance, pointed to Ramapo's long history of saving energy to "save the earth" as another reason for the choice. Energy efficient lights, reduced consumption showerheads and bathroom fixtures, plus other modifications and monitoring systems were installed to cut Ramapo's fuel and water usage.

This brand and type of fuel cell was purchased because at the time it was the only commercially available model. Ramapo purchased these fuel cells with the hopes of significantly reducing the amount purchased from the utility company and using the backup power potential to ensure that the campus can produce enough energy during an emergency situation or temporary loss of power. Their initial estimates were that the fuel cell would produce electricity at approximately three to four cents per kilowatt-hour as opposed to the approximate eleven cents per kilowatt-hour Ramapo was paying to the local utility company at the time. Ramapo also was attracted to the technology due to the promise of low maintenance. With no moving parts in the fuel cell and no combustion, it was hoped that there would be very little breakage with no need for oiling, greasing, or priming a motor. In the long run, Alagna estimated that the fuel cells would pay for themselves in about four years.

Due to Ramapo's first adopter status, they have experienced higher than expected maintenance costs, lower than expected life of the fuel cell stack. Purchased in 2000, the model of UTC Power's fuel cell (Model C) has since seen technical modifications to improve its performance. Its performance was lower than expected to do early maintenance issues related to the fuel cell stack. The high cost of natural gas has also reduced the financial payback of the fuel cell. As the oldest of the installed fuel cells at the University Partner schools, Ramapo is coming to the end of the life of its fuel cell stack and at this point is not expected to rebuild the stack without new or additional incentives from grants or the manufacturer.

Another unanticipated issue was the fuel cell's approved use for emergency backup. Being a public building, the state had the final approval on the use of fuel cells for emergency power. After a number of meetings, the state did not allow the fuel cell to serve as the emergency generator and a standard, natural gas fired, reciprocating engine generator was installed. Subsequently, these rules were modified to allow use of a fuel cell for emergency lighting. Also, the fuel cell was not initially incorporated into the design of the building and subsequent changes in site design and specifications resulted in higher installation costs.

Through the Ramapo Sustainability Center and its coordinator, Carmela Federico, Ramapo used its fuel cells both for demonstrations for students and for tours by off-campus visitors. Unfortunately, in 2006 this position was eliminated as part of budget cuts due to reductions in state funding.

The Richard Stockton College of New Jersey, Pomona

Stockton College is a leader in application of new and alternative technologies to reduce greenhouse gas emissions and fossil fuel use. An 400-borehole closed loop BTES (borehole thermal energy storage) geothermal heat pump system has provided heating and cooling to

academic facilities since 1994. A 200 kW fuel cell and 20 kW solar photovoltaic array are fully operational as well. Three buildings are in design or under construction with anticipation of LEED certification. Stockton's choice of a fuel cell was to evaluate its suitability for a medium sized campus. Some of the expected advantages of operating a fuel cell on their campus included:

- Avoiding cost of power delivery
- Reliability and support of emergency power needs
- Educational value as demonstration project
- Utilization of waste heat

The UTC PC25 fuel cell was purchased through a group contract organized by NJ Higher Education Partnership for Sustainability. In May of 2002, the College completed its feasibility study and decided to go forward with the project. It came online in March of 2003. The fuel cell in 2002 had an initial cost of $1.3 million dollars. The NJ BPU provided a grant to cover most of the cost of the unit, with the college paying only $ 305,000. South Jersey Industries (SJI) also provided a rebate of $710,000 for the unit. The fuel cell provides just under 10% of the total energy for the campus. The projected lifetime was 5 years, but it may be operational for 6 years. The fuel cell was estimated at its installation to provide a savings of over $80,000 per year in energy costs for the school.

There were no serious problems with the installation and initial testing. Natural gas is reformed into hydrogen externally from the fuel cell but part of a self-contained system. There is no gas cleaning equipment on the utility side of the meter. The pressure of natural gas supplied is 1 psi. Some of the "waste" heat is captured for boiler and domestic hot water use, but not all of it. Utilization could be increased, but Stockton estimates that the associated costs (design, plumbing, and mechanical) would be high. The best outcome would be attained if a fuel cell were designed into the associated buildings before construction. This project was a retrofit, and location was decided based on visibility to the public as well as proximity to heat using equipment. AC power is connected to campus distribution system through an inverter. Availability on a quarterly basis has ranged from 73% to 98.7%, averaging about 90%. This was less than anticipated.

