

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

December 12-13, 2018
National Renewable Energy Laboratory Conference Room
901 D Street SW, Suite 930
Washington, D.C. 20024

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DAY 1 – December 12, 2018

The Designated Federal Official, Shawna McQueen, commenced the Hydrogen and Fuel Cell Technical Advisory Committee (HTAC or Committee) meeting at 8:30 a.m. Eastern Standard Time (EST). She noted that HTAC Chairman Charlie Freese designated Vice Chairman Joe Powell to Chair the December 12-13 meeting in his absence. Vice Chairman Powell welcomed new Committee members and opened with an introduction of new and returning members. The full Committee then reviewed and approved the draft agenda.

Presentation summaries and highlights of the discussions that followed are provided below.

1. Opening Remarks: Under Secretary of Energy, Mark Menezes, U.S. Department of Energy (DOE)

Dr. Powell introduced Mark Menezes, Under Secretary of Energy, who provided opening remarks, followed by comments from the Committee.

Under Secretary Menezes praised HTAC initiatives as critically important, and thanked HTAC on behalf of the Secretary for its service and consistent feedback. He recognized the new members and welcomed them, praised the international collaboration, and noted the recent Hydrogen Energy Ministerial held in Japan. He acknowledged the legislation that established the Committee (Energy Policy Act of 2005 [EPACT], Title VIII) and the importance and continued relevance of the goals that it established. He emphasized that DOE management comes from a diverse background in industry and utilities, providing an opportunity for working across traditional silos to accelerate technology development, including in hydrogen and fuel cells. He stressed the urgency of independence from imported oil and the role that DOE and the national laboratories play in conducting research that private industry does not undertake.

- Mr. Markowitz highlighted industry accomplishments in the United States (U.S.) noting that there are currently three different fuel cell electric vehicles (FCEVs) on the road, but emphasized the need for continued DOE support.
- Dr. Ayers added that H2@Scale is incredibly important for hydrogen as a fuel. She noted that it is important to maintain the H2@Scale focus and utilize technologies (e.g., electrolysis technology) available in the U.S.
- Dr. Powell remarked that taking advantage of export technologies in the U.S. benefits the domestic workforce. He also commented that it will be important to keep hydrogen storage technology on par with battery electric technologies and asked Mr. Menezes what the Committee can do to help maintain funding commitments, especially when looking at a larger scale.
 - Mr. Menezes said the Department will evaluate all strategies for accelerating technology development, and decision makers need to know which applications are viable in order to make funding decisions.
- Mr. Novachek noted that DOE is working with utilities to explore large-scale energy storage and cost reductions for electrolysis, which could be partnered with renewable generation to make energy available as needed. Examining existing markets for hydrogen can generate impetus.
- Dr. Rogers commented that hydrogen for back-up power is potentially a big market for the U.S. Department of Defense, as battery or fuel cell power supports greater resiliency and greater power recovery potential in the field.

- Ms. Ffolkes noted that more public sector support for infrastructure development would be helpful. While industry is committed to invest, it is costly to deploy steam methane reformers, distribute the feedstock, and obtain permits.

2. Welcome from EERE Senior Management: Michael Berube, Acting Deputy Assistant Secretary for Transportation and Steven Chalk, Acting Deputy Assistant Secretary for Renewable Power and Energy Efficiency

Mr. Chalk and Mr. Berube introduced themselves and their new positions within EERE. Mr. Chalk commended Dr. Sunita Satyapal and her team on running one of the most impactful programs at DOE in terms of output per research dollar invested. Mr. Chalk noted that Title VIII of EPACT initially focused on transportation, but also includes the industrial and electricity sectors. He highlighted the success of fuel cell forklifts and indicated that the Office of Energy Efficiency and Renewable Energy (EERE) would like to find the next opportunity for hydrogen technology applications. He asked for ideas on how to drive costs down and achieve economies of scale. The Offices of Nuclear Energy, Fossil Energy, EERE, and national labs are considering broader systems integrations projects. Mr. Chalk discussed an initiative to explore energy storage more holistically through dispatchable generation. He noted a focus on battery (and other storage) technologies and real-time balancing of the grid, in which fuel cells and hydrogen have a role to play.

- Dr. Powell asked if energy carriers are part of the conversation on energy storage.
 - Mr. Chalk said yes, noting the need to look at multiple energy carriers, redox reactions, efficient liquefaction, etc., which is the heart of early stage R&D for the hydrogen at scale (H2@Scale) initiative.
- Dr. Rogers noted the national security benefits of hydrogen energy—silent mobility, low noise and heat signatures, and low emissions. He noted that the Department of Defense is a beneficiary of DOE’s leadership in hydrogen energy.
 - Mr. Chalk cited DOE’s goal of greater resiliency and using hydrogen for microgrids. Recovery from cyber-attacks or natural disasters are also important applications.
 - Dr. Rogers commended Mr. Berube and Dr. Satyapal on cross-program participation and collaboration.

