HYDROGEN AND FUEL CELL TECHNICAL ADVISORY COMMITTEE

MEETING MINUTES -- DRAFT

July 22-23, 2008

Courtyard by Marriott Pentagon South, Arlington, VA

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July 22, 2008

1. *Call to Order, Agenda Review*

Dr. Alan Lloyd, HTAC Chair, called the meeting of the Hydrogen and Fuel Cell Technical Advisory Committee (HTAC or Committee) to order at 9:07 a.m.

Roll call was taken (a complete list of meeting participants is provided at the end of the minutes).

Dr. Lloyd welcomed Mr. Steven Chalk, Deputy Assistant Secretary for Renewable Energy to the meeting, and invited him to make opening remarks. Dr. Lloyd commented on recent public remarks made by

Assistant Secretary for Energy Efficiency and Renewable Energy, which implied that hydrogen had received "undue financial support," and asked Mr. Chalk if he could address those remarks.

1.1 Opening Remarks: Mr. Steven Chalk, Deputy Assistant Secretary for Renewable Energy, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy

Mr. Chalk welcomed the new HTAC members and thanked those who are leaving the Committee. He noted that the HTAC members serve on a revolving basis, and the Committee is at the point where DOE is bringing a few new members in and rotating some members off. A new leadership will also be elected, since the HTAC Chair and Vice Chair are elected for two-year terms. Mr. Chalk thanked Dr. Lloyd and Congressman Walker for serving as HTAC Chair and Vice Chair, respectively, for the past two years and for the leadership they have provided. He also thanked Dr. Klaus Bonhoff and Mr. Haruhiko Ando for attending to provide their insights to the Committee on European and Japanese activities and experiences. He added that it is important to learn from each other and commended the addition of these international experts to the HTAC agenda.

Mr. Chalk stated that DOE is very interested in what experts and various stakeholder groups have to say about the health and the future of the hydrogen program, and the directions DOE is heading. He noted that DOE is interested in hearing the Committee's advice with respect to all aspects of the hydrogen program--energy efficiency, renewable energy, fossil, nuclear, and basic science. The HTAC can influence other Federal agencies as well, including the Department of Transportation.

Mr. Chalk announced that Dr. JoAnn Milliken is still the DOE Program Manager for the Hydrogen Program, but that she is also serving in an acting role as the Wind Program Manager. DOE has selected a person to take the position of Wind Program Manager, who is expected to start in early September. Dr. Milliken will then return to the Hydrogen Program. Dr. Sunita Satyapal is the Acting Program Manager for the Hydrogen Program until Dr. Milliken returns.

Mr. Chalk praised the recent report issued by the National Academies of Science, National Research Council (NRC), Transitions to Alternative Transportation Technologies: A Focus on Hydrogen. According to Mr. Chalk, the report evaluated the resources required for widespread implementation of hydrogen and fuel cells. While he has not yet read the report in detail, he has reviewed the conclusions and recommendations, and finds them to be "right on…with [good] quantification of the public policy [it will] take to make this transition… and see how that can address climate change and energy security." He noted that the most recent NRC report follows up on the 2004 report The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs, which he commended.

In response to Dr. Lloyd's request for comment on the remarks by Assistant Secretary Karsner, Mr. Chalk noted that one of the NRC's first recommendations was to have a balanced portfolio, adding he has heard many of the HTAC members agree that we will need all the energy options. He stated that hydrogen has received good support from Congress and is well positioned in the DOE portfolio, being perhaps the second-highest funded program right now. Congress and DOE are also looking at biofuels and vehicle efficiency technologies as ways to reduce oil use in the transportation sector. DOE has made a conscious decision to ramp up R&D in those areas, because they can have a greater near term impact on energy security. The balanced (near-mid-long term) portfolio approach is something of a change in DOE strategy over the past couple of years, and Assistant Secretary Karsner has been key in making this shift. Congress has passed legislation calling for increases in fuel economy by raising the standards for

corporate average fuel economy (CAFE) and a renewable fuel standard, which calls for 36 billion gallons of advanced biofuels by 2020. DOE thinks theses are appropriate actions, especially given the need for a response to climate change and to today's oil prices.

