

HYDROGEN AND FUEL CELL TECHNICAL ADVISORY COMMITTEE

MEETING MINUTES

November 18–19, 2014

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DAY 1 – NOVEMBER 18, 2014

The Hydrogen and Fuel Cell Technical Advisory Committee (HTAC or the Committee) meeting began at 8:42 a.m. (EST).

HTAC Chairman John Hofmeister welcomed all attendees and staff. He thanked Deputy Assistant Secretary (DAS) Reuben Sarkar for attending today’s meeting and welcomed honored guest Robert Walker, former Representative from the state of Pennsylvania and a former HTAC Chairman. He informed the Committee about several events over the summer, including the delivery of the 2013 HTAC Annual Report and subsequent related correspondence and dialogue with Energy Secretary Moniz, Assistant Secretary Danielson, and DAS Sarkar. He thanked those HTAC members who contributed to the report, as well as the special budget-related letter that was delivered separately to the Secretary. He thanked Dr. Sunita Satyapal for her help in organizing meetings with Assistant Secretary Danielson, DAS Sarkar, and Ms. Melanie Kenderdine, Director of the Energy Department’s Office of Energy Policy and Systems Analysis and Energy Counselor to the Secretary.

Chairman Hofmeister expressed encouragement about recent events in the marketplace, including Toyota’s announcement of the availability of the Mirai, the first fuel cell electric vehicle offered for sale in the United States. He noted that this could be a big step forward for the market and signal increased activity for the HTAC.

Chairman Hofmeister also informed the Committee of the release of a documentary film entitled “Pump,” which was developed and funded by the Fuel Freedom Foundation, for which Mr. Hofmeister serves as an advisory board member. The 90-minute movie has been shown in more than 50 theaters around the country, including simultaneous premiers in New York and Los Angeles. The subject of “Pump” is today’s potential, enabled by currently available and emerging technology, to offer consumers a choice of transportation fuels at the pump; fuels that are produced domestically from resources like biomass, natural

gas, and renewable power. He noted that the film primarily features fuels like ethanol, methanol, compressed natural gas, bio-diesel, and electricity. The film emphasizes the potential for this kind of fuel choice to end the “monopoly of oil” in the U.S. and other countries, and enable reliance on domestically produced fuels. Mr. Hofmeister added that current low oil prices are a result of a combination of factors that have led to short-term oil surpluses, i.e., the “de-leveraging” of oil assets by many large U.S. banks (in response to commodity trading regulations in the Dodd-Frank Act) and lower oil demand from sluggish world economies, including China. He expects oil prices to rebound once the surplus is absorbed, oil producers adjust production rates and, in the longer term, as an effect of continuing conventional and shale oil field depletion.

1. HTAC Business

1.1. Introduction of New HTAC Members

A number of new members were appointed to the HTAC by the Secretary of Energy and they introduced themselves:

1. **Catherine Dunwoody**, Chief of the Fuel Cell Program in the California Air Resources Board (since mid-2014) and former Executive Director of the California Fuel Cell Partnership (for the previous 15 years). Ms. Dunwoody’s work with the Air Resources Board includes support for the deployment of hydrogen fueling infrastructure for light duty vehicles being offered for sale and lease by auto companies in the region. It also includes efforts to expand the role of fuel cells and hydrogen in other applications, including medium and heavy duty vehicles. She noted that California is kicking off a large initiative on sustainable freight, so the freight industry is a particular target of interest. She expressed appreciation for the work of the Department of Energy’s Fuel Cell Technologies Office, noting that their past and ongoing work is critical to helping California meet its goals for improving ambient air quality and lowering greenhouse gas emissions.
2. **Margo Oge**, who served with the U.S. Environmental Protection Agency (EPA) for 32 years, spending her last 18 years as the Director of the Office of Transportation and Air Quality. Since leaving the EPA in 2012, she has served on a number of advisory boards and has been writing a book (to be published in April 2015) on past, present, and future trends in climate change and air pollution. She expressed her pleasure to be part of the HTAC and her opinion that fuel cells are an important part of the strategy for addressing future problems like climate change.
3. **Paul Leggett**, Managing Director at Mithril Capital Management, focusing on technology-enabled growth investments, largely in private companies. Previously at Morgan Stanley, Mr. Leggett helped lead the clean energy investment banking team including work in the fuel cell sector, solar, wind, electric vehicles, and other areas.
4. **Dr. Kathryn Clay**, Vice President for Policy Strategy at the American Gas Association (AGA), where natural gas vehicles are part of her focus area, and the nexus between hydrogen and natural gas is among her interests. She explained that she has a scientific educational background and has served previously as staff for several Congressmen, focusing primarily on energy and environmental issues. Prior to joining the AGA she worked for the Alliance of Automobile Manufacturers on advanced vehicle technologies.

1.2. Approval of Prior Meeting’s Minutes

The minutes from the April 1–2, 2014, HTAC meeting were unanimously approved.

2. U.S. Department of Energy Updates

2.1. DOE Leadership Update: Opportunities and Challenges in Sustainable Transportation. Reuben Sarkar, Deputy Assistant Secretary, Transportation, Office of Energy Efficiency and Renewable Energy (EERE), U.S. Department of Energy

Deputy Assistant Secretary Reuben Sarkar began by welcoming the new HTAC members and remarking on the added breadth of expertise and new insights they will bring to the Committee. He reported on his recent trip to California, during which he gave the keynote presentation at the 2014 Fuel Cell Seminar, toured a number of hydrogen fueling stations, and met with a number of automotive and hydrogen industry executives. He was impressed by the level of commercial activity in California and the experience left him with the perspective that fuel cells are “here and now,” and this is the “right point in time to make some traction and move forward.” He was particularly impressed with the different types of hydrogen fueling stations being implemented, including one that generates hydrogen, heat, and power from municipal wastewater treatment gas.

Mr. Sarkar went on to give a presentation summarizing activities in EERE’s sustainable transportation portfolio, which includes work in three EERE offices: Vehicle Technologies, Fuel Cell Technologies, and Bioenergy Technologies. He outlined the sector’s goals, core focus areas, key programs and initiatives, and portfolio of technology research and development (R&D) and market transformation activities. He emphasized that hydrogen and fuel cells are an integral part of the Administration’s “all of the above” energy strategy, and added that because fuel cells offer a “no compromise” solution for transportation they will likely play an increasing role over time. One of Mr. Sarkar’s key goals is to increase the exploration, coordination, and implementation of synergistic, crosscutting opportunities among the three EERE offices. In this regard, he is directing an analysis of the retail fuel market and “investable” retail fueling station strategies that can enable multiple fuel options; focusing crosscutting R&D to increase transportation efficiency (e.g., materials lightweighting, automation); increasing R&D efforts to replace the “whole barrel” of oil; and encouraging partnerships between the Vehicle Technology Office’s Clean Cities Program and the Fuel Cell Technologies Office. He then gave an overview of the EERE budget, noting that it is aligned with EERE’s overall strategy to meet targets on time.

>>see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_nov14_2_sarkar.pdf

Discussion

- Ms. Oge asked for Mr. Sarkar’s thoughts on the renewable fuels standard and the “blend wall” issue, and whether the work of DOE or others can help resolve the issue.
 - Mr. Sarkar acknowledged the current limits on ethanol use and production, owing to reduced gasoline consumption and infrastructure limitations for higher ethanol blends. He noted that the Department is conducting R&D to develop drop-in biofuels that are chemically equivalent to gasoline, as well as developing higher value products and chemicals from biofuels, such as bio-crude intermediate products that could be used in existing oil refinery systems.
- Mr. Rose noted that the DOE budget for hydrogen and fuel cells has declined substantially from its high point, and is now the smallest of the transportation programs and among the smallest in all of EERE. He asked whether Mr. Sarkar sees an opportunity to rebalance the funding among the offices under his leadership.
 - Mr. Sarkar responded that this is a difficult question to answer, but encouraged the Fuel Cell Technologies Office and its partners to continue the good work they have been doing, build on traction in the marketplace, and communicate commercial achievements

and technical progress. He explained that it would be valuable to raise awareness on why hydrogen is “here and now,” and how additional funding could accelerate progress.

- Mr. Eggert asked about the prospects for increased DOE support for RD&D on fuel cells in medium- and heavy-duty vehicle applications, particularly given California’s initiatives on lowering freight-related emissions and the fact that the industry itself has not traditionally invested as much in R&D as the light duty vehicle sector.
 - Mr. Sarkar agreed that DOE has not done much work to date on fuel cell powered medium or heavy duty vehicles, since the focus has been on passenger cars. He explained that DOE would be interested in hearing more about the specific opportunities in this area, particularly where partnership opportunities might exist.
- Ms. Dunwoody noted that in California, fuel cell vehicles are referred to as “electric vehicles,” with battery electric and fuel cell electric vehicles being the only true zero emission options. She asked whether there will be movements to include fuel cell vehicles in DOE’s electric vehicle initiatives, such as “EV Everywhere.”
 - Mr. Sarkar responded that DOE’s Fuel Cell and Vehicle Technologies Offices are working together to explore partnership opportunities, including in VTO’s Clean Cities Program and in efforts to support the State Zero Emission Vehicle (ZEV) Programs Memorandum of Understanding (MOU). He added that the H₂USA program is viewed as the fuel cell corollary to the EV Everywhere program, and noted that there is the possibility for adding specific challenges to H₂USA, such as EV Everywhere’s workplace charging challenge.
- Dr. Shaw observed that unless vehicles (or any new energy technology) are offered at prices that average consumers can afford, the market volumes needed to lower manufacturers’ prices will be very difficult to achieve. He asked whether senior EERE management is considering options to address this problem, particularly in the policy arena.
 - Mr. Sarkar replied that it is not the role of DOE to make policy, but that they do analysis to support R&D strategies and generate information to inform policy decisions. He explained that DOE sets technical targets for developing technologies based on analysis of what is needed for the technology to be competitive in the marketplace, which includes technology cost and pay-back periods. These targets are reviewed periodically, and the information generated helps define what is needed and how long it might take to move down the cost curve.
- Dr. Lloyd asked Mr. Sarkar to expand on his comment to expect more focus on hydrogen and fuel cells in the Clean Cities program.
 - Mr. Sarkar explained that Clean Cities is part of the Vehicle Technologies Office’s overall deployment program. It is involved in co-funding projects with community partners, as well as developing outreach and education programs. In one activity, for example, Clean Cities works with communities to develop a “Plug-In Electric Vehicle Readiness Scorecard” to help community leaders to prepare for the arrival of plug-in electric vehicles. Clean Cities could work together with H₂USA to get this same type of information out to its partners for hydrogen fueling infrastructure and fuel cell electric vehicles. He cited this kind of awareness building and outreach as an important function of Clean Cities. He noted that the program does co-fund some deployment projects, but with the intention that these will serve as catalysts for similar, non-federal funded projects in other cities. In this regard, there may be opportunities to engage Clean Cities coalitions in California on developing lessons learned and best practices that could be conveyed to the other 8 states participating in the ZEV MOU.
- Ms. Oge agreed that it is very important to work with states and cities, and encouraged Mr. Sarkar to apply his intent to better integrate the three offices under his management in this area, so that DOE can maximize the opportunities they have to work with the states.

