

**HYDROGEN AND FUEL CELL TECHNICAL ADVISORY COMMITTEE  
MEETING MINUTES**

**April 1-2, 2014**

**The Radisson Hotel, Reagan National Airport – Arlington, VA**

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## **DAY 1 – APRIL 1, 2014**

### **1. HTAC Business**

#### **1.1. Renewal of Existing Members**

There were no renewals of existing members or introductions of new members.

#### **1.2. Approval of Prior Meeting's Minutes**

The minutes from the October 29-30, 2013, HTAC meeting were unanimously approved.

#### **1.3. Vice Chair Approval/Next Chair Term**

Chairman Hofmeister noted that Mr. Jan van Dokkum, previously elected as HTAC Vice Chairman, had resigned from the HTAC for personal reasons. He thanked Mr. Frank Novachek for his willingness to be nominated as Vice Chair and reminded the Committee members about the on-line voting process, in which the Committee members unanimously voted in favor of the appointment. He confirmed that Mr. Novachek has accepted the role of Vice Chairman.

Chairman Hofmeister also stated that his 2-year term as Chair expires on June 30, and asked Vice Chair Novachek to lead a discussion on whether to extend his term, given the unanticipated resignation of Mr. van Dokkum. Whereupon, Mr. Hofmeister excused himself from the discussion and left the room. Dr. Shaw explained that since its formation, the HTAC has traditionally moved the serving Vice Chairman into the Chair role at the end of the 2-year term. Dr. Satyapal explained that the HTAC makes recommendations for the Chair and that there is no procedural problem with extending a sitting Chair's term for one year or more, depending on the renewal date of that member. She conveyed that since Mr. van Dokkum had just resigned and Mr. Novachek had only recently been appointed as Vice Chair, it is understandable if he would prefer not to take on the role of Chairman immediately. Mr. Novachek concurred, and expressed his willingness for Mr. Hofmeister to serve one more year as Chairman in order to ease the transition. A motion was made and seconded to recommend to the Secretary that Mr. Hofmeister's term be extended through June 30, 2015.

#### **1.4. Discussion on 2014 Meeting Schedule**

Chairman Hofmeister presented the results of a survey of HTAC members that showed November 18-19, 2014 would be the best dates for the next in-person meeting. No objections were raised, and members confirmed this date for the next HTAC meeting, to be held in Washington, DC.

#### **1.5. Approval of the Meeting Agenda**

The draft agenda was approved as the final agenda for the April 1-2, 2014 HTAC meeting.

#### **1.6. Public Comment Period**

Mr. Jeff Serfass provided comments on behalf of the California Hydrogen Business Council (CHBC). He noted the buildup in commitments for hydrogen fueling stations in California, and the appointment by Governor Brown of Tyson Eckerle (who is on the Board of the CHBC) as the zero emission vehicle (ZEV) infrastructure project manager at the Governor's Office of Business and Economic Development. He noted that hydrogen

energy storage is also receiving increasing attention in California: the CHBC has filed comments with California's Public Utility Commission to include hydrogen as one of the technologies relevant to and important to consider as they are ordered to use energy storage where economically viable. Similar comments have also been filed by the CHBC in comments to the California Energy Commission as part of their budget hearings.

On behalf of the Hydrogen Education Foundation (HEF), Mr. Serfass raised to the HTAC's attention the HEF's annual student design contest. He noted that the HEF was currently judging entries from six university entrants (four international and two United States) for the student design contest, which was focused on the design of a "packaged fueling station" that could be deployed independent of existing fueling stations, built/assembled quickly, and capable of being mass-manufactured. He asked HTAC members to let him know if they have ideas for the 2014-2015 contest, particularly for ideas that would be useful to the industry.

## **2. U.S. Department of Energy Updates**

### **2.1. DOE Leadership Updates: Reuben Sarkar, Deputy Assistant Secretary, Transportation, Office of Energy Efficiency and Renewable Energy (EERE), U.S. Department of Energy**

Chairman Hofmeister introduced the new Deputy Assistant Secretary for Transportation, Reuben Sarkar, who oversees the DOE offices of Fuel Cell Technologies, Vehicle Technologies, and Bioenergy Technologies. Mr. Sarkar noted that his is a new position, created by Assistant Secretary Danielson to unite the three EERE offices under one management umbrella focused on sustainable transportation. One of Mr. Sarkar's key goals is to increase the exploration, coordination, and implementation of synergistic, crosscutting opportunities among the offices. He affirmed that hydrogen and fuel cells are an important part of the President's "all of the above" energy strategy for achieving climate action and national energy security goals. He stated that there will continue to be a focus on hydrogen and fuel cells for stationary applications, since those are important early markets that will help build the path to their adoption in the passenger car market, where the largest petroleum and carbon reduction impacts can be made.

Mr. Sarkar explained his desire to bring his experience and background from the private sector, working with both large OEMs (original equipment manufacturers) and small entrepreneurial companies on strategic technology planning, to the DOE. His experience includes positions with Proterra, Inc., where he was involved in their fuel cell bus development and demonstration programs, and with General Motors, where he served as the lead design release engineer on the electric drive unit for the Chevy Volt. He thanked the HTAC for the opportunity to join and speak at their meeting, and asked members to let him know if they had questions, concerns, or suggestions for him.

### ***Discussion***

- Mr. Eggert asked for Mr. Sarkar's perspective on DOE's role in bringing technology to market, particularly with regard to hydrogen and fuel cells.
  - Mr. Sarkar noted that EERE is primarily focused on applied research, development, demonstration, and deployment. Often, he noted, DOE involvement has stopped when technical objectives are met. He asserted that it is important for DOE to facilitate dialogue among stakeholders on how to get emerging technologies to market, and noted H<sub>2</sub>USA as a positive example of a public-private partnership focused on

commercialization. He also noted that continuity in leadership and messaging is very important for technologies to succeed in moving from the lab to commercial markets.

- Dr. Lloyd noted that it will be important to couple the transportation and renewable power generation sectors in order to maximize the reduction of greenhouse gas and criteria pollutant emissions. He asked Mr. Sarkar how the interactions between distributed renewable power generation and transportation applications were being managed at DOE.
  - Mr. Sarkar explained that he works closely with Steven Chalk, the Deputy Assistant Secretary of Renewable Power, and pointed to a number of cross-cutting initiatives at DOE designed to focus on the energy “ecosystem.” These initiatives include the Grid Integration Initiative and an electrical systems facility initiative.
- Mr. Rose noted that the DOE budget for hydrogen and fuel cells has declined substantially from its high point, as the administration’s focus has shifted to batteries for electric drives. He asked whether Mr. Sarkar sees an opportunity to rebalance the funding among the offices under his leadership.
  - Mr. Sarkar noted that he has only been with DOE for two months, so he does not yet have answers to all their questions. He encouraged the HTAC members to provide suggestions on how much additional funding is needed, and for what it would be used.
- Dr. Ogden expressed her appreciation for DOE’s decision to create a sustainable transportation program. She asked Mr. Sarkar to explain more about DOE plans for convening stakeholders and facilitating dialogue among the many different “actors” necessary to succeed in moving hydrogen and fuel cells, among other alternative fuel pathways, into widespread consumer markets.
  - Dr. Satyapal offered several examples of ongoing or upcoming activities, including the Quadrennial Energy Review (QER) stakeholder meetings (see <http://energy.gov/epso/initiatives/quadrennial-energy-review-qer>) being held across the country to gather input for the QER report. She noted that HTAC members or others could also submit comments to the QER process via email through the DOE website. DOE is also updating the Quadrennial Technology Review (QTR), which was first released in the fall of 2011, and will be seeking input from stakeholders. Dr. Satyapal also pointed to the H<sub>2</sub>USA partnership, which includes a number of working groups targeting different aspects of the challenge. She offered to provide HTAC members with a list of the different avenues available, Department-wide, to engage in these types of dialogue opportunities.
- Mr. Koyama stated that getting hydrogen fueling infrastructure into place is really the gating item for commercialization of fuel cell electric vehicles (FCEVs). He noted recent announcements by automotive OEMs, particularly Hyundai and Toyota, to start producing and selling (or leasing) FCEVs in consumer markets, and the continuing concern of the car companies about the availability of public hydrogen fueling stations. He asserted that there is momentum from the automotive companies that could lead to the next electric vehicle success story if the infrastructure development can match pace.
- Mr. Eggert agreed, and stated that this is an area where DOE can have a particularly impactful role in FCEV commercialization. He supports DOE’s involvement in organizations like H<sub>2</sub>USA, as well as DOE’s role in funding R&D to continue improving the reliability, efficiency, and cost of these technologies as they are being deployed. He pointed to the tri-generation station in Orange County, California as an example of a project that is serving both a research role and as a public fueling station. He also emphasized the importance of DOE messaging and leadership, stating that strong public support from the Department is critical to sustain support and enthusiasm from state policymakers and the investment community.
- Dr. Shaw commended the work done by the Fuel Cell Technologies Office and the leadership of Dr. Satyapal, but argued that they are financially constrained. He argued that the U.S. federal government should play a more active role in moving technology to market, similar to

government efforts in Germany, China, South Korea, and Japan. In particular, he suggested that the federal government take a more active role in supporting “first mover” states like California and Connecticut with financial commitments. He conveyed the Committee’s concern that the U.S. is losing competitive advantage on hydrogen and fuel cells internationally. He also expressed his personal view that the government should be more proactive in encouraging investment in technology that has important social impact (versus “commercially exciting but without impact on the survivability of the planet”).