Mr. Chalk asserted that it will be necessary to "work all these options, [since] it will obviously take time to make an impact." No matter what the technology is, whether it is batteries, plug-in hybrids, or other alternatives, there are cost and performance challenges. "Asset turnover will be key," since it can take 15-17 years for the vehicle fleet to turn over. Policy will be needed to achieve faster change. One approach that the Hydrogen Program is now championing is using "market transformation" efforts to stimulate near term (stationary or specialty vehicle) markets for hydrogen and fuel cells. He reported that DOE has several alternative fuel vehicles in its fleet (including a GM Equinox fuel cell vehicle and a Ford flex-fuel plug-in hybrid vehicle) and is getting more people trained so that as many people can use the vehicles as possible.

Questions, Answers, and Discussion

- Congressman Walker conveyed that some HTAC members were concerned about Assistant Secretary Karsner's remarks because they "seemed to reflect a view that hydrogen may have some potential but it's 20 years out. That is the problem that we face in this arena…policymakers want to push it out further, and there are a lot of agendas [that can give] good reasons why they want to push it out. And yet [Mr. Karsner's] remarks came at a time when the price of gasoline was going to the point where hydrogen could certainly be competitive on the price front; where we have fuel cell cars being introduced for leases…and being put into consumers' hands; where there are opportunities opening up broadly in the hydrogen industry that go beyond just transportation, but where there are real opportunities." Congressman Walker continued, "[Mr. Karsner's] remarks seemed to reflect that we had just seen hydrogen disappear from presidential speeches. We've seen it disappear from the Secretary [of Energy's] speeches, and now we have the person who heads up [DOE]efforts for hydrogen basically say yes, we aren't putting a lot of emphasis on this because it is too distant for us to be really focusing on at the present time." Congressman Walker said that this point of view "ignores the fact that we are on the brink of some major breakthroughs," and expressed his opinion that "a lot of our international partners are far more aggressive in this area, believing that it's in the nearer term than we are prepared to do at the present time."
- Mr. Robert Rose offered to send Mr. Chalk the press report containing Mr. Karsner's remarks. He stated that he did not want to put Mr. Chalk into a difficult position, but that Mr. Karsner's language was that "the ramp up in hydrogen was a mistake; that it took money away from other near-term programs." He noted that while this quote and its context may have been "unfortunate," it is, in his view, "actually incorrect." Mr. Rose reported that his own analysis of the previous DOE EERE budget concludes that "the programs have been reasonably balanced since the very beginning." Mr. Rose expressed his opinion that the nation has "a problem that is big enough that we are going to need all these options pursued and developed, and we are going to need to extract value from all of them." He asked Mr. Chalk to convey the message that there is a need to "reshape the language so that the message about hydrogen is more positive."
- Mr. Chalk noted Mr. Rose's request, and replied that "the progress being made and the results of the program is really the best advertisement." He remarked that DOE is interested in hearing from HTAC on where the program is making progress and how to refocus.

