

HYDROGEN AND FUEL CELL TECHNICAL ADVISORY COMMITTEE

MEETING MINUTES

May 9-10, 2012

Radisson Hotel Reagan National Airport, Arlington, VA

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DAY 1 – MAY 9, 2012

1. Hydrogen and Fuel Cell Technical Advisory Committee (HTAC) Business

- **Approval of Meeting Agenda**
Agenda for the May 9-10, 2012 HTAC meeting was approved without comment.
- **Adoption of minutes from previous HTAC meeting**
The minutes of the November 3-4, 2011 HTAC meeting were adopted without comment.

2. Public Comment Period

2.1 Morry Markowitz, President and Executive Director, Fuel Cell and Hydrogen Energy Association

Mr. Markowitz reported on the state of the Fuel Cell and Hydrogen Energy Association (FCHEA), which resulted from the 2011 merger of the U.S. Fuel Cell Council and the National Hydrogen Association. In the last year, FCHEA has established new priorities, created a mission statement, moved offices, and increased its financial stability. The organization continues to work to increase funding for hydrogen and fuel cells from Congress by promoting the successful adoption of hydrogen and fuel cell technologies in the marketplace.

Questions, answers, and discussion

- Mr. Hofmeister asked for clarification on FCHEA's organizational structure.
 - Mr. Markowitz explained that the organization is divided into two main areas: external affairs and regulatory/technical affairs. The external affairs division includes government affairs, communication, and advocacy working groups; the technical affairs division is comprised of codes and standards, portable workings, stationary generation, and other working groups. Each working group is chaired by a representative from a member company.
- Chairman Shaw asked Mr. Markowitz to identify the biggest challenge FCHEA faces.
 - Mr. Markowitz responded that they have been working hard to remarket the hydrogen and fuel cell brand by reaching out to Congress, OEMs, the defense industry, and others.

2.2 Patrick Serfass, Vice President, Hydrogen Education Foundation

Mr. Serfass spoke about the Hydrogen Education Foundation's (HEF) upcoming event on June 19 at the Hyatt Regency on Capitol Hill. The event will focus on updating Congressional representatives and various Federal agencies on the status of hydrogen technologies, specifically stationary, transportation, forklifts, and hydrogen infrastructure. He invited members of the HTAC to attend.

3. Election of Leadership Positions

The terms of leadership for Chairman Shaw and Vice Chairman Novachek end on June 30, 2012. While the vice chairman traditionally assumes the role of chairman, Mr. Novachek had withdrawn his name from consideration due to his desire to continue leading the Renewable Working Group.

The following committee members volunteered for leadership positions: John Hofmeister volunteered to serve as chairman; Jan von Dokkum volunteered to serve as vice chairman; Joan Ogden volunteered to lead the writing and editing of the 2012 Annual Report; Maurice Kaya and Peter Bond volunteered to co-lead the Policy and Planning subcommittee.

Nominees were appointed unanimously.

Chairman Shaw was recognized by the Department of Energy for his years of dedication and service.

4. DOE Hydrogen and Fuel Cell Program Update

4.1 Dr. Sunita Satyapal, Program Manager, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Fuel Cell Technologies Program

Dr. Satyapal provided an update on progress made by the Fuel Cell Technologies Program (FCTP). She first gave a brief overview of the fuel cell industry, noting that more patents were issued for fuel cells in 2011 than for any other clean energy technology, and that leading automakers have committed to developing fuel cell electric vehicles. She remarked that key analysis guides focus areas and priorities for budgets, and that the revised hydrogen threshold cost is a key driver in the assessment of hydrogen production and delivery research and development (R&D) priorities. For example, Current DOE threshold costs can be met in some locations using electrolysis to produce hydrogen from wind. Dr. Satyapal also discussed the Program's collaboration with the International Energy Agency and International and International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) in performing comprehensive technical and market analysis of hydrogen technologies and resources, resource supply and demand related to projected hydrogen use, global hydrogen infrastructure, and greenhouse gas emissions. She then shared how the National Renewable Energy Laboratory's (NREL's) Hydrogen Secure Data Center (HSDC) is aggregating and analyzing both lab-generated and operational data from current global fuel cell market applications (e.g., early automotive, material handling equipment, back-up power, and stationary power) to provide important information on technology status and progress. Dr. Satyapal also discussed the Northeast hydrogen fuel cell cluster as well as the opportunities for distributed generation of hydrogen. Dr. Satyapal discussed recent, current, and upcoming Office of Energy Efficiency and Renewable Energy (EERE) hydrogen and fuel cells budgets and congressional appropriations, and explained congressionally directed changes to how new R&D awards can be funded (i.e., multi-year projects must be fully funded in the fiscal year they are awarded). She detailed the breakdown for fiscal year 2012 Funding Opportunity Announcements and described key activities of the Fuel Cell Technologies Program, such as funding the development and publication of key reports.

>>see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_may2012_satyapal.pdf

Questions, answers, and discussion

- Chairman Shaw suggested that the HSDC slides should show data for the fuel cell and alternative application(s) (e.g., fuel cell forklift and battery forklift) so that the side-by-side comparisons can be made.
- Mr. Eggert asked if the data collected by Idaho National Laboratory (INL) on battery vehicles will be in a form that can be aggregated and compared to the NREL data.

