

# HYDROGEN AND FUEL CELL TECHNICAL ADVISORY COMMITTEE

## MEETING MINUTES

May 16-17, 2007  
Arlington, VA (Crystal City Marriott)

---

### MAY 16, 2007

The meeting of the Hydrogen and Fuel Cell Technical Advisory Committee (HTAC or Committee) was called to order at 8:45 a.m. (EDT) by Dr. Alan Lloyd, HTAC Chairman. Eighteen HTAC members were present (list attached). HTAC members not in attendance included Dr. Uma Chowdhry, Dr. Byron McCormick, Mr. Ian Purtle, Mr. James Reinsch, Dr. Roger Saillant, Dr. J. Craig Venter, and The Honorable Robert Walker. Mr. Gregory Vesey joined the committee the afternoon of May 16.

Dr. Lloyd introduced Mr. Steven Chalk, DOE's new Deputy Assistant Secretary for Renewable Energy. Dr. Lloyd congratulated him on his promotion to the position and noted that his broad experience and excellent service bodes well for the Hydrogen Program. At Dr. Lloyd's request, the HTAC members introduced themselves.

#### **I. Opening Remarks from Deputy Assistant Secretary for Renewable Energy, Steven Chalk**

Mr. Chalk stated he did not have a prepared speech for the HTAC, preferring a more conversational approach. He noted that he enjoyed his one-year assignment in the Solar Energy Program launching the President's Solar America Initiative and also working in the Buildings Technologies Program to promote Zero Energy Buildings. He added that Assistant Secretary Karsner recognizes the importance of energy efficiency and the links between renewable energy and efficiency. This led to his decision to divide the management responsibility for the DOE Office of Energy Efficiency and Renewable Energy (EERE) into two—a Deputy Assistant Secretary for Energy Efficiency (Mr. David Rodgers) and a Deputy Assistant Secretary for Renewable Energy.

Mr. Chalk noted that a key area in the Energy Efficiency program is led by Mr. Ed Wall, Program Manager for Vehicle Technologies. This program is developing advanced batteries and other technologies for advanced hybrid vehicles, including plug-in hybrid electric vehicles. He stated that these technologies could play an important role in meeting policy initiatives or regulatory requirements that come into play over the next few years. The President's May 2007 Executive Order calls for federal agencies to start drafting regulations to cut U.S. gasoline consumption by 20% in the next 10 years and to cut emissions of greenhouse gases from motor vehicles. He noted that the Environmental Protection Agency (EPA), Department of Transportation (DOT), U.S. Department of Agriculture (USDA), and DOE will be working together to achieve that goal. The strategy will include a combination of increasing biofuels production and usage, potential regulation to increase fuel economy standards, plug-in hybrids, and then moving towards hydrogen fuel cell vehicles. Mr. Chalk noted that he will be working together with David Rodgers to bring together these different technologies and opportunities and show how they work together. He added that over the next few months they will start work on crosscutting plans that tie together to form a national strategy for addressing transportation and the "built environment." These plans will show how hydrogen fits into the overall picture in terms of policy, regulatory environment, as well as all the technologies that DOE (and other agencies) are working to address. Mr. Chalk said that DOE would draw on great examples, like what is going on in California to promote efficiency as a resource, and other activities around the world.

Mr. Chalk requested that feedback from the Committee on DOE's responsiveness and follow-through be provided to either Mr. Pat Davis, who is the Acting Hydrogen Program Manager, or to him. He commended Dr. JoAnn Milliken and Mr. Davis for filling the Acting Program Manager role and stated that DOE expects to fill the full-time HFCIT Program Manager position in the next month.

Mr. Chalk indicated that DOE has assembled the HTAC-recommended Hydrogen and Fuel Cell Interagency Task Force with Assistant-Secretary level representatives; he noted that the HTAC was provided with a list of confirmed members. Dr. Milliken noted that the first Task Force meeting will tentatively be held in August, immediately after the HTAC meeting so that members from HTAC could attend the Interagency meeting. Dr. Milliken named the Task Force members that have been confirmed:

- Andy Karsner, Assistant Secretary for Energy Efficiency and Renewable Energy; U.S. DOE
- Dan Byers, Deputy Associate Director, Office of Science and Technology Policy; Executive Office of the President
- George Gray, Assistant Administrator; U.S. Environmental Protection Agency
- Sam Hunter, Director, Office of Applied Science; U.S. General Services Administration
- Olga Dominguez, Assistant Administrator of Infrastructure and Administration; NASA
- Richard Buckius, Assistant Director, Energy; U.S. National Science Foundation
- Marilyn Freeman, Deputy Director for Technology; U.S. Army Office of Deputy Assistant Secretary
- Doug Falkner, Deputy Under Secretary for Rural Development; U.S. Department of Agriculture
- William Jeffrey, Director, NIST; U.S. Department of Commerce
- Maynard Sanders, Director, Defense Energy Support Center; U.S. Department of Defense
- Anthony Fowler, Director, Interagency Affairs/Math and Science Outreach; U.S. Department of Education
- Patricia Dehmer, Director of Basic Energy Sciences; U.S. DOE
- Jarad Daniels, Director of Planning and Environmental Analysis; U.S. DOE Fossil Energy
- Dennis Spurgeon, Assistant Secretary for Nuclear Energy; U.S. DOE Nuclear Science
- Walter O'Tormey, Vice President, Engineering; U.S. Postal Service
- Tyler Duvall, Assistant Secretary of Policy; U.S. Department of Transportation

Task Force members from the U.S. Department of Homeland Security (DHS), Department of Interior (DOI), and Treasury still need to be identified. Mr. Chalk requested Committee recommendations on agenda items for the first task force meeting, but Dr. Lloyd deferred this for the end of meeting.

Dr. Lloyd lauded DOE staff for their support and noted that they stepped up to many challenges. Mr. Chalk and Dr. Lloyd also commended Dr. Helena Chum's assistance to the Committee.

Dr. Lloyd expressed concern about the lack of Technology Validation funding beyond 2009, which worries some companies. Mr. Chalk noted that he could not publicly discuss DOE's FY 2009 budget request, but he did indicate that DOE does see great value in the program's data collection efforts and is considering expanding the Technology Validation budget to perhaps include other types of vehicles and fueling options that could reduce gasoline consumption (e.g., plug-in hybrids, diesel, E-15 or E-20 ethanol blends). In response to a question from Dr. Lloyd about the definition of plug-in hybrids, Mr. Chalk explained that the DOE is technology-neutral and that the hybrid could be a fuel cell hybrid, gasoline hybrid, or diesel hybrid. He added that this choice would be determined by industry based on what they think consumers would want.

Dr. Lloyd invited the Committee to ask Mr. Chalk any questions.

Dr. Mildred Dresselhaus asked if solar was considered by DOE to be a key competing technology, especially since it is a huge source of energy and European countries are serious about solar. Mr. Chalk agreed that solar is a critical resource, not a carrier, and that electricity or hydrogen would be the carrier. He noted that the goal is to flatten out the increase in carbon emissions and to decrease oil imports. The DOE will seek to set performance metrics towards this end and let the industry decide how to pursue that. He added that there is certain momentum with the way the infrastructure is today, so fossil fuels will probably continue to play a role, but they will have to meet the same performance metric on carbon or carbon emissions in the future. Therefore, DOE will not rule out the options. Dr. Dresselhaus stated her opinion that the goal should be to get renewables into the market as quickly as possible, since fossil fuels are the main culprit in the climate change scenario.

Mr. Chalk clarified the difference between the goal and the mission. The mission of DOE-EERE is to accelerate renewable technologies into the marketplace using policy, technology development, and other avenues. The overall goal is about carbon and about energy security, and there is more than one way to achieve this goal. Mr. Chalk reiterated that a number of different solutions are needed to meet the overall goal of flattening out carbon emissions and imports while providing the energy that the country needs at a reasonable price.

Mr. Jan van Dokkum expressed concerns about future funding gaps and the pressure that will be put on budgets as additional technologies move in, such as plug-in hybrids. He encouraged Mr. Chalk to be vigilant about future budgets and initiatives to make sure they are based on solid data analysis, noting that the marketplace responds quickly to signals from DOE. Mr. van Dokkum pointed out that a tremendous amount of progress and momentum has been built in fuel cells and hydrogen (as demonstrated by the large attendance at the 2007 DOE Hydrogen Annual Merit Review). He does not want that momentum to disappear and suggested that DOE should have a role in identifying which technologies represent the most appropriate solutions for society given the stated goals.

Dr. Robert Shaw commended the responsiveness of the DOE team. He expressed concern for what he sees as waning commitment to hydrogen on the part of the U.S. government and the private sector. This is in counterpoint to the Europeans and the Japanese, who continue to place extensive effort into these technologies. He warned that much of what is invented in the United States could end up being implemented commercially by foreign companies. He asked Mr. Chalk if he could see the possibility for the largest, most powerful nation in the world escalating its level of investment to “get into the game,” or is the United States more likely to continue on as a relatively modest player? He added that the United States investment in R&D is still relatively inconsequential when compared to what even small private sector companies are trying to spend to do work in this field. Mr. Chalk replied that this is difficult to answer since commercialization is driven by a combination of private investment, government policies, and the response of the marketplace. He noted that there are good signs that there will be more energy legislation from the new Congress and potentially extensions of the tax credits for fuel cells. He observed that long-term certainty of incentives helps investors. Mr. Chalk also pointed out that there are encouraging activities, such as early market adoption of fuel cell forklifts (that compete effectively with battery-powered forklifts) and other equipment, and the fact that DOE released a Request for Information on Hydrogen and Fuel Cell Early Markets in order to foster that part of the program. As technologies mature, marketplaces will be identified, investment will increase, and industry will solve more problems. Mr. Chalk indicated that involvement of the private sector is critical, since their investment is many times more than the government’s. Dr. Lloyd commented on Mr. Chalk’s experience with solar, and that the lessons learned there with foreign adoption of U.S. innovations can carry over to hydrogen and fuel cells, to which Mr. Chalk agreed.

Mr. David Friedman pointed out that recently there has been increasing emphasis by the Bush administration on global warming. With this in mind, he suggested an opportunity for DOE to include system greenhouse gas performance targets (e.g., carbon footprint, grams/mile) in its performance metrics and goals. Mr. Chalk replied that DOE could develop those metrics and perform well-to-wheels (WTW) analyses to describe the

suite of options and their energy security and greenhouse gas (GHG) impacts. He asserted that it would be up to others to debate on national goals and policies. He noted that it was a good suggestion, and that DOE could expand its efforts in that area to more of a global context to include all the technologies that DOE is working on—whether to supply electricity or fuel. He observed that when DOE talks about the hydrogen option, the comparison is to a gasoline hybrid vehicle, and that any option developed must be better than that on an energy and carbon basis. He suggested DOE must normalize its research technologies to calibrate them among the competing options.

Mr. van Dokkum compared the way the United States has aggressively pursued the automotive platform with hydrogen and fuel cell technologies, as opposed to other countries (such as Japan, Germany, and China) that started off in the stationary side of the business. He asserted that the transportation industry is not just difficult from a user standpoint but also from an infrastructure point of view; whereas stationary has less of a demand cycle, is an easier application, and it allows the industry to grow. Mr. van Dokkum urged Mr. Chalk to keep stationary applications in mind as early market drivers that can create a market and a foundation for the automotive platform work. He also encouraged DOE to evaluate new technologies on an even par and to strongly endorse tax incentives, especially for the financially disadvantaged, so there is a reliable indication of the direction that industry should go. He noted that since tax incentives are expiring in 2008, developers are not specifying fuel cells in planned buildings because they are unsure about the tax extension. Dr. Lloyd mentioned that portable power is also another early market.

Dr. Mike Ramage postulated that when DOE develops its R&D plan, it develops a set of goals, a timeline, and costs for delivering the results. Mr. Chalk concurred, noting that DOE costed out an R&D plan through 2015. Dr. Ramage pointed out that folks could disagree with the cost and claim that a much higher (or much lower) funding level is required. He asked if the program's progress could be accelerated if there was more R&D money. Mr. Chalk replied that with more money, more parallel approaches could be explored. He added that priority has been given to critical path technologies, and that with additional money, more funding could be directed towards market transformation. Dr. Milliken added that when she considers this question, she thinks about the number of proposals submitted in response to a DOE solicitation that DOE would like to award based on high-level reviews, versus what they can award based on available funding. She noted that using this criterion, the level of funding in storage is adequate, but the level of funding in Fuel Cells is low.

Dr. Ramage questioned the comfort-level of DOE with the high volume cost estimates and how confident they are that if the R&D is successful this will really play out in the marketplace. Mr. Chalk explained that DOE first works with the industry to develop performance requirements for market success, and DOE's goal is developing technology readiness to meet those requirements. With regard to DOE's high volume cost estimates, Mr. Chalk explained that those are developed by third-parties who obtain data from Tier 1 and 2 suppliers and look at manufacturing process details to make projections that are vetted by industry. However, it cannot be known if the private sector will choose to invest in building these manufacturing facilities or process lines; that is dependent on market dynamics, which DOE cannot control. He reiterated DOE's role in helping technologies meet market requirements, adding that demand- and supply-side policies and incentives will be needed to stimulate the market and move from production levels of zero to 10,000, 100,000, and so on.

Dr. Dresselhaus stated more could be done if there was more funding, especially in basic science, adding that the FY 2007 request was significantly higher than the appropriation. Mr. Chalk replied that DOE cannot control the appropriation, but that the FY 2008 DOE budget request for Basic Energy Sciences hydrogen research was consistent with the FY 2007 request, at about \$59 million (up from zero in FY 2004).

Mr. Bawden commented that he believes there is more than just technology readiness at issue—that even when technology is ready and able, there are other issues that can limit the technology's ability to penetrate the market. Mr. Chalk agreed but noted that for vehicle technology, technology cost is still a big barrier.

Mr. Mark Chernoby asserted that DOE's role should be more than getting the technology ready and letting the market decide where to take it from there. He suggested that DOE is one of the few organizations that can act as a third party and analyze data across a broad range of technological options in order to help guide the country on where it needs to go with the technologies. He also sees a need for DOE to develop and continually update an overriding strategy on how all these technologies—including biofuels, plug-ins, batteries, electrics, and hydrogen—might play out over the next 20 years.

At the request of Dr. Lloyd, Mr. Chernoby described the recent announcement that Chrysler will separate from DaimlerChrysler (assuming regulatory approval), and will be called Chrysler Holdings, LLC. Daimler will have a 20% ownership stake in Chrysler, and Mr. Chernoby reassured the Committee that they will have a strong relationship with Daimler and continue forward on hydrogen fuel cell technology and other technologies, sharing components, information technology, and R&D resources.

Mr. Hofmeister agreed with Mr. Chernoby about DOE taking a national leadership position on these matters since the United States is probably the world's largest consumer market. He also agreed with Mr. Friedman that scenario analysis and planning is helpful, particularly in dealing with complex and controversial matters like carbon management. He noted that scenarios that include robust carbon management strategies need to be considered and that DOE leadership and idea guidance in this area would be helpful. He added that he would not want to see hydrogen end up being a "stepchild" because other more powerful political interests in the short-term are pushing their particular agendas.