- Mr. Sarkar agreed that bridging the “valley of death” is a complex problem. He took note of Dr. Shaw’s request for feedback on these issues.
- Dr. Lipman asked what strategies DOE will employ to make sure that R&D on stationary fuel cells doesn’t get “lost in the shuffle” now that the program is under the umbrella of sustainable transportation.
  - Mr. Sarkar reaffirmed the Department’s goal to continue funding stationary fuel cells for distributed power production.
    - Dr. Lipman suggested that DOE develop a proactive strategy to reassure the stationary fuel cell community on this point.
- Chairman Hofmeister conveyed the Committee’s disappointment with the decision to cut back funding for the Hydrogen and Fuel Cells Program over the past several years, and their concern that the U.S. is losing its leadership position in the field. He believes there is a great opportunity for the U.S. to recapture the leadership role, particularly in the development of a supplier base for hydrogen infrastructure, an area with great economic and employment potential. He encouraged support from the Secretary in reestablishing international leadership in this area. Mr. Hofmeister also encouraged Mr. Sarkar to review the report of the HTAC’s Hydrogen Production Expert Panel, published May 2013, which identifies technology gaps and needs in hydrogen production. He commended the work of this and other HTAC subcommittees (including the completed work of the Hydrogen Infrastructure subcommittee led by Dr. Kathy Taylor and the Hydrogen Enabling Renewables subcommittee led by Frank Novachek, and two new subcommittees on Manufacturing and Retail Infrastructure), noting that their reports and outputs are key HTAC products.

## **2.2. DOE Program & Budget Updates, Dr. Sunita Satyapal, Director, Fuel Cell Technologies Office, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy**

Dr. Satyapal provided an overview of the Fuel Cell Technologies Office (FCTO). She described the mission and key goals of FCTO, as well as its key partnerships and activities, including critical partnerships with state-level organizations. She also summarized FCTO targets and progress toward those targets, and recent and ongoing communication and outreach activities. Dr. Satyapal discussed the recommendations to DOE from the HTAC and its subcommittees and detailed DOE’s responses and activities related to each recommendation. She detailed FCTO’s fiscal year (FY) 2015 budget requests and priorities and 2014 solicitations and awards. She pointed out that the Hydrogen and Fuel Cells budget has achieved stable and consistent funding over the last couple of years and with the FY 2015 budget request at about \$93 million. She also discussed key FCTO activities since the previous HTAC meeting, including a variety of analysis activities and continued support for strategic fuel cell demonstrations in new early market applications. She reported that the H-Prize criteria are now available for public comment, and thanked the Committee for their inputs to the topic selection and criteria development process. Lastly, she highlighted a few areas of interest where the FCTO could benefit from the Committee’s feedback: 1) manufacturing R&D needs, 2) ideas for projects that could be undertaken at the NREL Energy Systems Integration

Facility (ESIF), and 3) ideas on strategies and business models to increase hydrogen fueling station deployment.

>>see full presentation at [http://www.hydrogen.energy.gov/pdfs/htac\\_apr14\\_2\\_satyapal.pdf](http://www.hydrogen.energy.gov/pdfs/htac_apr14_2_satyapal.pdf)

### ***Discussion***

- Dr. Loyd recommended that the program take more advantage of the photo opportunities with the President, in particular the photos showing him with a fuel cell in his hand taken on his trip to Sweden.
- Mr. Eggert noted that while DOE is already playing a role in deployment, the agency could potentially be doing more with relatively modest amounts of funds and potentially very high impact. Specifically, by building on the work at the National Fuel Cell Technology Evaluation Center to increase secure data collection and analysis and then put that information back out to both the research community and the private sector.
- Mr. Kaya asked for more information on the Notice of Intent for the Fuel Cell Technologies “Incubator Program” that Dr. Satyapal mentioned in her presentation. As noted in the presentation, the program is intended to identify potentially impactful technologies that are not already addressed in EERE Technology Offices’ strategic plans or project portfolios.
  - Dr. Satyapal noted that the other EERE Technology Offices (i.e., vehicles, bioenergy wind, solar, and geothermal) are in the process of conducting similar incubator funding opportunity announcements (FOAs). This activity was initiated in the FY 2014 budget (and is also included in the FY15 budget language), with the intent that each office would commit five percent of its budget to incubator projects. So, in FY14 the available funding in FCTO would be as much as \$4.6 million. In response to Mr. Kaya’s questions on the types of projects that would be considered for funding, she replied that the intent is not to focus strictly on technology R&D, so projects that focus on innovative approaches to financing or reducing soft costs, for example, would be considered. In response to Mr. Kaya’s question about how the Incubator Program is differentiated from ARPA-E, she noted that focus of the EERE Incubator is still on meeting each office’s market-driven technical targets. It will also be a relatively small part of the overall portfolio, but available to a broader set of applications than what’s specifically targeted in the office’s other funding opportunity announcements.
- Dr. Kathy Taylor noted that there is a big opportunity for increasing the efficiency of energy use in medium- and heavy-duty trucks, and asked if her office is getting more involved in that now that it’s under the “sustainable transportation” umbrella.
  - Dr. Satyapal responded that the Vehicle Technologies Office has a big focus on heavy-duty trucks, e.g., through its SuperTruck program. FCTO has funded some work on auxiliary power units (APUs) for powering the hotel functions of trucks, but those are separate programs
- Dr. Thompson questioned whether the lower budget for the DOE Hydrogen and Fuel Cells Program over the last several years will result in fewer patents being filed and less intellectual property (IP) being generated over the next several years. He noted that available funding is often a leading indicator of IP.
  - Dr. Satyapal referred to the work of Fuel Cell Today to track fuel cell patents, and noted that 2013 data is not yet available. However, she pointed out that the number of fuel cell patents granted in the U.S. is the highest in the clean energy space, and that the number of fuel cell patents issued annually has fallen from its peak in the 2006-2008 period.
- Dr. Shaw thanked Dr. Satyapal for presenting information on DOE’s responses to HTAC recommendations. He also asked how DOE planned to protect IP in the incubator projects,

especially when the IP is not really patentable, but is more about being first-to-market with a breakthrough idea.

- Dr. Satyapal noted that DOE is sensitive to this, and has some flexibility in its active project management process for not publicly disclosing all project details. DOE will also try to work actively with the labs to facilitate early patent filing and IP management plans.

### **3. National Lab Initiative: Jetta Wong, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy**

Ms. Wong gave an overview of the National Laboratory Impact Initiative. She reviewed national laboratory commercialization metrics and discussed select reports on DOE laboratories. She listed past EERE and DOE commercialization and laboratory engagement efforts, as well as stakeholder engagement efforts. Ms. Wong then detailed the goal, assumption, priority areas, approach, and coordination of the National Laboratory Impact Initiative. She discussed the draft Impact Guidance, a possible “National Lab Manufacturing Partners” program, a possible voucher program for small businesses, and possible Lab-Corps. She also explained the benefits of connecting with DOE national laboratories.