Educational lecture tours for several classes and a student internship have been offered. Additional educational and public relations programs associated with fuel cell including the Stakeholder Networking event with luncheon, which was attended by representatives from NJ government agencies, architectural & engineering firms, other colleges and universities, and the general public. Sixty-five people attended the technical session. Architects received continuing education credit for attendance. Several small informal visits were hosted later.

The fate of Stockton's fuel cell is undecided. Natural gas prices have risen and reduced the savings expected. The annual maintenance contract cost has more than tripled since the fuel cell went into service. Rebuilding the fuel cell stack after the five or six year mark will be very costly. Major construction and expansion is planned for the College and some of that activity is already underway. A 150,000 gross square feet College Center may be constructed where the fuel cell stands. Moving it would cost more than $100,000. A decision about relocation is pending.

Ocean County College, Toms River

Ocean County College dedicated the installation 250-kilowatt Direct Fuel Cell power plant on April 22, 2004 at its Toms River, New Jersey campus. Funding was obtained and installation was initially announced in August 2002. The power plant supplies approximately 80% of the electricity needed in their 54,000 square foot Instructional Building. Additionally the power plant supplies preheated water to 250 horsepower boilers that feed an additional five buildings. The fuel cell was manufactured by Fuel Cell Energy of Danbury, Connecticut and installed by Millennium Builders, a subsidiary of PPL Energy Services.

The college elected to install a fuel cell because it generates electricity with no combustion. The hydrogen source used in the fuel cell is supplied from natural gas. Since the gas is not burned, there is less pollution than is associated with the combustion of fossil fuels. Because the hydrogen is generated directly within the fuel cell there is no need for a hydrogen infrastructure.

The total project cost was $1,650,000. Ocean County College received a grant from the New Jersey Clean Energy Fund in the amount of $827,000 to help with the construction of the fuel cell. The power capacity of the fuel cell is 250-300 kW. FuelCell Energy manufactures a molten carbonate fuel cell. The Ocean County College fuel cell is the only one of this type on a university campus in New Jersey. It was chosen because of the high temperature of the fuel cell allows for the waste heat to be used to reduce boiler use. This increases savings on cost and maintenance. In addition, the high heat and design of the FuelCell Energy system allows for the natural gas reformation to be done internally within the fuel cell increasing the overall electricity efficiency of the system. High fuel costs have reduced the savings but according to facilities director, Ken Olsen, its value proposition to save facility costs has still held up.

Installing back-up systems for critical parts has also been a learning experience for the fuel cell set-up. Recently, the water booster pump for the fuel cell had to be replaced. To prevent a reoccurrence, a spare pump was fully installed and wired. Now, if the primary pump fails, it is a simple matter of switching a couple of valves and unplugging the failed pump and plugging in the spare. It takes a matter of a minute to switch over. Previously, when the pump failed, it took approximately three to four days to get a replacement and install it.

The College of New Jersey, Ewing

Similar to Ocean County and Stockton, The College of New Jersey (TCNJ) purchased their fuel cell as part of incentives offered in 2002. The college sought to purchase the three Phosphoric Acid fuel cell units to provide power and heat to new dorms that were being built. However, delays in the building and then a complete halt to the building of the dorms part way through their construction, led the college to take delivery of the fuel cells and install them to their physical plant in Fall 2004. The three units were incorporated into TCNJ physical plant and are part of a comprehensive "Energy Master Plan." While the plan for the dorms now is to have them razed and then rebuilt, the hope is to still use the waste heat potential of the units when the dorms are completed.

The natural gas fuel cells cost over $3 million, most of which came from grants from the U.S. Department of Defense and the NJ BPU. The college was responsible for funding $770,000. The installation of the fuel cells was anticipated to provide a cost savings of $259,000 annually in energy costs. Like Stockton and Ramapo, the fuel cells are manufactured by UTC Power and each has a capacity of 200 kW for a total of 600 kW generation capacity. Because the dorms are not complete, the fuel cells have had their stacks flushed and are operating in a hibernate mode to maintain the life of the stack. They are expected to hibernate for up to 3 years pending the re-construction of the school dorms. More operational data will become available at that time.

The Rutgers EcoComplex, Bordentown

Many of the sources of hydrogen for today's needs are derived from fossil fuels. This results in the production of greenhouse gases much like other fossil fuels. For a hydrogen fuel economy to become environmentally sustainable, further development work is needed to identify renewable sources of hydrogen. Research on renewable hydrogen sources can be seen first hand at the Rutgers EcoComplex. Technologies to generate hydrogen from landfill gas and plant-based materials, called biomass, are being refined and demonstrated.