- Dr. Satyapal agreed that this will be a good opportunity for coordinating between two major vehicle data collection projects, especially as more electric vehicle data becomes available through the INL approach.
- Chairman Shaw asked whether or not funds can be rescinded from projects that are fully-funded upfront if milestones are not met.
 - The program will be able to recover and redistribute funds if specific project objectives are not met. However, Dr. Satyapal noted that the mechanics and timeline are still being defined and discussions with Congress are ongoing. The mandate to fully-fund new solicitations applies to all of DOE.
- Mr. Eggert stated that Dr. Satyapal's presentation was one of the most technologically rich and transparent demonstrations he had seen on contributions that the DOE has made to a specific technology.

4.2 Jason Walsh, Senior Advisor to David Danielson, Assistant Secretary for Renewable Energy and Energy Efficiency, U.S. Department of Energy

Mr. Walsh began by thanking the Committee for its work in helping to build a clean energy economy and extended the appreciation of Assistant Secretary Danielson to the Committee and the FCTP. He stated that one of Dr. Danielson's goals is to effectively promote the successes of the FCTP and other programs within EERE through engagement with the right stakeholders and audiences, and invited Committee members to contact him with ideas on how best to achieve this. Members proceeded to introduce themselves and share their background and specific duties within the Committee.

Questions, answers, and discussion

- Mr. Eggert stated that the California Energy Commission would be voting on an \$11 million refunding initiative for hydrogen infrastructure. He added that a collaborative partnership with the DOE is critical to the success of hydrogen and fuel cell technology in the State of California, and highlighted the fuel cell installation at the Orange County wastewater treatment plant as an example of successful partnering.
- Mr. Kaya asked how state governments can partner with the DOE.
 - Mr. Walsh responded that the Assistant Secretary is interested in leveraging state and federal partnerships, for example, through promoting industry clusters or connecting state economic development efforts with energy policy efforts.
- Mr. Kaya stated that he was surprised by Dr. Satyapal's metric that 45% of all fuel cell patents have been from U.S. companies. He suggested that it would be helpful to create a complementary metric that tracks the number of hydrogen and fuel cell patents transferred to the commercial sector and compare that to other countries. He also stated his support of improved messaging, especially in regard to working with states on their technology deployments, which collectively provide more funding for alternative energy technologies than EERE.
 - Mr. Walsh agreed with Mr. Kaya's points. Consistent metrics on commercialization are especially helpful in demonstrating the value of the Department's investments.
- Mr. Hofmeister warned against setbacks in transportation applications of hydrogen and fuel cell technologies and the implications of U.S. industry losing out to countries like Germany and Japan on commercialization of these technologies. He noted that the U.S. needs to consider more robust

organizational frameworks that include the right players in order to compete with these other countries.

- Mr. Walsh noted that Assistant Secretary Danielson is very aware of the potential for being surpassed by other countries in the race for commercialization and deployment. He agreed that the fuel cell story is a success story, and that we lose a lot if we are outcompeted on commercialization and deployment. He urged the Committee and others to develop messages that communicate this story to decision makers.

5. Hydrogen Codes and Standards: A Fire Marshal's Perspective, Martin Gresho, PE, Fire Protection Engineer, President, FP2FIRE, Inc.

Mr. Gresho offered a view of hydrogen codes and standards from a fire marshal's perspective. He described the multifaceted duties of fire marshals, and noted that the current municipal budgetary environment further limits their resources. He then detailed the importance of codifying research, making plan reviews easier, improving code harmonization, developing complete proposals, and providing technical assistance for fire marshals. He noted R&D is essential to develop technical information, but the other half of the job is codifying the research, i.e., creating an enforceable fire code from a technical report. Another useful tool for fire marshals would be a National Fire Protection Association (NFPA) handbook that includes the code requirement, any annex material that is not enforceable, and any additional explanatory text to aid the enforcer in understanding why the requirement is in place. He also noted that improvements to a small quantity of documents, namely, primary building and fire codes and hydrogen-specific codes and standards that are referenced by the International Building Code and International Fire Code, have the greatest impact.

>>see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_may2012_gresho.pdf

Questions, answers, and discussion

- Chairman Shaw asked who would potentially create the handbook reference by Mr. Gresho.
 - Mr. Gresho stated that if there is interest and a market for it, NFPA, with help from technical committee members and/or additional experts, would usually create the handbook.
- Chairman Shaw asked if a handbook existed that provided guidance on requirements of various types of installations and shared experiences of those involved in past projects.
 - Mr. Ruiz, FCTP's Safety, Codes & Standards (SCS) Team Lead, stated that the program has an on-line compendium that provides guidance through the entire process of permitting a hydrogen station.
- Chairman Shaw suggested focusing on the promotion of this and other such tools.
- Mr. Eggert asked Dr. Satyapal if the SCS subprogram is using third-parties to perform independent technical reviews, especially for hydrogen refueling stations.
 - Dr. Carl Rivkin of NREL responded that the program does provide this kind of support and will continue to focus on dispensing stations in particular.
 - Dr. Satyapal added that the program has an independent safety panel that reviews FCTP funded projects. Furthermore, the program participates in extensive safety, codes & standards education and outreach, having trained more than 23,000 first responders and code officials.
- Mr. Oros of Alteryx Systems added that his company has worked with hundreds of building department officials and has never encountered any problems.
- Dr. Carlin recommended creating a lessons-learned review of fueling installations, and shared some of his experience with the difficulty of permitting fueling stations on military sites.

- Dr. Satyapal responded that the program does have a database of best-practices, incidents and lessons-learned.

