HYDROGEN AND FUEL CELL TECHNICAL ADVISORY COMMITTEE

PUBLIC MEETING MINUTES

September 5, 2012

Webinar

Table of Contents

Note: this two-hour meeting was held by conference call with a live webinar.

1. Introduction and Call to Order

Jason Marcinkoski, U.S. Department of Energy (DOE) Designated Federal Official (DFO), welcomed the meeting attendees and noted that no public comments were submitted for this meeting. Mr. Marcinkoski encouraged that any future comments be submitted to htac@nrel.gov. He also suggested that full introductions of members be made at the upcoming November 2012 meeting, as there are new members on the committee. Mr. Marcinkoski ceded the floor to new Hydrogen and Fuel Cell Technical Advisory Committee (HTAC) Chairman John Hofmeister.

Chairman Hofmeister called the meeting to order and expressed appreciation for the interest and contribution of Secretary of Energy Steven Chu at the May 2012 meeting of HTAC's Hydrogen Production Expert Panel.

2. Public Comment Period

Chairman Hofmeister closed the public comment period as no comments had been submitted.

3. Discussion of "Report from the Steering Committee of the Hydrogen Production Expert Panel (HPEP) to the Hydrogen & Fuel Cell Technical Advisory Committee (HTAC)"

Dr. Levi Thompson, Chair of HPEP Steering Committee, provided a summary of the report that was generated using inputs from the HPEP workshop in May 2012 and moderated the discussion. The purpose of the presentation was not to edit the report, but to review the report and identify erroneous or objectionable content in the report. Comments are to be reviewed and incorporated by Dr. Thompson as appropriate, and the revised report will be sent to Chairman Hofmeister for final HTAC approval and delivery to DOE.

Dr. Thompson provided background on the steering committee, the workshop, and the production of the report.

- The steering committee and technical expert panel were comprised of experts in near- and long-term technologies from industry, academia, and national labs.
- Goals of the workshop were to evaluate, quantify, prioritize, and categorize research and development (R&D) programs focused on hydrogen production.
- After presentations by the technical experts and discussions in breakout sessions, the steering committee and the technical experts met to provide input to an early draft of the report.

The report includes key findings for near-term (commercialization within five years or less) and long-term (longer than five years to reach commercialization) technologies. Dr. Thompson suggested members refer to the draft report for full details but offered a summary.

Current Status:

- Over 50 million tons of hydrogen produced globally per year, enough to run ~250 million fuel cell vehicles per year.
- Hydrogen fuel for vehicles is competitive in price to gasoline: $1.50/kg at large-scale production, and $3–$6/kg in small-scale production.
- Progress in the area of hydrogen production from renewable resources has not kept pace with progress in fuel cells and hydrogen storage.

Near-Term Technology Key Findings:

- Large- and small-scale production technologies are currently commercially available.
- Large-scale hydrogen production is competitive in price to gasoline.

  Discussion:
  - Mr. Prentiss Searles from the American Petroleum Institute (API) asked if cost estimates and comparisons included the dispensing and delivery of hydrogen to stations for use in fuel cell vehicles.
  - Dr. Thompson responded that the estimates reflect full-scale infrastructure and vehicle availability; it is assumed that at scale, each station is sized to meet the demand for the number of vehicles expected to be served.
  - Mr. Anthony Eggert suggested adding information with regard to costs of production at scale.
  - Dr. Thompson replied that the details of the analysis were described in the full report. Dr. Robert Shaw added that the details have been closely scrutinized by reviewers of the report.
  - Mr. Searles asked if the report were publicly available yet.
  - Dr. Thompson responded that HTAC members can view the report, but it's not available to the public yet.

- The principal barriers to cost reduction of distributed production systems are achieving manufacturing on a large scale and expanding markets for fuel cell vehicles and energy storage for renewable energy.
- Current markets for fuel cells in forklift applications and power backup at remote sites, such as cell towers, are supporting learning and scale development.
- Recommendations for near-term technologies that evolved from findings and discussion of the workshop are broken into four categories in the report:
  - Transportation Applications—incentives to encourage early installation of fueling facilities; establishment of an agency similar to Rural Electrification Administration (REA) to ensure availability; cluster approach used for early roll-out of fueling infrastructure; and public/private partnerships to define and guide public and private ventures and safety regulations.