>>see full presentation at [http://www.hydrogen.energy.gov/pdfs/htac\\_apr14\\_3\\_wong.pdf](http://www.hydrogen.energy.gov/pdfs/htac_apr14_3_wong.pdf)

#### ***Discussion***

- Dr. Shaw commented on his experience in trying to take lab-developed technologies to market, noting that it’s *people* that do technology transfer, not technologies. He asserted that the few successful companies that have emerged from national labs have done so because the person who developed the technology moved to the company. While this does not guarantee success, he noted that in cases where the inventor has *not* moved to the company, the commercialization process almost always fails. He questioned whether the DOE could in some way help with this transition.
- Mr. Eggert noted that for universities, the most effective form of technology transfer is the knowledge that their Master’s, Ph.D., and post docs take with them to their jobs. He asked whether the Lab Initiative is planning to expand fellowship or postdoc opportunities at the national labs.
  - Ms. Wong agreed, and said that the Initiative would support this kind of activity at the labs, but is looking to the labs themselves to provide ideas on what will work best. She said that funding may be provided by EERE to support these positions, but it would need to be clear that the work is supporting EERE missions and goals.
- Mr. Kaya commented that it is important to identify appropriate metrics of success for activities aimed at technology transfer, commercialization, and economic development. He recommended reaching out to states that have been successful in the clean energy space, including their state energy offices and the policy advisors to the governors. He also noted that customer development is a very important part of successful commercialization. He recommended interfacing with state and regional organizations like the clean technology accelerators for ideas in this area. He also suggested that at least some of the labs may need a cultural/organizational shift in order to better understand the needs of external end-users and customers.
  - Ms. Wong emphasized Assistant Secretary Danielson’s interest in better engaging the states, and reported on one suggestion to have each Lab Director invite the heads of their state energy offices to the lab and start a dialogue.
- Dr. Cardillo asked whether DOE had statistics on the success and impacts of the National Science Foundation’s (NSF) “I-Corps,” on which the idea of a possible DOE “Lab-Corps” is modeled.

- Ms. Wong replied that a full report has not been produced by the NSF, but DOE has collected some statistics and would be happy to share them with the HTAC if they are interested.
- Dr. Shaw remarked that a number of the scientists and researchers who work at the labs may not be personally interested in the commercial aspects or applications of their work, and some may even consciously or subconsciously resist adopting that perspective. He noted that this will require an education process. Dr. Bond agreed that scientists often lack this perspective, and noted that over the years the labs have been subject to different guidance from different administrations on whether they should focus on basic or applied research, and how much attention they should devote to technology transfer.
- Dr. Satyapal informed the Committee that the FCTO plans to hold a meeting with its national laboratory program managers on June 16, and invite external stakeholders, especially industry, to contribute ideas on how the labs can better work with industry and improve getting technologies to market. She asked the members to pass along to her any recommendations they may have for good people to attend the meeting.

#### 4. **H<sub>2</sub>USA Update: Morry Markowitz, Fuel Cell & Hydrogen Energy Association**

Mr. Markowitz first offered congratulations for the large amount of positive press being generated about hydrogen and fuel cell technologies over the last 6 months. He is very encouraged by the announcements from Hyundai and Toyota regarding the launch of FCEVs into consumer markets, and their positioning as the “next generation of electric vehicles.” He displayed a list of the participants in H<sub>2</sub>USA, including new members since his last report to the HTAC. He mentioned that the partnership is also reaching out to the 8 states that are part of the Zero Emission Vehicle Memorandum of Understanding, as well as other high-impact states. He presented the current H<sub>2</sub>USA organization chart, which shows that the partnership is led by a Steering Committee (with the Fuel Cell and Hydrogen Energy Association serving as Secretariat) and includes 4 working groups who are overseen by a Coordinating Group comprised of the working group chairs and vice chairs.. He detailed the activities and progress of the H<sub>2</sub>USA working groups—the Market Support and Acceleration Working Group, Locations Roadmap Working Group, Hydrogen Fueling Station Working Group, and Investment and Finance Working Group. He highlighted major H<sub>2</sub>USA activities in 2014, as well as the H<sub>2</sub>USA steering committee’s timeline of activities for 2015 and 2020. He noted that the partnership hopes to have an active public website in the July-August 2014 timeframe, and plans to begin state and local outreach in the fall of 2014 to organizations like the National Governor’s Association, U.S. Conference of Mayors, National Association of County Officials, and the Urban League.

>>see full presentation at [http://www.hydrogen.energy.gov/pdfs/htac\\_apr14\\_4\\_markowitz.pdf](http://www.hydrogen.energy.gov/pdfs/htac_apr14_4_markowitz.pdf)

#### ***Discussion***

- Vice Chairman Novachek commented on the good work and suggested it would be beneficial to keep track of and report on lessons learned as to what has worked and what hasn’t.
  - Mr. Markowitz responded that the H<sub>2</sub>USA organizers recognize the importance of learning from the past as well as communicating lessons for the benefit of efforts. One of the first tasks this year is completing a situational analysis, to produce an inventory of what has worked and what has not worked to date, as well as an assessment of near-term needs and strategies to accomplish those needs.
- In response to questions by Dr. Shaw and Dr. Lipman about specific estimates of the number of FCEVs the automakers plan to produce for sale in the 2015-2020 timeframe, Mr. Markowitz responded that the Locations Roadmap working group, chaired by Mr. Joel Rinebold, is working this now, and has issued a survey to automakers. Collection of the data will be done by the



NREL's secure data center, and data will be compiled and published as aggregated data sets. He estimates that these data will be available in 2015.

- Dr. Ogden applauded this approach for collecting data on projected vehicle production, and suggested something similar be done for hydrogen fueling stations. She suggested setting up a secure way of collecting and compiling aggregated data on things like how well the stations are being used, if there are sites or business models that work particularly well (or not), how well equipment is performing, etc. She also noted that there may be similar hydrogen infrastructure build-out efforts going on in Germany, U.K., and Japan in this same timeframe, so we should take advantage of that experience as well.
  - Mr. Markowitz agreed, and noted that H<sub>2</sub>USA participants are aware of the ongoing initiatives abroad (e.g., H2 Mobility in the U.K., NOW in Germany, and Hy-SUT in Japan), and are actively engaged in learning from those activities. He is traveling to Germany next week, in fact, and meeting with BMW, Mercedes, and senior representatives of NOW.
- Chairman Hofmeister suggested that H<sub>2</sub>USA might want to give some thought to establishing a personal “champion” for the effort—a face and a voice to represent the initiative.

#### **5. Connecticut Center for Advanced Technology, Inc. (CCAT): Joel Rinebold, CCAT**

Mr. Rinebold described CCAT's scope of efforts. He detailed CCAT's work to update 2012 state roadmaps and conduct IMPLAN economic analysis regarding the Northeast economic impact. He also discussed CCAT's supply chain mapping activities and supply chain analysis work, which includes a searchable database. Mr. Rinebold provided more information on the H<sub>2</sub>USA industry survey on FCEV deployment and the effort to develop H<sub>2</sub>USA roadmaps for hydrogen refueling infrastructure. He summarized CCAT's outreach efforts, which include technology briefings, ride-and-drives, webinars, and presentations. He also discussed CCAT's intended future actions and shared a summary of different states' eligibilities for fuel cell/hydrogen policies and incentives.

>>see full presentation at [http://www.hydrogen.energy.gov/pdfs/htac\\_apr14\\_5\\_rinebold.pdf](http://www.hydrogen.energy.gov/pdfs/htac_apr14_5_rinebold.pdf)

#### ***Discussion***

- Dr. Shaw asked Mr. Rinebold about the roadmap for fueling stations in the Northeast, shown on slide 8 of his presentation. He noted that the stations seem to be spread out geographically and asked if there was concern over whether FCEV drivers would want more than one station in their normal daily driving vicinity, especially in high-traffic areas.
  - Mr. Rinebold noted that these locations are preliminary. The model assumes that there would need to be 200 vehicles per fueling station to be economic. This particular chart is an early market adopter map that shows potential station locations considering only households with incomes of \$200,000 or more. A next layer of modeling will include areas where there is large vehicle fleet usage, which would add stations to the map.
- Mr. Rose asked about slide 19, which shows state and federal incentives for fuel cells in the New England region. He asked whether all the states shown in the chart are “Section 177 states,” i.e., states that have chosen to adopt California's emissions standards in lieu of federal (U.S. Environmental Protection Agency) requirements. Mr., Rinebold replied that all but one (New Hampshire) are Section 177 states. He noted that only the states which signed the State Zero-Emission Vehicle Programs Memorandum of Understanding are shown in the chart as having incentives for hydrogen infrastructure, but that does not mean the potential or interest isn't there. He stated that Maine, in particular, is very active in working with CCAT in looking for opportunities for both stationary fuel cells and hydrogen refueling as part of a regional fueling network.