6. November Meeting Planning

Chairman Shaw led a discussion on ideas for future meetings. The next HTAC meeting will take place on November 15-16, 2012. The following is a list of ideas for future meetings generated by HTAC members:

- Brainstorm ideas on what strategies for long-term national policy support (for infrastructure, etc.) might work in the U.S. (and what wouldn't work), and what would need to happen to make them work, with consideration of effective models in other countries.
- Open discussion forum on what has enabled (or hindered) successful planning and engagement strategies, to include national and international government, industry, and others who have been directly involved in coordinating (or trying to coordinate) the deployment of fuel cells and infrastructure.
 - Consider a different format for this discussion, e.g., present a list of questions or topics for HTAC members to consider and discuss around the key challenge of solving the “chicken and egg” dilemma.
- Presentations on results of studies that are in process: 1) National Petroleum Council and 2) National Academies study in light-duty transportation.
- Presentation on EV and PHEV vehicle operating status from INL's vehicle data collection project.
- Presentations on large multi-megawatt systems that use fuel cells, hydrogen, and/or batteries in support of the grid for various reasons, in conjunction with wind farms and solar arrays and frequency regulation.
- Presentation on the practical issues associated with interconnecting distributed power sources to the electric grid.
- Presentations on strategic partnerships at the state and regional levels that are starting to emerge or underway: How are they balancing research and deployment? What drivers are creating value for the key partners? Are there specific actions or metrics that the states are using that would be useful for FCTP? Are there hydrogen production or infrastructure deployment initiatives at the state level that can be leveraged? Can the HTAC recommend specific follow-up actions for DOE with regard to facilitating or supporting these partnerships?
- Presentation on and input to any draft EERE or DOE programs (e.g., H Prize) or strategic plans that are accessible to the HTAC for review and comment.
- Discussion (or “idea session”) of strategies or approaches that have worked to create incentives for first investors in new technology deployment (especially with regard to those that might work for hydrogen fueling infrastructure).
- Briefing on highlights from Hydrogen for Energy Storage Workshop (being planned under the International Partnership for the Hydrogen and Fuel Cell Economy, to be held in Europe in the November 2012 timeframe).
- Presentations on vehicle and fuel cost and cash flow models for hydrogen fueling stations from NREL, Energy Independence Now, or others with recent modeling results.
- Analysis of vehicle life cycle costs considering the potential for re-use of parts or components, which could add flexibility to the business case for FCEVs.
- The impact of recent natural disaster in Japan and the role of hydrogen in the energy sector.

- Recent progress in producing hydrogen from landfill gas.
- Presentation on hydrogen leakage into the upper atmosphere.
- Consider HTAC meeting venue near NREL so HTAC can tour new testing facilities.
- Entrepreneurial presentations:
 - ITM Power (UK)
 - Element One (Dave Edlund)
 - Rolls Royce (Roger McCain)
- State presentation:
 - Ohio
- Confirmed presentations at November 2012 meeting:
 - Introduction of new members
 - Updates from HTAC working groups and subcommittees
 - Summary of Hydrogen Production Expert Panel (HPEP) Subcommittee Meeting and HPEP report from Levi Thompson
 - Presentation from Joan Ogden about her recent publication
 - Update on DOD from Rich Carlin, including LMI defense-wide analysis of potential early market applications of fuel cells
 - 2012 HTAC Annual Report planning

7. Entrepreneurial Presentations

7.1 Prabhu Rao, Vice President, Commercial Operations, Nuvera Fuel Cells

Mr. Rao outlined Nuvera's technological advances, current focus, challenges, and opportunities. He also described the company's current product offerings and on-site experience. He noted that Nuvera is focused on creating foundational technologies that can provide product opportunities in many markets, and that the company will leverage its high power-density stack technology to partner with original equipment manufacturers and integrators in a variety of markets. Mr. Rao also said that Nuvera is working toward being a hydrogen provider for low-volume applications (50–250 kilograms per day). He stated that the company is mainly focused on North American and European markets in the near term, with the goal of subsequently pursuing Asian markets.

>>see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_may2012_nuvera.pdf

Questions, answers, and discussion

- Chairman Shaw asked for more information on the cost per kilogram of Nuvera's small units.
 - Mr. Rao stated that Nuvera is currently able to sell hydrogen at \$12-\$13 per kilogram. He added that it will be very difficult to reach the FCTP's goal of \$2-\$4 per kilogram with low-volume production.
- Chairman Shaw asked if Nuvera will continue to own units and sell hydrogen.
 - Mr. Rao stated that they will continue to own the production units and sell the hydrogen, as they do for their hydrogen-powered forklift customers.
- Mr. Eggert asked about Nuvera's current cost to customer and how that will change in the next three to five years.
 - Mr. Rao responded that the selling price of a 20,000 hour, 13-kilowatt fuel cell stack for forklifts is around \$25,000; however, there is an additional tax credit for the buyer that is not

included in this price. In order to compete with batteries, they foresee needing to sell the stacks at no more than \$16,000 by 2016, the year the tax credit expires.

- Mr. Rose asked for Mr. Rao's opinion on the mechanism for providing infrastructure for fuel cell passenger vehicle.
 - Mr. Rao responded that the price at which hydrogen is sold at fueling stations is based on an assumption regarding the number of hydrogen vehicles in a market. All parties must agree on ways to protect against the financial loss incurred if that assumption is not realized.