One of the major challenges to using landfill gas and biomass for hydrogen production is the cleaning of the raw gas. Hydrogen generators, called reformers, are sensitive to sulfur, nitrogen, and many other compounds that can be found in these raw gases. Removing these compounds from the gas is critical for proper operation of the equipment. The EcoComplex is incubating a company that can clean the raw landfill gas in an economical and environmentally responsible process thereby allowing it to be utilized in hydrogen reformers. Other research work ongoing at the EcoComplex involves demonstrating small-scale anaerobic digesters that can generate biogas from waste food, paper and other biomass sources. Although the EcoComplex does not currently have a fuel cell that could produce electricity from refined landfill gas, its long-term goal is to be able to purchase one, as landfill gas purification technology matures.

Stakeholder Network Members

Business Stakeholders

Advanced Solar Products, Inc.
66 Snyder Road
Hopewell, NJ 08525
www.advancedsolarproducts.com
Contact: Lyle Rawlings
Phone: 609-466-4495
Fax: 609-466-8681
E-mail: lyle@advancedsolarproducts.com

American Wind Power & Hydrogen
92 Park Street
Montclair, NJ 07042
Contact: James Sherman, V.P.
Phone: 973-783-0284
Fax: 973-783-0285
E-mail: Dynequ@comcast.net
Contact: Charles Pratt
Phone: 212-836-4706
E-mail: cmpratt@att.net

BOC Gases
575 Mountain Avenue
Murray Hill, NJ 07974
www.boc.com
Contact: Mike McGowan
Phone: 908-771-1086
Fax: 908-771-1903
E-mail: michael.mcgowan@boc.com

First Energy, JCP&L
300 Madison Avenue
Morristown, NJ 07962-1911
www.firstenergycorp.com
Contact: Eva Gardow
Phone: 973-401-8347
Fax: 330-315-9720
E-mail: egardow@firstenergycorp.com

Foreman Architects & Engineers
PO Box 7037
Watchung, NJ 07069
www.formangroup.com
Contact: Ken Stromsland
Phone: 908-668-0111
Fax: 908-668-0111
E-mail: ken.stromsland@formangroup.com

Freedom Wind Energy, LLC
Executive Offices
PO Box 24597
Tampa, FL 33623
www.FreedomWindEnergy.com
Contact: Kennan George Dandar, Esq.
Phone: 813-289-3858 or 412-956-3846
Fax: 813-287-0895
E-mail: kgd@freedomwindenergy.com

FuelCell Energy
105 Maxess Road, Suite S124
Melville, NY 11747
www.fuelcellenergy.com
Contact: John Franceschina, P.E.
Phone: 631-574-4458
E-mail: jfranceschina@fce.com

Homeland Energy Development, LLC
22 Lenox Road
Rockaway, New Jersey 07866
www.homeland-energy.com
Contact: Chuck Feinberg
Phone: 973-886-1655
E-mail: cfeinberg@homeland-energy.com

Interstate Traveler Company, LLC
9594 Main St.
Whitmore Lake, Mi 48189
www.InterstateTraveler.us
Contact: Justin Sutton
Phone: 734-449-4480
Fax: 734-449-4486
E-mail: Justin@InterstateTraveler.us

Island Wind, Inc.
39 W. Indiana Avenue

Beach Haven, NJ 08008
Contact: Michael A. Mercurio
Phone: 732-740-6426
Fax: 609-492-6632
E-mail: Islandwind@aol.com

Mercedes-Benz USA
Contact: Mike Schweizer, Fuel Cell Specialist
Product Management - Advanced Product Planning
Phone: (201) 573-2642
Fax: (201) 573-6737
Email: michael.e.schweizer@mbusa.com
http://www.mbusa.com/

Millennium Cell Inc.
One Industrial Way West
Eatontown, NJ 07724
www.millenniumcell.com
Contact: Rex Luzader
Phone: 732-996-6544
Fax: 732-542-4010
E-mail: luzader@millenniumcell.com

Neighborhood Energy LLC
8 Anthony Drive
Burlington, NJ 08016-5148
www.neighborhoodenergy.com
Contact: Michael Parker
Phone: (800) 251-9545
Fax: (609) 239-4181
E-mail: mparker@neighborhoodenergy.com

NJS Associates, LLC
6 Whitman Drive
Denville, NJ 07834
Contact: Nick Stecky
Phone: 973-960-4275
E-mail: nstecky@aol.com

RAM Biotech, LLC
167 Keswick Drive
Piscataway, NJ 08854
www.rambiotech.com
Contact: Mahesh Varavooru
Phone: (201)637-5496
Fax: (201) 603-1121
E-mail: mahesh.varavooru@rambiotech.com