Mr. Berube noted that one of EERE’s R&D priorities going forward will be on opportunities where technologies can be integrated or combined to produce synergistic effects for improved system performance and lower cost. He identified H2@Scale as a leading example of the opportunity to achieve technological advances by incorporating multiple technologies and applications. He noted that energy affordability will continue to be an emphasis of EERE R&D, pointing out that technologies will not be adopted if they are not cost-effective to consumers. Dr. Satyapal highlighted some of Mr. Berube’s experience in industry and as former Director of the Vehicle Technologies Office and welcomed his insights and future leadership.

3. Fuel Cell Technologies Office Updates, Sunita Satyapal, Director, Fuel Cell Technologies Office, EERE, DOE

>> see full presentation at https://www.hydrogen.energy.gov/pdfs/htac_dec18_01_satyapal.pdf

Dr. Satyapal presented Fuel Cell Technologies Office (FCTO) updates since the last HTAC meeting. The presentation included an overview of the HTAC scope, objectives, and recommendations to DOE; responses from DOE to these recommendations; HTAC annual reports, and other HTAC efforts and

subcommittee activities. Dr. Satyapal highlighted accomplishments of FCTO and its partnerships to date as well as challenges going forward. She indicated that the Committee has had significant influence in the direction and accomplishments of DOE's efforts.

Discussion Highlights

- Dr. Powell asked if FCTO has investigated integrating hydrogen production research with carbon capture and storage.
 - Dr. Satyapal responded that the labs are looking at which regions can produce natural gas (a key feedstock for hydrogen production) and carbon capture and storage.
- There was discussion about the breakdown of current hydrogen fuel costs including delivery and dispensing costs.
 - Dr. Satyapal said that FCTO has conducted analysis for multiple hydrogen production and delivery pathways. She took an action to send the HTAC a 2017 report detailing these cost comparisons.¹
 - Mr. Marsh noted that there are challenges and concerns with the cost of liquid hydrogen, suggesting a review of or DOE collaboration with NASA's work in this area.
- Mr. Novachek highlighted the need for low-cost electrolysis and asked about relevant areas of focus.
 - Dr. Satyapal noted that HydroGEN was established to focus on advanced electrolysis and reducing costs to \$400/kW. H2@Scale targets will be \$400/kW, and eventually \$100/kW.

4. Update on Hydrogen-Related Activities, Brad Williams, DOE Office of Nuclear Energy

>> see full presentation at https://www.hydrogen.energy.gov/pdfs/htac_dec18_02_williams.pdf

Mr. Williams provided an overview of DOE's Office of Nuclear Energy, technical and economic policy, nuclear strategy, and how new opportunities can be explored with hydrogen fuel cell technologies. He cited a need for smaller, scalable, flexible, financeable, and transportable opportunities for hydrogen production.

Discussion Highlights

- Dr. Powell asked Mr. Williams to comment on spent nuclear fuel and rejuvenation.
 - Mr. Williams said currently proposed advanced reactors can reuse fuel, but noted it is cheaper to get the fuel out of the ground. He cited the Yucca Mountain nuclear waste repository, noting the law states if nuclear fuel is used by the government, it must be stored in Yucca Mountain. Funding has been requested by DOE to re-open the repository.
- Dr. Thompson asked about micro-reactor technology and how it relates to gas, fast, and molten salt reactors.
 - Mr. Williams said technologies vary, and the companies developing the technologies keep the information proprietary.
 - Dr. Thompson asked if these are non-water concept reactors, which Mr. Williams confirmed.
- Dr. Powell asked how small the reactors can be.
 - Mr. Williams responded 0.5 MW is currently the smallest reactor, but they could possibly be smaller. Companies like Westinghouse want to tailor the reactor size to the application.

¹ Hecht, Ethan and Pratt, Jpseph, *Comparison of conventional vs.modular hydrogen refueling stations, and on-site production vs. delivery*, 2017: <https://www.osti.gov/biblio/1347655-comparison-conventional-vs-modular-hydrogen-refueling-stations-site-production-vs-delivery>

5. U.S. Hydrogen Roadmap Study, Bernd Heid, McKinsey & Company

>>see full presentation at https://www.hydrogen.energy.gov/pdfs/htac_dec18_03_heid.pdf

Mr. Heid presented on the status of McKinsey's U.S. Hydrogen roadmap study. The presentation provided context of the study including objectives, approach, timeline, next steps, and deliverables.