- Dr. Ogden pointed out that there are an increasing number of studies on alternative fuel vehicles that include consumer choice modeling (including one published by the National Research Council in 2013¹) and asked if DOE is using this type of modeling in its analysis of early markets and transitions over time. Specifically, how “soft” factors (e.g., carpool lane accessibility, parking space priority, range anxiety, etc.) affect technology uptake.
 - Mr. Sarkar replied that consumer choice modeling per se is not a big element in DOE’s R&D analysis portfolio, but they do get a lot of input on this from outside stakeholders, including OEMs. He agreed that behavioral science is something DOE should factor into its thinking about technology uptake in commercial markets, and noted that the national laboratories are focusing more on this going forward.
- Chairman Hofmeister observed that name recognition can be very important for moving technology over early market hurdles. He alluded to the name recognition batteries have received with support from Elon Musk and development of the Tesla battery electric vehicle, and expressed his hope that hydrogen and fuel cells may have a similar champion.

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

Dr. Satyapal first discussed the HTAC charter, scope, and membership. She then gave an overview of the DOE Hydrogen and Fuel Cells Program’s (the Program’s) mission, targets, organization, subprograms, major milestones, and collaborations and partnerships. She reviewed the key HTAC recommendations in their recent letters to the Secretary of Energy, such as a stronger commitment to hydrogen and fuel cell R&D to ensure continued U.S. technology leadership, and reviewed recent DOE activities related to these recommendations.

Dr. Satyapal stated that DOE’s research, development, and deployment (RD&D) activities are enabling the commercialization of fuel cells, noting that DOE funding has led to approximately 500 patents and 45 commercial technologies. She reported that the Fuel Cell Technologies Office (FCTO) has experienced consistent R&D funding requests and appropriations in recent years. She also reported that revenues and additional investment in FCTO-funded projects are valued at greater than four and five times the DOE investment, respectively. She described the impact DOE funding has on early market purchases. She reported highlights from several fuel cell R&D projects, including progress on lowering the cost of catalysts, one of the key remaining challenges to lower fuel cell costs. She described the status of hydrogen infrastructure and relevant development efforts, including a three-fold increase in the number of partners participating in the H₂USA partnership. She also described DOE’s new H2FIRST (Hydrogen Fueling Infrastructure Research and Station Technology) project, which combines resources at Sandia National Laboratories and the National Renewable Energy Laboratory to address technical challenges to hydrogen station deployment and operation in the early market. This project is receiving \$1.4 million in funding, and its first tasks include developing 1) a device that can be used to validate hydrogen station equipment performance, 2) hydrogen station reference designs, and 3) a sensor system to rapidly detect hydrogen fuel contaminants that could damage automotive fuel cells.

Dr. Satyapal thanked the HTAC members for their input on topics for the \$1 million H-Prize, and reported that competition for the next prize, called “H2 Refuel,” has opened. She briefly described ongoing and new international partnerships, collaboration, and information sharing activities as well as the Program’s efforts to increase outreach and communication. She also

¹ National Academy of Sciences, *Transitions to Alternative Vehicles and Fuels*, 2013, <http://www.nap.edu>.

transmitted a request for HTAC input on the draft high-level goals for the four H₂USA working groups (Location Roadmap, Financing/Investment, Station Technology, and Communication and Outreach), as shown in slides 44 and 45. She concluded with a summary of FCTO's strategy going forward, which includes continuing to promote and strengthen R&D activities; validate the technology in hydrogen stations, fuel cell vehicles, distributed generation, forklifts, and backup power systems; conduct analysis that explores upfront and life cycle costs to guide RD&D efforts; and leverage other hydrogen and fuel cell activities in the U.S. and globally to multiply and maximize the impact of the Program's efforts.

>>see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_nov14_3_satyapal.pdf

Discussion

- Mr. Lloyd remarked that FCTO's return on investment and patent numbers are very impressive. He asked whether the other EERE offices do a similar analysis and how they compare.
 - Mr. Sarkar responded that FCTO sets the example for this kind of analysis within his program and that the other offices are being asked to do similar impact analysis this year.
- Dr. Shaw stated he would be interested in participating in the H₂USA working group on Financing/Investment, but it isn't clear whether he could participate as an individual. He noted that H₂USA membership is geared for organizations and the fee is cost prohibitive for most individuals; there doesn't seem to be a possibility for individuals to get involved. He asked Dr. Satyapal whether DOE could propose opening membership in working groups to individuals (free of charge) who are interested in contributing.
 - Dr. Satyapal said she would forward this request to the H₂USA Steering Committee.
- Mr. Kaya suggested that FCTO develop a simpler, less technical way of presenting progress and results, to make it easier for decision-makers and others to understand what government funding in this area has achieved, the roadmap forward, and what could be done with additional funding. He also expressed his appreciation for Dr. Satyapal's comprehensive presentation including her slide on input requested from HTAC members. He suggested that HTAC organize itself so they are responsive to these or other DOE questions/information needs.
- Given agenda time limitations, Chairman Hofmeister recommended that HTAC members review Dr. Satyapal's briefing and come prepared with more questions or input for discussion the following day.

3. General Electric Update on Megawatt-Scale Solid Oxide Fuel Cells (SOFCs): Johanna Wellington, General Manager and Chief Technology Officer, Hybrid Fuel Cells, GE Global Research

Ms. Wellington presented on GE's stationary fuel cells efforts, in particular the "incubator project" that GE announced earlier in 2014 to develop SOFCs for distributed power. She referenced several mega trends that are driving the opportunity for distributed power globally, such as the need for resilience, grid firming, and pollution reduction, and the increase in natural gas availability. She noted that SOFCs offer a number of distinct advantages for addressing these trends, including high efficiency, low emissions, fuel flexibility, scalable size/power output, and operating flexibility, but remarked that cost has always been a challenge. She explained that GE's innovative SOFC/Recip Hybrid System is addressing the fuel cell cost challenge with advanced manufacturing for making the fuel cells and stacks (a proprietary thermal plasma spray technology) and a hybrid system configuration that integrates a gas generator set which runs off the fuel cell tail gas. Features of GE's hybrid system include 1–10 MW electrical output, 65% electrical efficiency, minimal site

installation, turndown capability, low greenhouse gas emissions, and power when and where you need it without a large transmission and distribution network. Ms. Wellington described GE's past SOFC research, as well their state-of-the-art technology for producing fuel cells.

Ms. Wellington went on to describe GE's "Fastworks" business model aimed at bringing technology to market as fast as possible, and explained that the SOFC project is being run like an independent start-up operation, except that it's fully funded by GE. She also described the pilot scale development facility in Malta, New York, which includes state-of-the-art manufacturing equipment so that manufacturing readiness can be proven at the same time pilot-scale prototypes are being built and tested. The first demonstration product will be a 50-kW unit at nearby Hudson Valley Community College's TEC-SMART campus. She stated that while the stationary fuel cell industry is growing, it's still in its infancy so incentives and market transformation activities are needed to drive fuel cell adoption and reduce costs through economies of scale. She also noted that international competition is increasing, with a growing number of players in North America, Europe, and Asia.

>>see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_nov14_5_wellington.pdf

Discussion

- Dr. Shaw asked whether the spray processing technology has solved the heat transfer and delamination issues associated with plant cycling.
 - Ms. Wellington replied that the process of spraying the anode and electrolyte onto the same metal substrate does help with those issues, but they are still evaluating the impacts of cycling.
- Mr. Koyama asked Ms. Wellington to compare the GE SOFC technology with Bloom Energy's technology. He also asked for her thoughts on what the cost/kWh needs to be for commercialization.
 - Ms. Wellington replied that Bloom uses a proprietary tape-cast sintering process in their fuel cell manufacturing. The process requires the use of glass seals between electrolyte layers, which is limiting. GE is also focusing on the use of different electrolytes. With regard to where the cost needs to be, she stated that GE's technology will need to be able to compete with what is commercially available, but the higher efficiency could justify some price premium. She stated the competing conventional technology in the distributed power market would be a gas engine operating on natural gas.
- Mr. Lipman asked if GE is considering adding the capability for cogeneration, since utilizing the waste heat would boost the overall efficiency of the system.
 - Ms. Wellington replied that currently GE is focused on the SOFC/Recip Hybrid System as an electricity generator, and waste heat recovery for electricity production doesn't pay at this scale. She did note that the system efficiency and economics could be boosted in combined heat and power applications, where the customer has a use for the heat, but GE is not focusing on that in its initial product.
- Mr. Lipman asked about the turn-down ratio for the system, and Ms. Wellington replied that they do not know yet since they have not fully tested the technology at the system level.
- Mr. Lipman asked whether the system could run on pure hydrogen or a hydrogen rich fuel,
 - Ms. Wellington responded that they are focusing on natural gas as a fuel simply because it is abundant now, but that the system is fully capable of running on hydrogen and syngas, and that fuel flexibility is one of the advantages it offers.
- Dr. Thompson asked whether the GE fuel cell is tolerant to sulfur in the fuel.
 - Ms. Wellington replied that their catalyst is not sulfur-tolerant, and that they have a system for sulfur removal built into the unit.
- Ms. Dunwoody asked if GE's multigenerational product plan considers transportation applications.