7.2 Mickey Oros, Senior Vice President, Business Development, Alteryg Systems

Mr. Oros presented on Alteryg's product line, strategic alliances, fuel cell installation examples related to telecom networks, and challenges in bringing proton exchange membrane (PEM) fuel cell products to market. He described Alteryg's fuel cell engines, power cabinets, fuel cabinets, Transient Power Module, and wireless communication and monitoring systems. He noted that the company has deployments all over the world in a wide variety of settings. Mr. Oros explained how PEM stationary market penetration issues, membrane electrode assembly costs, and the lack of competition for hydrogen delivery have presented difficulties in bringing Alteryg's PEM products to market. He stated that subsidies for the PEM and hydrogen industries, increased government purchasing of PEM stationary products, and a nationwide delivery system using fill-in-place concepts would help drive new PEM technology and lower costs.

>>see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_may2012_altergy.pdf

Questions, answers, and discussion

- Mr. Freese asked Mr. Oros to expand on the membrane electrode assemble (MEA) cost drivers.
 - Mr. Oros stated that they are working with their suppliers to solve problems and reduce costs, for example, by moving away from frameless MEAs.
- Chairman Shaw asked for more information on Alteryg's financing.
 - Mr. Oros replied that Alteryg is financed by high net-worth individuals. After much trial and error they have learned to build systems in a low-cost manufacturing process and have no debt as a company. Most of the investors are the same year-to-year and there has been very little venture capital investment.

8. Indiana's Hydrogen and Fuel Cell Initiatives

Mr. Wylam shared some highlights from Indiana's historical involvement in electrification and the manufacturing of batteries for electric vehicles, dating back to 1912. He introduced the two speakers from nonprofit organizations based in Indiana that deal with renewable energy and electricity.

8.1 Paul Mitchell, President and Chief Executive Officer, Energy Systems Network

Mr. Mitchell outlined Energy Systems Network's (ESN's) services and project portfolio, as well as Indiana's ethanol and natural gas infrastructure and the state's efforts to deploy clean energy vehicles. He explained how ESN supports joint ventures and cooperative partnerships between network members seeking to bring new energy technologies, products, or applications to market. Mr. Mitchell described two projects in which ESN is involved: 1) Project Plug-In, a commercial-scale pilot featuring plug-in electric vehicles and smart grid technology working together; and 2) the Battery Innovation Center, which promotes safe, reliable, and lightweight energy storage systems for

commercial and defense customers. He also noted that there are more than 140 E85 stations in Indiana, and that the ethanol industry has created more than 3,500 full-time jobs within the state. Mr. Mitchell described Indiana's natural gas infrastructure, noting that as of 2007, the state ranked 24th in natural gas production, and that compressed natural gas refueling is available on Interstate I-65 within the state. He also shared how the Indiana Department of Transportation has retrofitted all 255 bi-fuel, light-duty trucks and vans to propane, as well as deployed 19 compressed natural gas dump trucks.

>>see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_may2012_esn.pdf

8.2 Dr. Peter Schubert, P.E., Director, Richard G. Lugar Center for Renewable Energy, Professor of Electrical and Computer Engineering, Indiana University–Purdue University, Indianapolis

Dr. Schubert provided an update on the Lugar Center's major initiatives, accomplishments, and other activities. He outlined progress made in initiatives such as the Li-ion Battery Safety Project and the Industrial Assessment Center. He then remarked that Lugar Center representatives were invited to speak at numerous events, and that several dignitaries, including Secretary of Energy, Steven Chu, visited the Center recently. Dr. Schubert also discussed the Sixth Annual Lugar Center Renewable Energy Forum, entitled "Waste to Energy, Chemicals, Fuels, and Heat." He noted that the Lugar Center is involved in numerous collaborative efforts, and that recently Lugar Center representatives produced inventions in battery technology, health care, superconductivity, direct ethanol production, and hydrogen generation.

>>see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_may2012_lugar_center.pdf

Questions, answers, and discussion for both speakers

- Mr. Kaya asked Mr. Mitchell to expand on his reasoning behind starting a not-for-profit organization, specifically why he chose not to do the work from the office of the governor, his former employer.
 - Mr. Mitchell responded that the nonprofit emerged from a need to separate the work from the governor's office in order to facilitate honest collaboration among companies without worrying about political sensitivities. They still partner with the government on some initiatives but the core business model is supported by companies' commercialization of their technologies. They receive corporate contributions in the form of membership dues but also receive grant funding.
- Mr. Eggert asked if either organization was involved in policy research.
 - Mr. Mitchell stated that Energy Systems Network tries not to involve itself in policy and does not lobby the state or federal government.
 - Dr. Schubert stated that they too do not advocate for specific issues. However, they do raise awareness of energy issues and educate elected officials.
- Chairman Shaw asked if both presenters could help install a hydrogen fueling infrastructure in Indiana in the next two years.
 - Both presenters agreed to help.
 - Mr. Wylam, a member of the advisory board of both organizations, will work with Mr. Mitchell and Dr. Schubert and report his findings to the Committee at a later date.

9. Working Group Updates

9.1 Hydrogen Enabling Renewables Working Group Update, Frank Novachek, Director, Corporate Planning, Xcel Energy

Mr. Novachek presented on the purpose, modeling approach, progress, and next steps of the Hydrogen Enabling Renewables Working Group. He explained that the preliminary results of the Working Group's modeling efforts show that only long-term hydrogen storage competes in single-day cycling. Mr. Novachek remarked that multi-day energy storage will likely be necessary in a high-renewables-penetration scenario, if there is more value placed on otherwise curtailed renewable resources due to higher renewable portfolio standards or carbon dioxide emission controls. He also discussed the importance of storage time and the unique competitive characteristics of hydrogen storage. He noted that the Working Group intends to complete energy storage application analysis, explore economic drivers for requiring greater energy storage capacity in high-penetration renewable scenarios, and begin exploring energy storage in gas pipelines and the use of hydrogen for heat.