Discussion Highlights

- Dr. Powell noted Europe is similar to the U.S. in terms of its diverse use of hydrogen and suggested that the Center for Energy Initiatives may provide context for assembling players in a road-mapping exercise.
- Commissioner Scott remarked that she looks forward to the release of the resulting data and findings. She noted the California Energy Commission, California Air Resources Board, and GoBiz would be happy to review and weigh in on roadmap logistics.
- Mr. Heid was asked how McKinsey will coordinate with DOE given the short timeline for this effort.
 - Dr. Satyapal noted that while DOE is coordinating with this effort, it is an industry-led activity. DOE analysis can feed into the report and collaboration and contributions from states, industry associations, and others is also key. She encouraged HTAC members to participate and provide input to the study.
- Dr. Rogers asked if there are considerations to include the Department of Defense.
 - Mr. Heid said military applications are often transferred to the private sector.
 - Dr. Satyapal said she will share the list of companies involved once she has received written approvals from all companies to release their contact information.
- Dr. Ayers asked if the need to scale up production to achieve the \$/kW targets has been addressed in cooperative research and development agreements (CRADAs). She noted that moving from bench-scale R&D to larger-scale production and manufacturing is challenging. Strategies are needed for down-selecting promising technologies and moving them to scale-up efforts so that these innovations can be ultimately be deployed actual systems (electrolyzers, etc.). For materials R&D, once a promising material is identified, there needs to be a pathway for conducting R&D on manufacturing the material.
 - Dr. Satyapal stated that FCTO can look into opportunities to include down-select and scale-up activities as part of the scope of work for its Energy Material Network (EMN) R&D projects.
 - She also noted that DOE's Office of Technology Transitions focuses on technology transfer (from national laboratories) and that the Technology Commercialization Fund helps with commercialization-related activity.

6. Update on Hydrogen Council Activities, Dave Edwards, Air Liquide

>> see full presentation at https://www.hydrogen.energy.gov/pdfs/htac_dec18_04_edwards.pdf

Dr. Edwards presented an overview of the Hydrogen Council, a global CEO-level initiative founded two years ago that leverages businesses to accelerate private investment and achieve the scale needed for hydrogen to be a cost-effective fuel. He discussed the Council's membership, objectives, and strategy, including highlights of key results from the Council's efforts thus far.

Discussion Highlights

- Commissioner Scott asked if the Council is currently engaged with legislators in Washington, D.C. and California. This engagement could help inform the public regarding developments in hydrogen and fuel cell technologies.
 - Dr. Edwards replied that it is up to the individual companies to engage with policymakers. The Council does, however, produce studies and communication materials that can be used.
- Dr. Powell asked how often the Hydrogen Council meets and what the participation requirements are for involved members.
 - The CEO-level meeting is once a year and there are four other check-in meetings throughout the year. Each meeting is focused on different focus areas and recent guidance.
- Mr. Marsh noted that the Council could benefit from additional representation from the broader energy sector, including utilities with expertise in complex projects that span energy sectors.
 - Dr. Edwards replied that the Council expects to bring in more members with a grid-level focus.

7. Hydrogen in Ammonia Manufacturing, Trevor Brown, AmmoniaIndustry.com

>> see full presentation at https://www.hydrogen.energy.gov/pdfs/htac_dec18_05_brown.pdf

Mr. Brown presented an overview of the ammonia industry in relation to hydrogen production from ammonia. He discussed the website ammoniaindustry.com that he launched to provide insights and analysis to the ammonia industry. The presentation focused on the status and advancement of ammonia industry technologies in relation to hydrogen as an energy source/carrier.

Discussion Highlights

- In response to a question from Dr. Powell about liquid organic hydrogen carriers and how the safety of ammonia is progressing relative to the other options for moving hydrogen, Mr. Brown stated millions of tons of ammonia are moved safely every year, despite its toxicity and flammability. Acceptable risks need to be defined and matched to specifications. Ammonia is safely stored every day, and, on product ton per mile traveled, ammonia has better safety records than gasoline.
- Dr. Thompson asked about opportunities for using the Haber-Bosch method using a downstream process and how high pressure, temperature, and financial cost contribute to innovating the method for hydrogen production.
 - Mr. Brown mentioned there is thermochemical, photochemical, and microbial/geological research being done involving ammonia synthesis.
- Dr. Nocera stated the biggest markets for ammonia and hydrogen technologies are in China and Africa. The largest agricultural company in the world is state-owned in China; and, its strategy is shifting towards distributed farming and fertilizer production, which would likely be a good market for electrolyzers with the purpose of producing hydrogen. Dr. Nocera suggested that DOE and the U.S. Department of Agriculture meet to discuss market synergies.
- Dr. Nocera noted that NO_x air emissions are a concern, since NO_x is more heavily monitored than CO₂.
 - Mr. Brown stated the ammonia R&D is heavily invested in preventing NO_x release. NO_x is also present in gas and diesel, and its release is mitigated today so the technology is known and used. Japan is trying to control NO_x release by capturing it and regulating its release to less than 10 ppm.