    Discussion:
    - Chairman Hofmeister commented that there was much reflection at the May HTAC meeting on whether transportation infrastructure roll-out should be a Federal initiative or a state-based initiative. Some states are interested in progressing toward hydrogen and fuel cell implementation, e.g., California and South Carolina. Secretary Chu made a good argument for regional roll-out at the National Petroleum Council meeting. Chairman Hofmeister asked whether the HTAC committee has interest in pondering this question more closely.
    - Dr. Thompson suggested that local implementations would be easier to administer and agreed that some states are ready to move forward.
    - Chairman Hofmeister expressed an interest in seeing a national infrastructure roll-out and noted that distribution infrastructures have historically been built locale by locale. Only since 1918 have people been able to drive a vehicle coast to coast, refueling all along the way. History may be repeated in the building of hydrogen

infrastructure. Chairman Hofmeister opined that this topic warrants more discussion.

- Dr. Shaw noted that the committee discussed infrastructure roll-out at one of the dinner meetings at the last HTAC meeting, leading to a conversation in Toronto at the World Hydrogen Energy Conference. As a result, HTAC and petroleum industry members have been considering a novel proposal, which might make an interesting topic at the November meeting.
- Mr. Eggert asserted that the cluster concept should be described as regional deployment with multiple clusters rather than a single cluster, which would be much harder to maintain.

- Hydrogen Production and Storage to Enable Renewables—detailed systems studies with utilities partners; modest scale demonstrations; and generation of data on the hydrogen in natural gas (NG) pipelines.

  Discussion:
  - Dr. Shaw noted that the HTAC subcommittee has worked on two models for energy storage which are planned for presentation at the November HTAC meeting.
  - Dr. Alan Lloyd encouraged the committee to consider the work that is underway in Europe on energy storage issues. Dr. Shaw reminded the committee that Siemens has previously presented on the European work at an HTAC meeting.
  - Mr. Frank Novachek emphasized that (1) the report needs to be clear that high levels of fuel cell vehicle penetration in the market are assumed in the analysis, and (2) the report should indicate that hydrogen energy storage will show value only in high-penetration scenarios, as hydrogen is only competitive with other energy storage options when the duration of energy storage is more than 10 hours.
  - Dr. Kathy Taylor suggested that the report state whether or not the workshop adequately addressed the charge put before the committee.

- Education—dissemination of information regarding hydrogen as energy to the public; informing codes and standards and public safety; publicity for DOE support of hydrogen; development of consensus on roll-out of supply infrastructure and fuel cell electric vehicles.
- Research and Development—improved materials for permeation, strength and ductility issues in membranes; advancements in fuel cells leveraged for use in proton exchange membrane electrolyzers; advancements in cost-reducing balance of plant components; technology needed for hydrogen separation from natural gas.

Long-Term Technology Key Findings:

- The time required to move hydrogen technology from R&D to the commercial market can be very long.
- DOE's program should support as many varied and innovative concepts as possible.
- Need to develop more effective communication between DOE Office of Energy Efficiency and Renewable Energy (EERE) programs and the DOE Office of Basic Energy Sciences (BES).

Discussion:

- Dr. Peter Bond recalled that at one of the first HTAC meetings he attended, there was a presentation from a joint EERE/BES committee that met on a regular basis. Dr. Eric Miller of DOE clarified that EERE and BES staff meet every other month, but the communication between the programs lags behind the technology development. The communications need to be improved.

- Low natural gas prices have a negative impact on implementation of hydrogen production infrastructure.

  Discussion:

  - Chairman Hofmeister asked if there was discussion of the potential of continuously rising oil prices and the effect these prices might have on hydrogen production infrastructure. He noted that Barclays suggests that a price of $180 per barrel of crude oil is likely by the end of the decade. Dr. Thompson replied that oil prices were not discussed at the HPEP workshop and asserted that although increased activity in renewable energy is observed while oil prices are rising, the interest wanes when oil prices drop.
  - Chairman Hofmeister suggested that the HTAC discuss the implications of rising oil prices on hydrogen at an upcoming HTAC meeting within the next year. He also identified the need for HTAC to be briefed on transportation fuel futures by experts with a variety of viewpoints and to determine the implications of transportation fuel price projections on hydrogen for mobile applications. Dr. Shaw suggested that fracking is increasing oil reserve discoveries, reducing concern that oil production is peaking. Chairman Hofmeister refuted this notion, asserting that new discoveries of oil and natural gas are not keeping up with increases in demand and that declines are not accurately reported.
  - Dr. Thompson recalled that concern was expressed during the workshop for the need to award grants and contracts for longer terms so researchers have longer continuous time to develop technologies without worrying about the fluctuations of funding.
  - Mr. Eggert noted the omission of any discussion of coupling hydrogen generation and CO_2 capture and storage. Chairman Hofmeister suggested that CO_2 capture and storage was not discussed because it is most often associated with production of hydrogen from coal, and use of long-chain hydrocarbons for hydrogen production was not a focus of the workshop. Mr. Eggert pointed out that CO_2 capture and storage could be required for centralized production from natural gas in light of recent natural gas supply extensions. Dr. Joan Ogden remarked that she prepared a report in 2008/09 that suggested that coal incurred the lowest cost for large-scale hydrogen production but has scale-up issues associated with carbon sequestration.