Questions, answers, and discussion

- Dr. Ogden asked if the group used any estimates for long-term battery energy storage goals.
 - Mr. Novachek stated that they did not, since credible public data is not yet available on this. The battery data used was for near-term energy storage.
- Mr. Eggert suggested that the working group's analysis include the incremental cost per kilowatt hour.
- Dr. Ogden asked if Mr. Novachek found any correlations between the storage time required and the level of reliability.
 - Mr. Novachek stated that the reliability needs are met with natural gas fired generation. The spinning reserve need would be met by the storage device, as opposed to another generation device. Furthermore, the capital costs' sensitivity to the capacity factor is not as great as previously believed.
- Mr. Hofmeister asked if the application could support an instantaneous grid recovery in a blackout scenario.
 - Mr. Novachek replied that it could with the right amount of momentum and a large enough storage capacity.
- Mr. George Sverdrup of NREL stated that NREL has been studying the time required for a hydrogen energy storage system to respond to a needed increase or decrease in electrical output, for example, to stabilize grid frequencies. Their findings indicate that the required response time of the electrolyzer is less than one second.
- Mr. Eggert added that the California Energy Commission is holding similar discussions on energy storage, and stated that cross-comparison of results would be useful.
- Chairman Shaw stated that Sandia National Laboratory recently published a paper on energy storage costs that were much lower than the Electric Power Research Institute (EPRI) numbers used by the working group.
 - Mr. Novachek responded that the numbers used in the analysis are very conservative estimates of future electrolyzer and fuel cell costs.
- Mr. Rose stated that it appears as though storage, regardless of the type, is not currently an economical option. He wondered about the financial impacts to the consumer.

- Mr. Novachek agreed that 100% renewable energy is very expensive.
- Dr. Ogden stated that the analysis shows that it would be beneficial to open a dialogue with the electricity sector and promote the intersection of hydrogen and electricity.
 - Mr. Novachek will send Dr. Ogden the group's analysis for her comment.
- Mr. Wylam cautioned that the use of re-purposed batteries and reconditioned fuel cells will complicate the analysis by introducing another element of cost.

9.2 Hydrogen Infrastructure Sub-Committee Report, Matt Fronk, Independent Consultant, Matt Fronk and Associates

Mr. Fronk described the objectives of the Hydrogen Infrastructure Subcommittee, issues related to hydrogen infrastructure and recommendations from the subcommittee. His presentation summarized relevant points from a forthcoming subcommittee report. Mr. Fronk explained that the subcommittee seeks to assemble information on worldwide hydrogen infrastructure development as well as identify hydrogen infrastructure opportunities for the U.S. Department of Energy (DOE) in support of the growing use of hydrogen in the United States. He said that the development of hydrogen infrastructure is not a technology issue, instead noting that the implementation of hydrogen infrastructure is a leadership issue, and that the United States has fallen behind other countries' efforts. He stated that subcommittee recommendations include federal commitment and support for the global fuel cell electric vehicle (FCEV) initiative, U.S. collaboration with other countries on developing rollout plans, DOE support for various state efforts to deploy FCEVs, and DOE development of a national rollout plan.

Questions, answers, and discussion

- Chairman Shaw asked if the working group would continue after the report was published.
 - Mr. Fronk stated that he and Dr. Taylor agreed that the subcommittee would dissolve upon completion of the report unless additional tasks were initiated.
 - Chairman Shaw stated that there may be an opportunity to examine the requirements for rolling out an entire hydrogen system, including vehicles and fueling.
- Mr. Eggert asked if the report articulates the need for the United States to commit to support the global fuel cell initiative.
 - Mr. Fronk responded that the report will include a focus on the importance of industrial competitiveness.
- Mr. Hofmeister commented that the HTAC should make the case that as a country, the United States has the financial, technological and human capital necessary to achieve success on transitioning to renewable transportation. The key missing ingredient is agreement on approaches, and fundamental policy that will help align the transportation, fuel, and electric utility sectors.
- Mr. Rose stated that the governments and industries of Germany and Japan are better organized and therefore more successful at implementing renewable energy policy. However, promoting renewable energy policy in the United States needs to be for our own good, not just to get ahead of other countries. He invited Dr. Satyapal to speak on the need for the U.S. to work with other countries to help achieve consistent rollout plans.
 - Dr. Satyapal replied that the program does coordinate with other countries, for example, by spearheading the International Partnership for Hydrogen and Fuel Cells in the Economy. Furthermore, the FCTP has been working with international stakeholders to inform American deployment initiatives. While it may not be obvious, other countries are still struggling with a lot of the same problems that the United States faces, for example, how to incentivize the first

- investor. Mr. Rose also suggested inviting a representative from the Office of Electricity and a member of the Secretary's advisory board to speak at an upcoming meeting.
- Chairman Shaw recommended the Committee promote something similar to the “get the lead out” campaign supporting CAFE standards.
 - Mr. Eggert stated that an analysis by the California Air Resources Board concluded that the 2025 fuel standard could be met without battery electric or fuel cell electric vehicles.
 - Chairman Shaw reinforced his belief that the Committee should continue to recommend ways of achieving hydrogen and fuel cell goals as part of its role.
 - Chairman Shaw and Mr. Hofmeister agreed that the best arguments for promoting hydrogen are climate change and the rising cost of oil.
 - Mr. Kaya and Mr. Wylam cautioned against not including energy security as a serious concern.