## **II. Agenda Review**

Dr. Lloyd explained that the agenda for the morning would include feedback from the HTAC subcommittees on various sections of the Hydrogen Posture Plan and comments from the Committee. He explained that the Committee will work towards creating a consolidated list of comments for its draft report. Dr. Geri Richmond speculated about the necessity for an August HTAC meeting if they could come to agreement on their comments during this meeting. This suggestion was noted by Dr. Lloyd for reconsideration at the end of the meeting on May 17. He noted that the DOE is also trying to schedule the first Interagency Task Force meeting to coincide with the August HTAC meeting, so this would also be a factor in the decision.

Dr. Ramage expressed concerns about how the Committee should handle consensus, noting that currently the HTAC does not have a formal process for this. He added that one way to reach consensus was to make the recommendations so "watered down" that everyone could agree to them. Dr. Dresselhaus suggested using the National Academies process, but Dr. Lloyd was unsure whether the Academies' process would be a suitable model for the Committee.

Dr. Shaw argued that the August meeting might be quite useful. He suggested that HTAC support staff incorporate and consolidate the HTAC's comments from the May 16-17 meetings and develop a draft report, which could be reviewed by the Committee members, marked up, and then discussed at the August meeting, with a focus on the particular recommendations with which members have problems. During the meeting, the Committee would discuss the comments and then work toward a consensus so a report can be published in October. Dr. Ramage and Dr. Lloyd agreed that this sort of procedure would likely be necessary.

Dr. Richmond suggested that the August draft of the HTAC report on the Posture Plan be condensed to a shorter version that would be more readable. Dr. Shaw agreed that a 40-page report was too long, suggesting that a 5- to 10-page report would be better. Mr. van Dokkum suggested that the HTAC report include a section on Posture Plan comments and a section on overall, higher-level policy recommendations. Dr. Lloyd concurred, noting that this could impact the length of the document. He further suggested that the Committee reach a consensus on the policy issues by raising hands during the process, noting that the Posture Plan comments may be able to be handled by each of the subgroups.

### III. DOE Update on the Interagency Task Force

Dr. Milliken indicated that she provided the update on the Interagency Task Force during the discussion session with Deputy Assistant Secretary Chalk (see Section I).

Dr. Shaw asked her opinion of the task force members' viewpoint on the prospects for hydrogen. Dr. Milliken replied that she had only limited telephone conversations with some of the members, so she could not gauge this until the first meeting. Dr. Dresselhaus inquired if there were members less than 40 years old, and Dr. Milliken answered that age was not a prerequisite for nomination or membership in the Task Force, nor was it requested information during the process.

### IV. Reports from Posture Plan Subcommittees

*Report from Subcommittee 1: Production and Delivery (including Basic Research) and Appendices A&B: Scenario for Hydrogen Production & Resource Needs and WTW Analyses (Members: Mr. Michael Mudd, Mr. Dan Keuter, Dr. Michael Ramage, Mr. Art Katsaros)*

Dr. Ramage reported for the Production and Delivery Subcommittee. He reported that the group strongly believes that the Posture Plan should include an upfront statement that hydrogen alone will not solve the problem; that a combination of technologies and fuels will be needed to address the total problem within the energy sector and reduction of CO<sub>2</sub> emissions and oil use. Likewise, multiple feed stocks will be needed to meet hydrogen demand.

Dr. Ramage stated that the subcommittee suggested the following wording: "The Posture Plan should recognize that achieving the goals of energy security, environmental quality, and economic competitiveness requires technologies that can cleanly, efficiently, and economically produce hydrogen from indigenous fossil fuels, nuclear power, and renewable energy sources."

Under the "**Production**" heading, Dr. Ramage reported that the subcommittee recommended the following bullets:

- The Committee believes that a balanced R&D program focused on short-term technologies for the transition and long term technologies for maximum impact needs to progress in a balanced way. From what the Committee can see, funding is moving in the right direction (if authorized funds are appropriated). Independent experts should continue to be used to review the program's spending levels and R&D portfolio to ensure that the program is balanced in terms of R&D timeframe (near-, mid-, and long-term) and feedstock targets. Value-based analysis would be useful in evaluating priority options for the short-term research program.
- The production R&D program should be tied back to the ultimate goals of reducing CO<sub>2</sub> emissions and oil use.
- The process for reaching technology/production pathway down-select decisions should be communicated in the Posture Plan.

Dr. Ramage commented that the subcommittee believes that the HTAC, as a body, is not qualified to judge the funding levels of individual Program elements.

With regard to the **Hydrogen Delivery** section in the Posture Plan, Dr. Ramage reported that the subcommittee made the following comments:

- The importance of off-board storage and delivery is under-emphasized in the Posture Plan. Delivery is a critical component of delivered hydrogen cost and is equally, if not more important than hydrogen production.

- Show Production and Delivery separately in the budget pie chart for the Hydrogen Fuel Initiative.
- The description of the delivery R&D program should have the same emphasis and level of detail as the production section. It should describe the entire delivery system—the components, challenges (including efficiency losses along the way), and R&D priorities for the entire delivery pathway (point of production through delivery to vehicle).

He added that the cost impacts of the components of delivery systems are not adequately addressed. The subcommittee also questioned why DOE is funding R&D on embrittlement, since the members do not think this is a problem at the pressures at which most of the systems run.

Dr. Ramage next discussed **Appendix A of the Posture Plan (Sample Scenario of Hydrogen Production Options)**, for which the group prepared the following comment:

- The Posture Plan should include a scenario analysis that looks at the potential for reducing greenhouse gas emissions and oil imports through the development a hydrogen economy. The scenarios should identify and analyze several aggressive but potentially feasible technology deployment targets, the estimated hydrogen production, reduction in energy imports, and the estimated GHG reduction potential that could result between now and 2030 through the deployment of the technologies.

Dr. Milliken remarked that identifying technology “deployment targets” will be difficult for DOE, because this takes DOE out of its role, and into making predictions about what the marketplace will do. She noted that DOE can and, indeed is developing potential deployment scenarios and potential market penetration rates and that these could be included in the Posture Plan. Mr. Dan Keuter added that the subcommittee would like to see the kind of scenario analysis that was recently completed by EPRI (and he referred the HTAC to the EPRI technology assessment analysis “Electricity Technology in a Carbon-Constrained Future.” He explained that the EPRI analysis examined the potential for significant CO<sub>2</sub> reductions from the U.S. electric power sector within the next 25-30 years that would result from reasonable but aggressive technology deployment scenarios. The technology deployment scenarios included improved energy efficiency, renewables, nuclear generation, advanced coal generation, carbon capture, sequestration, plug-in hybrid electric, and distributed energy. He noted that the study concluded that there is no silver bullet. In fact, there needs to be very aggressive goals for all of these technologies to have a significant impact on lowering carbon emissions. Mr. Keuter stated the subcommittee was suggesting that DOE run similar scenarios looking at ethanol, nuclear hydrogen from coal, and hydrogen from renewables to see what a realistic goal is and how achieving this goal would impact oil imports and CO<sub>2</sub> production. He suspects that the conclusions from this analysis would include: (1) we need more aggressive goals, and (2) there is not one technology that will meet the hydrogen demand. Dr. Milliken suggested rewording the subcommittee’s recommendation to reflect her concern that DOE cannot identify “technology deployment targets,” and the subcommittee agreed. Mr. Michael Mudd emphasized that the aim of the recommendation is developing a scenario analysis that will explore how these technologies can contribute to the goals of reducing CO<sub>2</sub> emissions and oil imports—how the rate of CO<sub>2</sub> emissions can be slowed, stopped and then turned down over time, and what combination of technologies is needed to achieve these goals.

Dr. Shaw stated that his subcommittee was somewhat confused by Posture Plan Appendix A until they realized what it really says. He thinks the description of Appendix A should be written more clearly to describe what the production scenario analysis actually does, which is to say, “If every vehicle in the nation was running on hydrogen, what kind of resources might be needed to produce the hydrogen needed to meet the demand?” The analysis arbitrarily assumes that each of the resources would provide 20% of the demand, and shows how much more of each resource would be required, beyond

currently used levels. He noted that the analysis shows that the situation is not hopeless and believes that this sends a useful message. Mr. Wooten commented that it would be useful to place some timeframes around this information so that it is understood what technologies need to be in place and when. Dr. Ramage noted that the cost projections for the different production pathways will come into play here, and that the transition scenario analysis that DOE is currently doing addresses some of this. Dr. Milliken reported that the DOE's draft scenario analysis report is currently being vetted within DOE, and she expects that it will soon be provided to the Committee, and that they will have the opportunity to identify gaps in the study.

With regard to **the well-to-wheels (WTW) Analysis, Appendix B of the Posture Plan**, Dr. Ramage echoed earlier comments from Mr. Wooten that there are some inconsistencies with the WTW analyses presented in the Posture Plan—noting that the cost projections are in some cases quite different from numbers developed in other studies, specifically the National Academy of Sciences (NAS) 2004 report on the Hydrogen Economy and reports developed by the DOE Fossil program. The biomass and coal pathways are the key problem areas. He noted that there is documentation of the assumptions, but that they tend to be too general to provide confidence on why these costs are moving like they are. The subcommittee believes that there is a need to compare these results with these other studies and make transparent the reasons the numbers are different.

Dr. Milliken suggested that it may be helpful to include on the next HTAC meeting agenda a presentation that would provide more detail on the modeling assumptions for the WTW analyses. She added that DOE's intent in the Posture Plan was to include a summary of the analysis results, and document in the footnotes as many assumptions as possible. Mr. Wooten expressed concern over the omission of a WTW pathway for biofuels. Dr. Milliken agreed and stated she did not believe DOE had the data necessary for the biofuels pathway at the time the Posture Plan was published. Mr. Wooten spoke directly to Chairman Lloyd, asking that Dr. Milliken's suggestion for a presentation on the WTW analyses be pursued for the next meeting. Dr. Lloyd asked if DOE's analyses of the biofuels pathways are looking at multimedia impacts like water and land use. Dr. Milliken replied that Mr. Fred Joseck (Hydrogen Program Technology Analyst) is currently working with the National Renewable Energy Lab to explore the water resource issues. Mr. Wooten made the final comment that the strength of Appendices A and B of the Posture Plan is that they show that there is justification for a diverse portfolio, and not just one pathway.

Mr. Hofmeister asked for a clarification on the subcommittee's reference to the overall goal of "reducing CO<sub>2</sub> emissions and oil use." He asked if the wording was correct. "Do they mean oil use itself, or is it oil imports?" Dr. Ramage replied that it is oil use, noting that these are really interchangeable terms. Mr. Hofmeister said they are interchangeable, in a sense, but that energy security revolves around reducing oil imports.

***Report from Subcommittee 2: Executive Summary and Chapters 1-3: Introduction, Key Drivers, and Development of Hydrogen as an Energy Carrier (Members: Dr. Robert Shaw, Mr. John Wooten, Mr. John Hofmeister, Mr. David Friedman)***

Mr. Friedman led the discussion, stating the subcommittee limited the scope of their review by looking through the Posture Plan with two questions in mind. First, does the Posture Plan accurately reflect what needs to be done to meet the President's goals? Second, because the Posture Plan is a statutory requirement, does it satisfy the requirements set forth in EPACT 2005? Mr. Friedman began by reporting on what the group sees as recurring themes in the HTAC discussions about the Posture Plan, as presented below.

1. "Potential benefits of hydrogen touted without sufficient disclaimers as to uncertainties of realizing such benefits—either because of failure of hydrogen to gain market acceptance or failure to overcome necessary technology hurdles. 'Promising the moon and not being able to deliver'." Mr. Friedman



noted the need for scale on what hydrogen can do and when it can do it. The group recommends providing more perspective on: (a) what the contribution from hydrogen will be over time; and (b) what the risks are, what the competition is, and on what basis hydrogen will compete (whether on a price basis, a carbon basis, an oil basis, etc.)

2. “There is inadequate linkage between the DOE program activities and what is happening in private industry/what needs to be done. The Posture Plan shows a false dichotomy between the U.S. government R&D role and private industry commercialization. More R&D in focused areas is currently being done by industry than by U.S. government. The Posture Plan should show DOE’s role in filling the R&D gaps, caused by insufficient industry funding and, thus, catalyzing industry R&D. Government should also play a key role in commercialization through incentives. “Complementarity” of government and industry roles needs to be emphasized.” Mr. Friedman explained that this recommendation concerns making clear in the Posture Plan the very vital role that DOE will play in complementing industry’s role. The subcommittee wants to make it clear they agree that DOE has a long-term role to play in R&D, but also that DOE also has a broader role in helping to gain market acceptance and market penetration.

Mr. Friedman went on to provide more detailed comments, some of which were editorial in nature. Higher-level recommendations included the following, by section:

#### *Executive Summary*

- On Figure ES-1, the Committee was concerned that it does not convey the importance of the transition process to get from the R&D to the commercialization stages. The figure or the write-up should convey that these are not discreet steps that will occur one right after the other, with government involvement in the former and industry involvement in the latter.
- The subcommittee noted that there is a mixture of administrative and programmatic accomplishments and goals in the Program Accomplishments and Next Steps sections of the Executive Summary. These mix strategic statements of accomplishments and next steps with specific programmatic activities. The subcommittee recommends that these be broken out and distinguished, with specific program activities omitted from the Executive Summary. Strategic accomplishments should also show a corresponding next step.

#### *Foreword*

- Include more of a story of where the hydrogen situation is going, and how things fit together—that there is a gradual transition between distributed and centralized.
- Articulate that the hydrogen initiative is surrounded by certain risks, including: (1) biofuels initiative eclipsing hydrogen in attention, resources, policy, etc.; and (2) fossil price drops. Increasing prices cannot be assumed for the long term.
- Articulate that additional policies will be needed to get hydrogen to market— technology alone will not be enough.

#### *Introduction*

- Focuses mostly on technology; recommend that it include the broader context on markets, competitiveness, costs, availability, and safety.
- Figure 1 includes portable power in with transportation—it should be addressed separately.

#### *Key Drivers for Developing Hydrogen as an Energy Carrier*

- Here, Mr. Friedman noted that there is some controversy over how we are measuring our dependence on oil and whether the projection for 60% dependence on oil imports by 2025 was too low. The group suggests that this number be double-checked (with the caveat that the EIA’s decision to include coal-to-liquids in AEO 2007, which reduces projections for oil import dependence, is viewed with skepticism by some).
- The subcommittee suggested that the “Environmental Quality” section title be rewritten as, “Environmental Quality and Global Warming Pollution,” or something similar, to better describe the subjects under discussion.

