

HYDROGEN AND FUEL CELL TECHNICAL ADVISORY COMMITTEE

MEETING MINUTES

April 6-7, 2016

Hilton Garden Inn, Livermore, California

TABLE OF CONTENTS

DAY 1 – APRIL 6, 2016	3
1. DOE Updates and Discussion, Reuben Sarkar, Deputy Assistant Secretary for Sustainable Transportation, Office of Energy Efficiency and Renewable Energy (EERE), U.S. Department of Energy (DOE) and Acting Director, DOE Clean Energy Manufacturing Initiative (CEMI).....	3
2. DOE Updates and Discussion, Sunita Satyapal, Director, Fuel Cell Technologies Office, EERE/DOE.....	5
3. California H2 Network Update, Wade Crowfoot and Tyson Eckerle, California Governor’s Office.....	6
4. California Air Resources Board (ARB) Update: Transforming Transit and Beyond, Jack Kitowski, ARB	8
5. California Hydrogen Refueling Infrastructure Activities: Present Activities and Future Plans, Jean Baronas California Energy Commission (CEC).....	8
6. Worldwide EV Policy: Best Practices to Promote Electric Vehicles, Nic Lutsey, The International Council on Clean Transportation (ICCT)	9
7. Impacts of Incentives and Policies: Policies to Promote Alternative Fuel Vehicles -- What can we learn from the literature?, Dr. David L. Greene, Howard H. Baker, Jr. Center for Public Policy, The University of Tennessee.....	10
8. CalCharge: California’s Energy Storage Initiative, Dr. Venkat Srinivasan, Lawrence Berkeley National Laboratory (LBNL).....	11
9. Metering for Hydrogen Stations: Commercial Hydrogen Measurement and Fuel Quality Requirements, Kevin Schnepf, California Department of Agriculture, Division of Measurement Standards.....	12
10. Hydrogen – Providing Infrastructure, Herie Soto, Shell, Hydrogen Technology US	13
11. Hydrogen at Scale, Dr. Bryan Pivovar, National Renewable Energy Laboratory.....	13
DAY 2 – APRIL 7, 2016	15
1. LBNL Hydrogen and Fuel Cell Activities Overview; Dr. Ravi Prasher; Division Director, Energy Storage and Distributed Resources, LBNL.....	15
2. Sandia National Laboratories (SNL) Hydrogen and Fuel Cell Activities Overview: Dr. Marianne Walck, Vice President, California Laboratory and Vice President, Energy & Climate Program, SNL and Dr. Chris San Marchi, Hydrogen Program Manager, SNL.....	15
3. Lawrence Livermore National Laboratory (LLNL) Hydrogen and Fuel Cell Activities Overview; Dr. Douglas Rotman; Director, Energy and Climate Security, Office of the Deputy Director for Science and Technology, LLNL and Dr. Salvador Aceves, Energy Conversion and Storage Group	16

4.	Empowering the Hydrogen Economy -- Telecom Backup Power: Fuel Cell Export Potential; Marshall Towe, Founder and CEO, Cascadian Energy	16
5.	H ₂ USA Update: Morry Markowitz, Fuel Cell & Hydrogen Energy Association (FCHEA), Steve Ellis (Honda), and Lance Atkins (Nissan).....	17
6.	2015 HTAC Annual Report Discussion	18
7.	Comments on the DOE Hydrogen and Fuel Cells Program Plan.....	20
8.	Reports from HTAC Subcommittees	20
9.	Other Business and Future HTAC Meetings.....	21
PARTICIPANT LIST		23

DAY 1 – APRIL 6, 2016

Chairman Novachek commenced the Hydrogen and Fuel Cell Technical Advisory Committee (HTAC or Committee) meeting at 8:00 am and reviewed the draft agenda. The agenda was approved as-is by the full Committee. He expressed support for locating the meeting in California, which he described as the nation's "foremost incubator of the hydrogen and fuel cell economy." He opened the meeting to comments from members of the public; no comments were received.

1. **DOE Updates and Discussion, Reuben Sarkar, Deputy Assistant Secretary for Sustainable Transportation, Office of Energy Efficiency and Renewable Energy (EERE), U.S. Department of Energy (DOE) and Acting Director, DOE Clean Energy Manufacturing Initiative (CEMI)**

Mr. Sarkar discussed the importance of hydrogen as a tool in the transportation portfolio, and the potential for hydrogen and fuel cells to decarbonize multiple sectors of the economy. He observed that many people think it is an "either/or" proposition for battery electric vehicles (BEVs) or hydrogen fuel cell electric vehicles (FCEVs), and that this misconception needs to be addressed through communication materials that speak to how different alternative fuel vehicles (AFVs) and alternative fuels complement each other in the national effort to achieve an 80% reduction in carbon emissions by 2050. He specifically pointed to unique FCEV benefits such as zero emissions, fast fueling, long driving range, suitability for long-haul driving and for use in medium- and heavy-duty vehicles, and ability to provide reliable power for other, ancillary uses (e.g., off-grid and emergency back-up power). He noted that while BEVs will have unique benefits in certain applications (especially commuter or city driving), analysis shows that FCEVs (fueled by renewable hydrogen) must be integrated into the transportation portfolio to reach the 80% carbon reduction goal. He also mentioned specific benefits of hydrogen that should be conveyed, including its ability to be produced from a diverse array of domestic, renewable resources and its potential to serve for energy storage, as a crosscutting energy carrier, or as a resource in making fuels from CO₂.

He went on to describe three new crosscutting initiatives at DOE that will focus resources and attention on achieving these benefits:

1. The **Energy Materials Network (EMN)**, a multi-office effort to accelerate materials development, with the goal of reducing the time and cost it takes to develop and incorporate new materials into products (from materials discovery through systems design, manufacturing, and certification) by half the time it takes today (which can be 20 or more years). The EMN will make national laboratory resources available to industry and universities to develop and demonstrate needed new materials at a much higher rate. Materials challenges exist across the entire DOE technology portfolio, so work is focusing on a variety of applications. Mr. Sarkar reported that DOE is kicking off seven consortia under the EMN, four in 2016 and three in 2017, focused in different classes of materials. Three of the seven will be focused on fuel cells related activities, including the **ElectroCat Consortium** (focused on platinum-free electrocatalysts for next generation fuel cells), **HyMARC** (the Hydrogen Materials—Advanced Research Consortium, focused on low-pressure, materials-based hydrogen storage), and a consortium to be kicked off in 2017 focused on renewable hydrogen production.
2. The **Solar-to-Fuels** initiative, being formed to explore and develop crosscutting opportunities around utilizing carbon feedstock (e.g., CO₂), water, and sunlight to create fuels and chemicals that are truly net-zero carbon. This initiative could include work on renewable production of hydrogen as a fuel in and of itself, and/or as a feedstock for the production of other chemicals and fuels (such as syngas).
3. The **H2-at-Scale** initiative, a laboratory consortia project which is being proposed at the national labs' 2016 "Big Idea Summit," that would focus on developing hydrogen and fuel cell applications in multiple sectors throughout the economy. Mr. Sarkar noted that the HTAC will be hearing more details on the H2-at-Scale proposal in a presentation later in their agenda.