- Dr. Ogden asked if the models being used are considering the supply side and how the hydrogen would be supplied.
  - Mr. Rinebold replied that this is a consideration but the intention is not to pick winners. Business and the market will decide what makes the most sense. The intent of the modeling is to help provide information on where the markets are, and what the barriers might be so that efforts can be taken to remove some of the barriers.
    - Dr. Ogden noted that policymakers are often interested in the answers to questions like “How many stations do you have to build?” and “How many cars have to be in use before you start to make money?”
- Chairman Hofmeister noted that the retail fueling marketplace in New England is very competitive, fragmented, and comprised of many family-owned businesses that may be hard to convince to offer new fuels. He asked if there is a strategy for reaching out to them about the prospects for hydrogen.
  - Mr. Rinebold replied that engaging potential investors and end-users is part of the plans for the future, but right now the focus is on assessing what the market opportunities might be.
    - Mr. Hofmeister added that understanding who owns the real estate and who has the licenses to move, handle, and sell hazardous materials will also be important. He suggested identifying and engaging these parties “sooner rather than later.”
- Chairman Hofmeister commended H<sub>2</sub>USA for bringing in the National Association of Convenience Stores as a participant. He noted that they are interested in anything that will bring more customers to their sites, including offering multiple fuels. He pointed out that it will be associations like these, as well as state-level associations that will be most useful in reaching players in the Northeast retail fueling marketplace, since the big energy companies generally only franchise their names in that region.

**6. Launching California’s Fuel Cell Electric Vehicle Market: Commissioner Janea Scott, California Energy Commission (CEC)**

Commissioner Scott presented on the launch of California’s FCEV market. She reviewed California transportation statistics, introduced the five CEC Commissioners and the Commission’s responsibilities, and detailed the state’s relevant policy goals and objectives. She also described several activities related to the launch of California’s FCEV market, including the 2013 Zero Emission Vehicle Action Plan, the Governor’s Office’s Zero Emission Vehicle Summit, and the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVT) implemented under California State Assembly Bill 118 (AB-118). She noted that AFRVT provides the CEC with up to \$100 million in funding per year. Recently, the California legislature (California State Assembly Bill 8) extended AFRVT through January 1, 2024 and added provisions to fund at least 100 hydrogen fueling stations with a commitment of up to \$20 million per year from the AFRVT Program. Commissioner Scott detailed the CEC’s hydrogen development projects to date, which include public station funding and other funding activities. She also mentioned market development challenges and discussed a solicitation on hydrogen fueling infrastructure that closed in February. She reported on the status of major automotive manufacturers’ fuel cell vehicle activities in California. She also described market development strategies and public-private partnerships in California.

>> see full presentation at [http://www.hydrogen.energy.gov/pdfs/htac\\_apr14\\_6\\_scott.pdf](http://www.hydrogen.energy.gov/pdfs/htac_apr14_6_scott.pdf)

***Discussion***

- Dr. Shaw commented on Commissioner Scott’s slide on California market development challenges (slide 13). He agreed that the relationship between the station builder/owner and the automakers is important, but added that it is important to also include a linkage to the hydrogen

suppliers. He suggested implementing some mechanism for engaging all three players in risk sharing, so that any one or more of the players isn't financially at risk if one of the necessary links in the chain doesn't perform up to expectations (e.g., doesn't deliver the cars when expected, build the station when expected, or build the hydrogen production capacity when expected). He argued that some kind of "take or pay" type of contract among the parties is needed to ensure confidence in each of the players that the commitments made by the others will be kept.

- Commissioner Scott agreed that adding the hydrogen suppliers to her presentation as a key market player is a good idea. She also agreed that finding ways to spread the risk is a good idea, but noted that it can be tricky to implement in an equitable way.
- Mr. Rose asked Commissioner Scott what the federal government could do over the next few years to help the California efforts to launch FCEVs.
  - Commissioner Scott replied that leveraging federal and state funding for demonstration efforts could be useful. She encouraged the placement of hydrogen fueling stations in the Washington D.C. area so that policymakers could see vehicles in daily use. She suggested continuing efforts to raise public awareness about the prospects for FCEVs. She also encouraged continued DOE funding for data collection and dissemination on early market deployments of fueling stations and FCEVs.
- Dr. Lloyd encouraged increased coordination between California and DOE when they design or revise emission regulations. He noted the tendency for the state to interact mainly with EPA, and suggested that DOE should also be in the loop since they have a lot of data and have done a lot of techno-economic analysis in this area. He also commended the CEC for how well it is coordinating with other agencies in California, including the Air Resources Board.
  - Commissioner Scott highlighted the California Governor and legislature's commitment to this initiative, which has helped foster collaborative efforts to get things done.
- Mr. Freese asked for Commissioner Scott's assessment on potential competition between the ZEV technologies for infrastructure (battery electric vehicles, plug-in hybrids, and FCEVs) as well as potential competition between the states for the limited number of FCEVs that the OEMs will be willing to produce for early markets.
  - Commissioner Scott replied that the legislature has required a portfolio approach, and directed that up to \$20 million be put into hydrogen. She noted that a 24-member advisory committee has been established to help advise the CEC on allocating the AFRVT Program funds. She conveyed her opinion that there is room for multiple types of alternative fuel vehicles in meeting climate and clean air goals, since different applications and users have different needs (e.g., rural vs urban drivers, light vs heavy-duty vehicles). She also conveyed her hope that the automakers would match pace with infrastructure development in the states and provide the cars needed to sustain the necessary hydrogen demand.
- Mr. Koyama asked whether home refueling stations are being considered by the CEC for funding under this initiative.
  - Commissioner Scott replied that only public fueling stations are being considered.
- Dr. Thompson asked about the information she presented on Hyundai (slide 16), and their commitment to lease Tucson FCEVs for \$499/month including unlimited free hydrogen. He asked if she knew how they planned to provide that fuel.
  - Commissioner Scott replied that she didn't know, but this information was taken directly from a slide presented by Hyundai at the national fuel cell symposium. Dr. Ayala replied that Hyundai is targeting the southern California market, and is actually taking applications for the FCEVs and assessing whether the buyer/lessee will have suitable fueling options to meet their driving pattern needs. Mr. Eggert added that Hyundai also plans to install hydrogen fueling stations at some of their dealerships.

- Mr. Eggert made note of California’s NOx emissions standard for 2023 which requires an 80 percent reduction, and which is also coupled with an even more stringent NOx reduction requirement in 2032 that is paired with particulate matter emissions. He noted that meeting these standards will require moving to zero or near-zero emissions technology for the freight sector, including short-haul, long-haul, and drayage trucks. He said that this could accelerate the deployment of alternative fuel technologies into those markets much faster than anybody had previously considered. Mr. Eggert also emphasized the importance of showing progress and maintaining momentum. He noted that even though the AFVRT Program has been authorized out to 2024, there will be a lot of scrutiny and a lot of competing interests will be looking for slipups and challenges. Anticipating and developing plans for managing those challenges, and leveraging resources from all stakeholders, will be important.
- Dr. Satyapal pointed out that DOE is doing work on freight trucks through the Vehicle Technologies Office and also has an ongoing hydrogen fuel cell hybrid truck project. Dr. Satyapal asked Commissioner Scott about the reporting requirements that she mentioned in her presentation, in particular the report timing and whether similar reports are required on the deployment progress of the other alternative transportation fuel technologies so that lessons can be learned from their experiences.
  - Commissioner Scott replied that the requirement is for a report from the CEC and the California Air Resources Board (CARB) to the California legislature on FCEV deployment at the end of 2015 and annually thereafter. She noted that this reporting requirement is unique to hydrogen and fuel cells, because the legislation requires that \$20 million be directed to hydrogen each year and the legislature wants to know what impacts this spending is having. The report outline has not yet been developed, but it will include statistics on the numbers of FCEVs on the road and the number and location of hydrogen fueling stations. She speculated that these data will be used to inform future decisions on how much of the “up to \$20 million” is directed towards hydrogen infrastructure deployment in future years. Commissioner Scott also noted that California is very focused on equity issues, so it will be helpful to include all vehicle classes in technology improvements, so that the beneficiaries aren’t only those who can afford personal vehicles.
- Mr. Taylor spoke from the perspective of a hydrogen supplier, and offered support for the station subsidy program in California. He noted that this kind of support will be needed for industrial gas companies to invest capital in new hydrogen supply capacity and fueling stations.
- Chairman Hofmeister raised several points on possible “speed bumps and obstacles” to Commissioner Scott’s attention. First, he was concerned to hear that the major oil companies seem to have adopted a defensive posture to the AFVRT program, and while he noted they are not necessarily popular, they do carry a voice. Second, he suggested that the affordability issue could become a point of contention with regard to equity and use of public funds, so making these technologies affordable sooner rather than later is important. Third, he noted that there is increasing advocacy for greater use of alcohol fuels, which could potentially hinder movement towards hydrogen FCEVs.
  - Commissioner Scott replied that the legislature has directed a portfolio approach that does not pick winners and losers, with a goal of accelerating progress toward achieving its climate and air quality goals. With regard to the affordability issue, she noted that there has been discussion on options, including rebates and “cash for clunkers” type programs. There is also a desire to make sure that public transit includes clean vehicle technologies, so people who do not have cars can still take advantage of the advanced technology opportunities. On Mr. Hofmeister’s first point, Mr. Eggert responded that the oil companies were instrumental in getting AB-8 passed by the legislature, which

required a two-thirds approval vote to carry. Dr. Lloyd noted that this support from the oil companies was negotiated and is not the status quo.