DAY 2 – MAY 10, 2012

10. Enabling Renewable Energy with Hydrogen, Frank Novachek

Mr. Novachek provided a brief introduction of the speakers and their respective companies' involvement in energy storage and hydrogen.

10.1 Hydrogen Energy Storage, Erik Wolf, Senior Consultant, Sector Energy, Siemens AG

Mr. Wolf gave a brief overview of Siemens and discussed technical aspects of energy storage. He discussed the motivations for storage, and noted that pumped hydro is the benchmark-setting storage technology in terms of grid compliance. He compared the volumetric energy density, specific capacity costs, and specific power costs of different storage alternatives. Mr. Wolf touched on levelized cost of energy methodology and storage, as well as dispatchable renewable power. He explained that Siemens has pursued proton exchange membrane electrolyzer development since 1998. He also discussed hydrogen gas storage, underground storage in the United States, and gas turbines.

<< see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_may2012_siemens.pdf

Questions, answers, and discussion

- Mr. Novachek asked Mr. Wolf to expand on his fourth slide which shows the energy storage capacity of the European Union.
 - Mr. Wolf stated that his chart indicated that the German energy system is reaching a saturation point. Without more adequate storage, they will not be able to build more renewable energy generation.
- Dr. Ogden asked what is included in the hydrogen capacity costs.
 - Mr. Wolf stated that the hydrogen costs include the electrolyzer and the gas turbine, but do not include the cost of the converter, tube storage, or compression. The electrolyzers in question are designed for 50 bar pressure output. The costs of compressing to 300 bar are negligible.
- Chairman Shaw asked if there was any performance degradation built into Siemens' models.
 - Mr. Wolf replied that the model is coarse and does not consider any decay in performance.
- Mr. Kaya asked Mr. Wolf to elaborate on the value of the dispatched energy capacity.

- Mr. Wolf stated that the tanks range from low pressure (20 bar, 150 megawatt-h) to high pressure. The high-pressure tube storage is in a range that is competitive with batteries.
- Mr. Novachek asked if they had explored natural gas reservoirs, rather than salt caverns, for storage.
 - Mr. Wolf stated that natural gas reservoirs can result in a discharge of unknown gases. Gas turbines, for example, are too sensitive to fuel quality for this. Furthermore, unwanted chemical reactions can take place in the porous environment and bacterial contamination can result.
- Chairman Shaw asked about the underlying cost assumptions leading to the €91/megawatt hour storage system with 60 megawatt output in a two-day operation.
 - Mr. Wolf stated that this cost includes all hardware, storage, conversion, and recovery, but not the costs of the wind farm.
- Chairman Shaw suggested Mr. Wolf and Mr. Novachek work together to understand why there is such a discrepancy in the cost result of the Siemens model compared to the Hydrogen Enabling Renewables working group model.
 - Mr. Wolf responded that some of the discrepancy may be due to a difference in the assumed operating time. The Siemens model assumes 3,000 operating hours per year.
 - Mr. Novachek and Mr. Wolf will further compare their models.

10.2 Hydrogen Technology for Integration of Renewables, Dr. Jérôme Gosset, Executive Vice President, Hydrogen and Energy Storage, AREVA Renewables

Dr. Gosset outlined some of AREVA’s products; the challenges and benefits of using hydrogen storage on islands; and how AREVA is working to deploy innovative, clean technologies for energy storage on islands. He discussed HELION, a subsidiary of AREVA that is dedicated to hydrogen and energy storage, and Greenergy Box, an “all-in-the-box” solution for energy management and backup power without gas logistics. Dr. Gosset examined the French Islands as a case study for hydrogen storage, noting that the islands have a unique driver—to meet the demand for electricity while reducing their dependence on fossil fuels. He described the challenges of utilizing renewables on islands, and explained how hydrogen is a unique storage technology option for islands because it preserves the environment, allows ports to focus on commerce and tourism, can be produced and stored locally, and considers the evolution of the grid and networks simultaneously. He discussed the MYRTE platform, which relies on large-scale integration of photovoltaics with hydrogen storage, and is being used on the island of Corsica. Dr. Gosset noted that the United States has many locations with similar features to islands. He also offered policy suggestions and ideas to facilitate technology acceleration and acceptance.

>>see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_may2012_areva.pdf

Questions, answers, and discussion

- Dr. Ogden asked about the relative roles of the battery and Greenergy Box in the photovoltaic micro-grid system.
 - Dr. Gosset explained that the Greenergy Box helps to manage the power on the microgrid and keep it operational at all times. The battery is there to help cope with the power fluctuations of the system and provide back-up power when needed.
- Mr. Novachek asked if unique permits were required to store oxygen and hydrogen tanks in the same location.

- Dr. Gosset stated that they have not had to receive special permits. According to French Law, authorization is required to produce hydrogen but not to store it.
- Mr. Wylam asked for the minimum kilowatt output of the Greenergy Box.
 - Dr. Gosset replied that the Boxes are scalable, from 10 kilowatts of output up to 100 kilowatts.