Discussion

- Mr. Koyama asked what fuels are being considered under the Solar-to-Fuels initiative.
 - Mr. Sarkar said that this has not been decided, and will be determined by analysis of the various possible pathways.
- Dr. Oge noted that achieving an 80% reduction in carbon emissions will be difficult, and agreed that a combination of technologies and approaches will be needed. She observed that there is “massive confusion” and conflicting messages about the role that BEVs and FCEVs are expected to play, and how they will compete/co-exist in the market. She suggested that DOE help tell this story. She also noted that infrastructure development is a critical issue going forward, and is concerned that DOE may not be putting enough effort into infrastructure development vs fuel cell and hydrogen technology R&D.
 - Mr. Sarkar agreed that a better job needs to be done in communicating the crosscutting benefits of hydrogen and fuel cells and on the need for both BEVs and FCEVs to meet the full scope of the nation’s low- or no-carbon transportation needs. He noted that a cradle-to-grave analysis of transportation options (being conducted by a team of analysts including representatives from DOE, oil companies, auto companies, and the Electric Power Research Institute), will soon be publicly available, and the automotive companies have also assembled a variety of communications materials to show how FCEVs fit into their portfolio. He also agreed that additional resources need to be focused on developing AFV infrastructure, and noted that this is being increasingly advocated by DOE stakeholders.
- Dr. Thompson asked if the funding being applied to the EMN was new funding, or whether it was coming out of existing allocations and appropriations.
 - Mr. Sarkar replied that it is existing funding which is being directed and leveraged to provide a framework and focus on particular high-priority RD&D needs. Dr. Satyapal noted that in the FCTO budget, the \$35 million line item for “Fuel Cell R&D includes \$10 million for the ElectroCat Consortium and the Hydrogen Fuel R&D budget line item includes funding for HyMARC and the renewable hydrogen consortium. Mr. Sarkar added that success of the efforts undertaken by the consortia could justify higher interest in future years.
- Mr. Koyama expressed his support for the analysis Mr. Sarkar is conducting, noting that the transition from low volumes of FCEVs and hydrogen stations to high volumes is a big challenge.
- Mr. Markowitz offered to send Mr. Sarkar some of the recent information products that the Fuel Cells and Hydrogen Energy Association (FCHEA) has developed to explain the need for both BEVs and FCEVs. He observed that the biggest push-back on FCEVs comes from BEV manufacturers, who feel that funding applied towards FCEVs is diluting the advancement of BEVs.
 - Mr. Sarkar noted that FCEV researchers and manufacturers would argue that it’s the other way around, so this is always an issue, especially in times of limited budgets.
- Dr. Ayers agreed that people are often surprised when they come to understand the current status and future potential of hydrogen and fuel cell technology, so more needs to be done to educate the wider public. She asked if her understanding of the EMN efforts is correct – that they will focus not just on materials development, but also on implementing those materials into components and showing the materials can be produced at scale, integrated into component manufacturing processes, and perform well in products.
 - Mr. Sarkar explained that she is correct – the EMN will cover materials development “end-to-end.”
- Mr. Freese noted that GM has continued to invest in both BEVs and FCEVs, even through bankruptcy, because both vehicle types are seen as an essential part of their future portfolio – it’s not “either/or” it’s “and.” He explained that both vehicles have roles to play, with FCEVs taking the bigger role in larger vehicles with heavier duty cycles. He showed several slides that GM has developed to communicate this role, including one that communicated the minutes spent fueling per miles driven of different vehicles types, and one that compared the different driving ranges and duty cycles of different vehicles. He observed that the tug-of-war is most difficult over the issue of resources for fueling infrastructure, since there are a number of different stakeholders involved in putting infrastructure in place. He asserted that

messaging is also needed to assure people that it's possible to meet the infrastructure needs of both technologies and assure that consumers have access to the utility they want from low-carbon vehicles.

- Mr. Sarkar thanked Mr. Freese for his offer to provide his slides to DOE, and noted that another key message to add is that not only do FCEVs offer zero-carbon vehicles in a product space where others don't, they also provide substitutes for the vehicles with the highest fuel consumption, so can make a big impact on the nation's transportation fuel use.
- Dr. Satyapal added that she also has a slide that communicates the cents/mile message on the infrastructure side, showing a comparison between an EV charging station (which can only charge one vehicle at a time) and a hydrogen fueling station (which can service many vehicles over the same time frame).
- Dr. Satyapal suggested that there is a lot of information available, and it might be useful for DOE to gather that together in a single slide deck and have HTAC take a look at it.
 - Chairman Novachek agreed and noted that it would be useful to have a slide deck available that could be used by multiple entities. (The draft slide deck was subsequently circulated the HTAC during the meeting).
- Ms. Dunwoody noted that what made the biggest difference in California was getting individuals at the highest levels of government (in the Governor's office and state agencies) to understand the need for both types of vehicles and generating that support, leadership, and messaging from those levels. She also expressed appreciation for DOE's efforts to accelerate R&D on affordable renewable hydrogen, noting that this is key to realizing the full benefits of hydrogen and fuel cells.
 - Mr. Sarkar noted that focusing renewable hydrogen on both hydrogen for fuel and hydrogen as a feedstock for CO₂-to-fuel brings more players to the table.

2. DOE Updates and Discussion, Sunita Satyapal, Director, Fuel Cell Technologies Office, EERE/DOE

Dr. Satyapal thanked the national laboratory staff for their support in coordinating the HTAC meeting in California, and echoed Chairman Novachek's appreciation for California's efforts to advance hydrogen and fuel cells.

She provided an update on the Fuel Cell Technologies Office (FCTO) and the DOE Hydrogen and Fuel Cells Program. Topics covered by her presentation included the following:

- Overview of HTAC's purpose and scope as defined by Energy Policy Act (EPACT) 2005 Title VIII, Section 802
- HTAC's current membership and new members
- Overview of FCTO's mission and its impact on fuel cell technology development
- DOE activities in the categories of hydrogen and fuel cell 1) research & development, 2) demonstration, and 3) deployment, including collaborative activities such as H2USA and several new programs that make it easier for U.S. companies to work with the national lab
- Metrics describing the growth in the fuel cell technology development including growth in patents, commercial technologies, jobs, and savings
- Near-, mid-, and long-term strategies for addressing barriers to fuel development and deployment
- The DOE Hydrogen and Fuel Cell Program budget (including DOE funding in the offices of EERE, Basic Science and Fossil Energy) and FCTO's budget
- Update on the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE), including a report on the upcoming May 2016 meeting in Oakland, CA
- DOE cost targets and current status in the areas of fuel cell systems, hydrogen production and delivery, and hydrogen storage
- Recommendations and information provided to DOE by HTAC since 2013 and relevant actions and responses from DOE and FCTO
- Requests to HTAC for future areas of input to DOE, including feedback on the H2-at-Scale initiative, hydrogen safety (response planning, etc.), hydrogen energy storage (including outputs from HTAC's Hydrogen Enabling Renewables Subcommittee), and how to improve outreach/awareness on hydrogen

and fuel cells and collaboration with state organizations. Dr. Satyapal also encouraged HTAC members to attend the May 20, 2016, IPHE meeting and asked for recommendations on other stakeholders to invite to the meeting.

>>see full presentation at https://www.hydrogen.energy.gov/pdfs/htac_apr16_01_satyapal.pdf

Discussion

- Mr. Kaya expressed appreciation for the information on the impacts HTAC has had on DOE programs. He also supported the increasing DOE emphasis on tech-to-market activities and collaboration with states and the private sector.
- Mr. Leggett pointed out that the California HTAC meeting location highlights key features of hydrogen that are important both to the local economy and national energy security—its role in renewable energy storage and meeting peak energy demands. He suggested that hydrogen might have a near-term role to play in these areas in California.
 - Dr. Satyapal agreed and noted the importance of identifying areas where there is a real opportunity (e.g., where are renewables being curtailed now? Where are there imbalances in the natural gas supply now?) and funding strategic demonstrations in these locations that can show a real impact.
 - Mr. Markowitz commented on a message he has been getting from H2USA and FCHEA members: it is important to make sure that the FCEV products now being sold or leased over the next several years are successful in the marketplace; otherwise, support for continuing R&D in this area may weaken.

3. California H2 Network Update, Wade Crowfoot and Tyson Eckerle, California Governor’s Office

Mr. Wade Crowfoot, Governor Brown's Deputy Cabinet Secretary focused on transportation, presented an overview of the drivers for California’s hydrogen network. He referred to the Governor’s 2012 Executive Order supporting the California Air Resources Board (ARB) zero-emission vehicle (ZEV) mandate, which directed the state government take a series of actions to achieve a goal of 1.5-million ZEVs on California roadways by 2025, including having sufficient infrastructure by 2020 to facilitate 1-million ZEVs. He noted that the Governor’s office followed up in 2013 (updated in 2015) with an Action Plan that had over 100 specific steps state agencies would take to help facilitate this market, including steps to support BEVs and FCEVs. He commended California Energy Commissioner Janea Scott and Catherine Dunwoody of ARB for their contributions to developing and implementing an infrastructure rollout strategy and for standing up and supporting a Hydrogen Policy Group that includes principals of state agencies and meets on a monthly basis in the Governor's Office to address associated issues and potential roadblocks. Mr. Crowfoot also emphasized the importance of FCEVs in addressing emissions from the medium- and heavy-duty vehicle sectors, and the important role that hydrogen and fuel cells can play in meeting criteria air pollution standards, especially in the Los Angeles area (which he noted has one of the busiest shipping ports in the world). He concluded by expressing California’s continued commitment to reducing the market barriers to entry for FCEVs, and his hope that DOE would continue to partner with California in this regard.

Mr. Eckerle, the Deputy Director of ZEV Infrastructure at the California Governor's Office of Business and Economic Development, described the current status of the hydrogen fueling network in California. He showed the change in the status of hydrogen fueling stations from October 2015 to March 2016, noting that the number of retail stations has grown from 2 to 14 over that time, and the number in late stages of construction and commissioning has also increased considerably. He presented maps showing location and status of currently funded hydrogen stations, and a graphic displaying the online/offline status of dispensing H35 and H70 at active retail and non-retail stations. He noted the importance of planning for and preparing FCEV owners for “growing pains” associated with a newly opened station (a time period they have labeled

the “soft opening”), which typically involves issues like credit card reader errors and dispenser outages. Finally, Mr. Eckerle announced the recent soft opening of new stations at UC Irvine and Long Beach.