- Mr. Koyama asked about the cost of the input and output of 1 kg of pure hydrogen vs. ammonia on the world market, excluding capital, and Mr. Brown noted that there is ongoing research into this, including work being done by the Commonwealth Scientific and Industrial Research Organization, an independent Australian federal government agency, and offered to provide additional details on this work.
- Ms. Ffolkes mentioned the footprint to develop that much ammonia is significant.
- Dr. Satyapal noted that a key aim of H2@Scale is to determine where there can be a colocation of hydrogen supply and demand. She noted that hydrogen from ammonia may be suitable in some locations, but a better understanding of costs are needed, and she suggested some technoeconomic analysis showing energy and cost curves.

8. DOE Loan Programs Office. Sydney Schneir, U.S. Department of Energy

Ms. Schneir presented on the DOE's Loan Programs Office (LPO) and its programs relevant to hydrogen and fuel cell technologies. She noted that LPO's Title XVII Innovative Energy Loan Guarantee Program could offer loans for projects associated with FCEV infrastructure. In addition, the Advanced Technology Vehicles Manufacturing Program also helps encourage domestic manufacturing of advanced vehicle technologies such as FCEVs, and can be expanded to include component manufacturers and organizations that are suppliers for those vehicles. She reported that the LPO held a webinar in October 10, 2018, for Hydrogen and Fuel Cell Day and provided an overview of LPO's portfolio of project investments, eligibility for Title XVII clean energy projects, and an overview of the application process. Applications for LPO funds are accepted on a rolling basis.

Discussion Highlights

- Asked if there are restrictions on the minimum or maximum size for a project, Ms. Schneir replied that there are requirements for receiving project funding. She noted that smaller projects may not be well suited for the program given the cost of the application process. She requested that interested HTAC members contact her directly if they have any questions.

9. Shell Hydrogen Refueling Station Cost Reduction Roadmap, Jason Munster, Shell Hydrogen

>>see full presentation at https://www.hydrogen.energy.gov/pdfs/htac_dec18_06_munster.pdf

Dr. Munster presented on Shell Hydrogen's light-duty and heavy-duty hydrogen station cost analysis. The presentation included discussion of hydrogen station economies of scale, breakdown of station costs, and liquid vs. hydrogen distribution considerations. Dr. Munster concluded by stating that Shell is rapidly expanding hydrogen station deployments in the U.S. and globally so production, distribution, and refueling costs can be lowered.

Discussion Highlights

- Dr. Satyapal asked about Shell's high volume "delivered" cost projection of \$2.00/kg hydrogen, and how much of this cost is attributable to delivery vs production.
- Dr. Munster answered that delivery costs are negligible because the hydrogen is assumed to be transported only about 20 km via tube trailer.

- Mr. Marsh asked for the definition of a “high-reliability” compressor in terms of uptime. Dr. Munster replied that Shell considers 95% uptime to be a highly reliable compressor and noted that compressors are still a major factor in the downtime of a station.
- Commissioner Scott stated both Honda and Toyota are paying for the hydrogen fuel fill ups for their estimated 5,000 fuel cell vehicle customers in California. She mentioned California Energy Commission will help fund the Torrance station and emphasized that uptime is important because otherwise people cannot fill their cars.
- Mr. Irvin noted that one option to build hydrogen and vehicle fleet demand (and public visibility) would be for a company like Disney to deploy hydrogen and fuel cell technologies on a big scale at its theme parks. He noted that forward-leaning companies place value on things other than strict capex/opex. For example, fielding a large number of buses and a fueling station at a place like Disney in Orlando, FL would create benefits such as noise and diesel emission reduction.
- Dr. Satyapal discussed the cost of hydrogen fuel cell buses (\$500,000) and reiterated the importance of getting the cost down. For example, the Recovery Act helped to infuse more money into improving fuel cell forklifts, which lowered the overall cost to the point where the market for this product is now sustainable without subsidies. She also asked the Committee members and speaker what R&D should be priority for DOE to work on, such as improving compressors or more efficient electrolyzers. Additionally, DOE needs to leverage the private sector to further the technology and reduce costs.

10. HTAC Subcommittee on U.S. Competitiveness, Hal Koyama, HTAC Member

>>see full presentation at https://www.hydrogen.energy.gov/pdfs/htac_dec18_07_koyama.pdf

Mr. Koyama presented on the HTAC Subcommittee on US Competitiveness (the Subcommittee) in the fuel cells industry. He noted that the Subcommittee is focused on exploring U.S. competitiveness in hydrogen and fuel cell technologies, with the technology scope being hydrogen production and infrastructure technologies for low-temperature polymer electrolyte membrane fuel cells in stationary and mobile applications. The Subcommittee found that historically, North America, the European Union and Japan have led the bulk of technological advancement in hydrogen and fuel cell technologies. He noted that China is making significant investments to adopt hydrogen and fuel cell technology. The U.S. is currently at a “tipping point” for making key decisions to secure its competitive technical and commercial advantage in this market.