- In response to a question about whether Mr. Karsner has been briefed on the NRC report, Mr. Chalk replied that Mr. Karsner received materials on the primary conclusion and recommendations of the NRC report via email, but has not been briefed in person.
- Mr. Chalk reported that when Mr. Karsner came into the position of Assistant Secretary, the EERE "budgets were very flat; the geothermal program was essentially being ramped down to zero, and the industrial efficiency program was being slated for zeroing out. Over the last two or three years [EERE] budgets have gone up, [which has enabled] a robust hydrogen effort while we've been able to resurrect the geothermal program." He noted the open DOE solicitation ($90 million over 2-3 years) for enhanced geothermal research, development and demonstration (RD&D), and that the Industrial Technologies Program is "making a comeback [and has] saved a lot of money over the last couple of years [by conducting] energy audits." Mr. Chalk continued by saying that "the increased focus on energy efficiency has been good…since it provides the nearest term payback." He noted that with the overall EERE budget going up, hydrogen funding continues to be robust and is still the second largest EERE program. He expressed his opinion that the current portfolio was "where we should be" and that "we have the appropriate amount of resources."
- Mr. Friedman noted that the NRC study suggested a Federal budget for hydrogen and fuel cells of $55 billion over the next 15 years. Mr. Chalk observed that the $55 billion included policy support to help "buy down" the cost of vehicles and infrastructure. He added that DOE is still analyzing what this means in terms of a recommendation for R&D funding support, but stated that he does not think that the amount will be much different than what DOE has estimated for the program. He suggested that the HTAC consider what the NRC requested for the R&D portion of the program and provide DOE with any advice they have on how to rebalance those funds. He added that Assistant Secretary Karsner has placed more of an emphasis on commercialization, and "getting the business acumen within the Department that is needed to execute programs, like the Loan Guarantee Program, that will be necessary to take the next step after technology is validated through our R&D efforts." He agreed that some of the changes the NRC report suggests for the future in the transportation sector can be achieved "if we solve the technology hurdles." He noted that the President's "20 in 10 initiative" called for decreasing gasoline use by 20 percent in 10 years (5 percent through CAFE standards and 15% through use of "technology neutral" alternative fuels), was codified into law by Congress through the Energy Independence and Security Act (EISA), which focused on the use of 15% biofuels and 5% fuel economy improvements to achieve the goal. Mr. Chalk added that a combination of technology development and policy support will be needed to achieve "asset turnover at a faster rate, because if we just let the technology come out of the pipeline and hope somebody picks it up without any government policies, then I think it's going to be a long time coming… [More attention to commercialization issues] will be needed f we are going to be serious about working the issues in a more urgent manner than we have in the past."
- Dr. Ogden explained that she was part of the team that worked on the NAS report, and conducted some of the scenario analysis work along with Mr. Friedman and others. She explained that she is concerned by some press reports that have picked up on the NRC report's total estimated cost of $200 billion for hydrogen and fuel cell vehicles over the next 15 years. She pointed out that this $200 billion number includes the entire cost for the fuel cell vehicles (FCVs), hydrogen fueling infrastructure costs, and public and private sector R&D spending. She asserted that the "most interesting" cost is the incremental costs of buying down the vehicles (the difference between the cost of a conventional vehicle, which is expected to be spent anyway, and the additional cost of a fuel cell vehicle). This incremental cost for fuel cell vehicles is estimated to be $40 billion (which is included

in the $55 billion total cost to the government). She urged Committee members to be clear on this point, since portraying the cost as $200 billion makes it "seem like a steep hurdle and [sends] the wrong message."