>>see full presentation at https://www.hydrogen.energy.gov/pdfs/htac_apr16_02_eckerle.pdf

Discussion

- Mr. Leggett commended the progress AC Transit has made on deploying fuel cell buses (FCBs) in California, but noted that substantial additional funding is needed to put more FCBs on the road.
 - Mr. Crowfoot noted that the California’s cap-and-trade program has generated substantial revenues (on the order of \$2 billion a year) which, by law, has to be put towards activities that reduce carbon emissions. He noted that some groups are lobbying to put some of this funding towards stimulating demand for alternative fuel technologies, adding that the cost of FCBs could be dramatically reduced by increasing the demand to dozens or hundreds per year.
- Dr. Ayers reported that one of the biggest problems Proton OnSite has with their station is the credit card reader, which is a software issue. The hardware for the hydrogen storage and dispensing has actually performed very well. She also pointed to the need for increased education of the public about the availability of hydrogen stations in California. In her conversations with CalTech students after a talk she gave there, she was surprised to find that these graduate-level students studying water splitting did not know there were active hydrogen stations close by.
 - Mr. Eckerle agreed, and hopes to do more publicity on the new stations once the shake-down process has been completed and the soft opening issues addressed. Mr. Crowfoot supported the need for more education, including raising awareness about the fact that FCEVs are now entering the commercial market, so there actually is and will be growing consumer demand for hydrogen fuel.
- Dr. Oge asked two questions: 1) what is the cost of hydrogen stations now and where do they expect the costs to go, and 2) what percent of California hydrogen network will be based on natural gas reforming and what percent will be based on making hydrogen from renewable sources.
 - Mr. Eckerle reported that the current average cost for a 180 -200 kg/day station is about \$2 million. He said that costs are coming down somewhat, but it is hard to project what they might be after the market is fully mature. Commissioner Scott noted that it will take more than 100 stations to build the supply chain and reach the economies of scale needed to significantly bring down costs, but lower costs are expected in more mature markets. Mr. Eckerle said that the majority of current stations are based on natural gas, and there are six electrolysis stations in development.
- Mr. Koyama asked what size FCEV fleet a 180 kg/day station could support.
 - Mr. Eckerle replied that the rule of thumb is one vehicle/kg, so a 180 kg/day station could support 180 FCEVs. He noted that the state does plan to install a few 300-350 kg/day stations as part of the initial network, but the majority are in the 100-180 kg/day range.
- In response to a question from Mr. Freese about what kind of help is needed, Mr. Eckerle said that having a nationally-recognized, standard method for certifying stations would be very helpful, to expedite the process of bringing fully operational stations on line. Ms. Dunwoody pointed to the success of the DOE-funded HySTEP device in collecting data to verify the fueling protocol at stations, and noted that more of these devices are needed. She also conveyed the need for help in testing the back-to-back fueling performance of new stations. Mr. Eckerle also noted that understanding the impact of contaminants and monitoring hydrogen quality is extremely important, since poor quality hydrogen introduced into an FCEV could cause damage to the vehicle or operating problems on the road. Ms. Dunwoody noted that similar assistance in developing and certifying fueling protocols for heavy-duty vehicles will also be needed.
- Dr. Thompson asked whether any modeling has been done on the cost of adding an attendant at hydrogen stations. He also asked whether FCEV users in California have been satisfied with their vehicle ownership and fueling experience to date.

- Mr. Eckerle replied that he didn't know of any studies done in the U.S. on the cost of adding an attendant. In Japan, where attendants are used, the hydrogen stations are only open during the day, which keeps this extra-added cost in check. He said that customers are generally happy with the stations as long as they are on-line; he gets complaints when they are off line.

4. California Air Resources Board (ARB) Update: Transforming Transit and Beyond, Jack Kitowski, ARB

Mr. Kitowski, Chief of the ARB's Mobile Source Control Division, began with an overview of ARB's mission and some of its major achievements. He outlined the key drivers for reducing mobile source emissions, and noted that transformational changes will be needed to achieve emission reduction goals. He described the key approaches for addressing mobile sources, and ARB's process for implementing an advanced technology policy framework through planning, regulations, and investment programs, with funding prioritized for zero emission transit, drayage trucks, and multisource facilities. Mr. Kitowski emphasized the importance of cross-sector collaboration and planning, including the need for better, coordinated regional transportation planning. He mentioned ARB's recent \$180 million competitive solicitation for commercial pilots of alternative fuel vehicles, which received more than \$290 million in proposals that are currently under review. He described the importance of continuing momentum on the growth of the FCB fleet in California, and the potential for fuel cells as motive power for freight trucks and other medium and heavy duty applications. Mr. Kitowski then noted the importance of DOE-ARB collaboration and outlined next steps for moving forward with fuel cell technology development: reducing capital costs through expanded deployment, and establishing a fueling network with near-, mid-, and long-term approaches.

>>see full presentation at https://www.hydrogen.energy.gov/pdfs/htac_apr16_03_kitowski.pdf

Discussion

- Dr. Lipman noted that there seems to be a big opportunity space for fuel cells in the medium-duty (class 3 or 4) vehicle size, especially since those vehicles are small enough that they might be able to use some of the retail fueling stations in the California hydrogen network.
 - Mr. Kitowski agreed, but noted that ARB's focus to date has been on transit buses. He expressed interest in getting feedback from HTAC or others on where the biggest opportunity space is.
 - Dr. Satyapal noted that DOE has funded a few parcel delivery van and airport ground support vehicle demonstrations (including projects with FedEx and UPS), but it has been challenging to find technology developers and system integrators that can work in this space. She suggested that more coordination between DOE and ARB would be useful to determine the best opportunities for regional deployments of medium-duty fleets.

5. California Hydrogen Refueling Infrastructure Activities: Present Activities and Future Plans, Jean Baronas California Energy Commission (CEC)

Jean Baronas, the Hydrogen Unit Supervisor in the CEC's Fuels and Transportation Division, presented an overview of hydrogen infrastructure development activities being conducted under the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP). She described the origins of ARFVTP, which was established by California Assembly Bill (AB) 118 in 2007 and extended to 2024 by AB 8 to "develop and deploy innovative technologies that transform California's fuel and vehicle types to help attain the state's climate change policies." She reviewed the Program's funding from 2009-2015 by investment area, including electric vehicle services equipment, biofuels, hydrogen, natural gas, workforce development, and market development. She described the activities of the eight staff in the Hydrogen Unit, which include managing grants and contracts as well as coordinating with DOE through activities such as participating in H2USA working groups, collecting and providing station cost and performance data to NREL's Technology

Validation program, and participating in the Hydrogen Safety Panel coordinated by the Pacific Northwest National Lab. Her team also works with ARB to produce the annual reports required by AB 8, the first of which was published in 2015 and entitled “Assessment of Time and Cost Needed to Attain 100 Hydrogen Refueling Stations in California.” She presented several charts from the report showing how installed capital costs for hydrogen stations have decreased over time and network utilization has increased. This was followed by an overview of ongoing and future projects being considered by her team, including improved human interface systems at the point of sale, improved fuel quality testing capabilities, continued improvement of standards and protocols, and mobile fuelers.

>>see full presentation at https://www.hydrogen.energy.gov/pdfs/htac_apr16_04_baronas.pdf

Discussion

- Mr. Koyama asked about the cost of a mobile refueler and if the CEC sees a role for them in accelerating the ability to service a larger amount of vehicles in the near term.
 - Mr. Baronas replied that they paid \$1 million for the mobile refueler they purchased in 2014 (with an additional \$600,000 private sector cost share), which carries 128 kg of hydrogen (compared to about 230kg for a standard tube trailer). She noted that California sees the best approach as a combination of mobile refuelers and local stations, with the stations serving as “anchor points” and sources of local pride, and mobile refuelers primarily serving as substitutes for the local station during times of planned maintenance or unplanned outage.
- Dr. Satyapal asked Ms. Baronas what assistance she thinks has been most valuable from DOE to date, and what additional help is most urgently needed.
 - Ms. Baronas replied that the technology validation work conducted by NREL through the National Fuel Cell Technology Evaluation Center (NFCTEC) has been invaluable, and is a great resource for the state. She said she often refers people to the NFCTEC website and the composite data products there when they have questions. She also values the ready availability of DOE staff and their quick responses to questions or requests for information. Help from Sandia National Laboratories in understanding hydrogen embrittlement and related safety issues has also been of value.
 - Ms. Dunwoody added that the most urgent technical need is getting the capability to detect and appropriately respond to contaminants in the hydrogen fuel (in-situ, on-line).
- Mr. Freese asked about the source of the data in Ms. Baronas’ presentation showing a maximum 75% availability of the stations in the network.
 - Ms. Baronas said that this figure is an average developed on the basis of extensive analysis.
 - Mr. Freese suggested that she also report data on the maximum and minimum availability, to help people understand how much variation exists in the network.
- Mr. Novachek asked if there have been issues getting insurance for the stations.
 - Ms. Baronas replied that this was an issue initially, but she has not heard anyone mention this as a problem for the last two years.