Discussion Highlights

- Gary Flood noted that the Chinese government is spending heavily on buying fuel cell buses and is subsidizing FCEVs (including the cost of fuel), but lacks technological prowess in hydrogen production and distribution technologies. He stated that China has instituted policies that make the cost of FCEVs lower for consumers. A lack of hydrogen infrastructure is a major roadblock in China. He noted that the U.S. still holds the technical advantage, but lacks the financial commitment.
- Ms. Ffolkes commented that there isn’t good communication from original equipment manufacturers (OEMs) about how many vehicles they expect to have in production and what the real demand for hydrogen is expected to be.
- Mr. Marsh stated that China aims to dominate the electric vehicle market and leapfrog combustion engines and liquid fuels. He noted that China did this in the telecommunications industry by going to wireless technologies instead of wired technologies.

- Dr. Satyapal noted the Zero Emissions Vehicle (ZEV) mandate helped drive efforts: key policies, priorities, and R&D can still incentivize and make progress. She suggested the Defense Production Act may provide a mechanism to help incentivize further build-up of scale to ensure the U.S. role in the future of hydrogen markets.
- Dr. Rogers said there may be opportunities for hydrogen in U.S. military applications, though the scale of those deployments would be limited. Though the military has a single-fuel policy to simplify logistics support for deployed forces, there may be potential for considering secondary or alternative fuel sources such as hydrogen, particularly in remote or hard-to-get-to locations. Technologies used in military applications are required to be manufactured in the U.S. per the Defense Production Act.
- Dr. Ayers commented that at-scale manufacturing technologies are needed: robotics, 3D printing, and other advanced manufacturing technologies that can help enable cost reductions and strengthen the U.S.' supply chain.
- Mr. Marsh remarked that the U.S. needs a secure, low cost, reliable supply of membrane electrode assemblies (MEAs) and the ability to manufacture them. U.S. OEMs are relying on foreign sources of MEAs (i.e., Johnson Matthey, Wuhan).
- Mr. Koyama urged that the U.S. needs to think about how to move through the next "S" curve of technology development/commercialization.
- Dr. Satyapal noted that some other countries have addressed demand by coalescing a number of companies together (e.g., H2 Mobility in Germany and Jaheem in Japan)
- Mr. Flood stated that OEMs are experts at systems integration and China is developing its own stack development teams by pulling talent from companies in the U.S., Canada, and Germany.
- An HTAC member also noted that the 2018 Foreign Investment Risk Review Modernization Act (FIRRMA), and its reforms to the Committee on Foreign Investment in the U.S. (CFIUS) could affect U.S. competitiveness in certain regions or technology areas going forward.

Dr. Powell adjourned the December 12 meeting at approximately 5:00 p.m. EST.

DAY 2 – December 13, 2018

Dr. Powell began the meeting at 8:30 a.m. EST.

11. HTAC Business and Discussion of Other Key Items

Recognition of Former HTAC Members

- The HTAC commended the participation and contributions from former HTAC members who have recently departed the Committee, including Anthony Eggert, Timothy Lipman, Catherine Clay, and Adele Ratcliff.
- ***Honoring Dr. M. Sam Mannan:*** the members offered condolences for the loss of Dr. Sam Mannan and expressed their appreciation for his efforts on the HTAC and for his broader body of work in industrial process safety. To honor the legacy of Dr. Mannan, Texas A&M University Department of Chemical Engineering has established an endowed scholarship in his name.

Scheduling Next HTAC Meetings

The Committee members discussed the format for future meetings, and agreed to try a long, one-day format rather than two-day meetings. The March 19, 2019, in Washington, DC will begin around 8:00 am and end around 6:30pm.

- The Committee also agreed to hold the fall HTAC meeting on November 4, 2019, in Long Beach, California, to take advantage of proximity to the Fuel Cell Seminar, November 5–7, 2019.
- The Committee tentatively chose March 9, 2020, for the spring HTAC meeting in Washington, D.C.
- Members were encouraged to submit any comments on the minutes from the November 2, 2018, webinar to Shawna McQueen as soon as possible.

HTAC Subcommittee Planning

Members discussed membership and planning for subcommittees, with actions and members recorded as follows.