- Dr. Shaw asked about the Hydrogen Program's continuity over the transition to the new administration and, in particular, whether Mr. Chalk would be remaining in his position in EERE. Mr. Chalk replied that he expected to remain in his position, adding that he, Mr. David Rodgers (Deputy Assistant Secretary for Energy Efficiency), and Ms. Rita Wells (Deputy Assistant Secretary for Business Administration) are the senior career employees within EERE that will be providing the transition for the new management team. Dr. Shaw observed that it would therefore be important for the HTAC to have an active dialogue with Mr. Chalk, Mr. Rodgers and Ms. Wells over the next few months to share the Committee's thoughts on how to sustain the program. He explained that there is some concern among HTAC members about hydrogen falling out of interest. Mr. Chalk disagreed, and stated that this is not likely to happen.
- Mr. Friedman asked Mr. Chalk about the subject of his testimony to Congress, which he was scheduled to give on July 23rd. He also asked Mr. Chalk to comment on a continuing concern HTAC has about where the renewable hydrogen pathway is going at DOE. He noted that the NRC report highlighted the need for sustainable and durable commitments to policies and programs. Mr. Friedman observed that one of the challenges for hydrogen or any developing technology is that changes in government funding can send very important signals, especially early on, to industry about what people think is important. While he understands the need to balance long term and short term RD&D, Mr. Friedman asserted that "if you over-balance, you end up losing the long term; you take funding that people thought was moving in one direction, and all of a sudden people lose confidence in that direction." He concluded that this is a key problem that needs to be addressed: balancing for the near term as well as the long term.
- Mr. Chalk agreed that stable policies are critical, especially from an investment standpoint. He noted that "on-again off-again" policies, like the renewable tax credits, can hurt investment. He observed that the existence of a tax credit for wind installations has had a strong influence on whether or not the private sector will invest. However, the policy realm is "a little outside [DOE's] control…We don't know what the next administration might emphasize." He stated that his job is to educate the new administration on what progress has been and why the program is doing certain things. He also agreed that it is important to have predictable budgets, noting that if budgets cycle up and down too widely, the private sector will not invest their R&D dollars because they will doubt the longevity of the initiative. Mr. Chalk asked HTAC to provide DOE with their comments on renewable energy, especially any advice from industry on large-scale renewable hydrogen production demonstrations that DOE could support (for any application, not just vehicles). One example might be a wind-to-hydrogen demonstration that might help provide electricity markets with storage capability that could "firm up" wind. These types of projects would be well-suited for the DOE Loan Guarantee Program, which currently has a solicitation open for $10 billion in loan guarantees related to renewable energy.
- Mr. Chalk reported that his testimony to Congress on July 23rd is focused on near-term actions for reducing gasoline use. He explained that Oak Ridge National laboratory will testify and address measures that can provide near-term, incremental benefits, such as low rolling resistance tires. Mr. Chalk said that his testimony will concentrate on the progress in biofuels, batteries, and the time that it takes to get new technologies into the marketplace. He reiterated his position that this will require the evaluation of future policies, since if we just "let it happen…it will take a long time [for the

- Mr. Friedman expressed his pleasure on hearing Mr. Chalk recognize the importance of policies, and the understanding that it will take more than just research, development, and demonstration to cross the "valley of death." He noted that there are "not enough concrete policy ideas out there," and suggested that there are "some real opportunities for HTAC and DOE to flesh [these policy ideas] out more, because Congress is going to need guidance." Mr. Friedman stated that there is a risk that people will "grab onto [policy ideas] that don't necessarily make sense but sound exciting." He believes that DOE needs to step up as an expert in the energy area to offer guidance on what makes sense and what does not. Mr. Chalk agreed, noting that "times have changed…Thirty years of R&D have paid off, and a lot of these technologies across the board are much more affordable today. So we need policies... [and] DOE does need to change and start focusing on that." Mr. Chalk pointed to several efforts that DOE has initiated in this direction:
    - an "entrepreneur in residence program" that places venture capitalists at DOE national laboratories to identify emerging business opportunities
    - a solicitation to national labs for technologies that can be commercialized over the next 2-3 years
    - recent testimony to Congress from Assistant Secretary Karsner on a "clean energy bank" to provide financing for energy projects within the United States
    - a commercialization team has been formed in the EERE Office of the Assistant Secretary.