6. Worldwide EV Policy: Best Practices to Promote Electric Vehicles, Nic Lutsey, The International Council on Clean Transportation (ICCT)

Mr. Lutsey provided an overview of the U.S. city electric vehicle project, a study he led for the ICTT that was published in the 2015 report “*Assessment of leading electric vehicle promotion activities in United States cities.*” He showed some of the results of this work including: electric vehicle activity across 25 U.S. cities, actions to promote electric vehicles broken down by category for each city, and a comparison of charging infrastructures in various locations. He presented a summary slide of the 25 U.S. cities selected for the study, showing their EV uptake, chargers per capita, and EV promotion actions. He pointed out that San Francisco tops the list, with the highest new EV sales share, second most extensive public electric charging infrastructure, and 23 of the 30 identified EV promotion actions. The findings confirm that EV promotion

actions (such as consumer incentives, charging infrastructure, vehicle model availability, and city non-monetary benefits) accelerate EV adoption. It also confirmed the importance of an “ecosystem approach” that includes promotion actions from multiple players, including cities, states, utilities, automakers, consumers, and local businesses. Mr. Lutsey presented a breakdown of global EV sales in 2015 by automaker and country, and showed how EV uptake is higher in locations where incentives are higher, with sales being highest in locations with a combination of national and regional support policies. Next, he presented on the newly established International Zero Emission Vehicle (ZEV) Alliance, which includes 14 governments (four European countries, eight U.S. states, and two Canadian provinces) to collaborate and share best practices and policies towards a target of 100% electric vehicle sales by 2050. Lastly, he presented the results of a survey of experts (in both the U.S. and Germany) on obstacles to the adoption of electric drive vehicles, and showed how responses to the questions varied by vehicle (BEV, PHEV, and FCEV).

>>see full presentation at https://www.hydrogen.energy.gov/pdfs/htac_apr16_05_lutsey.pdf

Discussion

- Mr. Kaya asked whether the ICCT has tracked any policy activity or effects thereof relating to grid connectivity of the EVs and their ability to provide ancillary services.
 - Mr. Lutsey replied that this is an increasing area of interest and conversation in the international community, but they have not specifically looked into this in any of their studies.
- Dr. Ogden asked if they had collected data or made any correlations on the number of chargers available per EV.
 - Mr. Lutsey said that there does not seem to be a correlation between number of chargers and rate of EV uptake. He said that the number of chargers available per EV varies from region to region, city to city, but on a national level it's about 1:10.

7. Impacts of Incentives and Policies: Policies to Promote Alternative Fuel Vehicles --

What can we learn from the literature?, Dr. David L. Greene, Howard H. Baker, Jr. Center for Public Policy, The University of Tennessee

Dr. Greene began by discussing the public policy challenge of creating a transition to AFVs, noting that these changes are complex and can take decades. He listed key barriers as reducing the cost of vehicles, reducing the cost of refueling, increasing the value of the vehicle, and building the fueling infrastructure. He presented findings from a number of reports that reviewed lessons learned from past AFV policies and hybrid sales data, and summarized lessons learned on AFV adoption rates with respect to the impacts of different factors. These factors included availability of financial incentives and non-financial incentives, attitudes on environmental issues, advertising/level of consumer awareness, fuel availability, and fuel prices. Dr. Greene presented findings from a number of studies looking at strategies for supporting early alternative fuels infrastructure. He showed data comparing the number of refueling stations/chargers in the U.S. for the different types of alternative fuels, and presented a matrix of the different policy strategies being implemented by countries with a high share of EV sales. He pointed out that leading cities in EV deployment tend to be in states that have adopted California's ZEV requirements, since mandates for manufacturers to sell ZEVs motivate car makers to both market ZEVs and engage in solving the “chicken or egg” infrastructure problem. He also emphasized the importance of engagement at multiple levels by state and local governments and organizations. Dr. Greene summarized some of the major lessons from literature on investing in refueling infrastructure, and presented his opinions on the most effective policies for supporting a transition to AFVs, noting that a multi-dimensional combination of policies is needed.

>>see full presentation at https://www.hydrogen.energy.gov/pdfs/htac_apr16_06_greene.pdf

Discussion

- Mr. Freese noted that Dr. Greene’s research identified the cost of conventional fuel (gasoline) as a major driver for adoption of AFVs. He asked how Dr. Greene would explain the large number of Tesla pre-orders given the current low gasoline prices.
 - Dr. Greene offered his opinion that Tesla has developed a very unique niche in the market, by establishing themselves as a luxury brand that conveys a certain status and has a reputation for high quality and high satisfaction. This created a big demand for the product when vehicles were offered in lower price ranges. He agreed that sales of other EVs are likely to fall off some with lower gas prices, but suggested that consumers understand that gasoline prices will fluctuate whereas electricity prices have remained fairly steady year-over-year.
- Ms. Gobin noted that Connecticut has adopted California’s ZEV regulations and is currently grappling with trying to get more EVs into the market and on the road. She noted that a big barrier to consumers is the higher purchase price an EV (even with the \$3,000 incentive offered by the state) and the fact that their resale value is lower (which also influences the cost to lease the vehicle). Since AFV technology is changing rapidly, a vehicle that’s two or three years old decreases more in value than a conventional vehicle. She asked if any research has been done on how to boost the resale value.
 - Dr. Greene replied that he did not know of any analysis that specifically addressed this issue, and suggested that this is a cost of the transition, since technology obsolescence is really an objective moving forward to more and better AFVs. He suggested that helping consumers understand the energy cost savings might help, since this is a feature that they often don’t fully appreciate.
- Ms. Dunwoody noted that the cost of hydrogen is very challenging, especially in the early stations and particularly given today’s low gasoline prices. She asked if there are lessons from the literature on how to address this. She noted that the automakers are currently addressing this problem by providing free hydrogen as part of the lease, but this is not sustainable.
 - Dr. Greene replied that the literature is not really helpful, and this is a key problem needing resolution going forward.
- Commissioner Scott noted that the market really needs to get engaged to move the needle from 100 to thousands of stations producing lower cost hydrogen. She asked what lessons there are from other infrastructure transitions for kick-starting the market and getting it engaged.
 - Dr. Greene noted that Brazil has successfully established an ethanol fuel infrastructure and a big contributor there was that policies have been pursued persistently over time and adapted to address issues that arise over time.

8. CalCharge: California’s Energy Storage Initiative, Dr. Venkat Srinivasan, Lawrence Berkeley National Laboratory (LBNL)

Dr. Satyapal introduced Dr. Srinivasan, a staff scientist with LBNL and Deputy Director of the Joint Center for Energy Storage Research (the battery “Hub”). She explained that FCTO has looked into some of the innovative partnership models being conducted at LBNL for batteries as potential models for fuel cells tech-to-market efforts. Dr. Srinivasan presented an overview of CalCharge, a public-private partnership established to accelerate battery technology development and deployment in the market. He described how the partnership helps companies, large and small, gain access to the research facilities and expertise of California’s national labs, including LBNL, Lawrence Livermore, and the SLAC National Accelerator. The partnership has also helped the lab researchers to better understand and focus on industry’s needs. Dr. Srinivasan described key features of CalCharge that have enabled these outcomes:

1. A process that enables member companies to begin working with the lab on proof-of-concept tests in as little as 2 weeks, which only requires the negotiation of a non-disclosure agreement.
2. An umbrella Cooperative Research & Development Agreement (CRADA) with the lab, which enables a CalCharge member company to be begin working with the lab in as little as 6-8 weeks.

3. An “embedded researcher” program, under which companies can place one of their researchers at the lab for a period of time or a particular activity.
4. Facilitation of an “ecosystem” that brings California universities, national labs, and companies together to address common problems (including standards and certification) and technology needs. This activity includes an annual event—the Bay Area Battery Summit—that in 2015 attracted 232 attendees (140 from industry) and development of an “Advanced Manufacturing Roadmap.”
5. A professional development program that is focusing on establishing a Master of Science in Engineering with a specialization in Battery Technologies (MSE-Batteries) program at California universities. An MSE-Batteries degree program is now being offered at San Jose State University, and the hope is to extend this to San Diego University and UC-Berkeley.