- Ms. Wellington replied that they haven't spent much time looking into this, but she doesn't see why the SOFC system could not be used in transportation, especially heavier duty applications like locomotives. She noted that questions around cycling and start-up time would need to be answered.
- Mr. Novachek asked about the power output ratio between the fuel cell and the gas engine, and whether they could operate independent of each other.
 - Ms. Wellington explained that the fuel cell provides most of the power, about two-thirds. The gas engine is used just to burn the fuel cell tail gas. She agreed that it would be ideal if the two systems could operate independently; she noted that the fuel cell system can, but they are not sure yet about the gas engine.
- Mr. Novachek followed up with a question about whether the systems are envisioned to be portable, in the sense that they could easily be moved from location to location to solve temporal grid issues.
 - Ms. Wellington replied that while the systems are being designed for relatively quick and easy install and uninstall, they will, at least initially, be more economical if they are used fairly consistently. She also noted that the system is expected to have some load following capability, but they are still evaluating how much.
- Mr. Rose commented that it is good to see GE involved with fuel cells again, since they are such a visible player in the electric power market. He asked how much support the project is getting from upper management within GE.
 - Ms. Wellington replied that she reports to the GE Chairman on a regular basis, and that the technology is seen as an option for rounding out GE's portfolio.

4. **H₂USA Update: Morry Markowitz, President and Executive Director, Fuel Cell and Hydrogen Energy Association (via telecon)**

Mr. Markowitz first discussed H₂USA's founding organizations, launch organizations, signatories on the Letter of Understanding, and organization chart. He noted that there has been significant progress over the last year, including launch of the H₂USA website, a number of outreach and communication efforts, and growth in the number of members to more than 35 organizations. He pointed out that DOE's H₂FIRST project is now an integral part of H₂USA, and they will be working on several hydrogen fueling station related tasks. He then gave updates on H₂USA's working groups. He reported that the Market Support and Acceleration Working Group is coordinating hydrogen refueling capability in the Washington, DC, metro area, among other accomplishments. He highlighted the Hydrogen Station Working Group's accomplishments, including developing technical and economically feasible fueling station designs and preparing to publish cost modeling information for H₂USA. The Locations Roadmap Working Group, Mr. Markowitz stated, has made progress related to automaker surveys. He noted that the Investment and Finance Working Group is continuing work on a Business Case Scenario model and conducting outreach to the investment community. He concluded by discussing H₂USA's 2015 objectives timeline.

>>see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_nov14_6_markowitz.pdf

Discussion

- Ms. Oge asked how H₂USA intends to decide what states or regions to focus on beyond California.
 - Mr. Markowitz replied that the National Renewable Energy Laboratory (NREL) is conducting a survey of automakers' marketing plans, which will help inform this decision, as well as H₂USA's ongoing discussions with automakers and state and local officials and associations. He added that the first priority is to support success for California's roll out of fuel cell electric vehicles (FCEVs) and hydrogen stations.

- Mr. Hofmeister asked if H₂USA is engaging with fuel retailers through organizations like the National Association of Convenience Stores (NACS).
 - Mr. Markowitz replied that NACS is a member of H₂USA. He noted that H₂USA had a display presence at the NACS national conference, and that he has met individually with Costco and several other large retailers.

5. DOE Nuclear Energy Office Update—High Temperature Nuclear Reactors for Hydrogen Production: Carl Sink, Advanced Reactor Technologies Program Manager, Office of Advanced Reactor Technologies, Office of Nuclear Energy, U.S. Department of Energy

Mr. Sink discussed the DOE Office of Nuclear Energy’s (NE’s) R&D in high-temperature nuclear reactors, which can produce hydrogen by high-temperature steam electrolysis or thermochemical direct water splitting. He described the Next Generation Nuclear Plant (NGNP) program, noting that its mission is to demonstrate high-temperature gas-cooled reactor (HTGR) technology to produce electricity and high-temperature process heat. When the 2005 Energy Policy Act directed NE to conduct work on hydrogen production in coordination with DOE-EERE, this mission was expanded to include production of hydrogen under the Nuclear Hydrogen Initiative (NHI). In 2009, the NHI was defunded, but some work on hydrogen production was continued within NE. Mr. Sink presented on several past nuclear hydrogen production activities, including high-temperature steam electrolysis R&D at Idaho National Energy Laboratory, a project that ended in FY 2012; thermochemical cycle R&D activities conducted by several national labs and universities (projects that ended after FY 2009); and international cooperation under the Generation-IV International Forum (GIF) on the Very High Temperature Reactor (VHTR) Hydrogen Production Project. He noted that 7 countries are currently participating in the VHTR project. Mr. Sink concluded by discussing the next steps in the NGNP project and the path forward, including results from analysis of how hydrogen production could be used as a way to store energy from HGTRs during periods of low electricity demand.

>>see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_nov14_4_sink.pdf

Discussion

- Dr. Shaw asked about the expected cost of a next generation nuclear power plant.
 - Mr. Sink replied that the first plant would likely be very expensive, and that it has historically been the federal government’s role to build the first plant. He reported that the industry R&D partners have said that the “nth plant” HGTR would be cost competitive with natural gas at \$7 to \$9 per million Btu.
- Dr. Ogden asked if alternative system configurations are being explored to take more advantage of the reactor heat.
 - He replied that they are looking into hybrid system configurations, and reported that he is also coordinating with the Fuel Cell Technologies Office on a new H₂A analysis of high temperature steam electrolysis, which is using some new data that’s become available over the last 5 years or so. He stated that he is excited to once again be working actively with the DOE Hydrogen Program on this analysis.

6. Overview of the Multi-State Zero Emission Vehicle (ZEV) Action Plan: Matt Solomon, Transportation Program Manager, Northeast States for Coordinated Air Use Management (NESCAUM)

Mr. Solomon presented on the Multi-State ZEV Action Plan agreed upon by eight governors in 2013 to put 3.3 million ZEVs on their roads by 2025. He discussed the initiative’s memorandum of understanding (MOU) and the MOU’s key commitments, including conducting a study of potential deployment strategies and infrastructure requirements for the commercialization of hydrogen fuel cell vehicles. He gave an overview of the Multi-State Action Plan that was released in May 2014,

noting that it was developed with a lot of industry and other stakeholder input and includes 11 broad recommendations and 50–60 subtasks. He described some of the hydrogen and fuel cell-specific actions, and reviewed the eight parallel Action Plan “implementation teams” that have been established : 1) Consumer Education, 2) Dealerships, 3) Fleets, 4) Hydrogen & Fuel Cells, 5) Infrastructure–Planning & Deployment, 6) Infrastructure–Regulatory, 7) Policy & Incentives, and 8) Workplace Charging. According to Mr. Solomon, a key output of the MOU (which they hope will expand to include more states) will be a “how-to” guide or handbook that states can use to put the recommendations of the Action Plan into practice. He displayed two graphs showing the steady rise in cumulative plug-in electric vehicle registrations in the United States and in the Eastern ZEV states since 2011, noting that the curves are similar in shape.

Mr. Solomon remarked that state ZEV programs are a key driver of early ZEV success and will be critical to ensure continued momentum. He noted that California’s ZEV mandate applies to all 15 of the “Section 177 states” (the states that have adopted California’s stricter vehicle emissions standards in lieu of the federal Clean Air Act standards). He pointed out that manufacturers have substantial flexibility in complying with the requirements, including “cross-state credit pooling” which allows the car companies to earn credit in all of a pool’s states (there is an eastern and a western pool) by placing vehicles in any of the pool’s states. He also described the “travel provision” of the ZEV regulation, which allows a vehicle placed in any Section 177 state to count towards compliance in all Section 177 states. This provision expires in 2017 for battery electric vehicles (BEVs), but there is no expiration date for FCEVs. Because California has been at the forefront of hydrogen infrastructure development efforts, this effectively focuses the manufacturers towards locating FCEVs in California, at least initially. Mr. Solomon explained that this is the reason the Eastern states are more focused on getting ready for BEVs in the near-term, but they are paying close attention to what is happening in California so they can be ready to move on hydrogen infrastructure when the time comes. He highlighted a number of ways for states to accelerate the ZEV market, including consumer incentives, infrastructure expansion, green fleets, regional coordination, codes and standards, and outreach and education.