- HTAC 2018 Annual Report Subcommittee
 - Chair: Joe Powell
 - Members: Frank Novachek, Nick Irvin, Henry Aszklar, Kathy Ayers, Hal Koyama, Charlie Freese
 - ACTIONS: prepare draft report for review by HTAC at March 19 meeting
- HTAC Subcommittee on US Competitiveness
 - Chair: Hal Koyama
 - Members: Kathy Ayers, Frank Novachek, John Mizroch, Morry Markowitz, Levi Thompson, Dan Nocera, Paul Leggett, Gary Flood (consultant)
 - + new members: Andy Marsh, Henry Aszklar
 - ACTIONS: Develop revised report and recommendations for DOE, for review by HTAC at March 19 meeting
- HTAC Leadership Subcommittee
 - Chair: Charlie Freese (HTAC Chairman)
 - Members: Levi Thompson, Marie Ffolkes
 - ACTIONS: No immediate actions. Members will help identify candidates for next HTAC Chair when needed.

Review of Tokyo Statement/Japan Ministerial and IPHE (International Partnership for Hydrogen and Fuel Cells in the Economy) Activities

- Dr. Satyapal noted that the statement from the Hydrogen Ministerial, held in Japan in October 2018, is provided in HTAC briefing materials. She requested input on concrete follow-up actions the DOE could take to respond to the Tokyo Statement’s agenda for increased international collaboration to accelerate progress.
- She also noted that DOE has assumed the role of Chair for the IPHE (with 18-member countries and the European Commission). The IPHE currently has two active working groups: (1) Regulations, Codes, Standards, and Safety (RCSS, with “Safety” recently being added to the working group’s scope) and (2) Education and Outreach. She noted that work of the RCSS will help foster harmonization of regulations and standards. This activity will also include China as they begin to develop their own markets and technologies for hydrogen and fuel cells.
 - The RCSS, working with the International Organization for Standardization, the Society for Automotive Engineers, and others, will work to develop a list of all relevant regulations, codes, safety and standards (RCSS) across key countries, and identify gaps and commonalities.
- Members agreed to serve as a resource to DOE for its involvement in these efforts, and will email Dr. Satyapal if they have interest in providing expertise in specific areas. Dr. Satyapal will alert HTAC as opportunities for input arise. Possible activities might include:
 - Requests for participation in or input to the IPHE working groups

- Requests for ideas on specific follow-up actions to the Tokyo Statement or collaborative activities created as a result
- Mr. Koyama suggested that DOE raise awareness within the IPHE member countries about immediately available fuel cell technology applications. He noted that raising awareness in India, Africa, and Southeast Asia could help uptake as they have limited exposure to fuel cells and their benefits.
 - Dr. Satyapal said that the IPHE Education/Outreach Committee focuses on a regional policy forum and efforts are ongoing. She also noted that item #4 in the Tokyo Statement’s agenda focuses on Communications, Education, and Outreach.
- Dr. Satyapal noted that DOE has developed train-the-trainer programs on hydrogen and fuel cell domestic codes and standards which have reached more than 30,000 code officials.

H-Prize Discussion

- Dr. Satyapal reported that several potential topics have been suggested for an H-Prize, but none have been selected. She noted that the Solar Energy Technologies Office launched a “Made in America” prize program, and FCTO is considering something similar.
 - HTAC Members were requested to provide prize ideas via email to Dr. Powell.

DOE Hydrogen and Fuel Cells Program Plan

- Dr. Satyapal reported that FCTO is currently drafting an updated version of the Program Plan, and will provide a draft to HTAC for review when it is available.

Suggestions for Future HTAC Meeting Topics

- Dr. Nocera noted the priorities emphasized by Under Secretary Menezes and suggested energy security and resiliency as future HTAC topics, including resiliency for military applications.
 - Dr. Satyapal agreed and noted that other high-level priorities for DOE include cybersecurity.
 - She suggested that Dr. Rogers provide input on DOD-related applications and he agreed to help coordinate this activity.
- Commissioner Scott suggested updates on light-duty vehicle activity and station activity in the Northeastern U.S. She noted that changes with low-carbon fueling standards will impact hydrogen fueling. She agreed to help coordinate activity on this topic.
- Mr. Irvin suggested future meeting topics on utilities/utility themes. He commented that utilities are now considering low-carbon targets and have discussed replacement of some natural gas with renewable hydrogen in combined-cycle fleets. He noted that this approach could be a viable alternative to carbon capture and storage. He also suggested exploring natural gas as a bridge to hydrogen and use of hydrogen as a swing fuel.
 - Dr. Satyapal suggested a report from the Leeds project in the United Kingdom.
 - Mr. Novachek suggested report-outs on the accomplishments of the H2@Scale CRADA projects, as well as the analysis of hydrogen for seasonal energy storage, existing markets for hydrogen, and regional analysis to help better understand the business case for hydrogen.
 - Mr. Irvin agreed to help coordinate this activity.
- Dr. Thompson suggested future topics on other hydrogen energy carriers and carrier technologies. Dr. Thompson and Dr. Powell volunteered to identify speakers on these topics.