>>see full presentation at https://www.hydrogen.energy.gov/pdfs/htac_apr16_07_srinivasan.pdf

Discussion

- Dr. Thompson asked what it costs to join CalCharge.
 - Dr. Srinivasan said that there are two different types of membership: General and Charter. General membership annual dues are based on a sliding scale (depending on number of employees or assets under management) and range from \$2,500 to \$25,000. Charter members pay an additional \$25,000 annually and get additional benefits, including membership on the CalCharge Leadership Council.
 - Dr. Satyapal noted that FCTO hopes to engage with LBNL and CalCharge to expand the partnership’s focus on hydrogen and fuel cells, and she asked the HTAC members for any input on what specific activities would be most useful (e.g., metering, supply chain, H2-at-scale).

9. Metering for Hydrogen Stations: Commercial Hydrogen Measurement and Fuel Quality Requirements, Kevin Schnepf, California Department of Agriculture, Division of Measurement Standards

Mr. Schnepf described the work conducted by the California Department of Agriculture’s Division of Measurement and Standards (CDFA-DMS) to establish attainable specifications and accuracy tolerances for hydrogen fuel dispensers at retail stations. He explained that Federal standards for retail hydrogen dispensers are documented in NIST (National Institute of Standards and Technology) Handbook 44 (HB-44), but most of the current hydrogen metering technology cannot meet these standards. The CFDA-DMS worked with industry, regulators, and other stakeholders to develop California regulations that amend HB-44. The new regulations relax the accuracy standards for hydrogen dispensers installed from now through 2020. The state then worked with NREL to develop a testing device and protocol for determining that hydrogen dispensers are meeting the standards (known as the “Hydrogen Fueling Standards” or HFS). Mr. Schnepf described the current status of field evaluations of stations and summarized the results gathered so far. He explained efforts to develop national uniformity in dispenser testing and certification, which will be considered at the National Conference on Weights and Standards (NCWS) in July 2016. He also discussed the CDFD-DMS efforts to establish methods of hydrogen sale, advertising, and labeling so there is consistency in marketplace, as well as their efforts to develop and put into place hydrogen quality testing capabilities and protocols.

>>see full presentation at https://www.hydrogen.energy.gov/pdfs/htac_apr16_08_schnepf.pdf

Discussion

- Ms. Dunwoody noted that the NCWS accepts inputs on topics that are coming up for a vote, so this is an opportunity for anyone interested to provide input on its decision on whether to accept the California expanded accuracy classes for hydrogen dispensers as part of the national standard.

10. Hydrogen – Providing Infrastructure, Herie Soto, Shell, Hydrogen Technology US

Mr. Soto provided a brief overview of Shell’s experiences in hydrogen station operation and related commercial activities. He reviewed Shell’s 15-year history with hydrogen, starting in 1999 with the formation of Shell Hydrogen, and described a variety of current activities, including Shell’s retail hydrogen fueling stations in California and Germany, plans for stations in the United Kingdom, and ongoing R&D to support the commercial program. He described the H2 Mobility Germany partnership, in which Shell is a member, and its approach of coordinating activities and sharing risk to synchronize station development with increased FCEV rollout (with plans for 400 stations in Germany by 2023). Next, he listed several current challenges for hydrogen station development, but noted that costs are coming down as more suppliers enter the market and more automotive companies announce vehicles. He closed by describing a number of ways that government agencies and regulators can help accelerate and support effective FCEV and hydrogen infrastructure deployment.

>>see full presentation at https://www.hydrogen.energy.gov/pdfs/htac_apr16_09_soto.pdf

Discussion

- Dr. Satyapal asked if Shell is thinking of focusing more on the California market, now that vehicles are being introduced there. She also asked if Shell is interested in the hydrogen energy storage opportunity space, either in Europe or the U.S.
 - Mr. Soto replied that Shell’s commitment to the station in Torrance demonstrates that Shell is interested in the California market. He said that Shell does have several teams that are looking into the opportunities around hydrogen energy storage.

11. Hydrogen at Scale, Dr. Bryan Pivovar, National Renewable Energy Laboratory

Dr. Pivovar briefly described DOE’s “Big Idea” process, in which National Lab teams identify high impact areas for collaborative R&D that are currently underemphasized or missed within the DOE portfolio. Selected ideas are presented at an annual “Big Idea Summit” (held since 2014) and some of these ideas have led to new programs and increased visibility for certain topics. The Hydrogen at Scale (H2@Scale) big idea was developed by a team of eight national labs and has been selected for presentation at the 2016 Big Idea Summit, to be held April 21-22. Dr. Pivovar noted that H2@Scale is strongly motivated by major administration energy goals such as reducing greenhouse gas (GHG) emissions, reducing net oil imports, and generating a larger proportion of electricity from clean energy resources. He explained the major challenges presented by deep decarbonization across all sectors of the economy, and how hydrogen, as a flexible, clean energy carrier is capable of linking our many diverse energy sources to all of our diverse energy applications. He described the vision of the future H2@Scale energy system, which links hydrogen with the electricity grid, renewable power generation, production of fuels and chemicals, and other value-added applications (such as cleaner, more energy efficient metal refining). He discussed and presented data supporting hydrogen’s potential to reduce emissions of GHG and criteria pollutants; provide cross-sector synergetic opportunities, and support the needs of dynamic, variable power systems. He concluded by asking HTAC members for any comments or support going forward, and for any advice on better communicating about the safety of hydrogen.

>>see full presentation at https://www.hydrogen.energy.gov/pdfs/htac_apr16_10_pivovar.pdf

Discussion

- Mr. Leggett commended Dr. Pivovar and the team for the combination of big vision and rigorous analysis evident in the presentation. He stated that he would like to offer any assistance he could from the industry

and private sector side. He noted that this is an important activity, given that it starts to speak to a real hydrogen economy versus point solutions only.

- Dr. Thompson observed that the potential for bringing some of the metals manufacturing industry back to the U.S. (by virtue of cleaner, more efficient manufacturing processes) could provide positive employment and national security impacts.
- Ms. Dunwoody pointed out that the low-carbon fuel standard in California includes renewable hydrogen and allows refineries to use renewably produced hydrogen as a credit towards reducing the carbon intensity of the products they produce. She noted that this is an example of a policy that could drive investments in renewable hydrogen production.
- Dr. Clay asked whether a nuclear pathway for hydrogen production is part of the H2@Scale concept. She also noted that the natural gas pipeline infrastructure is a good hydrogen storage option.
 - Dr. Pivovar replied that production of hydrogen from nuclear power plants, through high-temperature electrolysis or high-temperature thermochemical processes, is definitely part of the long term vision, and brings DOE's Nuclear Energy office in as a stakeholder for the H2@Scale big idea. He noted that multiple DOE offices and crosscutting initiatives have a role to play, and stressed the importance of bringing them in as active stakeholders.
- Mr. Freese also expressed his support for the H2@Scale concept and offered assistance from his team with analysis and messaging, noting that his team had done some simulations of this type of approach in previous years and has slides on hydrogen safety he can share with the team.
- Dr. Oge asked about how this gains traction going forward, in terms of getting additional funding for activities, especially with a new administration coming in.
 - Dr. Satyapal noted that increased visibility, buy-in from DOE stakeholders, and momentum and recognition from outside DOE will be important in future budget formulation and Congressional appropriations processes.
- Several HTAC members noted a number of missing elements from the future H2@Scale energy system graphic presented on slide 8 of the presentation, including direct hydrogen production from wind and solar, innovative low-carbon fossil fuel pathways, novel uses of hydrogen in electrochemical routes for producing fuels and chemicals or in direct thermal energy conversion, and hydrogen capture from various manufacturing processes.
 - Dr. Pivovar agreed, and noted that the goal was not to overcomplicate the graphic, though all of these ideas could be part of the H2@Scale system.
- Dr. Satyapal thanked Dr. Pivovar and the other members of the H2@Scale national lab team for their efforts in developing the concept and presentation. She noted that Dr. Pivovar will be presenting this information at the upcoming IPHE meeting, and that DOE also plans to hold a workshop on H2@Scale at NREL in the fall of 2016, to include international participants. She noted the importance of bringing in utility stakeholders and asked HTAC members for any suggestions on who to involve. She also mentioned that FCTO is expanding its hydrogen and fuel cells jobs analysis, and hopes to have an updated report out later this year.