**7. Achieving Climate and Air Quality Goals—Transforming California’s Vehicle Fleet:  
Dr. Alberto Ayala, California Air Resources Board**

Dr. Ayala shared three defining targets for the California Air Resources Board (CARB):

- 1) Achieving health-based ambient air quality standards for ozone in 2023 and 2032,
- 2) Rolling back greenhouse gas (GHG) emissions to 1990 levels by 2020 (~30% reduction), and
- 3) Reducing GHG emissions by 80% by 2050.

He then discussed CARB’s Scoping Plan, which serves as its climate and air protection policy framework for the path to 2050. He noted that there has been tremendous progress for clean air in California over the last several decades toward attainment, and detailed some of the state’s current nonattainment areas. Dr. Ayala then outlined other policies and their results towards reducing GHG emissions in California. These included NOx control, California’s Advanced Clean Cars Program, and zero-emission regulations for light-duty vehicles. He stated that both plug-in and fuel cell EVs are necessary for meeting California’s zero-emission goals, and showed how the prices for these vehicles are expected to decline by 2025. This culminated in a slide on average 2025 vehicle consumer impact, showing estimated savings over the life of the vehicle. Dr. Ayala concluded by showing the plan for fuel consumption and fuel economy reductions to 2050, and making the point that a 5% GHG emissions improvement per year is feasible with advanced technology.

>>see full presentation at [http://www.hydrogen.energy.gov/pdfs/htac\\_apr14\\_7\\_ayala.pdf](http://www.hydrogen.energy.gov/pdfs/htac_apr14_7_ayala.pdf)

***Discussion***

- Dr. Shaw asked how the CARB analysis accounts for GHG emissions from the source of the electricity used by the electric vehicles.
  - Dr. Ayala responded that this is looked at from a lifecycle point of view, so upstream emissions are accounted for in the vehicles as well as the fuel pathways.
- Mr. Rose asked what the source of the hydrogen and electricity was for the charts showing emissions of GHG and criteria pollutants from different vehicle types (slide 18).
  - Dr. Ayala responded that the source of hydrogen was natural gas and the source of electricity was the California generation mix. He noted that these data would be refined moving forward.
- Dr. Lloyd commented on slide 13 which showed projections of ZEV market penetration to 2050. He suggested that Dr. Ayala include information from the recent National Academies study, which projected that by 2035-2040 both battery and fuel cell electric vehicles will be less expensive than internal combustion engines and that they will always be less expensive than plug-in hybrids. He commended California’s attention to particulate matter (PM) and asked whether technology could meet the standards or whether filters for gasoline engines would ever be required.
  - Dr. Ayala stated that today’s technology can meet the PM standards.
- Dr. Lloyd asked what the Committee can do to keep the ZEV program going with the upcoming midterm review in 2016-2017.
  - Dr. Ayala noted that when the legislation was authorized, it included a requirement for a mid-term review in 2016-2017 to reevaluate the standards for the 2021 to 2025 timeframe. He emphasized the importance of success in California, which is making a big commitment and a big push for ZEVs. He asked the Committee and DOE to think about

what they can do to magnify the actions taking place in California, and how CARB and the CEC can work together with DOE to help make this happen.

- Mr. Eggert noted the significance of the data from the NAS study on the future incremental price of battery and fuel cell electric vehicles (slide 20). He stated that this indicates a future with not only societal benefits, but also significant private economic benefits for using battery electric and fuel cell electric vehicles, and suggested that this should be part of the message that gets communicated to the public and policymakers.
  - Dr. Ayala agreed and noted that Hyundai's plans are very exciting since they will be producing vehicles that will have the same platform (the Tucson model) with either a fuel cell engine or gasoline internal combustion engine. This should help to bring costs down more quickly.
- Vice Chairman Novachek asked Dr. Ayala to discuss the difference between the data in column 4 and column 5 of slide 20, which show the "Incremental Vehicle Price in 2025" and "2025 NAS" projections, respectively.
  - Dr. Ayala explained that the column 4 data show the results of the CARB analysis used in developing the rulemaking, and the data in column 5 show the results of more recent analysis conducted by the National Academies. He noted that the main message of this graphic was not really the exact amount incremental price, which was developed in 2011 to support the California legislation and depends heavily on assumptions, but the fact that the more recent NAS analysis shows the price difference coming down much faster than anticipated.

#### **8. Massachusetts FCEV Working Group Update: Charlie Myers, Massachusetts Hydrogen Coalition (MASSH2)**

Mr. Myers began his presentation with an overview of member organizations in the Massachusetts FCEV Working Group. He provided a summary of the Station Funding Program, detailing how stations get involved with it, and stating that it is based on a fleet hydrogen purchase agreement. Mr. Myers discussed how federal, state, municipal, utility, and rental car companies are all part of this team and how fleet profiling work was done, for ZipCar and other fleets, with the help of DOE. The results of this analysis showed how fleets were distributed based on location, and included data on frequency of breakdowns, etc. He discussed actions and strategies to increase the demand for hydrogen. Mr. Myers stated that the plan is to use the fleet as a springboard to create a critical mass, and that retail is the end game. He noted that the Greater Boston FCEV launch can serve as a model for other cities and regions. He also discussed market messaging, Massachusetts electric vehicle funding, and HTAC action requests.

>>see full presentation at [http://www.hydrogen.energy.gov/pdfs/htac\\_apr14\\_8\\_myers.pdf](http://www.hydrogen.energy.gov/pdfs/htac_apr14_8_myers.pdf)

#### ***Discussion***

- Vice Chairman Novachek asked Mr. Myers what data he would like to see (if available) from the work in California.
  - Mr. Myers responded that it would be the results of station economics modeling to help understand how many retail stations would need to be launched to bring certain costs down. He also noted that lessons learned on codes and standards and permitting unattended stations would be useful.
- Mr. Eggert noted that the signatory states to the State Zero-Emission Vehicle Programs MOU are working on their action plans, and asked Mr. Myers about his perception that some states are focusing only on battery electric vehicles in the near-term, seeing FCEVs as longer term options.
  - Mr. Myers responded that he is working to ensure that all of the states working on action plans understand 1) the actual status of FCEV technology today and 2) the timelines for

action and the need for language in their recommendations that is unbiased (e.g., not specifying “battery” or “fuel cell,” just “electric” vehicle..

## 9. Clean Energy Manufacturing Initiative: Libby Wayman, U.S. Department of Energy

Ms. Wayman presented a brief update on the Office of Energy Efficiency and Renewable Energy Clean Energy Manufacturing Initiative (CEMI). She described CEMI’s objectives, portfolio, and year 1 highlights. She noted that CEMI has expanded to be a DOE-wide initiative, carried out by a “Tech Team,” which allows collaboration among DOE offices on shared problems. She then detailed the DOE CEMI Tech Team’s deliverables and timeline. Ms. Wayman also shared some ideas currently under development. She highlighted three tiers of ideas—programs under development or piloting (Tier 1), earlier stage ideas (Tier 2), and blank page (new) ideas (Tier 3). Ms. Wayman introduced a Tier 1 idea: the “National Lab Manufacturing Partners Program,” which she said would be piloted within EERE with the intention of building on existing relationships between labs and the private sector to increase the success and impact of lab-industry research agreements. In Tier 2, Ms. Wayman described the nascent “Materials Acceleration Partnership,” which seeks to accelerate early-stage materials into widespread use in commercial products, and the “Clean Energy Manufacturing Scale-up Partnership,” which seeks to cost-share the scale-up of innovative manufacturing technologies.