>>see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_nov14_7_solomon.pdf

Discussion

- Mr. Sarkar asked whether they are looking into pooling purchases as a way of lowering vehicle or fuel costs.
 - Mr. Solomon replied that this is one of the options being explored by the Green Fleet working group, and they are currently looking at the multi-state MOU on the purchase of natural gas vehicles as a model for this. They have also initiated discussions with a number of groups on this, including the Department of Defense, which has interest in this area.
- Dr. Shaw suggested that fleet purchases are probably the best way to kick-start this market and get the volume of cars needed at fueling stations. He asked about the ramifications of the travel provision, especially for northeast states that have active hydrogen and fuel cell programs, like Connecticut and Massachusetts.
 - Mr. Solomon replied that it depends on what the car manufacturers are planning to do. If there’s an indication that the OEMs are willing to bring FCEVs to their states, they will work to support that.
 - Ms. Dunwoody explained that the travel provision reflects the recognition that you can’t deploy new vehicles without fueling infrastructure. California has made a huge investment in hydrogen infrastructure to launch the FCEV market in California, but with success of these investments and as infrastructure becomes available in other states, the need for the travel provision for FCEVs will likely be re-explored. She also referred to a report released

- by the Air Resources Board in June 2014² which provided the latest auto company survey results and projects 6,600 FCEVs in California by 2017 and 18,500 by 2020.
- Mr. Eggert added that California’s funding provisions for additional hydrogen fueling stations are contingent on the automakers bringing the vehicles to the market.
 - Mr. Eggert asked Mr. Solomon where he sees the biggest opportunity for DOE to help the states in their efforts.
 - Mr. Solomon replied that it’s difficult to pick the top priority among the options he enumerated. But he has already contacted DOE about help with the hydrogen infrastructure study, noting that they want to keep their analysis methodology consistent with efforts already conducted by DOE and California. He is also exploring data sharing opportunities with DOE to ensure the states don’t duplicate efforts and to make use of already available resources.
 - Dr. Ogden agreed with the rationale of focusing on a particular geographic region for the early FCEV market, and referred to a number of studies that support a “cluster concept.”
 - Ms. Oge noted that when the travel provision was put together, it was supported not just by California, but all the states. She agreed with Mr. Solomon that now is the time to start thinking about what the next market might be after California, and how that infrastructure might roll out.
 - Mr. Freese asked how the incentive amounts being offered to consumers for purchasing EVs (e.g., in Massachusetts and Maryland) are derived.
 - Mr. Solomon reported that the ZEV states have looked at a number of studies and discussed this issue with automakers and determined that the “sweet spot” seems to be about \$2,000–\$3,000. He explained that the states are continuing to evaluate the best use of their limited resources for incentivizing the market, including providing incentives to dealers rather than to consumers, among other options.
 - Dr. Shaw contended that a \$2,000 to \$3,000 rebate incentive is not going to make a big enough difference to most car buyers in bringing down the incremental cost of an FCEV. He suggested that a better way for the ZEV states to invest their resources is to support the deployment of fleets and lowering vehicle costs through pooled purchases.
 - Mr. Freese asked for Mr. Solomon’s opinion on how changes in state political leadership could affect support for the ZEV programs.
 - Mr. Solomon replied that there seems to be strong popular support for the ZEV programs, and in most states the programs have been on the books through multiple administrations and changes in party leadership. So there is a strong track record for continued support.

7. California Activities Update and Hydrogen Infrastructure Challenges: Tyson Eckerle, Zero Emissions Vehicle Infrastructure Project Manager, California Governor’s Office, Office of Business and Economic Development

Mr. Eckerle presented on California’s Zero Emission Vehicle Action Plan (part of an Executive Order signed by Governor Jerry Brown in March 2012) and discussed how his work contributes to achieving projects that fit into this action plan. He described the major hurdles for station development as: permitting and construction, commissioning, and keeping stations open. Regarding station codes and standards, Mr. Eckerle noted the significance of California being the first state to adopt NFPA2 for permitting stations, making gaseous hydrogen easier to site at local stations. He also provided some lessons learned for station development including connecting developers to city staff early, establishing site control, educating local communities on hydrogen, and acknowledging

² *Annual Evaluation of Fuel Cell Electric Vehicle Deployment and Hydrogen Station Network Development*, California Environmental Protection Agency, Air Resources Board, June 2014, http://www.arb.ca.gov/msprog/zevprog/ab8/ab8_report_final_june2014.pdf.

the importance of station aesthetics. Mr. Eckerle went on to describe the steps towards selling hydrogen to retail customers, developing dispensing standards, and ensuring hydrogen purity. He noted that the Governor's office is working with H2FIRST to ensure hydrogen purity is maintained. He then presented on the economics of keeping stations open, explaining the operation and maintenance (O&M) costs that are major factors, and discussing the importance of learning how to make station equipment more reliable. Mr. Eckerle concluded by showing a snapshot of the current hydrogen network in California and illustrated the progress that it is planned to make over the next few years.

>>see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_nov14_8_eckerle.pdf

Discussion

Questions and discussions were deferred until after the next presentation.

8. FirstElement Hydrogen Stations: Dr. Shane Stephens, Co-Founder and Chief Development Officer, FirstElement Fuel Inc.

Dr. Stephens' oral presentation was given by Mr. Eckerle, due to a last-minute conflict that prevented Dr. Stephens from attending the HTAC meeting. Mr. Eckerle explained that FirstElement Fuel won bids to install 19 hydrogen fueling stations in California and has a relatively low-cost, fast-install model for stations; their plan is to get all 19 stations built by late October 2015. He noted that they hired Black & Veatch to do the engineering and construction and described some aspects of their seeking to address the infrastructure challenge of hydrogen fueling stations. He noted that FirstElement Fuel integrates the supply chain so that the focus is on the retail customer. He shared the company's network development plan, displaying a map showing FirstElement stations in development as well as other planned hydrogen stations. He discussed FirstElement's plans for the transition to commercial scale and detailed the company's retail focus. He described the current method for hydrogen production and delivery, as well as highlighted three potential future strategies. He predicted that government will play a strong role in station build out until 2020, when the private sector will take over. He stated that FirstElement is seeking to initialize a retail hydrogen fuel market that will pull fuel cell vehicles in the near time, as well as to produce a business model in California that is scalable to other markets.

>>see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_nov14_10_stephens.pdf

Discussion

- Mr. Eggert asked what Mr. Eckerle sees as the greatest opportunity for partnership between his office and DOE.
 - Mr. Eckerle cited DOE funding of the HyStEP (Hydrogen Station Equipment Performance) device as a good example. He mentioned a number of other opportunities, including help with establishing best practices for O&M; targeted R&D on component or process cost reduction through research and development; help with increasing station capacity utilization; and exploring the potential for leveraging federal lands for station development (e.g., at Camp Pendleton in San Diego). He added that DOE R&D on large scale renewable hydrogen production is also needed for the longer term.
 - Ms. Dunwoody added that demonstrating fuel cells in medium and heavy duty applications could be another area of partnership. She reiterated the importance of the H2FIRST project (including tasks to develop the HyStEP device and the hydrogen contaminant detector), explaining that this is the kind of work the state would not be able to do on its own, without assistance from the DOE national laboratories.

- Dr. Shaw asked about the SAE J2601 standard (Fueling Protocol for Hydrogen Powered Vehicles) versus the MC Fill hydrogen fueling protocol developed by Honda, noting that some favor the MC Fill method as more cost effective in station design and operation. He also asked what data Mr. Eckerle’s office has on the true operating cost of stations
 - Mr. Eckerle stated that the MC Fill method is included as an Appendix in the J2601 standard, and can currently be used in station designs.
 - Dr. Satyapal concurred and said that part of the work of the H2FIRST will be to evaluate this and have the capability to evaluate other alternative fueling methods that could be formally included in the standard.
 - Ms. Dunwoody added that the next California program opportunity announcement (PON) for hydrogen refueling infrastructure would likely continue to specify J2601 with the MC method as an alternative.
 - Regarding Dr. Shaw’s question on O&M cost data, Mr. Eckerle stated that the optimal scenario is estimated at about \$100,000 for a station’s O&M costs. He stated that much of the cost is due to special orders required for parts, and that this may be addressed if the supply chain were improved. He stated that DOE might be able to help in addressing this.
 - Ms. Dunwoody added that the California Energy Commission has required station developers receiving awards to collect and provide data to the NREL technology validation program, so composite data products will be available.
- Vice Chairman Novachek asked about the lessons learned and issues that may arise with the different climate in the Northeast.
 - Mr. Eckerle responded that he did not know how cold weather would affect station operations, but a major lesson learned about infrastructure deployment in California is that education and outreach is key.
 - Chairman Hofmeister added that California has some of the strictest coding regarding O&M. Regarding cold weather issues, he noted the problems that may occur with water in tanks, but added that there would be strict standards on equipment regarding weather resistance.
- Mr. Leggett asked about the interest levels of station developers and owner/operators over time, whether that has increased or decreased.
 - Mr. Eckerle stated that the number of interested developers has grown each year since 2010. He noted that interest and involvement of station owners is more variable.
- Dr. Clay noted that ensuring fuel quality is also a big issue for natural gas powered vehicles, and wondered whether that might be an opportunity for joint R&D. The ideal solution, she stated, would be a tool that could rapidly diagnose and manage problems at the station level. She asked whether hydrogen fuel quality issues fall into general categories with certain areas that are generally the sources of problems.
 - Mr. Eckerle responded this is outside of his knowledge area, but hydrogen purity issues have come up with both delivered hydrogen and with on-site hydrogen production.
 - Dr. Satyapal added that DOE has continued to refine its analysis of key fuel cell contaminant species and levels to monitor. Work is now being focused on developing hydrogen contaminant sensors that can operate at fueling station pressures. She suggested that the allowable contaminant levels for compressed natural gas (CNG) are probably much less stringent, since CNG is burned in a combustion engine. But there may be synergies between CNG and hydrogen fueling that could be explored, such as carbon monoxide detection.
 - Dr. Clay noted that moisture in tanks might also be a common concern.
- Dr. Satyapal asked Mr. Eckerle to comment on the sense of urgency, visibility, and engagement of the Governor’s office or other levels of California government in the hydrogen initiatives.