- Dr. Ayers suggested topics on non-consumer medium- and heavy-duty transport trucks (e.g., delivery vehicles, buses, tractor trailers) due to the difference in their operational model versus light-duty vehicles.

12. HTAC Subcommittee on U.S. Competitiveness, Hal Koyama, HTAC Member

Continued from Day 1

- Dr. Satyapal requested specific recommendations for DOE from the subcommittee.
- Mr. Koyama noted that the study was of limited scope (current-scale hydrogen production and infrastructure technologies for low-temperature polymer electrolyte membrane fuel cells in stationary and mobile applications), which should be made clear along with any recommendations for follow-up analysis of other markets (e.g., large-scale hydrogen production/distribution, etc.).
- Dr. Powell suggested a “business plan” is needed to convey the economic value of competitiveness in these areas. This should include more clearly defined drivers of competitiveness and estimates on market potential to help prioritize resources in industry.
- Mr. Marsh said the Hydrogen Council has already published a report on the global market and the McKinsey U.S. Hydrogen Roadmap study is supposed to be out by June. These reports can be used for market data and can help shape or guide the Subcommittee’s efforts on a business case.
- Dr. Powell expressed concern that the scope of the initial report did not include large-scale infrastructure issues impacting competitiveness.
- Mr. Koyama specified that the report addresses the initial scope determined by HTAC and that recommendations are largely prioritized by time-sensitivity. He added that the U.S. market is not where the largest demand is currently located; the group should consider domestic and export demand for US intellectual property (IP) and technologies as a means for examining how countries are stimulating production of hydrogen and fuel cell technologies commercially. This is what is attracting U.S. talent and IP overseas and investigating this should be a key priority.
- Mr. Marsh and Mr. Aszklar volunteered to join the subcommittee.
- **ACTION:** The Committee agree that prior to next HTAC meeting the Subcommittee should refine the report:
 - Clearly define scope of effort.
 - Better define the recommendations to DOE (and/or for HTAC follow-up) and prioritize them. Consider reducing the number so there are fewer and define the “top 3” recommendations to take to the Secretary.
 - Provide more on the “why,” and back up the recommendations with business case/tangible benefits and opportunities.
 - Focus on how to leverage FCTO’s current R&D portfolio to achieve the Subcommittees recommendations. Utilize the FCTO multi-year program plan as reference for achieving the goals common to the Subcommittee and FCTO.

13. Key Topics in Public Transportation Research, Sean Ricketson, Federal Transit Authority, U.S. Department of Transportation

>>see full presentation at https://www.hydrogen.energy.gov/pdfs/htac_dec18_08_ricketson.pdf

Mr. Ricketson presented on the Federal Transit Authority’s (FTA’s) research activities, providing an overview of the National Fuel Cell Bus Program, the 2013–2015 Low or No Emission Vehicle Program (LoNo Program), and other relevant activities. He noted collaborations with National Renewable Energy Laboratory on fuel cell bus evaluations and discussed bus testing activities.

Discussion Highlights

- Dr. Thompson asked what the financial obligation is for grant recipients under FTA’s bus program.
 - Mr. Ricketson said transit agencies apply to FTA and sometimes find opportunities for other federal funds, and pool resources with expanded local funding.
- Mr. Marsh asked if FTA is seeing the same results as bus programs in China and inquired about what cost targets fuel cell engines have to meet to be competitive with electric buses.
 - Mr. Ricketson stated they have not studied the Chinese bus fleet, which includes 100,000+ buses, different scale of production, different markets, bus designs, quality, etc. He noted that the U.S. bus market demands 12-year buses. China’s market strategy accepts the use of 3-year buses.
- Dr. Satyapal will send Mr. Marsh the DOE cost targets for fuel cell bus powertrains, available here <https://www.energy.gov/eere/fuelcells/doe-technical-targets-fuel-cell-transit-buses>. The link to the NREL Fuel Cell Bus Evaluation report is here: <https://www.nrel.gov/hydrogen/fuel-cell-bus-evaluation.html>.
- Commissioner Scott asked if the FTA pays for both the bus and fueling infrastructure. She also asked if NREL is analyzing infrastructure data.
 - Mr. Ricketson specified that the LoNo program does pay for bus and infrastructure.
 - Dr. Satyapal indicated that NREL is not currently evaluating infrastructure data, but could consider it in the future.