>>see full presentation at [http://www.hydrogen.energy.gov/pdfs/htac\\_apr14\\_9\\_wayman.pdf](http://www.hydrogen.energy.gov/pdfs/htac_apr14_9_wayman.pdf)

### **Discussion**

- Mr. Rose asked whether a one-for-one exchange of personnel is necessary in the National Lab Manufacturing Partners Program. He noted that many companies don’t have people to spare and that it may be more effective to allow lab personnel to do details in industry.
  - Ms. Wayman responded that a one-for-one exchange is not necessary, but that they are trying to ensure that there is a person from both sides who is committed to ensuring that it is a productive relationship with a defined outcome.
- Vice Chairman Novachek asked about the issue of protecting the intellectual property (IP) of whatever is developed in the Lab Partners program so that the company can gain a sustainable competitive advantage.
  - Ms. Wayman stated that, at least in the pilot stages, EERE will not prescribe a particular IP policy, but will let the participating lab and company define the IP protection terms of their working agreement.
- Dr. Ogden noted that it would be useful to get information on potential issues with materials scarcity and amount and cost of energy to manufacture as part of the analysis done in the Materials Acceleration program.
  - Dr. Satyapal noted that DOE recently completed a “cradle-to-grave,” well-to-wheels analysis of various alternative fuel pathways and vehicles; the summary of the results will soon be published and can be circulated to the Committee.
- Mr. Eggert suggested making the supply chain analysis capabilities of the national labs available to address specific manufacturing conditions or facilities in the U.S. He stated that this could be a very useful technical service for industry that would also increase the knowledge base of the labs.
- Dr. Satyapal noted that the HTAC has formed a Manufacturing Subcommittee, and asked the subcommittee to consider developing feedback for the Clean Energy Manufacturing Initiative on hydrogen and fuel cells related needs.
  - Ms. Wayman responded that this type of feedback would be appreciated.

- Mr. Koyama noted the importance of supply chain issues, and pointed out that there are a number of materials that are common across fuel cells and hydrogen generation that could benefit from advanced or more efficient manufacturing.
- Chairman Hofmeister suggested adding water to the list of materials, since water is used in so many manufacturing and energy production processes.
  - Dr. Satyapal pointed out that there is also a crosscutting DOE Water-Energy “Tech Team.”
- Dr. Shaw recommended that DOE look into lessons learned from past efforts to fund materials development programs (including private venture capital funds, partnership programs, etc.), since this is very challenging and many of these efforts failed.
  - Ms. Wayman responded that DOE is still in a data gathering mode on this idea and would be interested in any recommendations for resources or references they could access.

## **DAY 2 – APRIL 2, 2014**

### **1. HTAC Annual Report Status, Dr. Levi Thompson**

Dr. Thompson reported that the current draft of the 2013 HTAC Annual Report includes input from all members. The draft has been distributed to all members for review and comment. He briefly reviewed the outline of the report, noting the topics covered and key messages conveyed, including progress on stationary fuel cell and FCEV commercialization, hydrogen fueling infrastructure, and partnership activities. The report sections reviewed were: Commercialization Initiatives; Research and Development; Policy, Regulations, Codes and Standards; Financial Climate; Continuing Challenges; and Conclusions. Dr. Thompson reviewed the process for finalizing and publishing the report. Committee members were asked to provide Dr. Thompson with any comments on the existing draft by April 18. The report subcommittee will review and incorporate substantive comments, and work with HTAC support staff produce a final, web- and print-ready product for delivery to the Secretary, and ultimately, publication.

>>see full presentation at [http://www.hydrogen.energy.gov/pdfs/htac\\_apr14\\_10\\_thompson.pdf](http://www.hydrogen.energy.gov/pdfs/htac_apr14_10_thompson.pdf)

### ***Discussion***

- Vice Chairman Novachek recommended that the work of the HTAC subcommittees be included in the report.
- Chairman Hofmeister recommended that, under the “Continuing Challenges” section, something should be added about education and communication. He noted that a continuing challenge is helping the public and industry be aware of activities and progress, but there has been a zero budget for education for several years.
  - In response to a question about the budget, Dr. Satyapal confirmed that the education line item in the FCTO budget, which in the past had been \$1 million, is now zero. She noted that the Office does some outreach activities through the Market Transformation and Safety, Codes and Standards sub-programs. However, student education activities are not within the budget.
- Mr. Rose recommended including the National Academies studies that were published in late 2013.
- Chairman Hofmeister offered to draft the cover letter transmitting the report to the Secretary.



## 2. HTAC Infrastructure Subcommittee: Status Update and Issues for 2014 HTAC Infrastructure Report, Joan Ogden

Dr. Ogden began by reviewing the status of the 2013 Infrastructure Subcommittee report, the results of which were summarized and delivered to Secretary Moniz in a November 2013 letter. She presented some of the highlights from the 2013 report cover letter in terms of the status of hydrogen infrastructure and recommendations. She reported that a new committee is forming to develop the second infrastructure report. She offered some suggestions for the key issues for the 2014/2015 Infrastructure Report, including technical advances in infrastructure technologies, tracking progress of worldwide hydrogen fuel cell vehicle roll outs, examining the evolving business case for hydrogen and fuel cell vehicles, and examining the role of policies. She asked the Committee for their input on these or other topics to include, and asked for volunteers to work on the report.

>>see full presentation at [http://www.hydrogen.energy.gov/pdfs/htac\\_apr14\\_11\\_ogden.pdf](http://www.hydrogen.energy.gov/pdfs/htac_apr14_11_ogden.pdf)

### *Discussion*

- Dr. Lipman recommended the topic of early learnings from the infrastructure that has been put in place so far.
- Dr. Lloyd stated that it would be useful to include progress on fueling infrastructure for medium/heavy duty vehicles as well as on light duty vehicles. He also suggested looking into learnings from the rollout of battery electric vehicles.
- Mr. Eggert suggested analysis on different infrastructure strategies and what they might mean for cost, looking at early stage vs commercial volumes. He also suggested using the report to present different hydrogen production technologies and when they might come to market.
- Mr. Rose suggested topics more focused on the evaluation side, as opposed to the data-driven side. He recommended looking at factors like infrastructure investments, and what can be learned from strategies that have been implemented around the world. He mentioned the four-country technical effort that was launched in Germany with a focus on metering, durability, and balance of system components. Finally, he suggested that the report provide data on the consumer price of hydrogen.
- Dr. Shaw recommended finding a way to track and report on consumer uptake of vehicles, and their experience/satisfaction with the available refueling infrastructure and the price of hydrogen relative to gasoline.
- Mr. Freese stated that, regarding getting vehicles accepted in the marketplace, there is a need to look at some of the other alternative fuel vehicles that are entering the market (e.g., battery electric vehicles) and evaluate consumer sensitivity to vehicle price and how this affects market penetration.
- Dr. Kathy Taylor emphasized the importance of building on the recommendations in the first subcommittee report.
- Vice Chairman Novachek pointed to the conceptual framework of a “three-legged stool” that is required to enable market penetration of hydrogen fuel cell vehicles: infrastructure + vehicles + fuel. While he agreed that the infrastructure report may need to include some analysis on the vehicles and fuel side of things, he questioned whether the scope of the subcommittee’s work was being, or should be, expanded. He recommended that automotive OEMs be invited to present to HTAC on experience with and plans with for deployment, and that fuel suppliers be invited to provide an update on the price of the molecules.
- Chairman Hofmeister noted that the consideration of wholesale vs retail markets is important, as well as the progression of public (consumer) vs. non-public (fleet-only) stations in the U.S. and in other countries.

- Dr. Ogden agreed that some localities are proposing public infrastructure growth out of fleets, so this is an important area to track.
- Mr. David Taylor recommended that the subcommittee define a tight scope or the project could get very large and take a lot of time to complete.
- Members volunteering to help with the subcommittee deliberations and report writing included: Mr. Rose, Dr. Shaw, Mr. Freese, Dr. Lipman, and Dr. Taylor.

### **3. Manufacturing Subcommittee Update, Hal Koyama**

Mr. Koyama gave an overview of the Manufacturing Subcommittee, including its members, focus, and process, as well as the initial, informal feedback it received from industry. He described the questionnaire used to gather industry feedback on issues such as how specific components make a significant difference in cost and performance, supply chain fatigue and quality performance, the potential for new manufacturing techniques to impact near-term commercialization, introducing automation for a wide variety of products at large volume, and specialized manufacturing techniques at the component supplier level. Mr. Koyama also discussed the topic of additive manufacturing, including its current state and value proposition for fuel cell manufacturing. He detailed the subcommittee's next steps, which include collecting and processing questionnaire feedback, producing findings and suggestions, and potentially inviting an additive manufacturing specialist speaker to the next HTAC meeting. He also shared some relevant resources.