- Mr. Eckerle responded that there is an unprecedented level of high-level coordination and that their work is highly visible. He participates in monthly progress report meetings with Commissioner Janea Scott, senior managers of the Air Resources Board, and key members of the Governor’s team. He also noted that the Governor’s office has been very accessible and ready to help when needed.
 - Ms. Dunwoody added that there are legislatively mandated reports required from the ARB each year, which include assessments of the current state of infrastructure and recommendations to the California Energy Commission for additional funding/stations based on automaker projections for the number of vehicles in the market.
 - Mr. Eggert added that, although commitment within the administration is strong, support isn’t universal within the state legislature or with advocates of other fuels that are competing for funding. He expects the program to be under heavy scrutiny and to be “a fight every step of the way” for at least the next 5 years.

9. **Linde Hydrogen Fueling Overview: Michael Beckman, Vice President/Head of H2 Fueling, Linde**

Mr. Beckman introduced Linde and its work in hydrogen fueling. He explained that Linde offers products in the entire hydrogen value chain, from production through dispensing, including a proprietary hydrogen compressor. He presented on Linde’s liquid hydrogen facility in Magog, Quebec which produces 15 tons per day of “green” liquid hydrogen by capturing hydrogen as a waste product of sodium chlorate production and using 97% hydroelectric power. This transitioned to examples of fuel cell forklift fueling stations implemented by Linde, including at the BMW plant in Spartansburg, South Carolina, which currently uses more than 600 kilograms of hydrogen day dispensed at 18 different indoor forklift fueling stations around the plant. He described these as “lighthouse projects” since they demonstrate safe commercial operation of these hydrogen and fuel cell systems. He also mentioned Linde’s hydrogen bus fueling stations, including AC Transit’s 12-bus station which is now the largest hydrogen bus station in the world.

Mr. Beckman described Linde’s current and planned station installations in California. He noted that Linde’s first retail (public) fueling station is scheduled to open soon in West Sacramento. This and Linde’s six other planned retail stations will be supplied with liquid hydrogen and feature Linde’s new ionic compression technology (known as IC-90). He described some of the key advantages of the IC-90 system, including the ability to supply high-throughput (up to 30 kg per hour per unit) stations. He also presented on a next generation technology (cryogenic liquid hydrogen pump) that could provide up to 100 kg/hour. Next, Mr. Beckman talked about the H2 Mobility project in Germany (Linde’s headquarters), and the joint venture of automotive and energy companies who will share the cost with the German government of installing 400 public stations by 2023. He listed a number of challenges the industry faces, including being extra-diligent on safety, finding space for stations, equipment costs (which need economies of scale to become more cost-effective), and ramping up production to meet demand. He then listed some of the limitations to hydrogen station deployment. These include overly conservative code limitations (such as the 75-foot setback distance for liquid hydrogen tanks in U.S. code), environmental liability concerns from legacy (gasoline) equipment, contracts that require franchise station owners to get permission from the franchisor to sell other fuels, and (potentially) higher costs of equipment deployment for compliance with NFPA 2016. Mr. Beckman ended with a discussion of “provocative ideas” including a paradigm shift that recognizes the high societal cost of gasoline.

>>see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_nov14_9_beckman.pdf

Discussion

- Mr. Koyama asked what the approximate cost is for a serialized station, e.g., 100 stations going out over a period of a few years.
 - Mr. Beckman responded that the cost for the Linde station at 400kg/day is about \$2.5 million (40% equipment costs, 60% installation costs), but that early-market installation costs include many things that will be lower in cost as more stations are installed. He estimated a 30% or more overall reduction in station costs with volume.
- Mr. Koyama asked, if 60% is the installation costs, is it feasible to think about mobile stations, or trailer-type stations.
 - Mr. Beckman responded that the compressor part of their station design is containerized, but that there are many other components outside this container, such as the dispenser, storage tank, etc. He noted that Linde continues to work on improving its containerized designs.
- Dr. Shaw asked about the importance of aesthetics for the types of stations being depicted. He also asked, regarding Germany's hydrogen commitments, where the cars are to match this supply, and he asked about Mr. Beckman's experience with the reliability of Linde's ionic compression station.
 - Mr. Beckman explained Linde's IC-90 ionic compressor has been run 10,000 hours in Germany on the test bench and that Linde's hydrogen station at BMW-Spartansburg has 24-7 reliability, though they do have three ionic compressors there to provide back-up in case one goes down. He also said having a robust supply of spare equipment is important for effective operations and maintenance, especially since it is still uncertain what parts are going to be problematic over time and as demand on the stations increase. Mr. Beckman explained that Daimler and Linde have committed to building 20 stations to kick-start the industry as part of the H2 Mobility partnership. Regarding Dr. Shaw's question about the lack of cars to match supply, he cited a McKinsey study that projects a growing FCEV market over time. With regard to the aesthetics of larger stations, Mr. Beckman suggested that ultimately, large hydrogen storage tanks will need to be buried, just as they are today for gasoline storage.
- Vice Chairman Novachek asked if there are any other limitations to station development that HTAC can help with.
 - Mr. Beckman noted that the setback distance issue is something that they could use help with, but that some analytical work is currently being done on this and they have talked to an OEM about supporting that effort. He also stated the need for language in the Energy Independence and Security Act to be changed to include hydrogen among the list of renewable fuels that are exempt from the need for franchisor approval at retail outlets.
- Dr. Lloyd asked whether Mr. Beckman had run into any hydrogen contamination and purity issues and also how the involvement of oil companies in Germany differs from the California Fuel Cell Partnership's interactions with oil companies.
 - Mr. Beckman stated that liquid hydrogen is difficult to contaminate, so hydrogen quality isn't really an issue at their stations. Regarding the involvement of oil companies with hydrogen station development in Germany, Mr. Beckman noted that the majority of retail fuel stations in Germany are owned by the major oil companies, whereas most of the retail stations in the U.S. are independently owned. The German government is also providing 50% investment support or tax credits, and has also required the oil companies to include green fuels in their portfolio of offerings if they want to expand existing stations.
- Chairman Hofmeister stated his opinion that Germany has been successful because their political system is consensual rather than adversarial. He suggested that one area for HTAC focus may be to think about processes and strategies for convening significant stakeholder leaders to reach broad agreement on various issues and "get it done."

- Mr. Beckman added that the German approach to liability is different, as it puts more responsibility for safety on the individual/consumer as long as proper safety standards are followed by the manufacturer/owner/operator.
- Dr. Satyapal added that H₂USA is envisioned as a convening force for bringing organizations together. She noted that DOE's involvement in H₂USA was authorized by the former Secretary of Energy in a letter of understanding. She said that current efforts within H₂USA are focused at the working group level, but the goal is to engage high-level government decision-makers and business executives. She pointed out that the last round table event with the Secretary of Energy (former Secretary Chu) was more than two years ago, and with all of the recent progress it may be useful to convene another such meeting.
- Ms. Dunwoody commented that California underwent quite a lot of convening effort, which included discussions with the oil industry and culminated in the passage of AB-8. She said that the key is to start making it happen, as they have done in California.
- Ms. Oge agreed, and supported the notion of convening the more proactive auto and energy companies under the Secretary's call.
- Dr. Shaw remarked that leverage points with industry and markets need to focus on the financial side, and noted that unless the oil industry sees a financial risk in basing its future on oil and gas reserves, they will continue to do so.

10. Honoring Peter Hoffman

The Committee members expressed their wish to honor the memory of Peter Hoffman, who passed away on April 18, 2014. He was a longtime chronicler and champion of hydrogen and fuel cells, who authored two books on the subject and was the editor and publisher of the "Hydrogen & Fuel Cell Letter," which he founded in 1986.

- Dr. Shaw honored Mr. Hoffman's hard work and the value to the community that was provided through his newsletter, and recounted speaking to Mr. Hoffman shortly before he passed away.
- Dr. Ogden stated that when someone in the future writes about the early history of the hydrogen economy, they'll go back to what Mr. Hoffman wrote in his newsletter and books. His books, she said, conveyed a sense of excitement about the prospects for a hydrogen economy and the beginning of the hydrogen industry.
- Dr. Lloyd stated that Mr. Hoffman was a great spokesman for the industry and published well-researched stories in a variety of news outlets. He commemorated the enormous amount of work Mr. Hoffman did in support of the industry, often with little or no remuneration.
- Mr. Rose recounted speaking with Mr. Hoffman's widow, and shared some stories about Mr. Hoffman's personal life. He added that the University of Tennessee would be digitizing Mr. Hoffman's written works.
- Dr. Satyapal acknowledged the strong relationship that she and others at DOE have had with Mr. Hoffman over the years, and his contributions to helping report on the program's activities and progress. She reported that his memory was honored at the 2014 DOE Hydrogen and Fuel Cell Annual Merit Review meeting, and noted that DOE has fielded questions about his legacy and the future of his newsletter from many of his admirers, in the U.S. and around the world.

DAY 2 – NOVEMBER 19, 2014

The second day of the Hydrogen and Fuel Cell Technical Advisory Committee (HTAC) meeting began at 8:30 a.m. (EST).

11. HTAC Business

11.1 Introduction of New HTAC Members (cont'd)

Another new member appointed to the HTAC by the Secretary of Energy introduced herself; she was not able to attend the November 18 meeting.

1. **Commissioner Janea Scott** is one of five Commissioners appointed to the California Energy Commission (CEC), and oversees activities in the transportation sector. This includes the state program that authorizes funding to build as many as 100 hydrogen fueling stations in California. Before coming to the CEC, Ms. Scott worked in Secretary of Interior Ken Salazar's office, on renewable energy. Prior to that, she worked for the Environmental Defense Fund as a senior attorney focusing on clean air issues.

