

# *Results of a Hydrogen Pilot Program*

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## ABSTRACT

State policy initiatives to support hydrogen energy and fuel cell technology have taken various forms across the United States. The rationale for different designs depends on the resources of the state and the aims of the policy. New Jersey is situated in a region of the country where relatively advanced state-level initiatives are already in place. Policymakers in New Jersey recognized the need for the state to be prepared for a transition to a hydrogen-based economy, but preferred a policy that would compliment the unique attributes of the state. The New Jersey Hydrogen Learning Center was a pilot project funded by a grant from the New Jersey Board of Public Utilities (NJ BPU) and administered by the Center for Energy, Economic & Environmental Policy (CEEPP) at Rutgers University intended to explore the options of hydrogen energy in New Jersey. The Learning Center has engaged stakeholders and students in a statewide discussion to determine the best approach for New Jersey to move toward a hydrogen-based economy. This article will describe the methods of outreach used by the New Jersey Hydrogen Learning Center and discuss the results and lessons learned from its first year of activities. The Learning Center focused on outreach to three specific groups: private companies, educators and students, and local code and zoning officials. New Jersey is just beginning to establish its own hydrogen and fuel cell policy, and the Learning Center has helped provide a unique perspective on building a stakeholder network to inform and develop state policy in the hydrogen and fuel cell arena.

## BACKGROUND

The New Jersey Hydrogen Learning Center was launched in September 2005 and recently completed its first year of operation. The

project grew out of a desire of energy policymakers from the New Jersey Board of Public Utilities to take steps to consider hydrogen as part of the state's energy portfolio. In 2003, the BPU commissioned CEEEP to conduct a study that explores the resources available in New Jersey that could help support the growth of the hydrogen economy. The conclusion of *New Jersey: Opportunities and Options in the Hydrogen Economy*, released in 2004 was that these resources are significant in the form of small business development in the private sector, demonstration projects on college campuses, and significant research and development work happening at universities located in New Jersey. The study recommended the development of the Hydrogen Learning Center as a way to formally convene these stakeholder communities to help identify strategies for achieving a hydrogen economy and barriers that New Jersey policymakers could help address.

By definition, 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. The stated goals of the Learning Center 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;
- Enhance and increase the dissemination and exchange of ideas and information among these stakeholders; and
- Develop greater understanding of hydrogen and fuel cell issues among local government officials.

In its first year of activity, the Learning Center provided opportunities for hands-on demonstrations, tours of facilities, and other education and outreach activities to enhance public knowledge about hydrogen and fuel cells. In addition, a hydrogen website was established to provide information on hydrogen and fuel cells for stakeholders in New Jersey, and a forum for discussion\*. Significantly, the Learning Center is designed to not be limited geographically to one location. It incorporates each of the university-based fuel cell demonstration sites as university partners into a single distributed center. This helps to maximize the ability for students and other stakeholders to obtain hands-on learning experiences at facilities close to their communities. CEEEP, as administrator of the Learning Center, coordinated the activities across the distributed sites. For all activities pursued, results were documented and findings were identified for lessons learned and areas of improvement in the Hydrogen Learning Center's education and outreach mission.

## NEW JERSEY HYDROGEN STAKEHOLDERS

Transitioning to a hydrogen-based economy would have a significant impact on the economy and businesses of the state. There are entrepreneurs and researchers in New Jersey developing technologies that could define the portfolio of technologies that form the foundations of this energy paradigm. One of the goals of the Hydrogen Learning Center was to leverage this expertise to articulate policy initiatives and barriers that need to be overcome in pursuit of a hydrogen economy. Stakeholders participated in a variety of ways. First, every quarter and for a kick-off and final symposium, stakeholders were invited to networking and educational events at the university partner sites. Keynote speakers addressed timely themes related to the hydrogen economy. Stakeholders participated by offering informal comments, participating in panel discussions, and raising awareness about the issues they were most interested in with respect to hydrogen and fuel cell technology. The events included networking lunches and tours of the on-campus fuel cell site, with presentations by the facilities managers at each school.

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\*The web address for the New Jersey Hydrogen Learning Center is: <http://policy.rutgers.edu/ceep/njh2lc.html>.