>>see full presentation at [http://www.hydrogen.energy.gov/pdfs/htac\\_apr14\\_12\\_koyama.pdf](http://www.hydrogen.energy.gov/pdfs/htac_apr14_12_koyama.pdf)

#### ***Discussion***

- Mr. Kaya reminded members about the request from Libby Wayman (Director of the DOE Clean Energy Manufacturing Initiative [CEMI]) for input and feedback on CEMI activities and plans.
  - Mr. Koyama agreed with this and stated that the subcommittee should engage with Ms. Wayman and provide her with input on this request.
- Dr. Satyapal noted that there are upcoming CEMI events in the San Francisco Bay Area that subcommittee members may want to participate in, and offered to send details to interested members.
- Dr. Carlin stated that there is a lot of interest in additive manufacturing at the Department of Defense.
- Dr. Lipman commented on the importance of manufacturing yield in the discussion on reducing costs.
  - Mr. Koyama agreed and stated that this topic should be included in discussions.
- Chairman Hofmeister asked if the subcommittee has a view of who the audience is for their work.
  - Mr. Koyama responded that there are two customers: component suppliers and producers of fuel cell and hydrogen production systems.

### **4. Solid State Energy Conversion Alliance Update, Darren Mollot**

Dr. Mollot gave an overview of the work on solid oxide fuel cells (SOFCs) being done under the Clean Coal Research Program in DOE's Office of Fossil Energy. He first discussed SOFC power systems in terms of cost of electricity and efficiency. He then summarized the SOFC program's mission, structure, budget, and project portfolio. He also described the SOFC program's Core Technology Program, Industry Teams, technology progress, and timeline. Dr. Mollot stated that SOFC is a transformational carbon capture and storage technology that also offers additional benefits. He remarked that there are also near-term opportunities for commercial demonstration and deployment in the distributed generation market.

>>see full presentation at [http://www.hydrogen.energy.gov/pdfs/htac\\_apr14\\_13\\_mollot.pdf](http://www.hydrogen.energy.gov/pdfs/htac_apr14_13_mollot.pdf)

### **Discussion**

- Vice Chairman Novachek asked whether the costs of the SOFC systems presented include carbon storage costs.
  - Dr. Mollot responded that, yes, storage costs are included and that carbon capture is a more significant portion of the cost than storage.
- Dr. Shaw asked how the work DOE is doing compares with the work Bloom Energy is doing, since Bloom already has commercial SOFC systems on the market.
  - Dr. Mollot responded that the work Bloom is doing is proprietary, and DOE does not have detailed knowledge on their system costs or durability, other than public information. Dr. Satyapal added that the DOE program would enable large-scale central power generation which is different from Bloom's work.
- Mr. Koyama asked for clarification on the "system cost" numbers presented on slides 12 (\$900/kWe) and 16 (\$6,000/kWe) of Dr. Mollot's presentation.
  - Dr. Mollot responded that he would have to review those figures and get back to Mr. Koyama on the costs and configurations represented by those systems, but noted that \$900/kWe is the cost target for the whole system.
- Mr. Eggert asked about how the system cost numbers were derived, and whether they resulted from bottoms-up cost analysis or whether they were based on "top-down" projections of what is needed for commercial success. He also asked what is required to meet the DOE cost targets—e.g., material cost reductions, technical breakthroughs, economies of scale, etc.
  - Dr. Mollot responded that the cost targets were based on a combination of "top down" and "bottom up" approaches, and that a variety of advances will be needed to achieve the targets.
- Dr. Ogden asked at what scale carbon capture becomes cost-effective.
  - Dr. Mollot stated that it would depend on the application, noting that it could be economical at smaller scales in niche applications, for example, those that require CO<sub>2</sub> (e.g., bottling plants).
- Vice Chairman Novachek asked whether the 60% efficiency rate included combined heat and power (CHP).
  - Dr. Mollot stated that it does not, so the efficiency would be higher with CHP, especially at 700°C.
- Vice Chairman Novachek asked about the ramp rates of the SOFC systems.
  - Dr. Mollot replied that he would get back to HTAC with those data.
- Vice Chairman Novachek asked about the operation and maintenance (O&M) costs and water requirements of the SOFC systems compared with conventional power plants. Dr. Mollot noted that O&M costs are expected to be lower with the SOFC system, which is one of the benefits of this system. With regard to water requirements, the goal for the SOFC system is to be water neutral.
- Vice Chairman Novachek asked about DOE's 2015 budget request for the SOFC program.
  - Dr. Mollot responded that the request was for \$3 million.
- Dr. Shaw asked about the planned 250 kWe field test shown on slide 14, and how practical carbon capture would be at this scale.
  - Dr. Mollot replied that at this scale, they plan to do some carbon capture with partial compression, but the carbon would be vented, not stored.
- Dr. Shaw asked about the challenges expected in scaling the systems from the kilowatt size to the megawatt size.

- Dr. Mollot responded that the larger systems will be built by combining stacks into modules; the core stacks will be 25 kW- 60 kW, depending on the manufacturer.
- Vice Chairman Novachek asked whether individual modules in the system could be replaced in isolation from the rest of the system to keep a plant running on a continuous basis.
  - Dr. Mollot responded that this would be possible.

## 5. Redox Power Systems SOFC Technology, Eric Wachsman

Dr. Wachsman discussed Redox Power Systems' bi-layer electrolyte solid oxide fuel cell (SOFC) technology, which can operate at lower temperatures (>600°F) than conventional SOFC technology. He described the 25-year process of moving from fundamentals to pre-commercialization of his technology. Dr. Wachsman presented data on the operating characteristics of the bi-layer electrolytes, including temperature, conductivity, stability, and volumetric and gravimetric power density. He described Redox's next-generation SOFC system, including its unique configuration and plans for continuing work to increase performance, lower operating temperature, and reduce cost. He also gave an overview of the company's scale-up and stack development efforts.

>>see full presentation at [http://www.hydrogen.energy.gov/pdfs/htac\\_apr14\\_14\\_wachsman.pdf](http://www.hydrogen.energy.gov/pdfs/htac_apr14_14_wachsman.pdf)

### *Discussion*

- Dr. Thompson questioned whether satisfactory performance is achievable for internal reforming of hydrocarbon fuel at only 350°F.
  - Dr. Wachsman stated that the first systems will operate in the 650°F range, and that lower temperatures are being looked at for future systems. He noted that operation in the lab at 550°F has been achievable without a problem.
- Mr. Freese asked how fast the system warms up.
  - Dr. Wachsman responded that this has not yet been determined, since they are still focused on stack-level testing. He estimated that at 600°F, it may take approximately 20 minutes to warm up the system.
- Dr. Satyapal asked for more information on the company's plans going forward.
  - Dr. Wachsman stated that the company is headquartered in Maryland, and R&D is performed at the University of Maryland, where they have a multilayer ceramic fabrication facility and a stack testing lab. Redox Power is partnering with several other companies for component and system fabrication, and plans on having 25-kW units for field testing by the end of the year.

## 6. Plug Power, Andy Marsh

Mr. Marsh presented on Plug Power's commercial fuel cell offerings, which currently focus on the material handling (lift truck) market. He described Plug Power's GenKey model, noting that it includes the hydrogen fuel cell system (GenDrive®), hydrogen infrastructure and fuel (GenFuel), and customer service (GenCare). He detailed the value proposition for the GenDrive system and highlighted the GenDrive product line. He also described the components and advantages of GenFuel and GenCare. Mr. Marsh explained how the GenKey system benefits customers, investors, and Plug Power. He discussed GenKey's deployment successes (including 4,500 units shipped to 44 sites and 24 different customers) and operating statistics (20 million hours of run time, 8,000 fills per day, 4,600 kg of hydrogen dispensed per day, and filling time of under 2 minutes). Mr. Marsh also described the company's aspirations to expand in European material

handling markets, and to expand into adjacent markets, including transportation refrigeration units, ground support equipment, and range extenders for battery-powered parcel delivery trucks and other fleet vehicles.