DAY 2 – APRIL 7, 2016

1. **LBNL Hydrogen and Fuel Cell Activities Overview; Dr. Ravi Prasher; Division Director, Energy Storage and Distributed Resources, LBNL**

Dr. Prasher provided an overview of Lawrence Berkeley National Laboratory (LBNL) and its hydrogen and fuel cell R&D activities. He described LBNL's mission statement and presented an organizational chart showing the lab's main focus areas. Dr. Prasher described LBNL's core competencies in fuel cell technologies and presented some of LBNL's projects and the industry, academic, and other lab collaborators with which LBNL has worked. He presented highlights of several LBNL fuel cell R&D projects, including new catalysts, 1-D intermetallic nanostructures, analysis of fuel cell transport phenomena, multiscale diagnostics of fuel cell membranes, and transport resistance at low platinum loadings. He also highlighted some of LBNL's R&D activities in hydrogen storage including hybrid graphene oxide-metal hydrides and hydrogen storage in metal-organic frameworks. He concluded with a brief overview of LBNL's participation in the Joint Center for Artificial Photosynthesis (JCAP), including a project to develop an integrated device for generating hydrogen from sunlight.

>>see full presentation at https://www.hydrogen.energy.gov/pdfs/htac_apr16_11_prasher.pdf

2. **Sandia National Laboratories (SNL) Hydrogen and Fuel Cell Activities Overview: Dr. Marianne Walck, Vice President, California Laboratory and Vice President, Energy & Climate Program, SNL and Dr. Chris San Marchi, Hydrogen Program Manager, SNL**

Dr. Walck provided an overview of Sandia National Laboratory (SNL), including its history; its locations; the strategic assets that it offers for collaboration with industry; and its collaboration and partnerships with other laboratories, universities, international organizations, and state agencies. She described SNL's energy program and hydrogen programs, summarizing the divisions of each. Dr. San Marchi presented on SNL's hydrogen R&D capabilities, including hydrogen behavior and risk evaluation; development of predictive engineering tools for safety, codes, and standards (e.g. the Hydrogen Risk Assessment Model [HyRAM]); international leadership in materials compatibility; large-scale renewable hydrogen production using solar power; and support for early hydrogen market demonstrations and hydrogen fueling infrastructure.

>>see full presentation at https://www.hydrogen.energy.gov/pdfs/htac_apr16_12_walck.pdf

Discussion

- Dr. Thompson asked how (by what mechanisms) the activities of the laboratories are coordinated.
 - Dr. San Marchi replied that, for collaborative projects currently underway such as H2FIRST, the project participants meet regularly and also receive oversight and guidance from the DOE technology development managers.
 - Dr. Satyapal added that DOE, under Secretary Moniz's leadership, has implemented a number of top-level coordinating mechanisms, including the National Laboratory Director's Council and the development of a core capabilities template.
- Mr. Koyama expressed interest in the Livermore Valley Open Campus (LVOC) concept, and asked what opportunities there are for industry access to the campus.
 - Dr. Walck responded that the intent of the new LVOC buildings is to increase access to universities and industry, by reducing security restrictions in these new facilities. She is not aware of any companies that are resident on the campus yet, but expects that there might be some in the future.
 - Dr. Satyapal added that the LVOC is being considered by DOE as a site for a showcase hydrogen fueling station that could be used for education, training, and testing.

3. Lawrence Livermore National Laboratory (LLNL) Hydrogen and Fuel Cell Activities Overview; Dr. Douglas Rotman; Director, Energy and Climate Security, Office of the Deputy Director for Science and Technology, LLNL and Dr. Salvador Aceves, Energy Conversion and Storage Group

Dr. Rotman provided an overview of Lawrence Livermore National Laboratory: its core competencies, technical workforce breakdown, and focus on national security challenges. He described the importance of getting technologies into the market, and provided examples of the lab's tech-to-market activities, such as technology licensing and successful business start-ups by LLNL scientists. Dr. Aceves presented on LLNL's hydrogen and fuel cell R&D activities, including its partnership with BMW to develop cryogenic pressure vessels for onboard storage of liquid hydrogen; development and operation of a best-in-class test facility that enables cost effective cycle, thermomechanical, permeation, leak, and burst testing of full-scale hydrogen systems; development of hydrogen storage and delivery cost models in partnership with Argonne National Lab; development of a system for thermal compression of liquid hydrogen to eliminate the need for compressors at 700-bar hydrogen refueling stations; the lab's participation in the EERE HyMARC consortium tasks addressing thermodynamic and kinetic issues in solid-state H₂ storage; and computational research supporting advancement of photoelectrochemical hydrogen production in collaboration with the University of Hawaii and NREL.

>>see full presentation at https://www.hydrogen.energy.gov/pdfs/htac_apr16_13_rotman.pdf

Discussion

- Ms. Dunwoody asked if the lab is looking into applications for the cryogenic vessels for larger vehicles, like medium- or heavy-duty trucks.
 - Dr. Aceves replied that the lab is looking into this, and the advantages of the systems should in fact improve as you move to larger vehicles.
- Commissioner Scott asked about the status of the thermal compression technology.
 - Dr. Aceves replied that the technology is still in the research stage – LLNL is currently modeling the system to optimize the design, but hopes to conduct a technology demonstration in the near future at their hydrogen test facility.
- Dr. Lipman relayed his experience visiting the hydrogen test facility several years ago and seeing the simulation of hydrogen safety incidents. He noted that this might be a useful educational tool, so people can witness what happens during incidents.

4. Empowering the Hydrogen Economy -- Telecom Backup Power: Fuel Cell Export Potential; Marshall Towe, Founder and CEO, Cascadian Energy

Mr. Towe provided an overview of Cascadian Energy, a clean energy solutions integrator and managed energy service provider with offices in Singapore, Australia, Bangladesh, Indonesia, Pakistan, Myanmar, and Vietnam. He noted that Cascadian has implemented and manages more stationary fuel cell sites than any other company, providing over 2 million hours of energy and producing in excess of 5,300 megawatts of clean power while abating more than 17,000 tons of carbon. Mr. Towe presented a snapshot of the growing wireless industry and the opportunity for fuel cells to provide off-grid and back-up power to wireless network sites. He described the opportunity for fuel cells in Indonesia's telecom sector, which emitted an estimated 60 million metric tons of CO₂ through its extensive use of diesel generators. He described details of the business model used by Cascadian, which is to sell a "managed energy service," in which they provide a turnkey system with (typically) a 5- to 7-year contract for power at a fixed price and a guaranteed availability of 99%, with low or no up-front capital expenses, operating expenses, or maintenance requirements. This de-risks the technology for the customer, and has been very successful in their target markets in Asia and Australia.

>>see full presentation at https://www.hydrogen.energy.gov/pdfs/htac_apr16_14_towe.pdf

Discussion

- Dr. Ogden asked about how the solar/fuel cell hybrid systems work, and if the fuel cell supplies energy when the sun isn't shining.
 - Mr. Towe replied that batteries are the first back-up system, and if they are depleted, the fuel cell turns on to provide power and re-charge the batteries. He noted that the systems are designed for an average of 180 hours/month of fuel cell use, but that during the rainy season, the fuel cells will sometimes run 24-7 for an entire month.

5. H₂USA Update: Morry Markowitz, Fuel Cell & Hydrogen Energy Association (FCHEA), Steve Ellis (Honda), and Lance Atkins (Nissan)

Mr. Markowitz provided an update on H2USA activities, and noted that membership has increased to 50 organizations with the recent addition of United Hydrogen and Hydrogen-XT. He reviewed the organization of H2USA around 4 active working groups – 1) Market Support and Acceleration, 2) Locations Roadmap, 3) Investment and Finance, and 4) Hydrogen Fueling Station Working Group – overseen by an Operational Steering Committee. He introduced the Chairs of the H2USA working groups, who provided updates on recent activities via phone. Highlights included the planned opening of a hydrogen fueling station on National Park Service land in Washington DC, development of new outreach and training materials, progress on new models to help state and regional organizations with decision-making about station deployment timing and siting, development of two investment analysis tools, and facilitating station improvement and deployment through coordination with H2FIRST (the DOE Hydrogen Fueling Infrastructure Research and Station Technology project).

>>see full presentation at https://www.hydrogen.energy.gov/pdfs/htac_apr16_15_markowitz.pdf

Discussion

- Chairman Novachek asked if the H2USA sees any indications that the Northeast states are willing to commit funding levels to hydrogen infrastructure proportionate to that in California.
 - Mr. Wimmer noted that Toyota is partnering with Air Liquide to construct 12 stations over the next year-and-a-half in five northeastern states: New York, New Jersey, Connecticut, Rhode Island, and Massachusetts. He said that these stations are being built with private funding, and these states do not yet have hydrogen infrastructure incentives in place. He also noted that there are some unique regulatory challenges in the Northeast.
 - Mr. Ellis replied that one of the goals of the H2USA Locations Roadmap working group is to help state decision makers understand what the “ask” is – where it would make sense to locate hydrogen stations, when, in what numbers, and why.
- Commissioner Scott commended the H2USA working group members for their efforts, and noted the importance of communicating that FCEVs are here and now. She supported the suggestion to put together communication materials (e.g., slide deck, talking points), and urged collaboration among H2USA, FCHEA, DOE, and others on that effort. She said that financial institutions should be considered as an audience for these materials, particularly with information on what the technologies cost.
- Mr. Freese noted that the fundamental challenge is how to make hydrogen and fuel cells economical in the near term, so that it can grow into a profitable market. He suggested that H2@Scale could move the needle by expanding the markets and applications for hydrogen and fuel cells, and this could perhaps be an area of collaboration between H2USA and HTAC. Dr. Thompson suggested that an HTAC subcommittee focused in this area may be warranted.