10.3 Power-to-Gas: Utility Scale Energy Storage, Daryl Wilson, President and Chief Executive Officer, Hydrogenics Corporation

Mr. Wilson presented on Power-to-Gas, which he described as a scalable energy storage solution that offers virtually unlimited storage capacity and flexibility, and can drive multiple revenue streams. He noted that while levelized cost and round-trip efficiency are the traditional measures for energy storage, capacity is a larger driver for renewable generation storage than efficiency. Mr. Wilson discussed the benefits of Power-to-Gas, stating that it integrates renewable generation while helping to stabilize the grid; converts surplus renewable generation to hydrogen using electrolyzers; stores the energy using the existing natural gas infrastructure; and enables discharge of the stored green gas at any time and place as gas turbine power, low-carbon heat, or compressed natural gas transport fuel. He highlighted the Hydrogenics-Enbridge agreement, which supports the joint development of utility-scale energy storage projects in North America. He also previewed the next steps for Power-to-Gas, including a detailed dynamics study and a 10-megawatt demonstration project.

>>see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_may2012_hydrogenics.pdf

Questions, answers, and discussion

- Mr. Kaya asked where Hydrogenics was planning on deploying its new 10 megawatt system.
 - Mr. Wilson stated that Hawaii would be the best environment given the numerous other hydrogen deployments, but California would also be a good option.
- Mr. Kaya asked for Mr. Wilson's opinion on how to break down what Mr. Wilson described as "silos" in the organization, planning, and management of different energy providers.
 - Mr. Wilson said that despite organizations such as the Public Utilities Commission created to help combat such disunity, silos seem to be a natural way of doing business so this is hard to overcome. He noted that times of crisis, like the natural disaster in Japan, have a way of bringing people together to work on energy systemically.

Questions for all three presenters

- Chairman Shaw asked Mr. Wolf and Mr. Gosset to react to Mr. Wilson's comments, and to comment on what is needed for the widespread deployment of hydrogen and fuel cells.
 - Mr. Wolf agreed with Mr. Wilson's assessment of the German appreciation for the environmental impact of energy. While Germany also has a segmented energy provider system, the Renewable Energy Act ensures investment security and as a result, the push for deployment of renewables has come from the private sector. However, Mr. Wolf went on to say that the deployment of energy storage will require government support, at least through the initial integration and launch phases.
 - Dr. Gosset stated that there has recently been an emphasis on power from gas in France. Furthermore, several companies, including AREVA, are in the preliminary stages of studying synthetic fuels or conventional carbon dioxide from clean energy. AREVA is also

working with a French chemical company to create methane from hydrogen and carbon dioxide. Dr. Gosset stated that he agreed with Mr. Wilson; widespread deployment of clean energy is not being hindered by technical limitations.

- Mr. Wilson added that Hydrogenics is not producing hydrogen in order to compete with natural gas, rather they are competing with other alternative solutions to solve a problem with the electrical grid system and the energy system as a whole. He stressed that hydrogen does have an economical, viable future.

11. Hyundai Motor Group's Development of the Fuel Cell Electric Vehicle, John Juriga, Director of Powertrain, Hyundai/Kia America Technical Center

Mr. Juriga gave an overview of Hyundai's progress and approach to fuel cell electric vehicle (FCEV) development. He discussed Hyundai's eco-friendly vehicle strategy, which involves preserving automobile mobility while creating a harmonious balance with the environment. He then detailed the progress that Hyundai has made for specific FCEVs and fuel cell stacks. Mr. Juriga also described Hyundai's FCEV testing program, which includes collision, freeze capability, and fire tests. He discussed Hyundai's international FCEV development efforts, highlighting the Korean Domestic Fleet Program, a test and deployment project in Scandinavian countries, and activities with the European Union government. He touched on U.S. FCEV development, as well as data collection and fleet validation efforts that will take place in the U.S. in the next five years. Mr. Juriga then detailed the steps for FCEV commercialization in the U.S., noting that refueling infrastructure is currently the biggest roadblock to FCEV deployment. He recommended that government and industry provide additional support for infrastructure.

>>>see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_may2012_hyundai.pdf

Questions, answers, and discussion

- Chairman Shaw asked Mr. Juriga to expand on Hyundai's FCEV testing.
 - Mr. Juriga stated that Hyundai has a number of fleets running in the United States, Europe, and Asia from which they will collect real world durability data over the next two years. The vehicles will be operated under a number of different conditions, from standard to extreme.
- Mr. Rose asked Mr. Juriga which Hyundai vehicle was its most expensive and how it would compare to the target cost for its FCEV.
 - Mr. Juriga stated that the most expensive vehicle currently is the Hyundai Equus at \$45,000-\$50,000. This is comparable to the 2015 target price for its FCEV.
- Mr. Rose asked if Mr. Juriga is confident that 13 hydrogen fueling stations in South Korea is enough stations to support commercialization 2015-2026 timeframe.
 - Mr. Juriga stated that because of the density of South Korea's population, 13 stations would get overwhelmed very quickly.
- Dr. Thomas asked what is needed to drive down the cost of the Hyundai FCEV to get to the 2015 target of \$50,000.
 - Mr. Juriga responded that while the cost of the vehicle does need to come down, in his opinion the best way to stimulate widespread commercialization is through incentives. He cited car pool lanes for environmental friendly vehicles as an example of an effective incentive.
- Dr. Thomas also asked for Mr. Juriga's opinion on how long it will take before incentives are no longer necessary.