>>see full presentation at [http://www.hydrogen.energy.gov/pdfs/htac\\_apr14\\_15\\_marsh.pdf](http://www.hydrogen.energy.gov/pdfs/htac_apr14_15_marsh.pdf)

### ***Discussion***

- Mr. Eggert asked about the key technical obstacles and cost reduction opportunities for stack systems and infrastructure, and where R&D resources should be focused.
  - Mr. Marsh responded that a technical obstacle on the infrastructure side is the liquid compressing system and its associated cost. From the design point of view, Mr. Marsh noted that his company spends most of its time on developing improved ways to integrate components into systems so they are simpler and lower cost. He agreed that this was more of a high-end engineering activity than a research activity, but emphasized that this type of engineering development work is needed to move technology into commercialization.
- Mr. Rose asked if Plug Power's business is mostly retrofits or new units.
  - Mr. Marsh responded that they do a lot of retrofits, since many of their customers want to convert their existing battery-powered forklift fleets to fuel cells. But when customers are building new facilities, they often choose to go with the GenKey system for the associated benefits, including the ability to eliminate the need for a battery charging room.
- Mr. Rose asked what the minimum number of forklift units is for the GenKey model to make economic sense.
  - Mr. Marsh responded that the current systems start making sense at about 50 units, but Plug Power is working on developing configurations that will work for smaller distribution centers.
- Dr. Lloyd asked about the basis for the claim of "up to an 80% reduction in carbon footprint" made in the presentation.
  - Mr. Marsh stated that this was based on a well-to-wheels analysis where the fuel cell forklifts were replacing liquid propane gas (LPG) fueled trucks and the hydrogen was made from natural gas. He noted that the figure would change depending on the sources of power, but they evaluate each customer's unique situation so the customer knows what they are getting.
- Dr. Shaw asked about the hydrogen pressure in the forklifts and ground storage.
  - Mr. Marsh responded that the pressure in both the lifts and the storage is 350 bar; he stated there is very little pressure loss in fueling and no compressor used.
- Dr. Shaw asked about Mr. Marsh's statement that the price of hydrogen is \$6.00/kg. He asked if that included all costs and profit.
  - Mr. Marsh replied that the \$6.00 is the dispensed cost to the customer, and includes all infrastructure costs and profit for the industrial gas company and for Plug Power.
- Dr. Shaw asked if there is an opportunity for cost reduction in the fuel cell itself.
  - Mr. Marsh responded that yes, there are opportunities, and that they are working on ways to reduce total cost of ownership.
- Dr. Satyapal pointed out that DOE and DOD funded early demonstrations of fuel cell forklifts; and while DOE no longer funds forklift demonstrations, it is providing funding for fuel cell demonstrations in several new applications, including refrigerated trucks, ground support equipment, and battery range extenders that Mr. Marsh mentioned. She noted that the timing for withdrawal of government support can be critical, and asked about the timing of DOE withdrawal from the forklift market, and whether this has broader lessons for when DOE should make the

technology “hand-off” to industry. She also asked Mr. Marsh about the export opportunities for Plug Power in the material handling equipment market.

- Mr. Marsh responded that federal support for the early commercial demonstrations of fuel cell forklifts was critical for the technology’s (and the industry’s) success. He agreed with DOE’s exit strategy, noting that it was time for DOE to step back from funding fuel cell forklifts when customers started buying them on their own. He expressed his opinion that federal R&D resources are also needed in the areas of hydrogen distribution and simplified reforming. He stated that Plug Power’s prospects for exports in Europe are strong, and they have active partnerships with some key companies, including IKEA, BMW, Air Liquide, and HyPulsion. They are working to find partners in Asia markets.
- Mr. Rose asked about the importance of the investment tax credit.
  - Mr. Marsh responded that it would be beneficial to the industry if it is continued. However, the company is not planning for it in their financial projections.
- Chairman Hofmeister asked about other prospective markets.
  - Mr. Marsh stated that he thinks the refrigerated truck market has a lot of potential, but he is not convinced that the cost and value proposition will be right. He expects the demonstration programs to help show how these systems will work in the field.

## **7. Open Discussion**

Chairman Hofmeister asked for feedback from the HTAC members on the agenda for the April 1-2 meeting, and for suggestions on topics or agenda items for upcoming HTAC meetings.

- Vice Chairman Novachek offered two suggestions for future agenda topics. First, updates on the plans and status of automotive OEMs for deployment of FCEVs, and what HTAC could do to help (or what new issues or concerns have arisen). Secondly, he suggested that HTAC provide more definition around what “competitiveness” really means. He suggested convening a group to identify metrics that indicate a competitive position, do some benchmarking of how competitive other countries are and what practices they are using to be in that position, and develop some tangible recommendations to DOE for how to improve U.S. competitiveness.
- Mr. Rose suggested that HTAC take up the issue of the DOE Fuel Cell Technologies Office budget, and the impact that the decline in the budget (since its peak) has had on R&D and technical progress.
  - Mr. Eggert agreed and proposed the idea of an agenda built around asking individuals what they would use additional funds for.
- Mr. Eggert noted that the pace of the April 1-2 HTAC meeting was good, and that it seemed that there was more time for question and answer periods than in the past. He also supported the idea for getting more information on planned FCEV deployments, as well as for discussions on how to track and document deployment progress and customer experiences.
- Dr. Shaw noted that the agenda for the meeting had a good balance between presentations from public and private organizations, and from both established and early-stage companies. He also supported the idea for presentations from the OEMs on their plans and on how customers are responding to product offerings. He also suggested inviting members of the financial or investment community to speak on the global financial outlook for hydrogen and fuel cells.
- Dr. Ogden commented that Hyundai is expected to have a number of vehicles available to consumers in late 2014. She also mentioned a study by Energy Independence Now on the business case for hydrogen fuel rollouts, and suggested that Tyson Eckerle could be invited to present the results.

Chairman Hofmeister thanked Mr. Rose for volunteering to serve as subcommittee chair for the 2014 HTAC Annual Report, and asked Mr. Rose and the other members for any preliminary thoughts on the report's structure or content.

- Mr. Rose asked the members to consider whether the report should focus more on the Committee's views or opinions on what's happening in the U.S. and around the world, as opposed to just reporting on status.
- Dr. Lloyd asked what products other DOE advisory committees produce, and whether these might offer any guidance for future HTAC work.
  - Dr. Satyapal responded that DOE could take an action to provide HTAC with information on the processes and products of other DOE advisory boards.
- Dr. Satyapal thanked the members for their service and expressed her appreciation for Deputy Assistant Secretary Reuben Sarkar's attendance for much of the April 1-2 meeting. She conveyed his positive feedback on the meeting. She also called out the recent letter to HTAC from Secretary Moniz, in which he responded to the Committee's recommendations. She noted that he is taking an active role in reviewing the make-up and activities of the various advisory committees, which will likely bring new members to the HTAC in the coming year.

## **HYDROGEN AND FUEL CELL TECHNICAL ADVISORY COMMITTEE (HTAC)**

### **PARTICIPANT LIST**

**April 1-2, 2014**

#### ***HTAC Members Present***

- Peter Bond
- Mark Cardillo
- Richard Carlin
- Anthony Eggert
- Charles Freese
- John Hofmeister
- Maurice Kaya
- Harol Koyama
- Timothy Lipman
- Alan Lloyd
- Frank Novachek
- Joan Ogden
- Robert Rose
- Robert Shaw
- David Taylor
- Kathleen Taylor
- Levi Thompson

#### ***HTAC Members Not Present***

- Gary Flood
- Joe Triompo

#### ***U.S. Department of Energy Staff***

##### *Office of Energy Efficiency and Renewable Energy*

- James Alkire
- Peter Devlin
- Sara Dillich
- Rick Farmer
- Monterey Gardiner
- Donna Ho
- Fred Joseck
- Jason Marcinkoski
- Eric Miller
- Reuben Sarkar (Speaker)



- Sunita Satyapal (Speaker)
- Ned Stetson
- Erika Sutherland
- Libby Wayman (Speaker)
- Jetta Wong (Speaker)

*Office of Fossil Energy*

- Darren Mollot (Speaker)

***Members of the Public in Attendance***

- Alberto Ayala—California Air Resources Board (Speaker)
- Gerald DeCuollo—TreadStone Technologies, Inc.
- Robert Friedland—Proton OnSite
- Erin Lane—Cascade Associates
- Morry Markowitz—Fuel Cell and Hydrogen Energy Association
- Andy Marsh—Plug Power, Inc. (Speaker)
- Charles Myers—Massachusetts Hydrogen Coalition (Speaker)
- Joel Rinebold—Connecticut Center for Advanced Technology (Speaker)
- Janea Scott—California Energy Commission (Speaker)
- Jeff Serfass—California Hydrogen Business Council
- C.E. Thomas—H2Gen Innovations (Retired)
- Eric Wachsman—Redox Power Systems (Speaker)

***Support Staff***

- Judi Abraham—Alliance Technical Services, Inc.
- Chaz Bennett—Capital Reporting
- Stacey Foster—National Renewable Energy Laboratory
- Shawna McQueen—Energetics, Inc.
- KP Murphy—Alliance Technical Services, Inc.
- Lilia Murphy—Alliance Technical Services, Inc.
- Neil Popovich—National Renewable Energy Laboratory
- Amit Talapatra—Energetics, Inc.
- Tom Timbario—Alliance Technical Services, Inc.