- The group suggested that a figure similar to Figure 2 (Transportation Oil Gap) be developed and included for the power sector side, not sufficiently addressed in the Posture Plan.
- On Figure 3, the group suggested that the figure clarify if emissions shown are tailpipe or WTW (noting that WTW should be used if available). The scale should also be adjusted to better illustrate the magnitude of CO<sub>2</sub> versus other emissions (i.e., present a blown-up scale for the smaller constituents). The group also suggests that the figure include SO<sub>x</sub>, particulate matter, and heavy duty vehicle pollutants. Also, the group pointed out that there is a discrepancy between the text and Figure 3. Does Figure 3 show only personal vehicles or all transportation?
- The group suggested that the Economic Competitiveness section include a description to show what needs to be done in order for the United States to become the leader in hydrogen technology. The section does not emphasize the real risks of economic competitiveness, and that this is a potential threat to U.S. industry and leadership.

*Development of Hydrogen as an Energy Carrier*

- The group felt that this was the “most honest” of the early chapters and suggested that some of these statements (e.g., page 9 discussion that technology development is only part of what is needed) be given more prominence and pulled up into the earlier sections. Mr. Friedman called particular attention to the sentences that read: "Developing hydrogen as a major energy carrier will require a combination of breakthroughs, market acceptance, and large investments in infrastructure. Success will not happen overnight, or even over years, but rather over decades...." He noted this statement is very true and powerful, and it should probably be featured up front to help people gain perspective.
- Figure 6: again, the figure should better illustrate the complementary roles of industry and government and better show the transitions between stages, as previously discussed. The group recommended taking out subheadings at the top of the figure. The group further recommended that a corresponding figure be added to show the DOE role in the transition stages with a “macro market maturity” chart (like a market penetration path).

***Report from Subcommittee 3: Fuel Cells, Hydrogen Storage, and Basic Research supporting these technologies (Members: Dr. Geri Richmond, Mr. Jan van Dokkum, Dr. Kathy Taylor, Dr. Millie Dresselhaus)***

Dr. Taylor made the presentation for the subcommittee on Fuel Cells, Hydrogen Storage and Basic Research. She made the statement that the subcommittee believes that storage is a critical path item, and is concerned that the current path includes going to high pressure storage tanks. The subcommittee sees high-pressure tanks as high risk. Dr. Taylor asserted that it will be important to offer a lower risk product if this is really going to play out in the marketplace and in the timeframe that is envisioned. She added that the storage piece is behind schedule and under funded, and it is not what is needed for the hydrogen economy in terms of where we are right now. Dr. Taylor also expressed the subcommittee’s concern that individuals and universities engaged in the storage activity may not see the continuity in funding that they need in order to keep working, noting that the program cannot be ramped up and down if quality results are desired. She further noted that grants to universities at funding levels below \$50,000 are below the minimum size to engage a single student, and therefore will be ineffective.

Concerning fuel cells, Dr. Taylor stated that the subcommittee would like to go back and take a look at development of other fuel cell technologies and see where there are opportunities that can be captured. She noted that due to the emphasis on the transportation sector, the focus is on PEM fuel cells, even though there is good work in other areas. Dr. Taylor said that the subcommittee believes there should be a long term look at the materials that are used in manufacturing. The worry is that suddenly a critical material could be banned for environmental reasons, and the sensitivities to this sort of thing are not understood. The subcommittee supports R&D to address seal durability, platinum reduction, catalyst durability, and the impacts of hydrogen quality. The subcommittee is also in favor of more demonstration programs to validate the technologies that are coming out of labs.

Dr. Taylor went on to communicate some of the subcommittee's general comments. First the group agrees with the notion that hydrogen is just one part of the overall energy picture and that the Posture Plan is too focused on the transportation sector. Dr. Taylor communicated the group's opinion that the \$1.2 billion over 5 years is short of the needs of the program, adding that the congressional authorization was actually higher than that. The subcommittee recommends that manufacturing and market transformation be added to the new initiatives listed in the report. She noted that basic research efforts should include coupled experimental, theoretical and computation work. She returned to the issue of high-pressure storage and noted that the subcommittee is concerned about safety risks and that going to high pressure storage could make U.S. products too U.S.-centric in a global economy. Dr. Lloyd asked for clarification and Mr. van Dokkum replied that there is discussion within the automotive industry and in supporting industries that going to high-pressure storage is the right thing to do for transportation in order to meet the required vehicle driving range on a single tank of fuel. Mr. Chernoby commented that a consensus process will have to be used to work through how the Committee will address this issue. He noted that he has a problem with use of the words "high risk" when it comes to high pressure tanks, stating that the industry would not put the technology on the market if it did not meet the safety requirements. He added that the industry fully supports R&D to look at other ways of reaching the on-board storage goals (e.g., metal hydrides, etc.). Mr. Hofmeister commented that there is also a risk factor that should be reflected in the delivery system. Dr. Ramage made a general comment that the HTAC needs to be careful about making blanket statements that are not consistent with how the program operates. He noted that there is a whole program looking at education and risk assessment and consumer markets.

Dr. Milliken followed up with a comment to clarify DOE's strategy for on-board hydrogen storage. She noted that DOE's primary R&D focus and spending is on *materials* for hydrogen storage, not high pressure storage tanks, for which DOE has only one or two projects. Dr. Taylor clarified that what she meant is that the subcommittee sees that the *industry* is moving towards these high-pressure options and that this could preclude the development of other options (she did not mean to imply that high-pressure tanks were DOE's focus). Dr. Milliken also commented that she is not aware of any projects that are funded by DOE at only \$50,000 per year. In the BES programs, there are no examples of universities receiving only \$50,000 a year. Dr. Dresselhaus responded that two of the three storage projects she is reviewing for EERE at the Annual Program Review have grant sizes less than \$50,000 per year. Dr. Milliken stated she would follow up with Dr. Dresselhaus on this matter. *In follow-up to this item, Dr. Sunita Satyapal, Storage Team Leader in DOE-HFCIT, responded that five storage R&D projects (out of 73) had funding levels below \$100,000 in fiscal year (FY) 2006 or 2007: two of these were terminated in FY 2007, two are in contract re-negotiation after the death of the principal investigator, and one has been put on hold while the scope of work is modified. Dr. Satyapal also pointed out that the project funding listed by a few principal investigators at the Annual Program Review was not the entire year's funding. Rather, these presentations showed only what the project had received at that point time - the remainder of the funding had not yet been received due to the delays caused by the Continuing Resolution for the FY 2007 budget.*

**Report from Subcommittee 4: Cross-Cutting Activities: Education, Systems Analysis, Codes and Standards, Technology Validation, and Manufacturing (Members: Mr. Larry Bawden, Mr. John Bresland, Mr. Rand Napoli, Mr. Mark Chernoby)**

Mr. Napoli reported for the subcommittee and noted that the group's technology and manufacturing experts (Mr. Chernoby and Mr. Bawden) were not able to participate in that subcommittee's session, but that they did provide some comments on the presentation. With regard to the Manufacturing section, the subcommittee recommended that more detail be included in the Posture Plan on the program's planned activities. Mr. Chernoby commented that the plan needs to articulate how manufacturing R&D is going to be aligned with the deployment plan, since the types of manufacturing used vary as you move from smaller to larger production levels.

For the Technology Validation section, Mr. Napoli offered the following comments from the subcommittee:

- The number of vehicles currently deployed in the United States is not statistically significant. This subcommittee supports deployment of more vehicles through demonstration programs.
  - Vehicles are not being driven by typical drivers; thus, safety is not being adequately demonstrated.
  - More bus demonstrations should be supported by government. Buses offer opportunities for hydrogen infrastructure development in and around cities.
  - Projects should be initiated with organizations (e.g., UPS and FedEx) that are highly visible and have fleets serviced by central hubs.
  - Gain experience with vehicles in different geographical regions and in different climates
- Validation should be conducted in conjunction with public safety agencies to capture real-world data on performance of hydrogen and fuel cells during emergencies

Dr. Dresselhaus asked whether the program is monitoring demonstrations being conducted in other countries, and Dr. Milliken replied that the program does this through its involvement in the International Partnership for the Hydrogen Economy and the International Energy Agency.

Dr. Milliken explained that the DOE technology validation effort is based on the *Fuel Cell Report to Congress*, which charts the progression in a number of vehicles in the demonstration. She noted that data does not come from all of the stations and vehicles that are on the road. DOE gathers the data through its agreements with the teams that are involved in demonstrations. Mr. van Dokkum recommended expanding the technology validation efforts to include stationary and other fuel cell applications that will build the foundation for other applications.

Mr. Napoli covered the subcommittee's comments on two sections: Safety, Codes and Standards; and Education and Outreach.

- Need to improve safety, codes and standards, and education and outreach activities to ensure that the public safety officials can help to facilitate public acceptance of any safety risks imposed by hydrogen.
  - Training programs for responders should have higher visibility and should be delivered through their traditional channels (e.g., community colleges, vocational schools, train-the-trainer programs, etc.)
  - Training programs for code enforcement officials should use existing training and education delivery systems and should ensure that the officials understand the principles and physics of hydrogen and fuel cells as well as the codes they are being asked to enforce.
- Government and industry should help to develop model codes as hydrogen technologies evolve to facilitate quicker consensus-building in the codes and standards bodies.

Mr. Napoli noted that the subcommittee wants to convey the message that more money should go to education, but did not offer any specific suggestions on the amount of budget needed. Dr. Shaw supported DOE's efforts to conduct hydrogen safety studies in comparison to the risks already present in the existing infrastructure. Mr. Chernoby remarked that he was troubled by the specific word "participate" used several times in reference to DOT and DOE involvement in codes, standards, safety, and education. He asserts that DOE and DOT should work together and take on a leadership role to bring local and state officials together and drive a consensus. He also commented that the web-based training and education is excellent, but that more needs to be done. He recommends including an education deployment plan in the Posture Plan.

Mr. Patrick Davis (DOE, Office of Hydrogen, Fuel Cells and Infrastructure Technologies Program—Acting Hydrogen Program Manager) commented that the DOE as a rule has focused risk assessment on

comparing hydrogen to existing fuels, with the goal of making hydrogen and fuel cell systems as safe as or safer than those of existing fuels. Concerning training, the DOE does plan to provide training at all levels. However, due to a limited budget, certain communities are focused upon, such as first responders and code officials. Concerning codes and standards leadership, the DOE feels it has taken a leadership role in trying to move the codes and standards process forward. He added that DOE and DOT do not have control over the codes and standards process because the codes and standards process in the United States exists for more than just hydrogen. Dr. Dresselhaus commented that professional societies might be able to help with distributing educational materials at minimum cost. Mr. Bawden then directly asked Mr. Davis if there is a way to place a priority on hydrogen regulations so it at least can move more quickly. Without a priority, it could take eight years, instead of two. Mr. Davis commented that this idea merits further discussion, but noted that even if it only takes a couple of years to write a standard or code, it can take much longer for it to be adopted. He noted that a state may not choose to adopt a code even when it is available. He noted that DOE does not have the authority to mandate a different process.

Mr. Napoli then commented that the key point is to get the code developed so that if and when the code official is faced with a permitting request they can go and find the code. He noted that codes can sometimes be adopted quickly by state code enforcement officials, especially if the community is motivated. He added that if training programs are made available sooner rather than later for code enforcement officials, they will better understand the issues around hydrogen, and the process will run more smoothly.

On the Systems Analysis section, the subcommittee offered the following comments:

- This subcommittee supports comparing the analysis of hydrogen fuel cell pathways to other technologies and fuels such as hybrid and alternative fuel vehicles.
- Energy technologies should not have to compete against each other at this point in time for R&D budgets; rather, the whole pie should be expanded.
- Systems analysis should consider the relative merits of hydrogen compared with other energy production technologies, not operate under the assumption that hydrogen is the best solution.
- Systems analysis activities largely neglect stationary applications. Stationary applications should be analyzed as well as transportation applications.
- Market transformation activities should take advantage of opportunities that are developing in the South as a result of hurricane Katrina. Emergency back-up energy generation systems are being mandated for high rises, gas stations, emergency shelters, and other critical infrastructures

Mr. Wootten commented on the budget-related statement that “the whole pie should be expanded.” He asserts that there will always be resource constraints, so systems analysis should be used to help guide R&D. Mr. Chernoby agreed to reword the subcommittee’s comments on the budget. Looking at the pie to date, there is a split of potential technologies that are somewhat reasonable given what we know about systems analysis.

## **V. Public Comment Period**

The floor was opened to anyone present wishing to provide public comments.

### ***Jerry Hinkle, Vice President, National Hydrogen Association (NHA)***

Mr. Hinkle referred the HTAC to a statement sent by the NHA to Senator Dorgan (Chair), Senator Domenici (Ranking Member), and Honorable Members of the Appropriations Subcommittee on Energy and Water Development. The statement, which provides comments on the DOE budget for the Hydrogen Program, was provided to the HTAC for their reference.

Mr. Hinkle went on to mention legislation proposed last year (H.R. 632 or S. 365) to create an “H Prize” funded by a separate authorization to DOE. The bill passed 416-to-6 in the House but died in the Senate. The House Science and Technology (S&T) Committee will be re-introducing the bill this summer. Mr. Hinkle stated that the S&T Committee, particularly Dan Lipinski (D-IL) and Bob Inglis (R-SC), are interested in having the HTAC take a look at the H Prize legislation and consider if the Committee would be interested in expressing support for the concept or the bill. Dr. Lloyd noted that a copy of the bill was provided to him and that he will arrange to have copies made available to all the HTAC members.

**VI. *Vision of the End State and Transition to the Hydrogen Economy: Mr. David Friedman (lead) with input from Dr. Robert Shaw and Dr. Roger Saillant***

Mr. Friedman expressed his desire to raise some general issues to the HTAC in order to open up a dialogue and consider what role the HTAC should have in advising DOE in these areas. He pointed particularly to the broad question of how well the vision of a hydrogen economy and a hydrogen pathway is being communicated. In his opinion, there has been a failure to communicate the hydrogen vision to the Congress, the public, and the market. He believes that we have done a good job of communicating the ultimate vision of what hydrogen *could* be, but a poor job of describing the process required for reaching that endpoint. In particular, he pointed out the need to better communicate the timeframe and the risks, and how hydrogen can be woven into the tapestry of energy options available to us over time. He believes that some of the waning support for hydrogen is due to unrealistic expectations, which could be managed through improved communication. Mr. Friedman offered the example of the environmental community, which went from being strong hydrogen advocates to some of the strongest hydrogen foes, almost overnight. He noted that it has been an uphill battle to re-educate the community about what hydrogen can do and when. He remarked that many of these former advocates perceived hydrogen as a “silver bullet” that would solve all the energy problems and then were disillusioned by the lack of progress. He pointed out that the NAS Resources study should go a long way in addressing this, since it will report on the budget requirements for moving to a hydrogen economy, how this will lay out over time, and how it fits within the competitive marketplace. He suggested that after the NAS study is completed, the HTAC should review the report and determine if there are messages and results that the HTAC wants to take up and communicate in their recommendations.

He also asked whether the HTAC should play a higher-level role by helping to further articulate and communicate the vision for a hydrogen economy or by urging the DOE to improve the way they articulate and communicate the vision and how the hydrogen economy may evolve over time (e.g., what will the “hydrogen future” look like in 5 years, 10 years, 20 years, etc.). He asked for feedback from other HTAC members on whether the HTAC should take on this role, and if so if it’s a task for sooner or later, and to what degree the Committee should interact with DOE on this subject.