Second, stakeholders could sign up to have their contact information and short descriptions of their activities posted on the New Jersey Hydrogen Learning Center webpage. The site offered a sign-up form to attract stakeholders not already included on the Center's mailing lists. The posted information was divided into four groups: (1) private sector; (2) government and public sector; (3) educational; and (4) non-profit organizations. In addition, the Learning Center attracted a number of interested individuals who regularly shared their thoughts and expertise. The public listing of stakeholders provided valuable networking opportunities for those interested in hydrogen in New Jersey and the region. The information provided Table 1 shows a breakdown of the official stakeholder network.

Third, a web-based discussion forum was developed to accommodate discussions among stakeholders in between quarterly events. CEEEP staff monitored this board and added comments when necessary. Finally, through contact with CEEEP staff directly, stakeholders received information about other members of the group that may be helpful for their purposes. These facilitated contacts used the New Jersey Hydrogen Learning Center as a point of reference, which represents a significant change in the level of organized hydrogen related activities in the state.

**Table 1. New Jersey Hydrogen Learning Center Stakeholders**

Group	# of Members	Sample*
Private Sector	45	<ul style="list-style-type: none"> <li>• Advanced Solar Products</li> <li>• Millennium Cell</li> <li>• BOC</li> <li>• First Energy/JCP&amp;L</li> <li>• Mercedes-Benz USA</li> <li>• Foreman Architects &amp; Engineers</li> </ul>
Government/Public Sector	6	<ul style="list-style-type: none"> <li>• NJ DEP Bureau of Sustainable Communities &amp; Innovative Technologies</li> <li>• New Jersey Commission on Science and Technology</li> </ul>
Education	8**	<ul style="list-style-type: none"> <li>• Bergen County Technical Schools</li> <li>• Center for Sustainable Energy at Bronx Community College</li> </ul>
Non-Profit	13	<ul style="list-style-type: none"> <li>• Clean Energy States Alliance</li> <li>• New Jersey Corporation for Advanced Technology</li> <li>• New Jersey Public Interest Research Group</li> </ul>

\* for a complete listing of stakeholders, visit <http://policy.rutgers.edu/ceeep/njh2lc.html>.

\*\* including the 5 university partners

## UNIVERSITY PARTNERS

When the Hydrogen Learning Center was conceived, it was envisioned that involving multiple colleges and universities would be important to ensure the broadest range of student involvement. The realization of a hydrogen economy is still a concept for the future. It will require, however, coming generations to be knowledgeable about hydrogen and fuel cell technology. To this end, one of the core purposes of the Hydrogen Learning Center was to engage students in learning the science, mechanics, environmental, and policy implications associated with hydrogen and fuel cell technology. This engagement was best achieved by building off a cohort of fuel cell demonstration projects already installed in the state. These projects, many of which were supported by the Board of Public Utilities or through grants from the U.S. Department of Energy, are in practical use, providing power and heat at their sites. Although several of the colleges received press coverage when the fuel cells were installed, none of them had formally integrated the units into curriculum. Four New Jersey colleges have fuel cells on their campus: The College of New Jersey, Ocean County College, Ramapo College of New Jersey and Richard Stockton College. A fifth institution, the Rutgers EcoComplex is a small business incubator and conducts research related to landfill gas reformation for purposes of fueling a hydrogen fuel cell. With their research work and their work with K-12 schools around the state, this group qualified as a university partner as well. The geographic diversity of the university partners, though unintended, encouraged stakeholder involvement in the communities closest to them.

Curriculum modules were included in a variety of courses on the four campuses depending on the field of the professor identified to be part of the Hydrogen Learning Center\*. All modules are available for download from the Hydrogen Learning Center website. 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. Very encouraging is that all of the professors agreed that they would continue teaching these modules in their classes,

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\*Each institution was approached through the facilities manager or environmental programs coordinator about their interest in participating in the NJ Hydrogen Learning Center. These individuals were required to identify a main point-of-contact and a collaborating faculty member. Each partner was given a small grant for developing the module and hosting one quarterly event.