14. Hydrogen Safety Panel and the AIChE Center for Hydrogen Safety, Nick Barilo, Pacific Northwest National Laboratory

>>see the full presentation at https://www.hydrogen.energy.gov/pdfs/htac_dec18_09_barilo.pdf

Mr. Barilo presented an update on efforts to sustain the Hydrogen Safety Panel (HSP) and the formation of the AIChE Center for Hydrogen Safety (CHS). He described the critical importance of ensuring safety in hydrogen R&D and commercial deployments, and reviewed the history of the HSP and the tools and resources that it developed. He then described the partnership between PNNL and AIChE to form the CHS, a not-for-profit member-supported organization within AIChE that will provide access to previous and future HSP resources and tools. CHS membership and membership benefits was also highlighted.

Discussion Highlights

- Asked about the services provided by the HSP under the new AIChE CHS, Mr. Barilo responded that members of the HSP panel are unbiased and non-regulatory, and their project reviews are strictly advisory.
- Dr. Thompson asked about the “accredited training” mentioned in Mr. Barilo’s presentation.
 - Mr. Barlio replied that the term “accredited” is probably inaccurate, but noted that the Center plans to offer training that provides continuing education credits and noted that first responders have been certified via the online training developed by the HSP.

15. Closing Remarks

Connor Dolan of FCHEA showed a brief video showcasing National Hydrogen Day 2018. Following this presentation, Dr. Satyapal emphasized the importance and impact of HTAC and noted that the U.S. is at a tipping point for hydrogen and fuel cell technologies, so all input and help is critical and valuable. HTAC’s subcommittees and industry engagement are very much appreciated. She also remarked that HTAC is seen

as one of the best of the DOE Advisory Committees and FCTO is seen as one of the best and most effective technology R&D offices.

Dr. Powell adjourned the meeting at 11:30 a.m. EST.

**HYDROGEN AND FUEL CELL TECHNICAL ADVISORY COMMITTEE (HTAC)
PARTICIPANT LIST
December 12-13, 2018**

HTAC Members Present

- Henry Aszklar
- Kathy Ayers
- Inês Azevedo (Remote)
- Marie Ffolkes
- Nick Irvin
- Harold Koyama
- Anthony Leo (Remote)
- Morry Markowitz (Day one only)
- Andrew Marsh
- Daniel Nocera
- Frank Novachek
- Joseph Powell
- Paul Rogers (Remote)
- Janea Scott
- Levi Thompson

HTAC Members Not Present

- Charles Freese
- John Mizroch
- Paul Leggett

U.S. Department of Energy Staff

- Under Secretary Mark Menezes (Speaker)
- Allan Webster

Office of Basic Energy Sciences

- John Vetrano

Office of Energy Efficiency and Renewable Energy

- | | |
|---|--|
| <ul style="list-style-type: none">• Anthony Belvin• Michael Berube (Speaker)• Steven Chalk (Speaker)• Shukhan Chan• Amberlie Clutterbuck• Salil Deshpande• Peter Devlin• Nancy Garland• Laura Hill• Donna Ho | <ul style="list-style-type: none">• Fred Joseck• Nacole King• Maxim Lyubovsky• Jason Marcinkoski• Shawna McQueen (HTAC Designated Federal Officer)• Dimitrios Papageorgopoulos• Neha Rustagi• Sunita Satyapal (Speaker)• Ned Stetson |
|---|--|

Loan Programs Office

- Sydney Schneir (Speaker)

Office of Nuclear Energy

- Brad Williams (Speaker)

Office of Secretarial Boards and Councils

- Darren Bossie
- Michelle Sneed

U.S. Department of Navy Staff

Office of Naval Research

- Leo Grassilli

U.S. Department of Transportation Staff

Office of Infrastructure and Asset Innovation

- Sean Ricketson (Speaker)

Members of the Public in Attendance

- Nick Barilo, Pacific Northwest National Laboratory (Speaker)
- Gerard Conway, Jr., Plug Power, Inc.
- David Edwards, Air Liquide (Speaker, remote)
- Trevor Brown, AmmoniaIndustry.com (Speaker)
- Bernd Heid, McKinsey & Company (Speaker, remote)
- Erin Lane, Cascade Associates
- Leland Cogliani, Lewis-Burke Associates, LLC
- Connor Dolan, Fuel Cell and Hydrogen Energy Association
- Gary Flood, GSF Consulting
- John Michael Parkan, Providence Entertainment
- Jason Munster, Shell Hydrogen (Speaker)
- Mark Ruth, National Renewable Energy Laboratory
- Gary Stottler, General Motors
- Sandy Thomas, retired H2Gen Innovations, Inc.
- Jon Zimmerman, Sandia National Laboratories

Support Staff

- Judi Abraham, Alliance Technical Services, Inc.
- Rachel Davenport, Alliance Technical Services, Inc.
- Kristian Kiuru, Energetics
- Neil Popovich, National Renewable Energy Laboratory