Dr. Dresslehaus asked whether it would be possible for Mr. Friedman to develop a draft “roadmap” for the HTAC to review and consider. Mr. Friedman replied that the NAS report could probably serve this purpose. Dr. Dresselhaus went on to caution that not everyone on the Committee is convinced that hydrogen holds the answer for the country’s transportation energy needs, adding that she herself is skeptical and does not believe she will, in her lifetime, be able to drive to a filling station and fill a fuel cell-powered car with hydrogen.

Dr. Ramage remarked on a general problem with the debate on this subject, both within and outside the HTAC: that it is very difficult to visualize what the future will or could hold, and to further imagine how a transition of this scale and magnitude could take place. He noted that the world of the future (2030 and beyond) will be a world with many different potential hydrogen sources and a world that will likely be carbon-constrained, adding that hydrogen in transportation has more potential for reducing CO<sub>2</sub> emissions than anything we have until renewable energy plays strongly in the power generation sector. He stressed

a need for a balanced strategy and R&D plan that includes hydrogen as part of the mix. He expressed his hope that HTAC would not be viewed as “advocates for hydrogen” but rather as a group that is concerned about the energy future of the country, in the short term and in the long term. He reiterated that while it is impossible to predict what the future will be, it is fairly clear that carbon emissions need to be reduced and hydrogen can be a big contributor to making this happen. Dr. Lloyd agreed and offered his opinion that the DOE could do a better job in the Posture Plan of communicating the compelling reasons for hydrogen.

Dr. Shaw brought up what he views as another problem with the debate: the tendency to compare the costs of future technologies with the status-quo, while not accounting for the “cost of doing nothing.” He stressed the need to internalize the costs of the negative impacts of technologies and to compare future technologies and options on this basis. This comparison will avoid the common and, in his opinion, mistaken presumption that future technologies must be competitive with the costs for doing things today in a way that we know is causing a problem. He asked whether the HTAC could agree to make the point in their report that there is a cost of doing nothing and that hydrogen is one of the solutions. Dr. Shaw referred to the draft “Stern Review Report on the Economics of Climate Change” as an example of some thinking on this subject.

Mr. Mudd identified a common theme: the need for a clear R&D roadmap that points to the tangible benefits of success to individuals and society (e.g., fuel costs, environmental emissions). He suggested that this sort of roadmap, rather than a “cost of doing nothing” approach, would be most effective in advising DOE.

Dr. Milliken noted that the DOE/EERE Office of Planning, Budget and Analysis does project oil savings and CO<sub>2</sub> emissions reductions from its R&D programs, in response to the Government Performance and Results Act (GPRA). She also pointed out that the Multi-Year Research and Development Plans represent the roadmaps for achieving these benefits. These R&D plans provide the details of the DOE program, whereas the Posture Plan was meant to be an overarching document that describes the broader goals and program areas. Mr. Mudd asked whether utility industry input was sought in developing the EERE R&D plan, and mentioned in particular working through groups like the National Hydrogen Association and the Electric Power Research Institute (EPRI). Dr. Milliken responded that EERE is taking steps in that direction and is working with the Hydrogen Utility Group and EPRI to get more utility industry input.

Mr. Davis commented on the notion that DOE may be “over- or under-advocating” hydrogen. He pointed out that DOE’s schedule calls for establishing technology readiness by 2015, allowing vehicles to be deployed in 2020. He added that DOE has always been forthright in saying that it will take decades to turn over the vehicle fleet and that significant benefits will not be seen until 2040. He does not think this could be categorized as “over-selling” and is not aware that DOE has ever conveyed the message that hydrogen was going to represent a near-term solution to the energy problem.

Mr. van Dokkum expressed his opinion that the October 2007 report of the HTAC to the Secretary of Energy should be divided into sections: one that addresses their recommendations and comments on the Posture Plan, and one that provides policy recommendations. He offered a suggestion for one policy recommendation, as follows: Hydrogen is a solution to two big problems: energy availability and carbon reduction. The HTAC should spell out the value proposition for what that means to society in the long term. He noted that there is consensus among the G-5 nations about hydrogen and its benefits, and that many countries are pursuing hydrogen far more aggressively than the United States, particularly when you look at per capita spending levels on hydrogen RD&D. He remarked that the United States is falling behind, rather than leading, even though the United States is the largest user of energy in the world. He urged the HTAC to clearly articulate in its report the important contributions and benefits that hydrogen can provide as part of the future energy mix. He also pointed out the importance of showing progress

along the way so that people don't lose interest, and doubt the practical applications of the technology. He believes that the HTAC should make an effort to identify and articulate progress and success with hydrogen and fuel cells in demonstrations. He urged the HTAC to consider formulating a policy recommendation for continuing demonstration programs on both stationary and transportation applications of fuel cells, since these provide great mechanisms for testing real-world applications and getting the technologies out into the public eye. Mr. van Dokkum also expressed his concern about public perception, noting that he is disturbed to hear Secretary Bodman refer to fuel cells in a negative way while continuing to highlight nuclear energy.

Dr. Lloyd asked the HTAC whether anyone objected to the idea of creating a section on Policy Recommendations in the October 2007 report to the Secretary, and suggested that the HTAC support staff could begin pulling this information together from the Committee discussions and present it as a draft for consideration by the Committee.

Mr. Chernicoff pointed out that the HTAC should keep in mind that the Hydrogen Posture Plan affects more than just DOE, and the Committee should consider how their recommendations and comments will affect and align with other Federal initiatives at other agencies (e.g., Departments of Transportation, Commerce, Labor, and Defense; EPA; etc.). Dr. Lloyd agreed on this point, and noted that the HTAC is very aware of the role that other agencies, DOT in particular, will play in the future of the hydrogen economy. (One member remarked that the HTAC's first recommendation was to create a high-level Interagency Task Force to address just this issue.)

Mr. Friedman re-emphasized the need for better communication on the hydrogen vision and pathway forward. He noted that while many of the Committee members understand how this could work and what progress has already been made, most of the public does not possess that understanding. Chairman Lloyd agreed, saying that many of the HTAC members have ridden in hydrogen fuel cell vehicles, seen or participated in building hydrogen fueling stations, and handled and operated stationary and portable fuel cell devices. He suspects that many of the hydrogen critics have not had this opportunity and are not aware of the progress that has already been made.

Dr. Shaw asked to bring another point to the attention of the HTAC, for possible consideration as a policy recommendation. He said that if the Committee (1) believes that hydrogen is an important part of the future of the energy system, and (2) recognizes that the pathway forward will likely be long and costly, then the HTAC should consider the level of private investment over time and whether this is adequate. He noted that there is a lot less cash flowing from private markets into hydrogen RD&D today than there was before. He suggested, therefore, that it might be appropriate for the Committee to recommend that it is imperative that the federal government—not just the DOE, but all the agencies that are involved— increase their level of effort on hydrogen. He urged the Committee members to consider recommending a substantial increase in the amount of resources going to the federal hydrogen program, maybe as much as an order of magnitude or more. He added that this level of funding is not out of line with the kind of incentives that have been provided to biofuels, and that hydrogen merits similar levels of support.

#### **VII. DOE/Industry Safety, Codes and Standards Activities: Mr. Jesse Schneider (Daimler-Chrysler) and Mr. Patrick Davis (DOE-HFCIT)**

Mr. Schneider began by introducing himself as the industry co-chair of the FreedomCAR and Fuel Partnership's Codes and Standards Technical Team (CSTT). He also introduced Mr. Davis (acting Hydrogen Program Manager and former DOE co-chair for the CSTT) and Mr. Antonio Ruiz (acting DOE co-chair for the CSTT). Mr. Schneider emphasized that the CSTT does not write codes and standards. Its role is to help direct research activities to support mostly national but also international activity in this area (with a primary focus on developing data required by the codes and standards process). The scope of



the CSTT includes safety as well as codes and standards. He noted that there are a lot of activities directed towards safety, mostly related to the interconnections between the vehicle and the infrastructure.

Mr. Schneider described the key goals of the CSTT. First, he noted that the Tech Team is working towards a goal of being ready for deployment of vehicle fleets and a hydrogen infrastructure by 2010. The CSTT aims to complete R&D to support essential hydrogen and fuel cell codes and standards by then. He added that the critical need is for timely implementation of performance-based codes and standards that will enable safe technology deployment without restricting technology development. Another key goal is conducting gap analysis to identify and prioritize areas where information is needed to advance safety, codes and standards. And finally, the Tech Team aims to ensure that the information and best practices that are developed are made available to the responsible standards development organizations (SDOs).

The membership of the CSTT includes four actively participating energy companies, three automotive companies, national labs, DOE, DOT, and ad hoc contributors from the DOE Hydrogen Quality Working Group, emergency response organizations, fuel cell companies, and other organizations as required. The CSTT maintains ongoing coordination with key groups such as the National Hydrogen and Fuel Cell Codes and Standards Coordinating Committee, the National Hydrogen Association, and the U.S. Fuel Cell Council. Many of the CSTT members actively participate on specific standards-development committees within organizations like the Society of Automotive Engineers (SAE), National Fire Protection Association (NFPA), and International Codes Council (ICC). Cross-cutting teams (e.g., the Hydrogen Quality Working Group) are formed as necessary to address critical topics.

Mr. Schneider stated that while significant progress has been made in development of codes and standards, there remains a lot left to do. He pointed to the following progress:

- Nine active U.S. codes and standards organizations are working on hydrogen.
- Twenty-two codes and standards have been published in this area, 10 of which are under revision.
- At least twenty-eight draft codes and standards are under preparation or review for publication.
- Four international codes and standards have been published, and 13 are in development.

When asked by Mr. Bawden to estimate how many more standards are needed, Mr. Schneider replied that he thought 50-70 more are needed.

Another accomplishment is the development of an on-line resource at <http://www.fuelcellstandards.com>. The site maintains, on a real-time basis: (1) the status of all fuel cell code and standard activities, (2) a calendar of meetings and other significant dates, (3) services related to the hydrogen and fuel cell industries, and (4) a bulletin board for posting questions and answers of mutual interest. The bulletin board allows any user to post questions and responses, and is manned by technical staff who will quickly respond.

Mr. Schneider identified some of the key challenges faced by the CSTT. The first challenge is limited historical data on the use of hydrogen in different applications. Because of the different properties of hydrogen and the different industries involved, there is a need for technical projects to develop valid data. Another key challenge is the large number of “authorities having jurisdiction” (AHJs) – with more than 44,000 AHJs in the United States. He noted that the AHJs can *choose* to adopt U.S. codes or state laws (if they are available), or they can develop their own codes and standards to meet their particular needs and requirements. He pointed to the need for uniform training of officials and for standard practices for conducting safety assessments. There is also a need for harmonization of domestic and international standards, which can be hampered by the tendency for different standard organizations to sometimes view each other as competitors.

Mr. Schneider noted that the United States has taken the lead in developing codes and standards related to hydrogen fuel cell vehicles and fueling stations. The International Standards Organization (ISO), at least at this time, is following the U.S. lead and harmonizing with U.S. standards. But there is still work to be done on international standards harmonization, particularly in the area of Global Technical Regulations (GTR). The GTR is a United Nations-led effort which is seeking to develop a single regulation for all vehicles (rather than different regulations for different vehicle types).

Mr. Schneider briefly described the Codes and Standards Tech Team Technology Roadmap, developed in 2004 and updated in May 2006. The roadmap details the gaps and needs required to meet the 2010 goal, and includes detailed Gantt charts and milestones for program activities.

In the area of accomplishments, Mr. Schneider first described two national templates, developed to help identify and coordinate development of codes and standards for different parts of the system. One template addresses all the different parts of the vehicle system, and the other addresses hydrogen generators and stationary and portable fuel cells. The CSTT has also initiated work developing data necessary to permit high-pressure (70 MPa or 10,000 psi) refueling. The team developed a statement of work and did some preliminary tests at Powertech on third party tanks to determine if the guidelines in SAE J2601 could be met. The study conducted 25 fueling trials with different types of tanks (large, small, type 3 aluminum-lined, type 4 plastic-lined tanks) to see what is needed to meet targets for a 3-minute fill at 98-100%. The study showed that pre-cooling the hydrogen gas going into the vehicle will be necessary for high-pressure fueling with fast fills. There may also be a need for communications from the station to the vehicle. Mr. Schneider noted that follow-on work will include a multi-client study funded by the energy companies and government, with six auto companies providing their next-generation on-board hydrogen storage systems for testing as in-kind cost share. The study will develop additional data on real vehicle tank systems, needed for codes and standards development. In addition, Sandia will use the data to develop a model for design and operation of on-board storage and hydrogen station dispensing.

Mr. Schneider next addressed the subject of hydrogen quality and the progress that the CSTT has made on this front. He noted that hydrogen quality is a big issue in the world of standards because of the hydrogen purity levels required by today's PEM fuel cells, adding that the initial hydrogen quality guidelines authored by both ISO and SAE are quite stringent. The CSTT is working on developing a test matrix to identify all the different constituents that must be tested for PEM fuel cells and whether the testing must be done at a single cell, multi-cell, stack or system level (the matrix also includes additional details such as membrane type, platinum loading, etc.). The quantity of testing required to support the matrix is very large, so the Team is working to divide up the effort among different organizations funded by DOE and international agencies in Europe and Japan. Standard testing requirements are also being developed to support the effort. The goal of the effort is to develop hydrogen quality standards with the proper balance between hydrogen cost and quality (from the perspective of fuel cell operation and durability). Mr. Schneider noted that the SAE and ISO are on a path to get standards in place by 2010 or even before, and the CSTT is trying to schedule the work plan to be responsive to that timeframe.

In response to a question from Dr. Shaw about how hydrogen quality is measured, Mr. Davis responded that it varies by constituent, but that typically the impurities are measured at the parts-per-million level (although the sulfur guidelines call for parts-per-billion). Mr. Bawden and Dr. Shaw asked if consideration is given to what happens if/when new technologies (e.g., high-temperature membranes) are introduced that would have different responses to the contaminants. In this case, the high-temperature membrane would likely make the PEM fuel cell more tolerant to contaminants, and thus should have a competitive advantage; however, restrictive quality standards for hydrogen could negate this cost advantage. Mr. Davis replied that in all cases the CSTT works towards developing data for performance-based standards that hopefully will not stifle competition or development of superior technology. He noted, however, that for the issue of hydrogen quality it is difficult to do this since right now the fuel cell

needs a certain quality to perform, and the automobile makers will be pushing for standards that do not harm the fuel cells. He agreed that this is a difficult issue, adding that as better fuel cells are developed, we will have to scramble to change the hydrogen quality standards. For this reason, DOE is urging the national and international codes and standards community not to rush to develop firm “standards” for hydrogen quality. Mr. Chernoby agreed, stating that in his work on these committees they are very conscious of not locking in a standard while the technology is moving. However, he noted that there is a big push from certain national and international constituencies that want to force the technology into the marketplace through regulatory requirements.