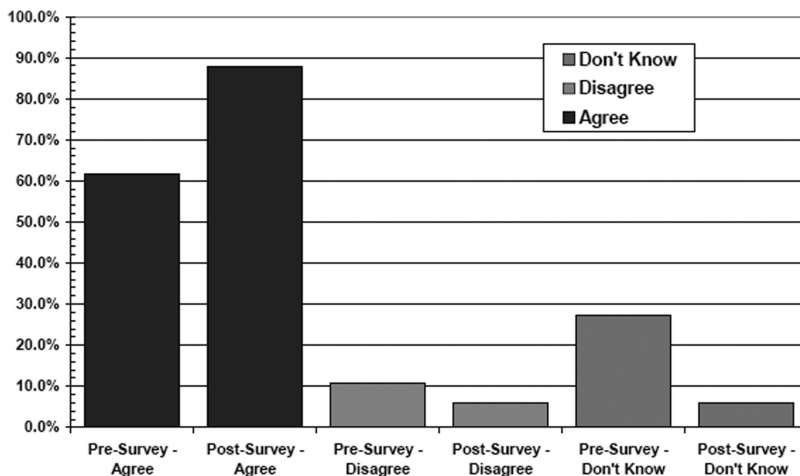
which means that approximately another 100 students will learn this content each year that the modules continue. Some of the activities so far have included online discussions, lab activities with model fuel cells, and design/redesign projects. Table 2 shows the department, title of the course, and short description of the module.

Before each module was executed, students were asked to fill out a survey to measure their previous knowledge about hydrogen and fuel cell technology. Upon completion of the modules, a post-survey was administered and the results tabulated. This exercise revealed significant educational gains, but also identified areas in need of improvement in the survey tool or the curriculum itself.

The figures below present the results of some of the pre- and post-survey questions posed in the following way: "Do you agree or disagree with the following statement? Hydrogen is \_\_\_\_\_." Standard answers were provided. In Figure 1, the large jump in the agree column after participating in the module shows that the vast majority of the students obtained the key idea that hydrogen is the most abundant element in the universe.

**Table 2. New Jersey Hydrogen Learning Center Undergraduate Curriculum Modules**

School	Department	Class Title(s)	Curriculum Module Description
The College of New Jersey	Mechanical Engineering	<ul style="list-style-type: none"> <li>• Thermodynamics II</li> <li>• Thermal System Design</li> </ul>	<ul style="list-style-type: none"> <li>• Introductory lecture</li> <li>• Reading assignment</li> <li>• Lab activities comparing relative efficiencies of fuel cell and internal combustion engines</li> <li>• Visit to fuel cell on campus</li> </ul>
Ocean County College	Science	<ul style="list-style-type: none"> <li>• Physics I</li> </ul>	<ul style="list-style-type: none"> <li>• Lab-based instruction using small-scale fuel cell units</li> <li>• Visit to fuel cell on campus</li> </ul>
Ramapo College of New Jersey	Environmental Studies	<ul style="list-style-type: none"> <li>• Energy and Society</li> <li>• Environmental Studies</li> </ul>	<ul style="list-style-type: none"> <li>• Reading and in-class lecture and discussion based on the environmental, economic, and geopolitical implications of hydrogen energy</li> <li>• Visit to fuel cell on campus</li> </ul>
Richard Stockton College of New Jersey	Chemistry/ Environmental Studies	<ul style="list-style-type: none"> <li>• Introduction to Pollution</li> <li>• Environmental Issues</li> </ul>	<ul style="list-style-type: none"> <li>• In-class lecture</li> <li>• Online discussion and assignments through WebCT</li> <li>• Assignment critiquing relative advantages and disadvantages of hydrogen and traditional fossil fuels</li> <li>• Visit to fuel cell on campus</li> </ul>
Rutgers EcoComplex	N/A	Curriculum geared toward K-12 classrooms visiting the EcoComplex on field trips	<ul style="list-style-type: none"> <li>• Interactive kiosk with lessons about renewable sources of hydrogen</li> </ul>



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

Figure 2 shows another sizable increase in the correct answer about the energy content of hydrogen atoms. There may be a need to revisit the curriculum or the phrasing of the question, as suggested by the slight increase in those who answered that they disagreed, and the remaining high proportion of students who felt they did not know the answer to the question.

Figure 3 provides a good example of where misconceptions about hydrogen may be hard to address. The emphasis of hydrogen being the most abundant element in the universe may have lead students to take away the wrong message that hydrogen can be found in the air. 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." This is an area in which future monitoring will be important. The modules should clarify that while hydrogen exists as part of all sorts of organic matter, it rarely is found on its own naturally in ambient conditions.