6. 2015 HTAC Annual Report Discussion

Dr. Lipman led a discussion of the draft 2015 HTAC Annual Report. Highlights of the discussion are presented below.

- The initial goal set in fall 2015 was to have a complete 2015 HTAC Annual Report drafted by March 31, 2016.
- The 2015 HTAC Annual Report is intended to reflect on the goals established in Section VIII-Hydrogen of the Energy Policy Act of 2005 (EPACT).¹ Dr. Lipman read the goals set for vehicles and infrastructure in the Act, as follows:
 - **For vehicles**, the goals of the program are (A) to enable a commitment by automakers no later than year 2015 to offer safe, affordable, and technically viable hydrogen fuel cell vehicles in the mass consumer market; and (B) to enable production, delivery, and acceptance by consumers of model year 2020 hydrogen fuel cell and other hydrogen-powered vehicles that will have, when compared to light duty vehicles in model year 2005, (i) fuel economy that is substantially higher, (ii) substantially lower emissions of air pollutants, and (iii) equivalent or improved vehicle fuel system crash integrity and occupant protection.
 - **For hydrogen energy and energy infrastructure**, the goals of the program are to enable a commitment not later than 2015 that will lead to infrastructure by 2020 that will provide (A) safe and convenient refueling; (B) improved overall efficiency; (C) widespread availability of hydrogen from domestic energy sources through (i) production, with consideration of emissions levels; (ii) delivery, including transmission by pipeline and other distribution methods for hydrogen; and (iii) storage, including storage in surface transportation vehicles; (D) hydrogen for fuel cells, internal combustion engines, and other energy conversion devices for portable, stationary, micro, critical needs facilities, and transportation applications; and (E) other technologies consistent with the Department's plan.
- Dr. Lipman asked for feedback on the following statement in the draft HTAC Annual Report: "It is clear that much progress has been made toward these goals, and the 2015 commitments have been met in principle. However, it is also important that an explicit plan, including progress milestones, should be provided in 2016 to 2017, for how the 2020 goals will be met."
 - Dr. Oge asked what the definition of "mass market" is, noting that while California is in itself a massive market, it is only one state. She suggested the Committee recommend that DOE take steps to accelerate the build-out in other states to achieve a national market. She disagreed that the 2015 goal has been "met in principle," since vehicles are only being offered to the U.S. consumer market in California.
 - Dr. Ogden said that in her view, the phrase "enable a commitment" implies that by 2015 automakers should have at least some cars ready to compete in the mass market; not that they have to be adopted yet, or even that they would have to be adopted throughout the whole country. She agreed that it is important to convey that a concrete action plan will be needed to meet the 2020 goals, and that it would be fair to say that the achievements so far are "fragile" without ongoing support and commitment from the government.
 - Ms. Gobin agreed with Dr. Oge, and added that it is not enough to have the technology available; it must also be cost competitive, which it is not today.
 - Mr. Freese noted that for FCEV costs to come down, economies of scale are needed; and for scale to be achieved, the supporting refueling infrastructure must be there. He suggested that getting to scale as quickly as possible is the only way out of the "valley of death."
- Dr. Oge offered two additional suggestions: 1) that HTAC recommendations be included in the Annual Report itself, not just in the cover letter to the Energy Secretary and 2) that the report include a graphic that clearly shows the progress made over the last 10-15 years (e.g., progress in the cost of a FCEV).

¹ Public Law 109-58, Energy Policy Act of 2005, August 8, 2005, <https://www.gpo.gov/fdsys/pkg/PLAW-109publ58/content-detail.html>.

- Mr. Koyama and Ms. Dunwoody agreed that a key issue is that infrastructure development/deployment lags fuel cell technology development/deployment. While automakers may be ready to offer FCEVs commercially, and are doing so in limited markets, they will not move anywhere close to mass market deployment until more infrastructure is in place.
- Commissioner Scott suggested that a one-page “Executive Summary” be developed for the report. She also asserted that while there is a long way to go to establish full market acceptance, hydrogen FCEVs have come a long way over the past 10 years, and this should be recognized in the report.
- Mr. Leggett stated that it is important to think about the role of policymakers and the private sector, and how they interact. He suggested that the most important role for policymakers in the transition is to 1) establish the “rules of the road” with a clear roadmap over an extended period of time and 2) provide guidance the economic returns that can be expected if the rules of the road are followed. The private sector will pick it up from there. He also noted that the progress in California is a state-level success, and can largely be attributed to the concerted actions of the state. Federal policymakers should pick up on lessons learned from California if they want to enact change at the national level.
- Dr. Ogden suggested that the report include some specific data on the progress made in California over the last 10 years (# stations, # vehicles, etc.).
- In response to a question from Chairman Novachek on whether the 2020 goal can be met for “widespread availability of hydrogen from domestic energy sources,” Dr. Ayers replied that, with current policies and funding resources, she does not think the goal could be met by 2020. She said that with significantly higher levels of funding and incentives, a 2020 goal could be met.
- Ms. Dunwoody cautioned against characterizing the progress in California as a “success.” She agreed there have been a lot of achievements that have enabled California to get the ball rolling, but there is a lot more work and a lot of challenges remaining to make the hydrogen and FCEV markets self-sustaining. She suggested that the EPACT writers probably intended the commitment to infrastructure be made by oil companies or other big energy service providers, but that hasn’t happened. So far, it has been the states, and to some degree the automakers, that are footing the bills. She added that the reason California decided to commit to early infrastructure was the commitment by automakers to deliver FCEVs if the stations were there to support them. She noted that widespread build-out will require investment and participation by the private sector.
- Mr. Markowitz noted the importance of extending the federal tax incentive, which is scheduled to expire next year, as well as addressing near-term problems such as regulations in New York and New Jersey preventing the transport of hydrogen through tunnels.
- Dr. Thompson suggested that, with regard to incentives, it might be useful to include a figure using data cited in Dr. Greene’s presentation documenting the impact and value of incentives.
- Responding to a question from Dr. Thompson on whether all the key R&D achievements were addressed, Dr. Lipman acknowledged that he did not have time to do a deep dive on R&D, and suggested that perhaps this job be tasked out to someone other than the report coordinator next year.
- Chairman Novachek suggested the Executive Summary include a summary of the conclusions and recommendations. He also suggested including some discussion of H2@Scale, and the flexibility hydrogen offers for meeting energy needs in many sectors of the economy. The members agreed to use the concept figure presented in Dr. Pivovar’s presentation, as long as it was appropriately captioned as a simplified concept diagram (i.e., not the complete picture). Mr. Freese agreed and suggested that the HTAC make a recommendation that DOE should actively pursue the H2@Scale concept as a “big idea.”
- Dr. Lipman asked the members to send him any suggested text for the conclusion section by email. He asked for any additional comments within 2 weeks. He will incorporate those comments and today’s discussion into the next and final draft. The goal is to have the report finalized by late May or early July.
- Chairman Novachek also asked members to send him (with copy to entire HTAC) any suggested language for specific recommendations to include in the Annual Report and/or cover letter to the Secretary.

7. Comments on the DOE Hydrogen and Fuel Cells Program Plan

- Chairman Novachek asked the Committee members to reflect on the written comments that were already provided to DOE by HTAC on the draft DOE Hydrogen and Fuel Cells Program Plan (2016). He asked if they had anything more to add.
- Chairman Novachek recommended that DOE include in the Program Plan a discussion of the development and the advancement of the H2@Scale concept.
- Dr. Satyapal noted that the last letter to HTAC from Secretary Moniz specifically mentioned DOE's anticipation of HTAC feedback on the Program Plan; she suggested that perhaps that could be included in the HTAC Annual Report cover letter.

8. Reports from HTAC Subcommittees

Chairman Novachek asked for reports from the HTAC subcommittee chairs; following are highlights of those remarks and discussion.