Mr. Bresland asked whether commercial hydrogen bought today from a typical hydrogen supplier would meet the SAE and ISO hydrogen quality guidelines for fuel cells. Mr. Davis responded that using standard pressure swing absorption (PSA) hydrogen purification technology, you can meet the current guidelines with the exception of the inerts (due to helium content, which poisons fuel cells but that cannot be removed by PSA technology). He added that very high purity hydrogen is available, but expensive. Also, there is the problem of verifying that the hydrogen coming out of a nozzle and into a vehicle has met a certain standard. Mr. Davis noted that the testing equipment and methods are not available to measure many of the contaminants at such low levels.

Mr. Davis went on to describe some of the other data products and information tools that the CSTT is generating. These include:

- Version 1.0 of a *Technical Reference for Hydrogen Compatibility of Materials* (see <http://www.ca.sandia.gov/matlsTechRef/>), which provides open access to technical data on the effect of hydrogen on materials.
- Experimental work on hydrogen combustion, flame characterization, heat fluxes, flammability limits and probabilities, and radiation, which is published in the open literature and is very useful in risk analysis work.
- Quantitative risk analysis (QRA) to help make risk-informed decisions using computer simulations (as a substitute for historical experience) to help define things like refueling station setback distances.
- A compendium of permitting tools that present experience-based information with already-approved hydrogen stations, including fact sheets, case studies, and a peer contact list. DOE is working with stakeholder groups of code officials and other industry experts (in collaboration with National Association of State Fire Marshals and the National Council on Building Codes and Standards) to develop these tools. The case studies of specific station configurations will be vetted and approved by a group of 50 code officials.
- Bibliographic database with over 400 publications related to hydrogen safety (<http://www.hydrogen.energy.gov>).
- Hydrogen incidents database (via voluntary reporting) to document safety incidents and lessons learned (<http://www.h2incidents.org>).
- Web-based, seven-course education module for first responders (also available in print and CD versions). The course was highly vetted by the community and has been taken by about 3,000 people since its release in January 2007.
- A hydrogen prop and a prop course for hands-on hydrogen training. The course is expected to be available in early summer 2008, and will be mobile and will be able to be moved to major fire training centers as needed.
- An introduction to hydrogen for code officials, which will be similar to the first responder course but provide more detailed information on technologies and equipment (early summer 2008).

Mr. Bawden asked whether safety incidents with any other fuels are specifically tracked by a government agency. Mr. Davis or Mr. Chernicoff could not identify any comprehensive data collection effort on the part of the government. Mr. Bawden and Dr. Shaw posed the question of whether creating a “hydrogen incidents” database when there's no comparative basis to other related fuels or energy sources generates

the perception of a level of concern on hydrogen safety that may be unfounded. Mr. Davis replied that DOE did weigh this risk, but decided that the benefit of learning from voluntary reporting of incidents outweighed the risk. He noted that the database has been publicly available for over a year, and it has not been used in a negative way.

Mr. Schneider went on to describe some of the remaining open issues or barriers, noting that these are a few of the top priorities. First, there is a need to streamline the process for permitting retail hydrogen fueling stations, which currently takes 2-3 years. The goal is to develop a workable method for making standards available while technology is still developing – such that baseline standards are available to support initial fleets and fueling stations without locking us into codes that impede technical advances.

Mr. Schneider identified several future research priorities, including:

- Collaborative international R&D testing on fuel quality with JARI, ISO and SAE
- Complete testing and data collection on 70 MPa fueling
- Publish best practices manual
- Continue work on materials compatibility testing, including materials at high pressure and high temperature and composite materials
- Provide technical support/guidance to local code officials to facilitate permitting of retail hydrogen facilities
- Work with the Education Team on emergency responder and code official training

Mr. Napoli pointed out that once emergency responders take the hydrogen training, they realize that there is not as much danger as many people think there is. He was concerned that his earlier comments might have given the impression that first responders will require massive re-training in order to deal with hydrogen incidents. He emphasized that this is not the case, and that the procedures used for dealing with hydrogen incidents are really a reiteration of things that responders do every day, noting that they already respond to alternative fuel vehicles that have high pressure (e.g., compressed gas), high voltage vehicles, etc. He added that the training really focuses on educating first responders about the properties of hydrogen, the differences (which are not all that dramatic in most cases), and the fact that the tools and equipment already used for fighting fires in vehicles or structures may also be used for hydrogen.

### **VIII. DOT Regulations: Existing Regulations, Research and the Rulemaking Process: Mr. William Chernicoff (DOT-RITA)**

Mr. Chernicoff, with the U.S. Department of Transportation (DOT), Research and Innovative Technology Administration began the DOT presentation by referring the HTAC to a website designed to help locate the responsible regulatory agency(ies) for different parts of the hydrogen and fuel cell infrastructure (<http://hydrogen.gov/regulations>). The site includes a “regulatory map” that allows a user to click on any part of the system (e.g., power plant, tanker vessel, airplane, pipeline, passenger car) and see which agencies are involved and what regulations apply. Mr. Chernicoff noted that some comments on this website were received as a result of the recent Federal Register notice (“Statement Regarding a Coordinated Framework for Regulation of a Hydrogen Economy,” Federal Register, January 5, 2007, Volume 72, Number 3, RITA-2006-26758). The Notice on the website describes and indexes several statutory provisions of each major agency and discusses possible application of the provisions to different aspects of a hydrogen economy. A public comment period was open on the Notice from January 5-March 6, 2007. Three sets of comments were received, from United Technologies Corporation (UTC), Alliance of Automobile Manufacturers (AAM), and American Society for Testing and Materials Standards (ASTM). Mr. Chernicoff reported that no immediate action items were identified among the comments (i.e., there were no specific requests to change any of the content of the site). He noted, however, that the comments provided valuable insights and information, and these are publicly available through DOT/RITA. The Ad Hoc Committee on a Regulatory Framework for a Hydrogen Economy will be looking into addressing some of these comments over the longer term, including: (1) UTC’s comment

on OSHA regulations in different settings and applications (e.g., industrial hydrogen applications versus retail fueling stations, etc.); (2) AAM's comment on the preference for Global Technical Regulations; and (3) ASTM's comment about a need for a fuel quality standard.

Mr. Chernicoff noted that DOT will continue to add content to this website as it becomes available or is needed to address new technologies or gaps. (He noted, for instance, that there may be an emerging need to include carbon emissions as part of the regulatory framework for vehicles.) He reported that for each code or regulation they will be adding a link to the supporting consensus codes and standards information and reference material.

Mr. Chernicoff also described a gap analysis completed by the DOT-RITA in April 2006 ("Hydrogen Infrastructure Safety Technical Assessment and Research Results Gap Analysis," available from <http://www.rita.dot.gov/publications>). The report documents the feedback received from industry on technology and research needs. DOT is currently developing an R&D plan to address the data needs that will help advance safety and provide the basis for future rulemaking activity as needed (in consultation with DOE, so as not to duplicate efforts).

#### **IX. Informal Rulemaking Process: Mr. Neil Eisner, Assistant General Counsel for Regulation and Enforcement, U.S. Department of Transportation**

Mr. Eisner opened by saying that his presentation on the basic requirements of the informal rulemaking process applies not only to DOT rulemaking, but generally to all federal agencies who seek to promulgate a rule with binding requirements on the public. In accordance with the Administrative Procedures Act (APA), there are four basic steps involved:

1. Issuance of a Notice of Proposed Rulemaking (NPRM).
2. Public comment period.
3. Issuance of a final rule that responds to public comments.
4. Publication of any exceptions to the rule.

In response to a question from Mr. Bresland on whether there is a "formal" rulemaking process, Mr. Eisner replied that the informal rulemaking process is used for the vast majority of rulemakings in the United States. A formal rulemaking process is provided for in the APA, but it is very cumbersome and rarely used.

Mr. Eisner noted that rules are often issued to address a specific statutory mandate (e.g., the National Highway Traffic Safety Administration's statutory mandate to establish minimum levels of safety). They are also issued to address problems that agencies identify (large numbers of accidents, environmental damage, etc.), petitions from the public, new policy initiatives, or recommendations from oversight agencies like the General Accounting Office or the Inspector General.

Mr. Eisner described the basic contents of an NOPR: (1) a preamble (required), (2) rule text (optional), and (3) a public comment period (required). He stated that the preamble describes what the agency wants to do and why: the authority for the rule; what the problem is; the proposal for addressing the problem; and the effects of the proposal (including costs, benefits, environmental effects, etc.). He noted that the NOPR will generally ask a lot of questions in an effort to seek public feedback on critical aspects and assumptions of the rule proposal. It will also summarize and refer to the various analyses that have been conducted to support the rulemaking. The public comment period is generally 60 days, but it can be very short or much longer if the agency has justification for that. Mr. Eisner noted the preamble for the final rule must address all comments received to the NOPR. The final rule also has to have the rule text (describing the binding part of the rulemaking), which is updated in the Code of Federal Regulations.

Mr. Eisner went on to describe options to a basic NOPR that agencies can use to address particular sets of needs or circumstances. An Advanced Notice of Proposed Rulemaking could be issued before the NOPR to gather information from the public on how to address a particular problem. Following the NOPR, a Supplemental Notice of Proposed Rulemaking could be issued to gather more information on particular public comments, or to modify the proposed rule and seek further comment. He also noted instances where an agency will have the authority to issue a final rule, but will decide to issue an Interim Final Rule (IFR) instead. The IFR allows the rule to go into effect on a specified date, but asks for further public comment on minor changes made to the rule since the NOPR or how the rule is working in the real world. He noted that agencies can use other means for gathering comments from the public on particular issues, such as requests for information, public hearings, or allowing a second round of comments in order to allow the public to view comments from the first round and provide replies or additional comments.

Mr. Eisner pointed out a couple of other issues that affect rulemakings. One is the Paperwork Reduction Act, which requires agencies to do a special analysis of information collection burdens. For example, if an on-board recording device on an airplane, truck, or railroad were to be required, this would be an information collection burden that requires OMB approval and a specific Information Collection Budget. There is also a statutory requirement that the federal government must use high-quality data (i.e., all lab tests must be reproducible; data must come from reliable sources and be well-documented, etc.) Therefore, any data used to support rulemakings (whether it was generated by the government or obtained by the government from an outside source through the comment period) must be high-quality. He stated that there is also an Executive Order (EO12866) which requires OMB to review any regulations that are “economically significant” (over \$100 million a year in costs or benefits). Before issuing rules (or even NOPRs), the agencies must also check with the states (Governor’s office) and Tribal Governments to make sure there are no major conflicts or adverse affects.

Mr. Bawden asked whether Mr. Eisner could provide a concrete example of what it would take (and how long) to go through those steps for a commercial product that is ready to go to market. Mr. Eisner replied that it is difficult to say because it depends, for example, on how much research is required to support the rule (risk assessment, costs and benefits) and how complex the analysis is. He mentioned that the DOT has handled very complex and controversial rulemakings that have gone from nothing to a final rule in a year. But, he noted, these rulemakings only happened because there was a high level of attention and priority placed on getting the rule out by the Secretary, the Deputy Secretary, the General Counsel, and the appropriate Agency Administrator throughout the entire process. Mr. Eisner also noted that some of the hydrogen infrastructure and products could fall under existing regulations and might not require new regulatory action at all. Mr. Chernicoff pointed out that rules are often developed to prescribe certain ways of doing things in order to protect safety. If the goal is to change that rule in order to allow a new use or new procedure, then enough analysis must be done to show that there will be an equivalent level of safety. This analysis is often done through the consensus codes and standards organizations, and there is a lot of variability in how long this process can take. Mr. Chernicoff noted that once you get to the point of issuing an NOPR, the time frame variance is smaller (averaging 2-3 years). Mr. Bawden noted that there is a big need to synchronize the regulatory process with the R&D pipeline so that commercialization efforts will not be stymied by lack of regulations. Mr. Eisner acknowledged the point but stated that synchronization is difficult to achieve while a technology is still developing and when it is unclear what the potential risks, costs and benefits will be. He noted that the efforts already underway to identify all the existing statutes that might be restrictive and what needs to be done to address these issues and other regulatory gaps will be important. Mr. Chernicoff added that the companies looking to bring products to market should look at how these products will align with the existing regulations; if problems are identified, there is a process, which Mr. Eisner described, for changing existing regulations or developing new ones.

Mr. Hofmeister asked whether regulatory decisions in other countries could help to facilitate or accelerate the development of revised or new regulations in the United States. Mr. Eisner replied that it can help a



lot. He noted that the U.S. Government is very interested in harmonizing regulations internationally. In addition, the United States is working with other countries and international organizations to develop open rulemaking processes. Mr. van Dokkum asked whether there is still a competitive advantage for the first movers in developing regulations, even with full and open collaboration. Mr. Eisner agreed that rulemakings can definitely be used to provide competitive advantages, and he said that is why governments are working hard to make sure everyone can participate. Dr. Lloyd noted this subject brings to light one particular problem in the hydrogen industry, in which the Japanese government has promulgated high pressure industrial gas laws that are very, very difficult for a Western company to comply with. He suspects their vehicle regulations will be even more complex. Dr. Lloyd suggested this might be an area that the HTAC should monitor and bring to the attention of the Secretary of Energy.

**X. National Association of State Fire Marshals (NASFM): Issues on Codes and Standards: Mr. Peter Sparber**

Mr. Sparber is with the NASFM office in Washington, D.C. He began his presentation by telling the HTAC about the NASFM. The NASFM's members include the nation's State Fire Marshals, who are the most senior fire officials in the United States. Their statutory authority varies by state, but Marshals tend to be responsible for fire safety code adoption and enforcement, fire and arson investigation, fire incident data reporting and analysis, public education, and advising Governors and State Legislatures on fire protection. Some State Fire Marshals are also responsible for fire fighter training, hazardous materials incident responses, wild fires, and the regulation of natural gas and other pipelines. He noted that most Fire Marshals are appointed by Governors or other high-ranking state officials and they come from diverse backgrounds, including state police officers, fire fighters, fire protection engineers, state legislators, insurance experts, and labor union officials.

He stated that the Department of Transportation engaged the NASFM a number of years ago in an effort to "calm public fears" about the energy infrastructure, particularly issues associated with gas and liquid pipelines, liquefied natural gas (LNG) terminals, and emerging alternative energy sources. The NASFM agreed to collaborate and participate with the DOT in developing programs that help to address public safety, like fire fighter safety training, accident prevention, and reducing the likelihood of incidents. In the area of alternative fuels, the DOT asked for NASFM to help build public confidence as we move from fossil fuels to other fuels. Mr. Sparber noted that the NASFM recognizes that there will always be incidents and accidents involving hazardous and/or combustible flammable materials. The issue is how to minimize these and how to ensure the safety of first responders who deal with these events.

He added that training fire fighters is complicated by the fact that it is a very decentralized system, requires hands-on training materials, and experiences high levels of turnover. In addition, the 150,000 building and code enforcement officials in the country have very different backgrounds and levels of training; many of them do not have any formal education in building construction or engineering. He noted that as new fuels move into filling stations, there may be a need to address conditional permits, or to open up old permits for new uses. This issue could be challenging for permitting officials to deal with since there are so many filling stations.