11.2 Dates for 2015 HTAC Meetings

- After some discussion, it was agreed that Committee members would be polled for available dates for two in-person meetings in 2015: one in the April/May timeframe and one in the October/November timeframe.
- Vice Chairman Novachek stated that they may want to keep the option open for a third meeting, given the possibility for report-outs on progress and issues with the roll-out in California.
 - Others suggested that a webinar might suit the purpose for a possible third meeting.
- Commissioner Scott asked that the fall 2015 meeting be scheduled so as not to conflict with the Los Angeles Auto Show.
- Mr. Rose noted that about half of the HTAC members are from the west coast, and many of the members were at the 2014 Fuel Cell Seminar in California. He suggested co-locating the fall 2015 HTAC meeting with the 2015 Fuel Cell Seminar or the California Hydrogen Business Council's annual summit, which will also be held in California. He noted that these events attract an international audience, which adds to the choices of speakers for the HTAC meeting agenda.

12. Perspectives and Discussion on Hydrogen, The Honorable Byron Dorgan

Deputy Assistant Secretary Sarkar introduced former United States Senator from North Dakota, Byron Dorgan, who served in the senate leadership for 16 years, including as Chairman of the Committee on Energy and Water. Senator Dorgan emphasized the need for alternative energy vehicles to address environmental issues, and recounted how he worked to restore the budget for the DOE Hydrogen and Fuel Cell Program under former Energy Secretary Chu, since he believes that R&D support is needed for transformative technologies like hydrogen and fuel cells. He expressed his appreciation for the work of the late Peter Hoffman in communicating the potential for the industry. Senator Dorgan stressed the importance of working towards a low carbon future, and expressed his support for an "all-of-the-above" approach to the energy industry. He suggested that HTAC members "turn up the heat" on hydrogen and fuel cells, by actively communicating about its progress and potential. Finally, he expressed his interest in seeing what HTAC has been working on.

Discussion

- Mr. Rose asked what advice Senator Dorgan has for the Committee on how to be most effective in advising Energy Secretary Moniz and the broader community.

- Senator Dorgan stated that the Committee needs to “make as much noise as possible” about the progress being made with hydrogen fuel cells. He recommended that HTAC members write op-ed pieces, hold press conferences, etc., to gain press attention on the progress being made with hydrogen fuel cells.
- Mr. Eggert reflected on former Energy Secretary Chu’s early statements about hydrogen fuel cells and credited Dr. Chu for changing his mind on fuel cells and recognizing their potential. He asked the Senator for his opinions on the best way to communicate science and technology to Congress to better inform policy and help create new policies to address climate change.
 - Senator Dorgan noted that he had created a fuel cell caucus in the Senate to gather like-minded people. He recommended that HTAC hold briefings for this caucus to show Senators and staff members the progress that is being made and the potential that fuel cells have.
- Dr. Shaw pointed out that Toyota, Hyundai, and Honda are leading the way on commercializing fuel cell vehicles in the U.S. and expressed concern over America losing its leadership position. He stated that fuel cells will be a dominant industry in the future, but Congress does not seem to be concerned about helping to maintain or build America’s competitive position in the industry. He asked Senator Dorgan for ideas on how to change their perspective.
 - Senator Dorgan stated that, at least over the next couple of years, the levers in Congress to affect this issue may be limited. He noted that signals from key government officials like the Secretary of Energy can be very influential, and that the states are also key players in setting the tone for the alternative energy industry.
- Dr. Satyapal acknowledged Dr. Chu for protecting the hydrogen and fuel cells budget in his later years as Secretary and for signing DOE on as a partner in H₂USA. She pointed again to several metrics of success for DOE’s Hydrogen and Fuel Cells Program as well as other examples of growth in the U.S. fuel cell industry. She noted that while there hasn’t been as much progress in the U.S. on manufacturing fuel cell electric vehicles (FCEVs), there has been progress in growing the U.S.-based supply chain for components such as fuel cell stacks and hydrogen tanks. Dr. Satyapal pointed out that U.S. tax credits for FCEVs are relatively low compared to those for plug-in electric vehicles and for FCEVs in some other countries. She noted that tax credits for both FCEVs and hydrogen infrastructure expire at the end of this year, and conveyed the concern of industry for extending the credits.
 - Senator Dorgan noted that the oil industry is doing much to eliminate competition and expressed uncertainty for tax credits given the recent change in legislative leadership. He recounted how much the oil industry has been incentivized historically and today, and stated his belief that alternative fuels should also have such incentives.
- Chairman Hofmeister recounted his experience in the oil industry and asked about the prospects for minimizing the influence of special interests on energy policy.
 - Senator Dorgan responded that special interests do have an influence and that it is up to groups such as HTAC to push back against them with good ideas.
- Ms. Oge expressed her concern about the debate over the Renewable Fuel Standard and the oil industry’s strong lobbying efforts against it.
 - Senator Dorgan recounted his work on legislation for the Renewable Fuel Standard and expressed his hope that the Environmental Protection Agency would soon establish the Renewable Fuel Standard for 2014.

13. Public Comment Period

- 1) Mr. Jeff Serfass spoke on behalf of the California Hydrogen Business Council (CHBC) and the Hydrogen Education Foundation (HEF). He provided an overview of the CHBC, its growing membership, and progress that it has made in the past year. He described growing momentum for the industry, and good attendance at two recent events: the CHBC’s annual summit and the

2014 Fuel Cell Seminar held in Los Angeles. He described some of the current focus areas for the CHBC, including raising awareness for hydrogen as an energy storage option (especially for renewables), adding hydrogen and fuel cells as zero emission technology options at shipping ports, building pathways to increase the production of hydrogen from biogas, and getting California's low carbon fuel standard to include hydrogen from electrolysis as a low carbon fuel. For the HEF, Mr. Serfass reported on two competitions that the organization is managing for the DOE, the \$1million [H-Prize](#) and the [hydrogen student design contest](#), both of which are focused on hydrogen fueling station design.

- Dr. Lloyd noted, regarding zero emission energy technologies at ports, that Jon Slangerup was appointed CEO of the Port of Long Beach and there may be opportunities to work with him.
 - Vice Chairman Novachek asked about power-to-gas (hydrogen energy storage) and stated that more information is needed on the value proposition, from the perspective of both electric and gas utilities. He suggested that a briefing on this topic to the HTAC would be helpful.
 - Mr. Serfass stated that Jeff Reed (Southern California Gas), Chairman of the CHBC's Hydrogen Energy Storage Committee, may be able to present to the Committee on this topic next spring.
 - Mr. Rose noted that Hydrogenics may also be able to provide some information on this topic.
 - Dr. Shaw stated that it is challenging to make power-to-gas work in the U.S. without more incentives. He noted that the situation is different in Europe where this is a large stranded wind power resource, so companies like Hydrogenics are focusing their efforts there.
 - Ms. Dunwoody added, regarding California's low carbon fuel standards (LCFS), there are ongoing talks at the Air Resources Board to consider including hydrogen from electrolysis. She noted that the key challenge is figuring out how to account for using renewable power via "renewable electricity credits" or RECs in order to reduce the carbon intensity of hydrogen using electrolysis. She also mentioned that Energy Independence Now will be publishing a paper on the potential dollar value of LCFS credits and RINs generated from renewable hydrogen.
- 2) Mr. Andy Kaldor introduced himself as a small business executive representing Power & Energy, a company that makes hydrogen reformers among other products. He stated that they find messaging from the DOE and state of California confusing, in particular DOE's position that government R&D support is no longer needed for producing hydrogen from natural gas. He also cited mixed messages from California on the use of natural gas as a hydrogen source. He stated that Power & Energy is developing technology to produce hydrogen from natural gas or other hydrogen-rich gas at much lower cost than current technology, but is not getting needed encouragement or support from the public sector. He contended that if the goal is getting large numbers of FCEVs on the road, then providing lower cost fuel from a readily available resource would be more effective than offering a few thousand dollars as a vehicle purchase incentive.

14. Retail Fueling Infrastructure Subcommittee Update, Dr. Joan Ogden

Dr. Ogden requested input from the Committee on key topics that should be investigated and discussed in the Infrastructure Subcommittee's report. She noted that thinking on hydrogen infrastructure is evolving rapidly and there are new design ideas, system concepts, and practical experience that could be mined from ongoing work in California, Europe, and Asia. As an example, she pointed to California and how ideas for station locations and designs have changed since 2004. She noted that different types of public-private partnerships are emerging in different countries, and

referenced a graphic^{3,4} that illustrates the actions and roles of key stakeholders in California, including government, automakers, and station developers. Dr. Ogden presented several ideas for key issues to address in the subcommittee report, including technical advances in hydrogen infrastructure, tracking worldwide progress on FCEV and hydrogen station rollout, examining the evolving business case for FCEVs and hydrogen and the role of policies, and making some recommendations. She concluded by asking for input from Committee members.