- Mr. Juriga stated that if costs can be reduced rapidly by 2020, a tipping point will be reached and volumes will increase, further reducing costs. He added that technology is not the problem; rather, motivating people is the biggest hurdle.
- Chairman Shaw asked if Hyundai would be manufacturing all of its FCEVs in South Korea and shipping them to the United States.
 - Mr. Juriga confirmed that that was indeed the plan.
- Chairman Shaw asked if Hyundai had considered using the dealerships as fueling stations, especially in densely populated areas.
 - Mr. Juriga stated that Hyundai had discussed this and the dealers are willing to install fueling stations as long as the company provides funding. However, this is currently a topic of debate as Hyundai Motor Company does not feel it should be developing or funding infrastructure. He added that they probably will have some stations but do not plan on a significant rollout of fueling stations. Their philosophy is that funding is best directed at developing a reliable, low cost vehicle.
- Chairman Shaw asked why Hyundai doesn't build a manufacturing facility capable of producing a large number of vehicles in order to take advantage of economies of scale.
 - Mr. Juriga stated that he was not prepared to comment on that but would take the question back to his colleagues.
 - Mr. Hofmeister suggested keeping a list of unanswerable questions in order to further explore the topics in upcoming meetings.

12. FCEVs and Hydrogen in California – Preparing for Market Launch, Catherine Dunwoody, Executive Director, California Fuel Cell Partnership (CAFCP)

Ms. Dunwoody presented on the current status of FCEV deployment and hydrogen refueling infrastructure in California, and discussed the access to refueling stations that is needed for self-sustaining FCEV adoption. She noted that there are approximately 200 fuel cell electric cars and buses on the road in California, and that the state is on track to have approximately 20 publicly-accessible hydrogen refueling stations by the end of 2013. She reported that original equipment manufacturers identified having 68 stations in California by 2015 as the tipping point for providing sufficient refueling opportunities, consumer and automaker confidence, and commercial opportunities for self-sustaining growth. She remarked that 37 stations are already in process or expected to be funded, meaning additional funding is needed for 31 more stations.

>>see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_may2012_cafcp.pdf

Questions, answers, and discussion

- Mr. Hofmeister asked if the CAFCP was engaging small, independent fueling station owners about the prospect of hydrogen fueling.
 - Ms. Dunwoody responded that the majority of stations in California are owned by one of about 70 different medium-sized companies. These are the companies they have been working most closely with, but the CAFCP does not work directly with independent station owners due to concerns of efficiency. Medium sized businesses are also a better option because they have established relationships with creditors and can afford to take some risks.
 - Mr. Hofmeister suggested approaching owner-operator businesses due to their flexibility and their interest in incentives such as tax deferrals or tax abatement.

- Mr. Cardillo asked if there are standards in place that dictate who can operate a hydrogen fueling pump.
 - Ms. Dunwoody responded that anyone is able to fuel the vehicle, including the owner.
- Mr. Cardillo asked if Ms. Dunwoody was aware of how many kilograms per day would have to be sold from a fueling station in order for the station to be profitable.
 - Ms. Dunwoody stated that CAFCP has conducted this analysis, examining a range of station costs, station size, and made assumptions over time. Results will be published in an upcoming white paper.
 - Chairman Shaw added that he believed the conclusion to be that it is difficult to ever turn a profit on a small station and it is difficult to turn a profit on a large station early on.
 - Ms. Dunwoody confirmed Chairman Shaw's statement. She added that 500 kilogram-per-day stations are the minimum size for profitability; therefore, investments must be incentivized by offsetting negative cash flow, a cost-share approach, or a combination of the two. In locations of slow growth demand, capital costs may need to be 70% cost shared. In fast-growth markets the best approach may be offsetting negative cash flow.

**SEVENTEENTH MEETING OF THE
HYDROGEN AND FUEL CELL TECHNICAL ADVISORY COMMITTEE (HTAC)**

PARTICIPANT LIST

May 9-10, 2012

HTAC Members Present

- Peter Bond
- Mark Cardillo
- Richard Carlin
- Anthony Eggert
- Charles Freese
- John Hofmeister
- Maurice Kaya
- Frank Novachek
- Joan Ogden
- Geraldine Richmond
- Robert Rose
- Robert Shaw
- Levi Thompson
- Bill Wylam

HTAC Members Not Present

- Harold Koyama
- Alan Lloyd
- Kathleen Taylor
- Jan van Dokkum

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy Staff

- Peter Devlin
- Kathi Epping Martin
- Rick Farmer
- Will James
- Jason Marcinkoski
- Sunita Satyapal
- Jason Walsh

Speakers

- Catherine Dunwoody—California Fuel Cell Partnership (CaFCP)
- Matt Fronk—Matt Fronk & Associates
- Jerome Gosset—AREVA Renewables
- Martin Gresho—FP2Fire, Inc.
- John Juriga—Hyundai-Kia American Technical Center, Inc.

- Paul Mitchell—Energy Systems Network
- Mickey Oros—Altery Systems
- Prabhu Rao—Nuvera Fuel Cells
- Peter Schubert—Indiana University-Purdue University Indianapolis
- Daryl Wilson—Hydrogenics
- Erik Wolf—Siemens

Members of the Public in Attendance

- Leo Grassilli—Office of Naval Research
- Christopher Guzy—Ballard Power Systems
- Brad Johnson—PurEnergy
- Charles Lakeman—AREVA Renewables
- Morry Markowitz—Fuel Cell & Hydrogen Energy Assoc.
- Bill MacLeod—Hyundai-Kia American Technical Center, Inc.
- John Parkan—Providence Entertainment
- Neil Popovich—National Renewable Energy Laboratory
- Carl Rivkin—National Renewal Energy Laboratory
- Patrick Serfass—American Biogas Council
- George Sverdrup—National Renewable Energy Laboratory
- Sandy Thomas—consultant

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- Melissa Laffen—Alliance Technical Services, Inc.
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