Safety and Event Response Subcommittee

- Ms. Dunwoody reviewed the focus of the subcommittee, which is communication regarding hydrogen safety-related events, both immediately following the event and over the longer term to follow up on assessing the event, learning from it, and reporting on it.
- She reported that the subcommittee met recently and has started identifying gaps. She hopes to have a draft report with recommendations from the subcommittee before the next HTAC meeting in September 2016.

Near-Term Fueling Infrastructure Subcommittee

- Mr. Koyama asked whether HTAC is still in support of convening this subcommittee, and to confirm that its focus should include home refueling as well as other technology options for early-market, low-volume refueling (e.g., mobile refuelers; modular, scalable options; etc.).
 - Dr. Ogden suggested that another early market avenue to explore is producing multiple products (e.g., "trigeneration" of heat, hydrogen, and power) from the reformer, especially those sited in neighborhoods or multi-family buildings.
- Ms. Gobin noted that states do not want to spend their very limited funding on fueling (or charging) stations that will quickly become obsolete, especially if those stations require a significant capital investment. If there are smaller scale, lower cost options, those would be welcomed.
- Chairman Novachek asked for volunteers to work with Mr. Koyama on this subcommittee.
 - Mr. Freese said he could assign someone from GM to help.
 - Dr. Lipman volunteered and said he could probably get someone from Honda to participate.
 - Mr. Markowitz said he could assign FCHEA staff to help with logistical or administrative tasks, if needed.
 - Dr. Ogden volunteered to help with the trigeneration piece.
 - Dr. Clay said she would be interested if hydrogen from natural gas is being considered as one of the technology options.

HTAC Oversight Framework

- Chairman Novachek reported that he has held one meeting of the group developing the HTAC oversight framework. He noted that work on reviewing and providing input to the HTAC Annual Report and the DOE Hydrogen and Fuel Cells Program Plan has been helpful for structuring thoughts on the framework. He plans to convene a meeting of the subcommittee after the Annual Report is issued to further develop the framework as a guiding document for future HTAC chairs.

Hydrogen Enabling Renewables Subcommittee

- Chairman Novachek asked if any HTAC members would like to be added to the list of participants in this subcommittee.
 - Additional volunteers included Mr. Koyama, Mr. Kaya, Dr. Lipman, Mr. Leggett, and Commissioner Scott.
 - Dr. Satyapal suggested that it would be useful to include additional utility experts.

Education and Outreach Subcommittee

- Chairman Novachek recalled the HTAC discussion about the need for outreach materials on hydrogen and fuel cells that explain where and how they play a role. He asked if members were interested in forming a subcommittee around that task.
 - Vice Chairman Freese volunteered to lead the subcommittee, and noted that the H2@Scale concept should be a featured part of the communication materials.
 - Volunteers to participate included: Mr. Markowitz, Dr. Thompson, Dr. Ogden, and Dr. Ayers. Dr. Satyapal said that Dr. Oge had indicated an interest, but she had to leave the HTAC meeting early. Dr. Ogden suggested inviting David Green to participate.
 - Dr. Satyapal noted that subcommittee products might be useful for news items that go into weekly bulletins for the Energy Secretary and other senior DOE officials.

New subcommittee on infrastructure

- Dr. Ogden asked if there was interest in doing an update of the 2013 report from HTAC's Infrastructure Subcommittee. She noted that there has been a lot of analysis and progress since 2013, and it might be useful to take a look at that and provide some guidance on how fueling station infrastructure might expand nationwide, beyond the initial 100 stations in California. She offered to chair the subcommittee if others are interested in joining.
 - Ms. Dunwoody volunteered to assign someone from her staff.
 - Commissioner Scott said she could also provide help from her staff.
 - Chairman Novachek asked those interested in this subcommittee to email Dr. Ogden. He also asked Dr. Ogden to produce a brief charter for the group.

9. Other Business and Future HTAC Meetings

- Mr. Alkire reported that the next HTAC meeting has been scheduled for September 21-22, 2016, in Washington, DC.
 - Mr. Freese noted that he can only attend on the 21st, and requested that HTAC business be included on Day 1 of the agenda.
- Chairman Novachek thanked outgoing HTAC member John Hofmeister for his service on the Committee, and his significant contributions as Chair and Vice Chair in previous years. He noted that Mr. Hofmeister has been instrumental in the success of the Committee and has been a solid voice for the community for many years. He also thanked outgoing HTAC member Dr. Richard Carlin for his service on the Committee, and his unique perspectives on Department of Defense R&D activities.
 - Dr. Satyapal agreed, and noted that DOE plans to present Mr. Hofmeister with a plaque for his service as HTAC Chairman.
- Dr. Satyapal reported that she checked with DOE General Counsel (GC) on whether HTAC can address Congress if they were specifically invited to do so. The response from GC was that HTAC cannot make presentations to Congress as an organization, since this type of activity is not included in HTAC's charter. While HTAC as an organization cannot make a presentation to Congress or congressional caucuses, HTAC members are allowed to do so representing their individual organizations or themselves as US citizens.
 - Mr. Markowitz reported that each year, FCHEA organizes a Congressional Fuel Cell and Hydrogen Policy Briefing (for House members and staff on odd years and Senate members and

staff on even years), and they would be happy to include individuals who wish to speak on the agenda.

- Dr. Satyapal concluded the meeting by extending her appreciation to all of the HTAC members for their work on the Committee, noting that HTAC is recognized as one of DOE's most effective advisory committees. She expressed appreciation for their input and recommendations. She noted that terms for individual HTAC members are likely going to be limited to 2-6 years, depending on their role in the Committee. She encouraged departing members to continue to participate in the subcommittees if they are interested in doing so, saying that DOE may be able to cover travel expenses, depending on the situation.
- Chairman Novachek adjourned the meeting at 1:17 pm.

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

PARTICIPANT LIST

April 6-7, 2016

HTAC Members Present

- Kathy Ayers
- Peter Bond
- Richard Carlin
- Kathryn Clay
- Catherine Dunwoody
- Charles Freese
- Anne Gobin
- Maurice Kaya
- Harol Koyama
- Paul Leggett
- Timothy Lipman
- Morry Markowitz
- Frank Novachek
- Joan Ogden
- Margo Oge
- Janea Scott
- Levi Thompson

HTAC Members Not Present

- John Hofmeister
- Drew Kodjak

U.S. Department of Energy Staff

Office of Energy Efficiency and Renewable Energy

- James Alkire (DFO)
- Erika Gupta
- Fred Joseck
- Michael Mills
- Reuben Sarkar (Speaker, remote)
- Sunita Satyapal (Speaker)

Members of the Public in Attendance

- Salvador Aceves—Lawrence Livermore National Laboratory (Speaker)
- Suresh Advani—University of Delaware
- Lance Atkins—Nissan Technical Center, North America (Speaker, remote)
- Jean Baronas—California Energy Commission (Speaker)
- Steve Bohlen—Lawrence Livermore National Laboratory
- Wade Crowfoot—Office of Governor, California (Speaker)
- Tyson Eckerle—Office of Governor, California (Speaker)
- Steve Ellis—American Honda Motor Co. (Speaker, remote)
- Peg Folta—Lawrence Livermore National Laboratory
- David Greene—University of Tennessee (Speaker)
- Sung Johnson—Hydrogen Business
- John Kato—California Energy Commission
- Awais Khah—DOE Fellow Candidate
- Jack Kitowski—California Air Resources Board (Speaker)
- Ahmet Kosoglu—Lawrence Berkeley National Laboratory
- Nic Lutsey—International Council on Clean Transportation (Speaker)
- Bryan Pivovar—National Renewable Energy Laboratory (Speaker)
- Guillaume Petitpas—Lawrence Livermore National Laboratory
- Art Pontau—Sandia National Laboratories
- Ravi Prasher—Lawrence Berkeley National Laboratory (Speaker)
- Jeff Roberts—Lawrence Livermore National Laboratory
- Doug Rotman—Lawrence Livermore National Laboratory (Speaker)
- Chris San Marchi—Sandia National Laboratories (Speaker)
- Ayhan Sarikaya—Saint Gobain Corp.
- Kevin Schnepf—California Division of Measurement Standards (Speaker)
- Herie Soto—Shell Global (Speaker)
- Venkat Srinivasan—Lawrence Berkeley National Laboratory (Speaker)
- John Stevens—Lawrence Berkeley National Laboratory
- Patrick Sullivan—Sandia National Laboratories
- Marshall Towe—Cascadian Energy Solutions (Speaker)
- Marianne Walck—Sandia National Laboratories (Speaker)
- Robert Wimmer—Toyota Motor North America/H2USA (Speaker, remote)

Support Staff

- Judi Abraham—Alliance Technical Services, Inc.
- Dottie Bunn—Bunn & Associates
- Rachel Davenport—Alliance Technical Services, Inc.
- Stacey Foster-Simmons—National Renewable Energy Laboratory