>> see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_nov14_12_ogden.pdf

Discussion

- Dr. Lipman suggested reporting on the cost of ongoing operation and maintenance (O&M) at stations, as well as best practices for optimizing up-time.
 - Dr. Ogden agreed, noting that there likely will be some available information on this, including what components seem to be having the most problems.
- Dr. Shaw expressed interest in examining how much government support is needed and for how long before the hydrogen stations can become fully viable commercial opportunities. He noted that a better understanding of station O&M costs would be needed for this, and volunteered to help work on this section of the report.
 - Dr. Ogden stated that it would be useful to have this information vetted by people in the financial industry.
- Mr. Rose noted the lack of agreement around the world for what a public hydrogen fueling station is supposed to be. He added that it would be a leadership opportunity for HTAC to try to establish and promote some definitions.
 - Dr. Ogden agreed and noted this might be a good project for a graduate student, who could start with the IPHE database.
- Commissioner Scott suggested providing some context by comparing the issues and concerns for hydrogen infrastructure with those for hybrids and battery electric vehicles.
- Ms. Dunwoody noted that a number of Committee members, including herself, will have first-hand experience with what is happening on the ground as stations are getting built and used in California. She suggested that one role for HTAC or this subcommittee could be informing DOE about anticipated challenges going forward and how DOE could help. For example, potential workforce limitations and what can be done to help build a workforce of skilled technicians and engineers that can build stations.
 - Dr. Ogden agreed that presenting on limiting factors like this would be useful, and suggested that this may be something to work on in collaboration with the other HTAC subcommittees.
- Mr. Eggert suggested looking at how deployment strategies are informed by analysis, particularly the new analysis that is coming out of places like U.C. Davis, U.C. Irvine, NREL and others.
- Dr. Lloyd suggested looking at how hydrogen is treated in different rules and regulations addressing low-carbon fuels, and seeing how this might vary from state to state or country to country.
- Chairman Hofmeister noted that hydrogen infrastructure will develop in phases, which will have very different characteristics depending on the maturity and profitability of the market. He noted

³ Ogden, Joan, Christopher Yang, Michael Nicholas, and Lew Fulton. "NextSTEPS White Paper: The Hydrogen Transition," Institute of Transportation Studies, University of California, Davis, July 2014. <http://steps.ucdavis.edu/files/08-13-2014-08-13-2014-NextSTEPS-White-Paper-Hydrogen-Transition-7.29.2014.pdf>

⁴ Eckerle, Tyson and Remy Garderet, "Incentivizing Hydrogen Infrastructure Investment: An Analysis of the Use of Cash Flow Support to Incentivize Early Stage Hydrogen Station Investment," Energy Independence Now, June 19, 2012. <http://cafcp.org/incentivizing-hydrogen-infrastructure-investment>

that the market is currently in the early phase with a lot of government support and guidance, but in later phases there will be more mature supply chains, competing fuel providers, and real estate developers involved in how, where, and when stations roll out.

- Dr. Lipman proposed tracking data and trends in the consumer fueling experience and perceptions about safety, etc., as a potential area of research.
- Mr. Rose suggested tracking and reporting on the cost of building hydrogen stations.

15. Manufacturing Subcommittee Update, Harol Koyama

Mr. Koyama reported on the activities of the HTAC Manufacturing Subcommittee, and noted that a first draft of the subcommittee's report has been included in the HTAC members' briefing materials for their review. He listed the subcommittee members and described its charter to investigate potential opportunities for advanced manufacturing to benefit hydrogen and fuel cell production and commercialization. The target output is a report on the status of the industry's manufacturing techniques, identification of additional opportunities for advanced manufacturing, and identification of ways to facilitate their further exploration and use. Mr. Koyama explained the subcommittee's focus and process, including the use of an industry questionnaire and in-person interviews to gather information. He also reported on the subcommittee's participation in several regional Clean Energy Manufacturing Initiative (CEMI) events. He described the methodology used for the questionnaire, and presented the key topic areas addressed. Mr. Koyama presented the subcommittee's recommendations for future work: 1) targeted demand stimulation programs (focusing on proven commercial products) in and outside the U.S.; 2) cost reduction and standardization for key, high-cost components, and 3) providing greater access to additive manufacturing and other advanced manufacturing techniques. He asked the Committee for feedback on the draft report, and conveyed the subcommittee's plan to gather these inputs over the next several weeks and produce the final report.

>> see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_nov14_13_koyama.pdf

Discussion

- Dr. Shaw and Mr. Kaya, members of the Manufacturing Subcommittee, commended Mr. Koyama for his work on the report.
- Mr. Rose asked what will happen to the final report after it is submitted.
 - Mr. Koyama replied that this is for the HTAC to decide, since the report was produced at the request of the Committee.
- Mr. Kaya remarked that access to the resources of the national laboratories can be very helpful, especially for small and medium-sized business. He expressed his support for EERE's new national lab initiatives and his hope that it might provide greater access to the advanced manufacturing R&D facilities.
- Ms. Dunwoody asked if the subcommittee looked at issues related to manufacturing capacity constraints, particularly for hydrogen station components or vehicle hydrogen storage tanks. She noted that the supply chain is fairly limited so manufacturing lead times can be long. She also reported that finding ready capability for manufacturing storage tanks for medium and heavy duty vehicles has been a problem area.
 - Mr. Koyama commented that they did consider technologies related to hydrogen production, and this should also be part of their recommendations.
- Ms. Oge asked Mr. Koyama to elaborate on the statement in his executive summary that "Suppliers and OEMs are reluctant to invest in areas which could achieve these cost reductions, due to uncertain demand and timing of demand." She asked him to contrast this behavior with that experienced in the emerging battery electric vehicle industry.

- Mr. Koyama noted that he attended the San Francisco regional CEMI summit, and a lot of the electric vehicles OEMs and suppliers expressed similar problems with forecasting market demand or when the break-even point will be reached. Mr. Koyama stated that this is a barrier for a lot of new technologies, but that very large companies, or wealthy individuals, can sometimes pay their way past this barrier.
- Dr. Satyapal thanked Mr. Koyama for chairing the subcommittee, and expressed her appreciation for how quickly the subcommittee was able to work and put together some detailed recommendations. She urged the full Committee to move just as quickly to review the subcommittee's report and decide on whether to forward it along to DOE as an approved HTAC report, so the report can be made public.
 - Dr. Lloyd asked whether the Committee could vote on this matter via email.
 - Mr. Hofmeister clarified the process for finalizing HTAC subcommittee reports: 1) the draft subcommittee report is submitted to the HTAC for review; 2) a date is set for receiving any comments from HTAC members via email; 3) the subcommittee chair addresses any substantive comments in consultation with the subcommittee; 4) if there are no unresolved issues that require further discussion with the full Committee, the report is considered to be a final HTAC report and is submitted by the subcommittee chair to the HTAC Chair along with a cover letter; and 5) the HTAC Chair then forwards the report to DOE.
- Mr. Koyama asked HTAC members to send him feedback on the draft report of the Manufacturing Subcommittee by the end of November 2014.

16. Additive Manufacturing in Fuel Cells Manufacturing: Blake Marshall, DOE Office of Energy Efficiency and Renewable Energy, Advanced Manufacturing Office

Mr. Marshall began with an overview of EERE's Advanced Manufacturing Office (AMO) and its coordination with the Clean Energy Manufacturing Initiative. He presented on AMO's shared R&D facilities and how they support industry by providing affordable access to advanced manufacturing tools and expertise, such as additive manufacturing. He described two such programs aimed at supporting collaborative, cross-cutting R&D: the Manufacturing Demonstration Facility (MDF) at Oak Ridge National Laboratory and the multi-agency America Makes initiative, which provides industry access to a number of federal facilities and resources. He noted that there are different ways for companies to access these facilities, including as part of longer-term, cost-shared R&D projects, or just as short-term users to try equipment out. He went on to describe additive manufacturing (also known as 3-D printing) technology, and the seven different process categories currently used to make different kinds of products. He described a number of advantages offered by additive manufacturing, including consolidation of complex assemblies, distributed on-demand production, energy and materials savings, and localized modification of materials and properties to enhance product performance. Mr. Marshall presented on several additive manufacturing R&D projects, including the design/build of a compressor/expander, turbine combustor, and car chassis. He also referred to several slides presented at a 2014 webinar⁵ on the use of additive manufacturing for fuel cells, which described the advantages of using direct metal laser sintering (DMLS) to produce several integrated fuel cell system components. He also mentioned a number of other possibilities for using additive manufacturing in fuel cell applications, including novel flow field designs, tailored surface chemistries, and conformal gas storage.

>> see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_nov14_14_marshall.pdf

⁵ DOE Fuel Cell Technologies Office, Additive Manufacturing for Fuel Cells webinar, February 11, 2014, <http://energy.gov/eere/fuelcells/2014-webinar-archives#date021114>.

Discussion

- Dr. Carlin noted that the Department of Defense is doing a lot of work in this area, and that his program funded a project that used additive manufacturing to produce a titanium bipolar plate for a fuel cell powered UAV (unmanned aerial vehicle). He asked what product areas additive manufacturing shows potential for.
 - Mr. Marshall replied that high-value product areas like the medical and aerospace industries are especially ripe for additive manufacturing. Parts made in small lots or that require minor modifications for different applications would also be targets. He noted that as costs for the various additive manufacturing tools and techniques come down, the product slate will likely expand.
- Vice Chairman Novachek asked whether the thermal spray technology presented by Johanna Wellington from GE on the first day of the HTAC meeting would be considered an additive process.
 - Mr. Marshall stated that he could not be certain since he did not see Ms. Wellington's presentation. He noted that additive manufacturing typically involves a layer-by-layer approach and some spray technologies might be considered additive, especially if they are building up a significant mass of material. He pointed out that simple cladding would not be considered an additive process.
- Mr. Novachek asked what limits there currently are on the kinds of materials that can be used in additive manufacturing.
 - Mr. Marshall stated that the material set is growing, but is still limited since developers tend to stick with materials they know. He stated that essentially any material that can be reduced to a powder form and bound together with glue can be printed (e.g., plastics, glass, ceramics, metal alloys).
- Mr. Koyama asked how a small company should proceed if they are interested in working with the MDF or other federal facility. He also asked if there is a particular volume of production for which additive manufacturing would be applicable.
 - Mr. Marshall stated the MDF is open to anyone; companies can contact him directly and he will put them in touch with a person at the lab to arrange a tour of the facility and discuss the opportunities for applying one or more of the tools to their application. He noted that Cooperative Research and Development Agreements between the company and the lab can be completed in as little as 6 months, at which point work can begin. Regarding the question on required production volumes, Mr. Marshall responded that additive manufacturing machines vary widely in cost, from millions to hundreds of dollars, so it's a case-by-case decision.