Mr. Sparber pointed to the story of ethanol as one that is "not going especially well." He noted that in October of 2006, Underwriters Laboratories (UL), with very little warning to anybody, suspended the listings for E-85 dispensers at fueling stations. UL said the standards they were using were inappropriate for alcohol because gaskets and other materials in the dispensers would deteriorate with on-going exposure to alcohol. In response to intense pressure from the industry and other stakeholders, the UL issued a statement that it will develop a "provisional listing" to allow listing of the E-85 dispensers for use by the end of 2007, to be followed by standards development under the ANSI process. The questions remain: will the provisional listings be recognized by the states and by OSHA, and will they be sufficient

for legal defense? Mr. Sparber also described another recent problem with ethanol. A tanker truck full of ethanol burst into flames in Baltimore and killed the driver. Fire fighters responding to the scene used foam to fight the fire—foam that is effective on gasoline fires, but is soluble in alcohol. This situation left a very bad impression with the fire fighting community and made them ask the question: what else are we missing?

As part of its work with NASFM, the DOT has funded a three-year project to support the “Hydrogen Executive Leadership Panel” (HELP). The goal is to bring together key stakeholders (fuel cell developers, auto companies, insurance companies, regulators, code and permitting officials, emergency responders, public interest groups, etc.) to discuss the issues around hydrogen use and safety and try to better manage the process for introducing new codes, training, etc. The group did achieve some success in bringing people together and was able to achieve ANSI certification. He described four project areas that have been defined by HELP:

1. Responder Safety Training: using HELP to review, guide, and distribute training materials.
2. Codes and Standards: using HELP to educate code officials on interpretation of codes.
3. Data Collection and Analysis: using HELP to mobilize fire departments to help collect incident data.
4. Public Education: offering public safety officials as spokespersons.

He went on to describe some of the key lessons learned in the process. First, if safety becomes an issue, the transition will not happen. Second, there is a strong need for coordination, communication, and cooperation among public safety officials and the industry. Third, the organization is about more than hydrogen – it needs to address the whole spectrum of emerging alternative fuels and technologies. Fourth, the real value of HELP lies in serving stakeholders in order to enable the safe transition to alternative fuels. Next steps could include making HELP a separate, service-oriented organization that could help in the four areas previously described. He ended by saying that the organization is in its final year of funding from DOT and will, if it continues on as an organization, be seeking new funding mechanisms.

Dr. Milliken noted that there appears to be significant overlap between what the HELP is doing and what DOE is doing with first responder safety training, codes and standards, data collection and analysis, and public education. However, she does not see any mention of HELP working with DOE in the NASFM presentation. Mr. Sparber agreed that coordination with DOE will be important, but he noted that much of the HELP focus is on the perspective of state and local regulatory officials.

Mr. van Dokkum expressed his support for the HELP group and his hope that it will continue. He especially sees value in continuing efforts on the education of Fire Marshals with new technologies and extending this education into the communities of first responders and code officials so that our communities are ready for safe deployment when needed. Mr. Sparber pointed to the California Fuel Cell Partnership as a model for working with the State Fire Marshal, HAZMAT experts, and others in the public safety community. He noted that these representatives were involved and consulted throughout the process, and argued that this is likely why very few mistakes had been made in California’s progress towards alternative fuels. Mr. Chernoby also expressed his support for the organization and its role in education and collaboration. He asked Mr. Sparber if he could identify the biggest philosophical gap among the group members. Mr. Sparber replied that it was the simple fact that people did not want to communicate—that once the group members dropped their sense of “arrogance” and began discussing the issues, there really were no philosophical disagreements.

In a later discussion, the HTAC members suggested formalizing its support for groups like this that help to facilitate collaboration and coordination of key participants in energy transitions. Dr. Shaw suggested that this sort of comment could be included in the Committee’s recommendations and comments on the Safety, Codes and Standards section of the Posture Plan. The Committee generally agreed that there is a



need for Federal support for organizations that can engage and involve important stakeholder communities. There followed a discussion about funding for HELP in particular and the fact that DOT funding, at least at the level needed to allow the group to continue and grow its operation, will expire after this year. Dr. Milliken and Mr. Davis commented that DOE could perhaps provide some funding to support the distribution of education and training materials.

#### ***XI. Closing Comments for May 16, 2007***

In response to a question from Deputy Assistant Secretary, Steve Chalk, about the quality and responsiveness of DOE support for the HTAC, Dr. Lloyd posed the question to the HTAC. He asked for a show of hands from the Committee on whether they would echo Dr. Shaw's sentiments and strongly endorse the support for Dr. Milliken, Ms. Kathi Epping and Dr. Helena Chum (of the National Renewable Energy Lab). All members present raised their hands in a show of support for the DOE team. Dr. Ramage noted he has been involved with several DOE advisory panels and review committees over the past several years, and that he has found the DOE staff to be very responsive and cooperative. He added that for all the volunteers on these panels, it makes the participation worthwhile, since they see that their recommendations make a difference. Dr. Milliken thanked Dr. Ramage and the Committee for their vote of confidence. She added that the DOE staff recognizes that all the HTAC members are very busy and that they do their best to make their time productive and worthwhile. Mr. van Dokkum expressed his hope that the same level of cooperation and responsiveness will be received from the Assistant Secretary and Secretary level. Dr. Milliken reminded the Committee that the HTAC is very important to the Department and the Secretary, and she expects that they will see the same responsiveness. Dr. Ramage noted that the important thing is what is actually done in response to the Committee's recommendations. He noted that the DOE did make very concerted efforts to respond to the recommendations of the 2004 NAS report ("The Hydrogen Economy")—adding that DOE took the report very seriously and made real program changes, across DOE, as a result.

(Whereupon, at 5:26 p.m. (EDT), the May 16, 2007, session was adjourned.)

**MAY 17, 2007**

The May 17 meeting of the Hydrogen and Fuel Cell Technical Advisory Committee (HTAC or Committee) was called to order at 8:42 a.m. (EDT) by Dr. Alan Lloyd, HTAC Chairman. Eighteen HTAC members were present; HTAC members not in attendance included Dr. Uma Chowdhry, Dr. Byron McCormick, Mr. Ian Purtle, Mr. James Reinsch, Dr. Roger Saillant, Dr. J. Craig Venter, and The Honorable Robert Walker.

**I. Production Subcommittee Report: Mr. Greg Vesey**

Mr. Vesey began by stating that he has not yet pushed forward on forming a standing subcommittee on production, but he intends to do so. He plans to contact the HTAC members who expressed interest in being on the subcommittee, and get the group in place so that it is available to address issues as they arise. He suggested that he would query the HTAC with regard to what issues the subcommittee should address once it is formally established. He noted that the lessons learned from the ongoing DOE-industry infrastructure demonstration could be valuable in providing guidance to DOE on what that next five years should look like. In response to a question by Mr. Mudd on whether the infrastructure demonstration just focused on transportation, Mr. Vesey replied that it currently does focus solely on transportation.

Mr. Vesey reported that three key learnings from the demonstration program are: (1) regardless of the production technology, safe station construction/operation is not simple or trivial, and much has been learned to smooth this process; (2) off-board hydrogen storage systems will need 10 to 15 times more hydrogen capacity to meet future demand at high market penetration; and (3) the cost of constructing a station needs to be reduced by 60%. Mr. John Wooten voiced a concern that the subcommittee that Mr. Vesey is forming could really be called a “fueling” subcommittee. He asserted that a dedicated “production” subcommittee may also be needed, and he volunteered to form such a group. He noted that there are five or six significant production pathways, and the costs and priorities of the pathways need to be understood. Mr. Mudd supported the proposal for two separate subcommittees on production and delivery. Mr. Friedman expressed the opinion that the value of the HTAC lies in its higher-level recommendations, and a concern that by parsing the subcommittees too finely, they might be going into a level of detail that is redundant with other, more focused, hydrogen program review efforts. Mr. Vesey and Mr. Wooten agreed to further discuss this issue off-line. Mr. Katsaros suggested that they consider the context for the subcommittees and how they will contribute to or fit in with the HTAC’s overall work plan and entire subcommittee structure when making this decision. Later in the meeting, it was noted that the Transportation Infrastructure subcommittee, headed by Dr. Byron McCormick, may provide what is needed for the delivery side of things and that perhaps only another production subcommittee is needed.

Dr. JoAnn Milliken mentioned that she had been asked to bring the subject of the proposed H Prize to the attention of the Committee, and to ask the HTAC to consider endorsing the H Prize by sending a letter to the legislative sponsors (as also mentioned, May 16, in the Public Comment Period by Mr. Hinkle). Dr. Milliken made it clear that she was not personally endorsing the H Prize, but was bringing it to the attention of the HTAC at the request of the legislators so that the Committee can review the information and decide for themselves whether it is valuable. In reply to a question about whether the HTAC could send a letter to Congress endorsing a specific piece of legislation, Dr. Milliken replied that she would need to consult DOE General Counsel to be certain. She explained that the \$50 million in prize money is not meant to support R&D, but to provide a prize to a person or an organization that comes up with a breakthrough in the area of hydrogen. She added that the process has yet to be established, and the legislation will instruct the process. The proposed prize is for \$50 million over 10 years, and is not necessarily DOE-endorsed. The bill is sponsored by Congressman Inglis of South Carolina and Congressman Lipinski of Illinois.

Mr. Wooten expressed concern that the funding would be subject to political infighting and, more importantly, that the funding may not be directed at efforts that are consistent with current plans and programs. He added that it would be better to direct an additional \$50 million at the specific R&D targets described in the roadmaps. Mr. van Dokkum agreed, stating that the real reward for inventions is the marketplace, and that the prize funding would dilute the efforts of many companies working towards real solutions on a timeline that the marketplace will accept. Mr. Chernoby supported the comments of the previous two speakers and added that the amount of funding for the prize should be looked into. He stated that he would support the prize if the motivation is to provide incentives to small entrepreneurs around the country who may not be engaged right now in hydrogen R&D; however, he asserted that the amount of funding could be significantly lower to achieve this objective. Dr. Milliken pointed out that DOE has argued in testimony that funding for the H Prize should in no way negatively impact R&D money; that its funding should be provided in a separate appropriation, rather than as part of the R&D appropriation. She expressed the belief that the legislators understood this point, but could not comment on their follow-through. Dr. Shaw asked the HTAC to look at the prize as extra money for hydrogen that is not coming out of existing R&D funds. He compared the H Prize to the “X PRIZE,” which has stimulated a fairly significant amount of innovation, particularly on the part of individuals, researchers, and small companies. Mr. Vesey pointed out that competition for the X PRIZE caused teams to spend over \$100 million to win a \$10 million purse, and attracted significant media attention. Dr. Richmond stated that it would be better to wait for a private entity to provide funding for the prize, similar to how the X PRIZE works. Dr. Ramage suggested that these types of issues should be brought before the HTAC in a more organized way by providing the same information to everyone, in advance. He noted that the members of the Committee have different levels of understanding about the X PRIZE and the proposed H Prize, and that makes reaching consensus difficult. Dr. Milliken agreed, and offered to pull together more detailed information for the Committee so that they could continue the discussion (if desired) at the next HTAC meeting.

The Committee continued discussion on developing its report to the Secretary of Energy focusing on HTAC’s review of the Hydrogen Posture Plan. Mr. Mudd expressed concern about using language that would imply that the HTAC is endorsing policies to reduce carbon emissions or reduce oil use. He stated that he does not think this should be a recommendation of the Committee. He noted that, at least within FutureGen, it is alright to advocate technology advancement and deployment, but not to advocate any particular policies. He stated that asking representatives of different companies and industries to try to develop consensus on policies that impact CO<sub>2</sub> emission reductions, or that impact the use of oil, would be very difficult. Dr. Shaw agreed, but noted that the Committee members are serving as individual experts, not as representatives of their companies, and this must be made very clear. Mr. Mudd asked whether the Committee should be “technology-oriented” or whether it would “open the door towards advocating policies,” adding that DOE’s role is in advancing technology towards a hydrogen economy. Mr. Chernoby asked Mr. Mudd if it would be acceptable to have the HTAC make the point that the technological program alone probably will not be sufficient to drive the hydrogen economy into market—that the government probably will need to consider incentive policies, to help build up market interest and market implementation (without specifically advocating policies for carbon emission reductions). Mr. Mudd stated he would be comfortable as long as there was a “counterpoint that such policies maintain alignment with technology.” Mr. Wooten added to this comment, saying that policies can have unintended consequences and can sometimes drive the implementation of unintended technologies with negative impacts. Mr. Friedman clarified that the intent was not to support a particular policy, but to make the point that if the vision or goal is carbon reduction, environmental quality, energy security, and competitiveness, R&D may not be enough, and policy or other government action may be needed. Mr. Katsaros agreed with this comment and added that any policy-related statements or recommendations by the HTAC should be “technology agnostic;” that is, they should be crafted in order to let the market decide the best technology—the policy is intended to level the playing field and give alternative technologies a chance. Dr. Ramage stated that he thought the Committee had already agreed to the idea

that *once technologies are market-ready*, policies may be necessary to stimulate consumer acceptance/market deployment, but that those policies need to go away in time. Mr. Mudd stated he could agree with that. Mr. Friedman cautioned against making a specific statement that “policies must be phased out over time,” since there may be instances when a policy may need to be consistent over time in order for the market to accurately value the problem (e.g., with climate change). He proposed a more general statement, along the lines of “policies can change and vary over time...” Mr. Mudd asked whether the general position of the Committee might be summarized as, “Policies will have a significant impact on the market acceptance and penetration of hydrogen technologies,” without including any references to particular policies. There was no dissension to this suggestion. Dr. Lloyd noted that the HTAC members could provide further comments on this wording at a later date.

With regard to the subject of technology competitiveness, Mr. Vesey, Dr. Ramage, and Dr. Lloyd agreed that the HTAC should craft any recommendations or position statements with the clear message that hydrogen research, innovation and technology development is occurring globally, and that an important issue for economic competitiveness is whether the United States will be competitive in bringing technologies to market. In relation to the topic of the cost of the transition, Mr. van Dokkum asserted that if the transition is something that the government wants to achieve, then it should have a role in lowering these costs through policies and incentives.

A suggestion was made to include an HTAC position statement or recommendation that the Posture Plan should “recognize that achieving the goals of energy security, protecting environmental quality, addressing global climate change, and economic competitiveness requires technologies that can cleanly, efficiently, and economically produce hydrogen from indigenous fossil fuels, nuclear power, and renewable energy sources.” Dr. Taylor disagreed with the idea that the fuel source must necessarily be indigenous. She pointed out that U.S. food supplies come from all around the world and that the sources are so varied that it is not a problem. The key problem with energy is that oil imports come from a relatively small number of countries, many of which are in unstable regions.

Mr. Friedman noted that there have been a number of different discussions and comments around the idea of whether or not DOE should select or prioritize pathways, and when and how DOE should make down-select decisions. He cautioned that picking the fuel of tomorrow, today, is difficult, especially given the fact that natural gas will be the primary hydrogen source for the next 15 to 20 years. He expressed concern that the Committee may be encouraging DOE to pick the fuel of the future or to down-select too many things too early in the process. He noted that down-select decisions are needed, but it must be clear how these decisions are made.