## LOCAL CODE AND ZONING OFFICIALS

Addressing one of the main barriers to the growth of the hydrogen economy, the New Jersey Hydrogen Learning Center sponsored a train-

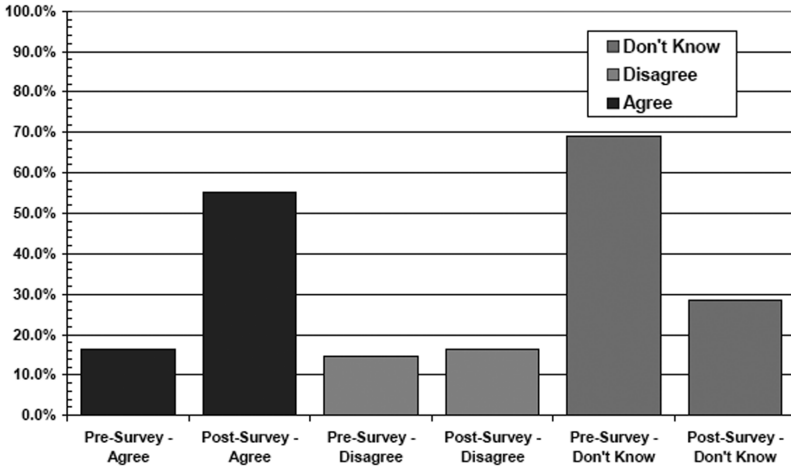


Figure 2. Do you agree or disagree with the following statements: Hydrogen gas has the most energy content by weight of any fuel.

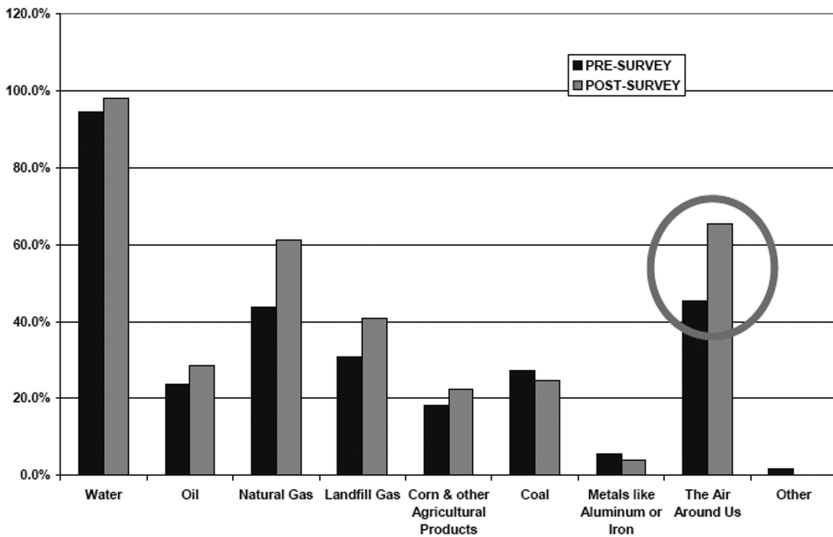


Figure 3. Can you identify one or more sources of hydrogen?

ing course for local planning, zoning, and code officials on key hydrogen and fuel cell building, fire, and other safety codes. The course was developed in cooperation with the Center for Government Services at Rutgers and Davidson Code Concepts\*. Although there are proper ways of handling hydrogen that ensure an adequate level of safety, studies have shown that widespread misconceptions about the combustibility of hydrogen (e.g., through historical references to the Hindenburg explosion or the hydrogen bomb) lead to fears in the general public about its use as a form of energy†. Local code officials are responsible for ensuring public safety through monitoring and inspecting buildings and property. The goal of the Local Code and Zoning Official Workshop was to educate these individuals working in municipalities around New Jersey in the secure handling of hydrogen, with the aim of preparing them in the event a building application for a fuel cell installation is submitted to their office. This popular course enrolled over 150 officials over 3 courses throughout the year¶.

## CHALLENGES

There were a number of challenges faced in the first year of the Hydrogen Learning Center. First, perhaps the greatest challenge was to build private sector stakeholder consensus about the next steps for New Jersey. This can likely be attributed to the early stage of market development in which hydrogen and fuel cell technologies still reside. Competing technology visions and beliefs lead to a plethora of ideas about the best way to reach a hydrogen economy. This proved somewhat of a hindrance to in-depth, hypothetical, and big-picture discussions of what may be best for New Jersey as a whole in moving into a hydrogen economy.