- Recommendations for long-term technologies that evolved from findings and discussion of the workshop fall into four main categories:
  - Communication and Guidance—creation of networking team for communication between BES and the DOE Office of Advanced Research Projects Agency-Energy (ARPA-E); DOE assembly of groups to work on specific problems; BES development of stronger links with industry to help with R&D; development of overall roadmap to link near-term and long term efforts.

- Evaluation—definition of metrics for all types of contracts; requirement for R&D programs to develop rough estimates of product costs.
- Programs—evaluation and characterization of biomass waste streams for use as hydrogen production feedstock; DOE exploration of additional concepts for production.
- Policies that encourage longer-term R&D should be considered. Hydrogen production could be used as an example to re-establish the importance of science and technology in the public eye. Policies encouraging longer-term R&D will assure that the nation maintains a leadership position not only in energy research, but in all fields.

Chairman Hofmeister opened the floor with a motion to accept the report, with amendments made directly by Dr. Thompson within the next seven days, for completion and forwarding to Chairman Hofmeister for approval and final delivery to DOE. The motion was supported by Bob Shaw. David Taylor of Air Products seconded the motion.

The motion passed unanimously.

4. Consultation in Establishing the Criteria for the H-Prize Competition

Chairman Hofmeister gave a short history of the H-Prize. The H-Prize was attached to the Energy Independence and Security Act (EISA) of 2007 as an incentive to researchers to participate in hydrogen research. The first H-Prize competition was held in 2010, but no award was granted. Additional excitement, interest, and information in hydrogen research is needed. Mr. Hofmeister welcomed Sarah Studer of the DOE-EERE Fuel Cell Technologies Program (FCTP), who is working on opening a new competition for the H-Prize.

DOE is working with the Hydrogen Education Foundation to establish a new H-Prize competition. The FCTP needs input from HTAC members on the criteria for a potential prize competition. The competition criteria are to foster entries to meet the technology goals. The goal of the H-Prize competition is to encourage breakthrough solutions to enable widespread commercialization of hydrogen and fuel cell technologies.

The previous competition, which began in 2009, solicited "Breakthrough Advances in Materials for Hydrogen Storage," but when the competition was closed in late 2010, no entry met the criteria that had been established for the prize. Thus, no prize was awarded. H-Prize categories may include advancements in technology components and systems, production, storage, distribution, and utilization.

Currently, the FCTP is considering a competition for hydrogen metering to ensure customers get what they pay for. With automobile manufacturers planning to start selling fuel cell electric vehicles in 2015 and commercial hydrogen fueling stations being developed, more accurate meters in fuel dispensers are essential to give stakeholders confidence that customers receive the amount of fuel for which they pay. The FCTP proposes to offer $1 million to the team that can make the most accurate meter that meets National Institute of Standards and Technology (NIST) measurement standards and can work in a hydrogen fueling station dispenser.

High-accuracy meters are needed for fueling station roll-out. Criteria fall into three categories.

- Measurement accuracy as defined in NIST Handbook 44.
- Fueling system requirements—need to be able to work with SAE J2601 hydrogen fueling guidelines.
- End user requirements—need to determine what is actually needed to function in fueling station.
- Competition criteria do not specify the technological type of meter.

Measurement accuracy:

- Error tolerance of 1.5% or better is required based on NIST Handbook 44. Entries must also meet accuracy requirements of SAE J2601 fueling protocols. Spec pressure pulse must be within 2 g of 20 g pulse.
- Meters must be compatible with systems that would meet requirements of NIST Handbook 44, including design compatibility with security sealing methods and elements of continuously indicating and recording measurements of dispensed fuel.

Fueling system requirements:

- Meters must perform under the vehicle fueling conditions defined in SAE J2601.
- Meters must remain accurate under all combinations of conditions—flow rates, ambient temperature range, gas temperature, gas pressure.
- Meters must withstand maximum allowable station pressure of 105 MPa.