Reaction Sciences, Inc.
22 Lambert Johnson Drive
Ocean, NJ 07712-3748
www.reactionsciences.com
Contact: Steve Amendola
Phone: 732-643-0447
Fax: 732-643-0446
E-mail: info@reactionsciences.com

Solara Energy, Inc.
55 Cross Keys Road
Berlin, NJ 08009
www.solaraenergy.com
Contact: Peter Burcat
Phone: 866-476-5272
Fax: 408-782-0882
E-mail: pburcat@solaraenergy.com

TurtlEnergy, LLC
1900 Lower Road
Linden, NJ 07036
www.turtlenergy.us or www.turtle.com
Contact: John Millard
Phone: 908-397-5740
Fax: 732-574-2353
E-mail: john.millard@turtlenergy.us

UTC Power
195 Governor's Highway
South Windsor, CT 06074
www.utcpower.com
Contact: Robert Tierney
Phone: 860-727-7054
Fax: 860-998-9008
E-mail: robert.tierney@utcpower.com

Education Stakeholders (Non-University Partners)

Bergen County Technical Schools
327 E. Ridgewood Avenue
Paramus, NJ 07652
www.bergen.org
Contact: Peggy Frizzell
Phone: 201-343-6000 ext. 2219
E-mail: peggro@bergen.org

Center for Sustainable Energy
Bronx Community College, CUNY
University Ave. @ 181rst St.,GML104
Bronx, NY 10453
http://www.csebcc.org
Contact: James Quigley
Phone: 718-289-5334
Fax: 718-289-6496
Email: mail@csebcc.org

Toms River High School South
55 Hyers Street
Toms River, NJ 08753
www.trschools.com/staff/g/cgirtain
Contact: Christine Girtain
Phone: 732-505-5734
Fax: 732-341-1321
E-mail: cgirtain@trschools.com
Activities: Student research, curriculum, information base and networking for student research.

Non-Profit Stakeholders

Center for Economic & Environmental Partnership, Inc.
2160 Bolton Street
Bronx, NY 10462
Website: www.nhf2.org
Contact: Gelvin Stevenson, Ph.D.
Phone: 718-863-4156
E-mail: gelvin@optonline.net

Clean Energy States Alliance
50 State Street, Suite 1
Montpelier, Vermont 05602
www.cleanenergystates.org
Contact: Cameron Brooks
Phone: (802) 223-2554
Fax: (802) 223-4967
E-mail: cameron@cleanegroup.org

New Jersey Corporation for Advanced Technology
New Jersey EcoComplex
1200 Florence Columbus Road
Bordentown, NJ 08505
www.njcat.org
Contact: Rhea Weinberg Brekke
Phone: 609-449-3600 x 227
Fax: 609-499-3647
E-mail: rwbrekke@njcat.org

New Jersey Public Interest Research Group
11 N. Willow Street
Trenton, NJ 08608
www.njpirg.org
Contact: Adam Garber
Phone: 609-394-8155
Fax: 609-989-9013
E-mail: agarber@njpirg.org

New York Academy of Sciences
2 East 63rd Street
New York, NY 10021
www.nyas.org
Contact: Karin Pavese
Phone: 212-838-0230 ex. 421
E-mail: kpavese@nyas.org

Government Stakeholders (Non-NJ BPU)

Bureau of Sustainable Communities & Innovative Technologies
NJ Department of Environmental Protection, Division of Science, Research & Technology
PO Box 409
Trenton, NJ 08625
www.state.nj.us/dep/dsr/bscit.htm
Contact: Marty Rosen
Phone: 609-984-4661
Fax: 609-292-7340
E-mail: martin.rosen@dep.state.nj.us

New Jersey Commission on Science and Technology
P.O. Box 832
Trenton, NJ 08625
www.state.nj.us/scitech
Contact: Joseph Tetteh
Phone: 609-984-1671
Fax: 609-292-5920
E-mail: joseph.tetteh@scitech.state.nj.us

New Jersey Division of the Ratepayer Advocate
31 Clinton Street 11th Floor
P.O. Box 46005
Newark, New Jersey 07102
http://www.rpa.state.nj.us
Contact: Susan McClure, Esq.
Phone: (973) 648-2690
Fax: (9730 624-1047
Email: smcclure@rpa.state.nj.us

List of Files on Project CD

- All power point presentations
- Event photos
- Previous quarterly reports
- Event invitations

RUTGERS

Edward J. Bloustein School
of Planning and Public Policy

33 Livingston Avenue, Suite 100
New Brunswick, NJ 08901-1958
Phone: 732/932-5680 Fax: 732/932-0934
Email: ceeep@policy.rutgers.edu
Web: http://policy.rutgers.edu/ceeep