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\*For more information on the Center for Government Services, visit <http://www.policy.rutgers.edu/cgs/>; for more information on Davidson Code Concepts, visit [www.davidsoncodeconcepts.com](http://www.davidsoncodeconcepts.com).

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

¶Davidson Code Concepts and the Center for Government Services have continued to offer the course independent from the New Jersey Hydrogen Learning Center. The workshop hosted directly by the Learning Center was attended by approximately 75 code and zoning officials on July 12, 2006.

Second, many stakeholder companies working exclusively with hydrogen or fuel cells do not necessarily relate to New Jersey as their strategic location of choice. The fuel cell manufacturers located in Connecticut, for example, relate to that state because the state has given tax incentives for the manufacture and purchase of fuel cells and counts kWh generated from fuel cells in the state's RPS. In New Jersey, as a result of aggressive policies in support of solar energy, solar companies are beginning to have a state-based identity. This is not the case for many Hydrogen Learning Center stakeholder companies.

Third, time constraints for many stakeholders limited their ability to participate in the online discussion forums or in working group meetings in between the regularly scheduled events. In addition, the large group format of the quarterly meetings seemed to occasionally hinder discussion or people from making comments; some people would feel more comfortable in a more intimate setting. The last three events had slightly lower attendance and seemed to spur more mingling and discussion than previous events. The ultimate goal of the Hydrogen Learning Center was to give a number of policy recommendations to the BPU on moving forward with a hydrogen energy policy, and this seemed to work better with smaller groups.

Fourth, the price of natural gas was an indirect challenge to the Hydrogen Learning Center. The direct challenge was faced by university partners trying to economically operate and maintain fuel cells on their campuses. All of them installed fuel cells with rebates from the state and/or federal government and based on the value proposition of cost savings over 5 to 10 years in which the price of natural gas stayed at levels of the late 1990s and early 2000s. With increasing natural gas prices, the cost of operation and maintenance climbed significantly and has led a number of the partners to seriously consider not renewing the fuel cell stacks or selling the units all together. The challenge for the Hydrogen Learning Center was one of messaging. The leveraging of stationary fuel cells as the educational focal point of the project was based on the argument that this market may be a viable foundation for the outgrowth of the hydrogen economy. The recent experiences of the university partners suggest that even these technologies may not be entirely ready for widespread use.

Finally, the ultimate goal of hydrogen energy use is a complete transition from imported petroleum in transportation fleets to domestically produced hydrogen. Many of the stakeholders have a strong inter-

est in transportation. The Learning Center was somewhat limited based on the scope of work defined by the funding for the project. A second year of activities would need to include a greater focus on transportation technologies.

## RECOMMENDATIONS AND CONCLUSIONS

The New Jersey Hydrogen Learning Center was the first statewide effort to engage stakeholders and academic institutions in a unified discussion about the future of hydrogen energy in the state. Although it faced a number of organizational challenges, achievements were made in creating a stronger recognition among stakeholders, policymakers, and academics about the range of activities happening in New Jersey. Regular meetings helped familiarize the stakeholders with one another and forged, though nascent, a hydrogen and fuel cell community in the state. The enthusiasm of the university partners helped create successful meetings and strong involvement by students. The training workshop for local code officials reached more individuals than anticipated and Davidson Code Concepts along with the Center for Government Services continues to offer this course for continuing education credits. Since the final symposium in September 2006, several stakeholders have been in touch with CEEEP staff regarding future events and activities, suggesting a continued interest in pursuing the Hydrogen Learning Center's objectives and activities.

Through discussion and concerns raised throughout the year, the Hydrogen Learning Center was able to define a number of recommendations that will be given to the NJ BPU in its final report. Table 3 summarizes these recommendations.