- Mr. Rose asked if DOE will develop its 2010 budget request routinely as it does every year. If so, he asked when it would be best for the HTAC to provide recommendations to the Secretary of Energy. Mr. Chalk replied that it is unclear how or when the transition to the new administration will occur. He noted that there has been some discussion about the possibility for a continuing budget resolution through January 20th, so that the new Congress and new administration could influence the 2010 budget. He advised that the 2010 budget request is already under development, and that "recommendations are timely now," and the HTAC's "recommendations always would be looked at and considered seriously." In response to a question from Mr. Rose about when the draft 2010 budget request is submitted to the Office of Management and Budget (OMB), Mr. Chalk replied that it typically would be submitted in late August or early September, with an OMB passback in late November.
- Dr. Lloyd asked Mr. Chalk for DOE's reaction to the "Pickens Plan" (put forth by T. Boone Pickens) and its focus on wind energy. Mr. Chalk replied that DOE has not analyzed the plan in detail, but noted that the Pickens Plan builds on a recently released DOE report that concludes that the nation can get 20% percent of its electricity from wind power by 2020. The biggest challenge to wind-generated electricity (and other types of renewable power) will be transmission, and policy will be needed to help meet the challenge. Mr. Chalk noted that some DOE representatives met with Mr. Pickens to talk about his plan, and are excited by the fact that Mr. Pickens can leverage the right-of-way he owns in Texas to provide transmission for at least two gigawatts of wind power to the Dallas metropolitan area. In response to a question from Dr. Lloyd about the size of the geothermal and solar power resources, Mr. Chalk explained that DOE estimates the nation's geothermal resource at about 10 times what is currently installed (or about 30,000 megawatts); DOE is in the process of analyzing the potential of concentrated solar power. He added that a report from the Massachusetts

Institute of Technology (MIT) estimated the resource for enhanced geothermal to be 100,000 megawatts in 2050.

- Dr. Lloyd remarked that he had read the recent news stories about Honda's release of their hydrogen fuel cell vehicle, the Clarity, and was surprised by quotes from Honda that said things like "we can mass produce these vehicles now," and "infrastructure is not a problem." He wondered how this type of language can be coming from Japan, and "whether DOE listens carefully to those words, and…why the Congress does not hear what is being said by a leading automotive company when it introduces its products?" He explained that he has some experience working with Honda and other Japanese companies in the venture capital world, and he tends to believe "sober comments coming from a big Japanese company." Dr. Lloyd asked Mr. Chalk for his opinion on the Honda statements and how DOE responds to that kind of input. Mr. Chalk agreed that the Honda Clarity is a beautiful, well-engineered vehicle that is "a great example of what can be done with the technology." In terms of DOE's response, he replied that "we come back to what the program is working on." The Hydrogen Program is focusing on lowering the cost of fuel cells and addressing other barriers (such as durability). The technology is still not affordable compared to other vehicles that are being sold today. Honda is saying it can mass produce the vehicles, but no one is saying that it can be done at a competitive price. Mr. Chalk added that we need to make sure the Hydrogen Program is targeted on addressing the right barriers, so that the cost competitiveness and durability of fuel cell vehicles and the cost of producing hydrogen from various feedstocks are improved. He asserted that technology development, in combination with policies, will "make it happen, but it just can't happen right today… [we can't] flip a switch and start making these vehicles affordable; they're in competition with vehicles today." Dr. Lloyd agreed, but noted that it is important to compare the cost of a fuel cell vehicle with the appropriate alternative (e.g., FCV versus plug-in hybrids or versus diesel hybrids).
- Mr. Hofmeister picked up on an earlier reference by Dr. Lloyd to an expression popularized by T. Boone Pickens: "we can't drill our way out of it." Mr. Hofmeister claimed that, in an interview on CNBC that featured Mr. Pickens and Mr. Hofmeister, Mr. Pickens "subsequently [said] that he didn't mean to disparage drilling." In the interview, Mr. Hofmeister explained that "drilling is important because of the declines we are seeing in natural production areas, which [will] inevitably continue." Mr. Hofmeister also asserted that without more drilling, the issue of "middle-of-the-barrel products" (diesel, aviation fuel, heating oil, etc.) will become even more of an import problem over the next decade or two.
- Dr. McCormick pointed out to Mr. Chalk that, "relative to durability and things…this is past being a science program. And if we keep casting it as a science program, it's an issue." He stressed that the biggest barriers to commercialization will not get solved in the science lab. Manufacturing processes need to be developed, and doing this "takes time and cycles of learning." He noted that the automotive companies "tend to think in terms of three commercialization cycles… to get through those generations of learning." Policy support is critically needed to help get through these cycles, and "is probably far more important than the research investment." He clarified that he did not mean to disparage science, or suggest that continued improvements are not needed, but he wanted to make the strong point that a much larger investment is needed on the policy side. Policies are needed now that will support the first commercialization cycles at low volumes, and then grow to higher volumes.
- Mr. Chalk pointed out that DOE is considering what the next phase of the current learning demonstration project will look like. He posed the question, "Is it going to take three generations to work everything out?" and noted that the answer "should influence what we do next in the infrastructure- vehicle learning demonstration."