End user requirements:

- Safety standards:
    - Wetted meters must be compatible with high pressure and low temperature hydrogen.
    - The portion of the meter internal to the fuel dispenser must be able to be certified by a third party.
- General station operations:
    - Documentation of specs: maintenance and recalibration requirements.
    - Meters must communicate with the distribution system equipment.
    - Effects of temperature and pressure on meters must be documentable.

Prequalification criteria:

- Entrants must be able to submit administrative forms and documents required by the administering entity and the Hydrogen Education Foundation.
- Entrants must submit documentation of meter specifications and evidence the meter can receive third party certification for safety requirements (will be required at end of competition term).
- Entries will be tested at an independent facility (TBD) for a period of time and under a range of conditions.
- Winner will have to be able to produce additional units (e.g., 40 units by 2017).

Key criteria (critical):

- Error tolerance under fueling conditions—NIST Handbook 44 code is tentative. Improvements to the current status are encouraged.

    Discussion:
    - Dr. Shaw asked about the dispensing accuracy of gasoline. Dr. Studer replied that the accuracy standards for gasoline are much lower than those proposed for hydrogen–0.1% or 0.01%. The standard of 1.5% is based on current natural gas standards. Dr. Shaw and Chairman Hofmeister voiced concern that customers may not be satisfied with a standard of 1.5%. Chairman Hofmeister stated that lawsuits continue to be raised against the gasoline industry alleging meter inaccuracy in spite of the low meter error standards.

- Cost and availability of meter for dispenser users; lack of meters may be business case challenge as well as technical challenge.

Potential alternative prize structure—If 1.5% accuracy requirement is not achievable, progressive prizes may be awarded if all other requirements can be met and the accuracy still meets the current status of 5%. The award would then go to the top entry.

- Example tiers: 1.5-2%, $850,000; 2-3%, $650,000; 3-5%, $500,000.
- The idea is to incentivize continuing improvements in accuracy and improvements over the current state.

Discussion:

- Mr. Shaw asked if multiple prizes could be awarded. Dr. Studer replied that the answer will depend on the amount of money available. It may be possible to award 1st, 2nd and 3rd prizes.

Dr. Studer requested the following input on the proposed H-Prize competition criteria:

1. Will a meter produced using these criteria be able to help stations meet measurement standards?
   a. Chairman Hofmeister asked whether the H-Prize criteria assume that the consumer fills his/her own tank or that a trained professional fills the tank. He pointed out that wear and tear affect the measurement accuracy and suggested that criteria for ensuring ruggedness of the application be added.
   b. Dr. Shaw asked how the winner would be determined if one entry produces a meter that achieves 1.5% error tolerance but is expensive to produce, while another achieves 2.5% error tolerance at a lower cost. Dr. Studer replied that under the current criteria, the entry with the lower error tolerance would win.
   c. Mr. Eggert asserted that entrants will be motivated to minimize costs in order to develop marketable products for potential customers, regardless of whether or not cost criteria are applied in the H-Prize competition. He suggested that cost comparison criteria be developed for the H-Prize.
   d. Dr. Studer asked for specific suggestions on how to incorporate cost comparison measurement criteria. Dr. Shaw suggested attaching relative weights to the technical specifications (safety, durability, etc.). Mr. David Taylor suggested that FCTP solicit input from experts to determine a target cost to be met by competition entrants. Mr. Charlie Freese noted that prototype costs are different than production costs and added that the entries would have to be audited by a manufacturer of similar products to evaluate the production costs. Chairman Hofmeister remarked that only a couple companies manufacture meters, and these can be identified easily.
   e. Dr. Ogden pointed out that the requirement to produce several units at the end of the competition will motivate contestants to minimize the costs of the meters they develop.
   f. Mr. Frank Novachek asked how intellectual property will be handled in the H-Prize competition. Dr. Studer explained that the FCTP expects to conduct a forum on that topic. She anticipated that intellectual property will remain with the company developing the entry. Entering the contest does not transfer intellectual property rights to DOE.
   g. A question was raised regarding the selection of product evaluators and the protection of intellectual property during the competition's evaluation process. Dr. Shaw expressed his expectation that a non-disclosure agreement between entrants and competition evaluators would be sufficient to protect the intellectual property of the entrant companies.
   h. Dr. Shaw suggested that DOE issue a Small Business Innovation Research (SBIR) Phase I request for proposals to run concurrently with the competition, so that smaller entrepreneurial companies could obtain resources to do the research that would enable them to participate in the competition. The H-Prize would provide incentive to develop the best meter, but everyone who participates in the competition would receive funding for their work through the SBIR program.