With regard to recommendations or position statements relating to the FreedomCAR and Fuel Partnership, the Committee agreed that they did not have enough information available at this time to make any statements, other than to note that this group is operating to provide outside input to the program. Dr. Ramage reminded the Committee that the report of the NAS review of the Partnership will be available in September 2007, and will be a useful resource for the group. Mr. van Dokkum noted only that he has structural problems with the Partnership, since it does not enable the participation of many manufacturers who would broaden the perspective and bring forward a wider variety of technical solutions. Mr. van Dokkum added that he thinks it is important for the HTAC to recognize the importance of the technology demonstration programs and the learning that is produced, which helps to more quickly move technology from the lab to the market.

In reviewing the compiled summary of comments from the HTAC on the Posture Plan, Dr. Chum read the following bullet points:

- The Committee commends the Plan’s allocation of a large percentage of the budget on R&D at the component level. Each of the five technical areas called for in the basic science solicitations (novel

material membranes, catalysts, bio, solar and hydrogen) was specifically addressed within the Plan's R&D sections.

- Prioritize the Program's activities and consider de-selecting some pathways (HTAC may provide guidance on this prioritization). The National Academies' 2004 report serves as a valid roadmap for selecting priorities and identifying needed breakthroughs. Pathways DOE should continue to pursue include: (a) those likely to meet the cost goals, and (b) those that industry will not pursue on its own (e.g., physical and chemical storage).
- Explicit attention should be given in the next Plan to the next steps of nanoscience into applications. Nanosciences blur the boundaries between the different disciplines and will require rethinking collaborative work from lab scale to demonstration and scale-up and the relationship between science and engineering. *Mr. Vesey took issue with use of the term "explicit" here, noting that the HTAC has taken a position that it will provide general guidance and support, rather than advocating particular technologies. Mr. van Dokkum suggested rephrasing this to say that the "particular attention should be given to emerging technologies like nanoscience."*
- The research reward system in the United States does not support areas of work in need of long-term sustained research funding. This reduces the competitiveness of our programs in some areas. This is particularly relevant to hydrogen and fuel cell R&D. Creative thinking is needed by the program to overcome this obstacle and provide sustained interest and support for long-term efforts.
- The Committee is supportive of the approach to foster diversity of hydrogen supply pathways in order to have a broad domestic resource base for hydrogen production. The Committee recognizes that a multi-pathway program is complex and challenging to manage, particularly when budget appropriations require that difficult choices in prioritizations must be implemented.
- The Committee believes that a balanced R&D program focused on short-term technologies for the transition and long-term technologies for maximum impact needs to progress in a balanced way. From what the Committee can see, funding is moving in the right direction, if authorized funds are appropriated. Independent experts should continue to be used to review the program spending levels in the R&D portfolio to ensure that the program is balanced in terms of R&D timeframe and feedstock targets. Value-based analysis would be useful in evaluating priority options for the short-term research program.

Dr. Ramage pointed out that the production and delivery subprogram was significantly under-funded in 2004, 2005, and 2006, which moved some of the component milestones out. He suggested that the HTAC may want to make a specific statement about their concern for continued delays in the production and delivery budget and how delays would impact the long-term program. Dr. Lloyd supported such a comment, adding that he was not completely comfortable with the language that "funding is moving in the right direction." Mr. Davis pointed out that DOE agrees that production should have received more funding than it did. He explained that the program was faced with having to fund many earmarks, and so—based on an analysis of the critical path for reaching the 2015 technology readiness milestone—several areas, including production and delivery, were reduced to provide the needed funding. He asked the Committee to place its comments in context so that readers understand why the production budget was cut. He also noted that language from the Committee that specifically asks DOE to emphasize or "protect" certain program areas may result in DOE prioritizing that program over others in future budget prioritization exercises, so the Committee should take that into consideration. Dr. Ramage voiced his concern again about the reduced funding for production and delivery, particularly delivery, arguing that he thought this reduction should be specifically called out by the Committee. Mr. Davis said that in hindsight, the DOE may have cut the delivery program too much, but that is being rectified in 2007 with a significantly increased budget. He also noted that the delivery funding in 2004-2006 was used to conduct analysis which has helped DOE to understand some of the critical issues. Mr. Katsaros noted that the Committee needs to decide whether it will make a recommendation for more money for the program, adding that he shares Dr. Shaw's view that the budget needs to be bigger overall. Mr. van Dokkum noted that the Congressional authorization was higher than the budget, so there is room for increase. He expressed a desire to see more alignment between the Congressional authorization and the budget

appropriations. Mr. Chernoby recommended gathering hard data on how the United States compares with other countries on hydrogen R&D spending and allocations. He continued by saying that if the United States is found to be deficient compared to what is going on in other parts of the world, then the HTAC should make the point that growth is needed. He also expressed his view that earmarking has no place in an R&D program, and he suggested that the HTAC make that clear in their report. Mr. John Hofmeister stated the HTAC could be helpful in depoliticizing a request for more funds, by making the request to Congress directly, as an independent panel, rather than through the DOE Secretary.

Mr. Wooten expressed disagreement with the comment, "From what the committee can see, funding is moving in the right direction..." He is concerned that the Posture Plan does not explain why the program is continuing to pursue biomass gasification as a hydrogen pathway when the NAS report ("The Hydrogen Economy," 2004) said it will not deliver the desired results. He also stated that there is no justification in the Posture Plan for pursuing biofuel reforming, and he asserted that these two pathways must be better understood.

At this point, Dr. Lloyd suggested that the Committee, for the sake of time, needed to turn its attention to the two "summary" strawman documents prepared by Mr. Katsaros and Dr. Shaw. He asked the Committee members to provide any comments to him and to Dr. Chum on the document that Dr. Chum prepared the evening of May 16 to compile and summarize Committee comments on the Posture Plan.

## **II. List of potential recommendations for the First HTAC Report**

Dr. Shaw suggested that HTAC form an "executive committee" consisting of three to five members (e.g., leaders from the subcommittees), to produce a draft report for final comment from the Committee. Mr. Chernoby agreed that in order to produce a report by October, either an executive committee is needed, or the subcommittees that met on May 16 could focus on writing certain sections. Dr. Shaw suggested that the leaders of the subcommittees could serve on the executive committee. Mr. Friedman supported the formation of an executive committee and expressed his opinion that the group's goal should be to figure out the themes (i.e., big picture messages) from all of the comments instead of trying to incorporate all the detailed comments and figure out whether or not each HTAC member supports all the detailed changes. Dr. Dresselhaus pointed out that one of the recurring messages she heard was that hydrogen should not be considered by itself, that it should be considered in terms of other technologies. Another theme, she explained, is the need to consider hydrogen as part of a bigger picture, not just for transportation, but for stationary also, with short-term gains resulting from the early adoption of stationary and portable power. (See also Section II.C., "Formation of Writing Subcommittee.")

### **A. HTAC Strawman Report to the Secretary: Mr. Art Katsaros**

Mr. Katsaros explained that on the evening of May 16, he compiled a two-page synthesis of the Committee's comments, in an effort to distill down the key themes of the discussions in the past meetings. He presented this to the HTAC as a strawman for review, discussion and debate. He stated that he composed the strawman as comments to the Secretary, adding that something like this 2-pager could serve as the report to the Secretary or as an executive summary to a longer report. He noted that he had probably left out a lot of things, but hoped that this document represented a start on a summary of the key themes.

Regarding a bullet in the Policy Recommendations section, Dr. Lloyd asked if the HTAC had agreed to advocate more oil and gas exploration. Mr. Katsaros responded that he was piggybacking off of Mr. Hofmeister's discussion of the National Petroleum Council's Global Oil and Gas Study, which, at the request of the Secretary of Energy, is looking into factors affecting future global oil and gas supply, and U.S. policies and strategies that would promote sustained economic growth and security. Both Mr. Hofmeister and Mr. Katsaros agreed that more oil and gas exploration is needed to make any movement toward energy security, especially given the timetable for alternative energy pathways and the enormous pressures on oil supply if the

United States is to maintain economic growth in the next decade. Dr. Richmond objected to this particular recommendation, saying that it was outside the purview of the Committee. Dr. Lloyd also said that he would have difficulty with including that recommendation, since some of the barriers to oil and gas exploration may be legitimate (e.g., environmental concerns). Mr. van Dokkum stated that he, too, would stop short of endorsing more oil and gas exploration, but he would like to make a statement that conservation, energy efficiency, and the search for new resources should be continued, noting that the importance of conservation and efficiency should be stressed. Mr. Katsaros indicated that the bullet points in the strawman are not his personal positions, and that they are subject to approval, revision, or deletion by the HTAC.

Dr. Ramage suggested one way to circumvent the oil and gas policy recommendation is to explain that the hydrogen program is part of an overall energy strategy for the United States, which includes renewable, fossil, nuclear, coal, etc. Dr. Lloyd agreed, noting that there are many precursors and various pathways to hydrogen. Mr. Friedman suggested that the HTAC describe that hydrogen will most likely play one of the important roles in our energy future, but that the technology is evolving in a world where there will be other options and competition from other energy sources. He advocated writing this broad type of statement instead of trying to enumerate all the possible energy sources and risking leaving one or more out. Mr. Chernoby agreed that HTAC should convey hydrogen as part of the overall strategic roadmap, which he felt DOE has to help manage. He worried about being too general or suggesting that there are lots of different answers, and advocated for a more pointed statement that hydrogen continues to be, until we find another solution, one of the options that we absolutely have to keep on the table and push. With regard to this suggestion, Mr. Vesey noted that the administration has recently focused attention on biofuels as the “end all,” adding that this focus has taken away some of the focus that needs to be put back on hydrogen. Mr. Friedman agreed that there is value in somehow getting across the message that a long-term focus is needed—a statement that will convey the fact that the solution is not about jumping from silver bullet to silver bullet.

Mr. Chernoby implored HTAC to recommend policies that drive market pull, not push. He noted that new technologies cannot be forced onto the market, and that zero emission mandates will not draw the United States into the hydrogen economy.

Mr. Vesey cited an inconsistency between the first and second bullet of the strawman report: the first describes the “elimination” of dependence on imported oil, and the second describes imported oil “reduction.” He suggested use of the term “reduction,” at least as a start.

Mr. Wooten stated that he felt comfortable with this revised, two-page report going forward as the Committee’s report to the Secretary, along with an attached summary of specific comments on the Posture Plan. Dr. Lloyd concurred, but noted that additional information will be needed from DOE in order to finalize the last two bullets. Ms. Epping responded that she thought that could be accomplished.

Dr. Ramage suggested adding a statement about the importance of DOE taking leadership not only through the technology-readiness point, but also through commercialization. He would like to see DOE go beyond demonstrations and help technologies survive the valley of death. Dr. Lloyd agreed, adding that it is also important to convey a sense of where we are in the continuum.

Mr. Wooten requested a closed private session so that the members can speak directly and succinctly about what they believe the recommendations should or should not be. Dr. Milliken indicated that they are having difficulty getting approval from General Counsel for a closed session, but said such a session might get approval for the next meeting. She further explained that written comments submitted by members are open to public scrutiny.

### **B. Report from Dr. Robert Shaw: High-Level Comments on “Why Hydrogen”**

Dr. Lloyd introduced Dr. Shaw’s briefing and indicated that it describes some of the benefits of hydrogen and provides some of the high-level reasons for pursuing hydrogen as an energy solution; Dr. Lloyd also suggested some of these points could be combined with Mr. Katsaros’s strawman to produce a strong report to the Secretary.

Dr. Shaw introduced his 3-page briefing by saying that it was motivated by a lunch discussion on May 16 with HTAC members, during which he was asked to try to capture some of the discussion for consideration by the broader Committee. He explained that he is aware that some of the statements may be controversial and will generate some discussion, and encouraged the HTAC to question the truth of his statements. He began by saying that he strongly believes that the Committee should promote hydrogen since it is a very important resource and because they are members of the “Hydrogen” Technical Advisory Committee. Dr. Shaw asserted that the Committee has an obligation to go forward and say, “We believe hydrogen is critically important,” not just write a broad statement that it is one of many things. He acknowledged that his viewpoint might not be endorsed by everyone. He also pointed out that he purposefully did not make any statement about the source of hydrogen, which can come from many sources and be produced in a distributed or central manner.

Dr. Shaw reiterated the question, “Can we afford not to make the transition?” He assessed that the transition would be very expensive, but also acknowledged that it is not beyond the scope of what the government is prepared to do when acting in the public’s interest. Dr. Shaw stated that if the transition or “crossing the chasm” (offered as a more positive metaphor than the “valley of death”) is governed by market forces, then waiting for the market to act could take longer than we can afford to wait, as carbon levels in the atmosphere continue to rise. He indicated that time is short and offered to provide evidence for that statement, if needed. Dr. Shaw said that waiting for the market to act is not absolutely necessary since HTAC could make a recommendation to move the ball forward faster. He felt that if the Committee does nothing, everyone pays a price, and this point should be continually emphasized—that there is a price for waiting as much as a price for moving faster (referring the Committee again to the “Stern Review Report on the Economics of Climate Change”). He asserted that paying the price to propel the renewable hydrogen energy system across the chasm (noting that when he thinks of hydrogen, he places it in the broader renewable context and not just as a single, stand-alone thing) is in society’s best interest, and not doing anything would incur an unacceptably high price for future generations.

Dr. Shaw contended that the United States must take the lead. He attests that the United States is falling behind, noting much of what is invented here is being manufactured and implemented offshore, which he feels is a major problem. He argued that the United States, as the richest and most powerful nation in the world and also the largest carbon user, should rightly lead the transition to a “renewable-hydrogen system.” Dr. Shaw pointed out that in his professional life he sees what the private capital markets are doing, and he noted that money is not flowing today into the hydrogen and fuel cell sector in the way that it was in the late 1990s and early 2000s. He indicated that there is now an enormous gap, where there used to be several billions of dollars that flowed into the sector before the crash of the market, now there is almost none. To fill the gap left by the exit of private capital from the fuel cell/hydrogen space, he asserted that DOE needs to step up the pace of funding. In this regard, he urged the HTAC to recommend that the DOE hydrogen program funding be significantly increased (perhaps as high as ten times). He suggested that the funds be directed towards carefully targeted investments, not only in R&D but much more broadly and deeply, to include demonstration programs and government purchase programs, which would pull the market forward. Finally, he proposed that the government should seriously consider implementing large and (very importantly) *durable*, incentive programs (at least as aggressive as the German “feed-in-tariff” for solar) to carry hydrogen across the chasm quickly. He closed his remarks by urging the HTAC to advocate strongly for the government to play a significant role.



Mr. Hofmeister agreed that the HTAC serves both a technical role as well as an advocacy role, adding that the advocacy role will be important if they are to do something in a meaningful timeframe that will impact the country. He noted that global companies can take their business wherever they choose, wherever the market conditions are convenient, which could cause some companies in the United States to spend more time and attention in other parts of the world developing what is possible there. He stated that it would be to the regret of the United States, which remains the largest market in the world, if we cannot capture the economic value of developing a new stream of energy. Mr. Hofmeister acknowledged that existing energy streams and other competing energy streams will be developed at the same time, because it is a growing economy and *all* of the above energy sources will be needed—not one or the other. He noted, however, that public policies (e.g., carbon management policies) may have more or less impact on particular streams of energy (such as fossil fuels), and he commended that. He compared the Posture Plan to a Christmas tree, whereby the Plan is the tree itself and the points of advocacy are decoration that enhances the tree, making it more impactful than the tree itself.