2. *Introduction of New HTAC Members*

Ms. Kathi Epping Martin introduced the new members of the HTAC, who were just recently appointed by the Secretary of Energy:

- Mr. Anthony Eggert – Science and Technology Advisor, California Air Resources Board
- Dr. Janice Hicks – Executive Officer, National Science Foundation, Division of Chemistry
- Mr. Maurice Kaya – Energy and Management Consultant
- Mr. James Narva – President, Narva and Associates, Inc., National Association of State Fire Marshals
- Mr. Frank Novachek – Director, Corporate Planning, Xcel Energy
- Dr. Joan Ogden –Professor, Dept. of Environmental Science and Policy, University of California, Davis; and Energy Policy Analyst and Co-director of the Sustainable Transportation Energy Pathways Program at the Institute of Transportation Studies (ITS-UC Davis)
- Dr. Kenneth Schultz – Operations Director, Energy Group, General Atomics

Those new HTAC members who were present at the July 22-23 meeting introduced themselves and provided background on their experience, as follows.

Mr. Narva explained that he began his career as a line firefighter; after about 20 years at that he moved into the position of Wyoming State Fire Marshal, where he served about four years. He now represents the National Association of State Fire Marshals (NASFM), which is made up of 50 fire marshals. He noted that his expertise is focused on fire safety, codes and standards, training, investigations, and enforcement. With the NASFM, he is working with DOE and other organizations to develop fire and safety codes and standards that ensure that any transition to alternative fuel, whichever one it might be, is done safely. He stressed the importance of public acceptance, and noted that one of his roles is to help "bridge the gap," so that the public is assured that the fire service is confident that proper safety and emergency response procedures are in place. Mr. Narva added that an endorsement by the fire service brings a tremendous amount of credibility, so helping to educate the public and policymakers is one of their unique roles.

Dr. Ogden explained that she is a professor at University of California at Davis (UC-Davis) and has worked in the area of energy technology assessment and energy policy for about 20 years. She began her career as a physicist (and holds a Ph.D. in theoretical physics) and worked in nuclear fusion research for a number of years (at Princeton Plasma Physics Lab and as a consultant). She became interested in energy more broadly and went to work in another part of Princeton University, working for about 17 years there with a group that conducted assessments of new energy technologies. Dr. Ogden brings expertise in modeling, and was part of the team that conducted scenario analysis for the recent NAS report "Transitions to Alternative Transportation Technologies—A Focus on Hydrogen." She has also evaluated and modeled a number of applications of hydrogen and fuel cells in transportation and stationary markets, among other energy-related analysis work. At UC-Davis, Institute of Transportation Studies, she is Co-Director of the Sustainable Transportation Energy Pathways (STEPS) Program, an industrial consortium with 22 members, which conducts analysis to compare different pathways for moving forward on alternative transportation systems. She noted that hydrogen and fuel cells are a major part of their scenarios, but the program is also looking at technologies like biofuels and plug-in hybrids, among others. The STEPS team includes 15 senior researchers and faculty members and 25 grad

students. Dr. Ogden noted that she has served on several committees in California, including the Hydrogen Highway Advisory Committee and the Economic Technology Advancement Advisory Committee (ETAC) that is advising on the implementation of California's greenhouse gas mitigation bill (AB-32). She has also been involved with several of the NAS committees over the years.