This option would alleviate intellectual property concerns, as intellectual property protection is well established in the SBIR program.

2. Do the criteria allow entries to meet other relevant requirements for fueling station dispensers?
   a. Chairman Hofmeister encouraged DOE to include criteria to ensure ruggedness in all types of climate conditions.
   b. Dr. Bond suggested that the range of the quantity of uses needs to be determined.
   c. Mr. Freese promoted criteria, particularly with respect to the accuracy requirements of the competition that achieve parity with current gasoline meters.
   d. Chairman Hofmeister identified a need to determine maintenance parameters. Entrants need to be able to address whether equipment can be maintained and repaired onsite, or whether it must be sent to another facility.
   e. Mr. Taylor offered to provide information on current stations and imparted a caution that the criteria should not be overly constraining.
   f. Dr. Tim Lipman recalled recently seeing a Coriolis-type meter on a pipeline in California. He wondered what meter maintenance will entail, as well as how often meters will need to be calibrated and how difficult it will be to calibrate the meters.

3. Is 18 months adequate time for completion of the competition?
   a. Dr. Shaw asked how long it would take to see significant improvement over the current state-of-the-art meter.
   b. Mr. Taylor opined that 18 to 24 months is a reasonable amount of time.
   c. Mr. Eggert noted that one advantage of the H-Prize competition is the possibility of attracting innovators that may not otherwise think about hydrogen metering.
   d. Antonio Ruiz of the DOE FCTP explained that DOE proposed the time frame of 18 months to coincide/coordinate with other deployment deadlines of the program; a time frame longer than 18 months may delay the program's deployment schedule.
   e. Chairman Hofmeister identified the need for products to be tested before the market will accept them. Station owners and suppliers and state regulators will not allow further development of renewable energy sources if they don't have credible and reliable dispensing and measuring equipment.
   f. Dr. Taylor noted that the proposed competition criteria, as written, are directed toward companies. She asked if the prize can be awarded to individuals. Dr. Studer replied that DOE has focused on the team project idea.

Chairman Hofmeister called for additional comments on the H-Prize presentation. None were offered.

5. Action Items for Future Committee Meetings

The following topics for future HTAC consideration were suggested.

- Consider whether offering initiatives, setting policies, and governing infrastructure of hydrogen production, delivery, and distribution should be coordinated at the federal, state, or regional level.
- Study the effect of fluctuating oil prices on public interest in renewable and alternative energies.
- Develop incentive to keep interest piqued even when oil and natural gas prices are low.

6. Administrative Business

- The minutes from the May 2012 meeting will be distributed to the members and approved at the November 2012 meeting.
- The meeting was adjourned at 1:58 P.M. EDT.

EIGHTEENTH MEETING OF THE

HYDROGEN AND FUEL CELL TECHNICAL ADVISORY COMMITTEE (HTAC)

PARTICIPANT LIST

September 5, 2012

HTAC Members Present

- Peter Bond
- Anthony Eggert
- Gary Flood
- Charles Freese
- John Hofmeister
- Maurice Kaya
- Harold Koyama
- Tim Lipman
- Alan Lloyd
- Frank Novachek
- Joan Ogden
- Bob Shaw
- Kathy Taylor
- David Taylor
- Levi Thompson
- Jan van Dokkum
- Bill Wylam

HTAC Members Not Present

- Mark Cardillo
- Richard Carlin
- Geraldine Richmond
- Bob Rose
- Joe Triompo

U.S. Department of Energy Staff

Office of Energy Efficiency and Renewable Energy

- Sara Dillich
- Will James
- Jason Marcinkoski

- Eric Miller
- Antonio Ruiz
- Sarah Studer
- Erika Sutherland
- Reginald Tyler

Members of the Public in Attendance

- Seth Barna—American Chemistry Council
- Leo Grassilli—Office of Naval Research
- Virginia Neale—Northwestern University
- Brian Schorr—Hydrogen Education Foundation
- Prentiss Searles—American Petroleum Institute
- Satish Tamhankar—Linde LLC

Support Staff

- Kristine Babick – Energetics, Inc.
- Rachel Davenport—Alliance Technical Services, Inc.
- Melissa Laffen – Alliance Technical Services, Inc.
- Dee Scheaffer—National Renewable Energy Laboratory