Mr. Friedman supported Dr. Shaw's briefing as directionally useful, and he advocated combining these remarks with Mr. Katsaros' strawman in the report to the Secretary. He identified one major gap, indicating that there needs to be recognition of the risks and timeframes involved when making a case for hydrogen, and asserted that this risk identification should be part of the government role. He cautioned that if the HTAC over-promises, and then a similar bioenergy advisory committee does the same thing, that would create a situation where we are competing for slices of the pie rather than trying to get together and enlarge that pie. Mr. Friedman agreed with Mr. Hofmeister that the HTAC has real potential to influence how people perceive and how the Secretary looks at this issue.

Mr. Wooten disagreed with the comments in Dr. Shaw's briefing, stating that it identifies only one pathway, a pathway that in his estimation can neither sustain nor deliver the amount of energy that is needed in the United States. He suggested that it would be "foolish" for the HTAC to recommend only one pathway, asserting that the United States should pursue a broad basket of technologies from all the resources available.

Mr. Keuter expressed general agreement with Dr. Shaw's briefing but suggested that it may be a little too focused on renewables, especially since there are other pathways that can meet the goals (noting that distributed natural gas will be needed in the early years for hydrogen production). He proposed exchanging the term "renewable hydrogen" with just "hydrogen" every time it appears in Dr. Shaw's slides. Dr. Shaw agreed that there are other pathways and supported production of hydrogen from sources such as distributed natural gas, nuclear, and coal with sequestration. He also noted that hydrogen can greatly enhance the value of intermittent renewables, which is a valuable aspect of hydrogen.

Mr. van Dokkum complimented Mr. Katsaros and Dr. Shaw for their writing and insights. He stated that if the Committee could draft anything close to one of these recommendations for hydrogen then he would feel good about being on the Hydrogen Technical Advisory Committee. He agreed with the emphasis of Dr. Shaw's remarks and recommended that HTAC give a lot of consideration to going forward with the document as a strawman—with some broadening and generalization being incorporated.

Mr. Chernoby pointed out that Mr. Katsaros' document serves as a great starting point for the Committee, noting that it "goes right at the heart of one of the things EPAct asks the Committee to do." He suggested HTAC take the key points from Dr. Shaw's briefing and add them to the Policy Recommendation section of Mr. Katsaros' strawman in order to broaden it. Mr. Chernoby further recommended that DOE provide help in cutting across the broad range of technological energy options and provide guidance on when decisions need to be made to cross the chasms, and when the policy system needs to be "kicked off" in order to do that.

Dr. Dresselhaus agreed with the previous comments from Committee members, but she added that there should be information about DOE's unique role in order to make the hydrogen economy happen within a reasonable time frame (e.g., R&D, new discoveries in basic science, crossing the chasm, accelerating

timetables, etc.). She asked for further help from Committee members in fleshing out a bulleted list to describe DOE's unique role.

Dr. Lloyd agreed that the United States should take a leadership position, asserting that the Committee, with its outstanding expertise, should be able to say something strong and impactful in its report, otherwise he declared it would be a waste of time. He stated that he would like to produce a document that the Committee can be proud of, and that the documents developed by Mr. Katsaros and Dr. Shaw are a good starting point.

Dr. Ramage advised that the transition to alternative energy sources will take decades, pointing out that it could be 2030 before renewable sources of hydrogen could have any significant impact. He explained that all energy resources—biofuels, oil, gas, coal, nuclear, etc.—will play a role in our energy future going forward. The key point is that since the transition to alternative energy systems will take decades, a sense of urgency is needed. He added that policy will also be needed—that the transition will not happen only because of straight market forces. Dr. Ramage recommended a message that is broad, urgent, and explains the timing of the transition and the fact that hydrogen can have a big (though not the only) role in the energy mix. He explained that hydrogen can play one of the biggest roles in transportation, because it can take carbon out of that sector.

Mr. Wooten again voiced criticism that the two strawman reports are overly focused on one pathway and would not be taken seriously as currently structured. He stated that he would be more comfortable if the sources of the hydrogen were broadened. He noted that energy is a global problem, and that renewable energy would be unlikely to provide more than 8-14% of energy needs.

Dr. Taylor expressed appreciation and agreement with both documents. She stated that it is important to keep communicating why hydrogen is needed and to keep that in perspective. She noted that although hydrogen itself is not an energy source, the characteristics of hydrogen allow it to fill a gap to connect our energy sources. She explained that technologies are needed that allow hydrogen to be applied optimally, and it may not be the best solution for energy delivery in all applications.

### **C. Formation of a “Writing Subcommittee”**

Dr. Lloyd proposed the following members for a writing subcommittee:

Dr. Shaw  
Mr. Wooten  
Mr. Katsaros  
Mr. van Dokkum  
Mr. Chernoby  
Dr. McCormick  
Mr. Vesey  
Mr. Walker  
Dr. Taylor  
Dr. Lloyd

Dr. Lloyd stated that the subcommittee will develop (using the two strawman reports, the compiled summary of HTAC member comments prepared by Dr. Chum, and drawing from minutes from the previous meetings) an integrated draft report for review and discussion by the HTAC. He suggested that a first draft be circulated for review within several weeks, and that Committee members provide any further detailed comments on the Posture Plan in writing to Dr. Chum. Dr. Richmond asked the Writing Subcommittee to make sure that Dr. Ramage's comments, concerning looking at this as an integrated approach, are included.

#### **IV. Next HTAC Meeting**

Ms. Epping announced that the next HTAC meeting will be July 31-August 1, 2007. In response to an inquiry, she responded that an agenda has not been developed. Dr. Lloyd noted that one hoped-for agenda item for the next meeting is the private session with industry groups to provide the HTAC members with state-of-the-art information on technology progress. Dr. Dresselhaus said that she would like to have some forward thinking about the role of the Committee and where HTAC can have an impact. She agreed with the plan to produce a short and “punchy” three-page report to the Secretary of Energy, followed by more detailed comments on the Posture Plan as the Committee’s first “deliverable.” Mr. Katsaros suggested HTAC input on topics for the interagency task force to discuss during their first meeting would be a good agenda item for the July HTAC meeting. Dr. Shaw recalled one item for the task force that he thought the Committee had already agreed to: asking the task force to consider how it might support the HELP program and other ways to get interagency cooperation and collaboration on accelerating needed codes and standards.

With regard to HELP, Mr. Davis clarified that DOE would consider providing funding support for HELP to accomplish specific tasks, such as distributing training materials, but that it is not currently DOE’s intent to blanket-fund them in the manner they were funded by DOT. Mr. van Dokkum noted that he is an Executive Committee member of HELP, and he reported that the organization is restructuring itself so that it focuses on all new energy technologies, not just on hydrogen. He recommended that HTAC wait for that restructuring to finalize. Dr. Lloyd requested an update from Mr. van Dokkum on HELP’s restructuring at the next HTAC meeting.

Picking up on Dr. Dresselhaus’ call for considering next steps, Dr. Shaw offered the issue of codes and standards (or, more broadly, all barriers to rapid implementation in transportation, stationary, and portable power) as an area that HTAC must immediately address. He also urged HTAC to consider issues in public education and what needs to be done to convince consumers that hydrogen is a good solution. He noted that the various HTAC subcommittees have developed work plans that provide some specific action plans and deliverables.

Mr. Bresland asked whether the agenda for the July meeting could include an overview of where the hydrogen program fits into the overall DOE picture, and how it meshes with issues like oil imports, the carbon issue, and other energy options. Ms. Epping stated that DOE could do this at the next meeting.

#### **V. Public Comments**

Dr. Lloyd first introduced Ms. Catherine Dunwoody, Director of the California Fuel Cell Partnership.

##### ***Ms. Catherine Dunwoody, Executive Director, California Fuel Cell Partnership***

Ms. Dunwoody explained that she is the Executive Director of the California Fuel Cell Partnership (CaFCP), but would like HTAC to take her comments as a Californian. She began by providing some background information on the CaFCP, stating that it was started in 1999 before the community had decided that hydrogen was a fuel for fuel cell vehicles, before energy security and global warming were in the limelight as public policy issues, adding that the motivation for the Partnership was air quality, which is still a critical issue in California. Her organization has evolved over the years, but primarily now focuses on technical projects and communications. On the technical side, the CaFCP seeks to fill gaps in areas where California may be ahead of the curve. For example, the CaFCP has worked in areas such as fueling interface protocols, hydrogen quality, first responder training, and safety. As these areas are being taken up by other organizations, the CaFCP is now making a big push on station access issues. She noted that the Partnership’s

third phase of activity will focus on building market foundations between the years 2008 to 2012, with activities directed at supporting the implementation of vehicles and fueling stations in greater numbers. Ms. Dunwoody emphasized the importance of DOE's R&D and technology validation programs to California, adding that the demonstration programs are critical.

Ms. Dunwoody stressed the importance of real-world validation since it provides the opportunity for communities to have a first-hand experience with the technology and to get data back to the developers to make the next generation a better product. She explained that she is a driver of a fuel cell vehicle and that it has been an invaluable experience to use the vehicle and use the fueling station on a day-to-day basis. The partnership has performed outreach activities to educate local officials, stakeholders, the fire community, and the public, which she believes is critical for broad consumer acceptance. Ms. Dunwoody explained that the phase of building market foundations will focus on the customer's perspective and seek to provide customers with an "excellent experience." Therefore, she noted there is a big emphasis on station access, making sure customers can get fuel for vehicles, and that they really like driving fuel cell vehicles. She reiterated that DOE's technology validation program has been extremely valuable, adding that the recent activity in scenario analysis has been very helpful in setting forth a vision. She declared that setting a vision and commitment for the nation is a key DOE role.

Ms. Dunwoody offered her opinion that a geographic focus in early development areas will be important, and suggested that California (by virtue of current private and public sector involvement and ongoing activities) is clearly an area where early markets will develop. She appreciated hearing about DOE's focus on early market applications aside from vehicles because most parts of the country will not have fuel cell vehicles in the near term. She agreed that early market activities are a great way to promote other applications of fuel cell technology. Lastly, Ms. Dunwoody indicated that she participated in a DOE workshop on permitting guidelines; she noted that it was very useful and provided a higher authority to point to with regard to accessing technical guidance on permitting, codes and standards, and case studies.

Dr. Shaw asked Ms. Dunwoody whether a significant increase in the CaFCP's funding would enable a faster pace of technology adoption. Ms. Dunwoody deferred the question to the members of the Partnership, noting that they may all have different opinions about that question.

Mr. van Dokkum asked if Ms. Dunwoody has seen significant improvement over the past seven years and if her confidence level in the technology and infrastructure has grown. Ms. Dunwoody replied that she has indeed seen progress, relating that when the program first started, the vehicles and stations were very closely held by the engineers and company employees. Now the technologies are much more accessible, to the point where she is told "take the keys, go off and do your errands, take your kids to school, give the car to legislators to drive." She noted that initially the program was not focused exclusively on hydrogen as a fuel, but she believes this is the right direction. She added that hydrogen needs to be put into context with other technologies that are out there and show that vision for the future, as opposed to fighting among the different options that are emerging.

Ms. Dunwoody indicated that she thought it was unfortunate that the fuel cell bus and fuel cell car activity was split between DOT and DOE, respectively. She understood that there may be regulatory reasons for this split, but stressed the importance of fuel cell buses and questioned whether there was any way to include bus demonstrations in DOE's program since it has done such a good job with the other demonstrations. She explained that in California they are looking to explore synergies and ways that building infrastructure for buses can be a model for high-volume passenger car fueling, since you do not need as many vehicles to deliver large amounts of fuel.

***Mr. Leo Grasilli***

Mr. Grasilli indicated that he was speaking as an American who has spent too many tours overseas, on board too many shipboard cruises in the Middle East. He stressed that much more must be done, and questioned whether the integrated Hydrogen Posture Plan does enough to include and stretch the resources of all the different Federal agencies. He asked specifically about the Department of Defense and whether the Committee believed that they were sufficiently included in the Plan. He noted this is a good opportunity to think about integration and creativity when it comes to legislative and executive direction, because he believes that HTAC will be listened to if they get creative and stretch the envelope. He alluded to the childhood lesson “if you never ask a question, the answer is always going to be no,” noting that the Committee may want to consider the questions that are not being asked.

Mr. Grasilli described his Department of Defense experience with efforts to develop codes and standards as frustrating, noting that a six- to nine-year process seems to be the best that can be hoped for. He questioned what this sort of time frame would mean for industry. He explained that the lack of codes and standards has caused efforts to be shut down at Camp Pendleton and in San Diego, which has been painful. Mr. Grasilli urged the HTAC towards actions that would help expedite the codes and standards that industry needs. He closed by reiterating his desire for the HTAC “to be bold as possible...since we’ve got tomorrow’s generations to worry about.”

***Dr. Christine Sloane, General Motors***

Dr. Sloane introduced herself as an interested party on behalf of General Motors (GM), and as a close colleague with one of the HTAC members who could not be here for the meeting, Dr. Byron McCormick. She stated that GM has a very strong sense of urgency—that there are forces now converging (including forces around energy security, global climate, balance of payments, economic competitiveness, etc.) that point to a change in the transportation system. She explained that GM believes it has a responsibility beyond just serving the market, but also in providing leadership for that market and where it needs to move. Borrowing a surfer phrase from her son, she exclaimed this is the time to “catch the wave,” and we must move fast to catch that wave or we might sit for a long time. She pointed out that the momentum is here now, which calls for a sense of urgency.

She indicated that GM’s press release on May 15, 2007, conveys GM’s desire to move quickly toward diversified fuel sources (including fossil fuels with CO<sub>2</sub> capture) and a future where renewables can start to blend in strongly to provide the security and the air quality that we need. Dr. Sloane described Mr. Larry Burns’ (Vice President, GM) announcement in the press release that a fuel-cell powered Chevy Sequel drove 300 miles across New York, in and out of traffic on public roads, on one tank of hydrogen. She noted that the vehicle was driven on both city roads and the highway over the course of the 300 miles, with two full-weight people in the car. She pointed out that Mr. Burns also announced GM’s intention to produce these vehicles and to make these vehicles available in the market by 2012. She noted this will not be high-volume production, but it will not be small-scale (50-100 vehicles) either—adding that this is an “enormous statement for GM to make in public.” She contended that the HTAC is not just a review committee, but has the tremendous opportunity to provide direction and leadership, moving beyond technical readiness and into the transition and the market.

---

Dr. Lloyd thanked the presenters for their comments and closed the meeting by expressing his gratitude to DOE and the support staff for their assistance.

The proceedings of the May 16-17, 2007 Hydrogen Technical Advisory Committee meeting were adjourned at 11:52 a.m. (EDT).