17. 2014 HTAC Annual Report Planning, Robert Rose

Mr. Rose, chair of the subcommittee for producing the 2014 HTAC Annual Report, presented statistics on HTAC website traffic in the interest of understanding how frequently the HTAC annual report was accessed. He pointed out that several other annual reports (which are available at no charge) focus on similar topics, and questioned whether there is a continuing need for the HTAC annual report in its current form. He posed a list of questions to HTAC members regarding the report including: Who is the audience? Are we reaching this audience effectively, or are there better ways to do it? If we do continue with the annual report, how can we make it better? If we don't continue to do the report, could we invest that time in something more valuable?

>> see full presentation at http://www.hydrogen.energy.gov/pdfs/htac_nov14_11_rose.pdf

Discussion

- Mr. Koyama asked if the HTAC annual report adds value beyond what is provided in the other reports mentioned by Mr. Rose. He also asked if there are ways republish or repackage the findings in the HTAC annual report for other audiences beyond the Secretary of Energy and other DOE managers.
- Ms. Dunwoody noted that she has used the annual report in the past as a way to review information and accomplishments from the past year. She suggested that in addition to Mr. Rose's question about the audience, they also consider what the annual report's message should be. She asked if it should include issues such as what the remaining challenges are, additional work that needs to be done, how much funding is needed, and where DOE can help and why.
 - Chairman Hofmeister noted that HTAC has tended to stay away from making specific budget recommendations. He added that HTAC's key messages in this regard has been that more funding for R&D is needed, the U.S. is losing global competitiveness in this industry, and lack of leadership is part of the problem.
 - It was also pointed out that Title 8 of the Energy Policy Act (EPACT)⁶, which created the HTAC, provides some specific budget recommendations, as well as specific language about what DOE's program goals should be for 2015 and 2020 with regard to both fuel cell technology and hydrogen production, delivery, storage, and infrastructure development. This may provide a foundation for HTAC recommendations, since their role is to advise the Secretary with regard to the implementation of EPACT Title 8.
- Dr. Ogden noted that the HTAC annual report stands out in that it is more concise than the reports mentioned by Mr. Rose, and includes R&D progress as well as commercial progress. She noted that the HTAC report draws on those reports as well as other information sources, and provides a useful summary. Also, by comparing annual reports year-to-year it is possible to see trends in the industry. Because she considered the audience for the annual report to be primarily federal policy makers and DOE managers, she focused on including items of interest to those audiences when she chaired the HTAC Annual Report Subcommittee.
- Mr. Freese asserted that the HTAC should continue to produce an annual report but suggested the Committee consider how to make it a more valuable document. For example, by including some recommendations for action and more actively distributing the document so that it gets in front of the right people and has more impact. He reminded the Committee about the idea to include some kind of "dashboard" in the report as a quick visual reference on status/gaps/path forward.
- Vice Chairman Novachek supported continuing the annual report with modifications to make it more valuable, and proposed publishing the HTAC annual report simultaneously with a Senate fuel cell caucus briefing or other major event so that the Committee could present on its key points and messages.
 - Dr. Satyapal noted that U.S. Senate and House fuel cell caucus events were held in 2014, and she took an action to see if future caucus events could be held in conjunction with HTAC meetings.
- Mr. Eggert proposed making the annual report more reflective of the Committee's findings, insights, and recommendations over the past year, rather than making it a general review of the state of the industry. He noted that the report could do this by synthesizing or summarizing information they receive and discuss at their meetings as well as reports produced by HTAC subcommittees (e.g., the infrastructure and manufacturing subcommittees). He also mentioned that his organization publishes research findings through a number of different channels and formats, including webinars and social media.

⁶ Energy Policy Act of 2005, Public Law 109-58, August 8, 2005, Title VIII—Hydrogen, <http://www.gpo.gov/fdsys/pkg/PLAW-109publ58/pdf/PLAW-109publ58.pdf>.

- Chairman Hofmeister commented that he considers the annual report to be an important HTAC product, and that HTAC members themselves are an audience, since the reports organize a lot of information and keep members up to speed on industry developments. He also pointed out that the target audience(s) may vary from year to year. He noted that he sends electronic copies of the annual report to various people of interest, and suspects that other HTAC members do so as well.
 - Dr. Ogden noted that she often sends the HTAC report(s) out to people who write her with questions about hydrogen or fuel cells. In her work as a professor and lecturer, she may also bring the reports with her as a handout.
- Ms. Oge reported that, when doing research for her book, the HTAC’s annual reports did not come up in her online searches. She suggested the Committee consider other ways of publishing the report so it’s more accessible.
- Vice Chairman Novachek added that a lot of the recommendations and key messages from the Committee are included in the report’s transmittal letter (to the Secretary of Energy), and the Committee may want to consider including this information in the actual report.
- Dr. Satyapal noted that the Fuel Cell Technologies Office considers the HTAC annual report to be a very valuable independent reference. She also reported that the HTAC is upheld as a good example of a well-functioning federal advisory committee. She took an action to work with DOE’s Public Affairs office to see if there are other ways the DOE can publicize the annual report.
- Ms. Dunwoody expressed surprise over the lack of face-to-face meetings with the Secretary, and offered to brainstorm about ways to make that happen. She also agreed that EPACT Title 8 provides some fairly specific language regarding DOE’s hydrogen and fuel cells programs, and suggested that the HTAC annual report describe the progress towards those goals and how well DOE’s programs are (or are not) supporting that progress.
- Chairman Hofmeister noted that the Secretary has never met with the full Committee, and he hopes this will change with Secretary Moniz. Dr. Satyapal noted that former Secretary Chu did attend a meeting of the HTAC’s Hydrogen Production Expert Panel, and that there are so many federal advisory committees and that it is not common for the Secretary to attend (noting that the previous Under Secretaries had attended).
- Mr. Kaya concurred with Ms. Dunwoody’s comments about focusing the annual report more on the DOE programs. He also reiterated his suggestion to include a summary of key findings in the HTAC subcommittee reports. He noted that providing this information in the annual report would be a good way to transmit the more substantive work of the HTAC to a broader, more general audience
- Dr. Bond proposed that since HTAC is an “advisory” committee, it should specify what the needs are and why additional funding is needed. He noted that one challenge with creating a progress dashboard is that the specific metrics for current status are periodically revised, and this can create a confusing message.
- Mr. Koyama offered his support for a dashboard, noting that it could be a good tool for consistent, concise annual reporting.
- Mr. Rose thanked the members for their input. He agreed in principle to the concept of adding a progress dashboard, but noted that it could be challenging due to the difficulties and timelines for getting data. He offered to begin by producing a much shorter version of the 2013 HTAC Annual Report, which he would then share with HTAC as an example for 2014.
- A number of HTAC members responded to Chairman Hofmeister’s request for volunteers for the 2014 HTAC Annual Report Subcommittee, including Dr. Shaw, Mr. Freese, Dr. Bond, Mr. Novachek, Ms. Dunwoody, Dr. Oge, and Dr. Lloyd.

The HTAC meeting was adjourned at 12:19pm EST, November 19, 2015.

**TWENTY-FOURTH MEETING OF THE
HYDROGEN AND FUEL CELL TECHNICAL ADVISORY COMMITTEE (HTAC)
PARTICIPANT LIST**

November 18–19, 2014

HTAC Members Present

- Peter Bond
- Richard Carlin
- Kathryn Clay
- Catherine Dunwoody
- Anthony Eggert
- Charles Freese
- John Hofmeister
- Maurice Kaya
- Harol Koyama
- Paul Leggett
- Timothy Lipman
- Alan Lloyd
- Frank Novachek
- Joan Ogden
- Margo Oge
- Robert Rose
- Janea Scott
- Robert Shaw
- Levi Thompson

U.S. Department of Energy Staff

Office of Energy Efficiency and Renewable Energy

- James Alkire (DFO)
- Peter Devlin
- Rick Farmer
- Nancy Garland
- Laura Hill
- Donna Ho
- Fred Joseck
- Blake Marshall (Speaker)
- Eric Miller
- Geoffrey Morrison
- Tien Nguyen
- Reuben Sarkar (Speaker)
- Sunita Satyapal (Speaker)

Office of Nuclear Energy

- Carl Sink (Speaker)

Members of the Public in Attendance

- Michael Beckman—Linde (Speaker)
- John Christensen—National Renewable Energy Laboratory
- Honorable Byron Dorgan—former Senator, North Dakota (Speaker)
- Tyson Eckerle—Office of Governor, California (Speaker)
- Leo Grassilli—Office of Naval Research
- Tom Gross—Consultant
- Andrew Kaldor—Power and Energy, Inc.
- Morry Markowitz—Fuel Cell and Hydrogen Energy Association (Remote Speaker)
- William McLeod—Hyundai
- Jay Mok—Hyundai
- Jeff Serfass—California Hydrogen Business Council
- Matt Solomon—Northeast States for Coordinated Air Use Management (Speaker)
- Robert Walker—Wexler and Walker
- Johanna Wellington—GE Global Research (Speaker)

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- Larry Flowers—Ace Federal Reporters
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- Lilia Murphy—Alliance Technical Services, Inc.
- Neil Popovich—National Renewable Energy Laboratory
- Amit Talapatra—Energetics Incorporated (Day 2)
- Tom Timbario—Alliance Technical Services, Inc.