### **Acknowledgements**

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**Table 3. Recommendations of the New Jersey Hydrogen Learning Center**

Recommendation	Explanation
Define a State Policy	<ul style="list-style-type: none"> <li>• Define state position through articulated policy for fuel cells and hydrogen</li> <li>• Hydrogen and fuel cells may complement existing state energy policies               <ul style="list-style-type: none"> <li>– Renewable energy &amp; energy efficiency</li> <li>– Distributed generation</li> <li>– Increased reliability</li> <li>– Economic development</li> <li>– Research, development &amp; demonstration</li> </ul> </li> </ul>
Broaden Education & Outreach	<ul style="list-style-type: none"> <li>• Partner with national and regional organizations to share educational materials</li> <li>• Identify opportunities to create regional educational campaigns for the general public</li> <li>• Continue targeted efforts for students, educators, and local officials</li> <li>• Create a state speakers list of experts from stakeholders and university partners</li> <li>• Expand hydrogen portal <a href="http://policy.rutgers.edu/ceep/njh2lc.html">http://policy.rutgers.edu/ceep/njh2lc.html</a> with interactive information</li> </ul>
Support Complementary and Innovative Hydrogen Projects	<ul style="list-style-type: none"> <li>• Innovative renewable to hydrogen demonstrations (i.e., photovoltaic to solar home)</li> <li>• Consider opportunities for wind to hydrogen demonstration</li> <li>• Support R&amp;D efforts (e.g., photoelectrochemical hydrogen generation, nanotechnology storage, and landfill/bio-gas purification)</li> <li>• Large-scale hydrogen production (e.g., Integrated Gasification Combined Cycle (IGCC), biomass gasification)</li> </ul>
Review Economic Incentives	<ul style="list-style-type: none"> <li>• Identify federal incentives that may increase savings</li> <li>• Establish an appropriate rebate level that allows for a return-on-investment (ROI) over life of stack</li> <li>• Consider creating a separate fund for fuel cells within the combined heat and power (CHP) program</li> <li>• Consider bonus incentives for fuel cell distributed generation in distribution congested areas</li> <li>• Partner with gas utilities and fuel cell installers to do site-specific efficiency assessments of the economic potential of a fuel cell</li> </ul>
Include a Transportation Component	<ul style="list-style-type: none"> <li>• Form inter-department and agency working group</li> <li>• Examine federal funding for energy stations – combining stationary and refueling capabilities</li> <li>• Identify a vehicle fleet or transportation cluster that could best support a hydrogen refueling station</li> </ul>
Coordinate Research & Development	<ul style="list-style-type: none"> <li>• Expand university partners to any college and university with hydrogen and fuel cell facilities or research on campus</li> <li>• Develop a database of research and development related to hydrogen and fuel cells at NJ colleges and universities</li> <li>• Identify companies doing hydrogen and fuel cell industrial and applied research</li> </ul>
Build Regional Cooperation	<ul style="list-style-type: none"> <li>• Coordinate and pool resources and activities where possible with:               <ul style="list-style-type: none"> <li>– National Hydrogen Association</li> <li>– Mid-Atlantic Hydrogen Coalition</li> <li>– NY/CT/PA/DE/MD are active in fuel cell development</li> <li>– high potential for collaboration</li> <li>– Clean Energy States Alliance (Public Fuel Cell Alliance)</li> </ul> </li> </ul>

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#### ABOUT THE AUTHOR

**Nora Lovrien, MCRP**, is Research Project Coordinator at the Center for Energy, Economic and Environmental Policy at the Rutgers' Edward J. Bloustein School and Planning and Public Policy. With the Center for Energy, Economic and Environmental Policy, Nora has expanded her interest in energy and environmental policy by working on several projects. As a coordinator of the New Jersey Hydrogen Learning Center, she has helped to build a solid network of New Jersey-based academic and private sector stakeholders in the emerging hydrogen energy economy through organizing and hosting regional quarterly networking events and maintaining the New Jersey Hydrogen Learning Center website. For the New Jersey State Energy Master Plan, Nora supports policy makers and working groups involved in the process with data and analysis. In preparation for the current Energy Master Planning process, she co-authored of a complete straw draft of the plan for the New Jersey Board of Public Utilities. In conjunction with the Energy Master Plan she has lead a group of graduate student researchers in developing the New Jersey Energy Data Center, an online source of energy and environmental data to be used by policymakers, utilities, and the general public.

Ms. Lovrien joined the Center for Energy, Economic and Environmental Policy in September 2003. Prior to coming to New Jersey, Nora worked as a Research Associate for the Committee for Economic Development in Washington, D.C. Nora holds a B.A. in economics and political science from Macalester College and a Masters Degree from Rutgers, the State University of New Jersey. Nora may be contacted via e-mail at [nlovrien@rci.rutgers.edu](mailto:nlovrien@rci.rutgers.edu).