Mr. Eggert explained that he began his career in the automotive industry, working first as a mechanical engineer for Ford Motor Company's vehicle environmental engineering program, and then as the manager of Ford's Fuel Cell Partnership Office in West Sacramento, CA. He next took a job as Associate Research Director at the UC-Davis, Institute of Transportation Studies, where he helped put together the Hydrogen Pathways Program, which was the precursor to the Sustainable Transportation Energy Pathways Program. He has since served as energy policy advisor to the University of California's Office of the President in Washington, DC, and worked with the California governor's office on climate policy. He is currently serving as the Senior Policy Advisor to the Chair of the California Air Resources Board. In that capacity, most of Mr. Eggert's focus has been on the implementation of AB-32, as well as other relevant programs, including the Zero Emission Vehicle Program and the Hydrogen Highways Program. He noted that California is in the process of "trying to rethink and reformulate all of our vehicle-related programs," including the Zero Emission Vehicle Program, the Low Emission Vehicle Program, and the Pavley Program (which includes a greenhouse gas standard for vehicles). The goal is to craft policies that maximize the potential of the programs so that they can contribute to meeting California's 2050 target for greenhouse emissions (80 percent below 1990 levels); to do this, he said, the transportation sector has to be almost entirely decarbonized.

3. ***Role of Government Vision and Policy***
Mr. Haruhiko Ando and Dr. Klaus Bonhoff

3.1 Hydrogen and Fuel Cells Save the Earth: Mr. Haruhiko Ando, Cabinet Office, Japan
>> see full presentation at http://www.hydrogen.energy.gov/advisory_htac.html

Mr. Ando spoke on various hydrogen initiatives within Japan, particularly the efforts that he helped to organize and spearhead in the Cabinet Office over the period 2003-2008. He described his mission as "encouraging people to find real breakthroughs for hydrogen and fuel cell technologies…to create and cultivate technology options [and] let promising options compete with each other to [push] them toward completing their goals, leading to real products and entire systems." He asserted that "To establish a well equipped international stadium for competition is a role for the public sector." He pointed to an ongoing example of this in Japan in which the government organized a "PV Wimbledon" as an international competition of next-generation, thin film photovoltaic modules. The competition, which includes both small, newly established and larger, mature companies from nine countries, will test 10 types of solar cells in 26 different modules. The project, which will be run in three phases, will award the winner(s) an increasingly larger area to test their systems, and a large amount of public visibility and exposure.

Mr. Ando attributed his success in launching effective government technology programs to his ability to identify, empower, and entrust "innovation samurai:" scientists and engineers who innovate in universities, government, and industry. He argued that a key role of government is, "for those projects that have a higher chance of success, [to] find responsible and dedicated key persons; ceaselessly encourage them through the innovation process; [and] show robust, consistent official support both

physically and psychologically, placing real trust in them while exerting pressure at the same time." Mr. Ando portrayed these innovation samurai throughout his talk as the essential motivators towards real breakthroughs in renewable energies through their hard work and dedication to real changes.

Mr. Ando described hydrogen as a "very strong option to replace the carbon cycle….Hydrogen is clean to use and potentially free from time, location and original source constraints." A major challenge for the Japanese hydrogen work is facilitating collaboration between various companies. Mr. Ando conveyed that he heavily relies on samurai from various companies and groups to facilitate these interactions so the projects are useful but also competitive. He also stressed the importance of international collaboration and expressed his hope for more meaningful collaboration on technology roadmaps.

Mr. Ando described a number of hydrogen and fuel cell projects underway in Japan, including the following:

- **1-kW polymer electrolyte membrane (PEM) fuel cell residential co-generation systems (2002-2008)**
    - Japan focused on very small (1kW) home stationary systems for the following reasons:
        - They are less expensive to install than larger systems, allowing more field installations for the same budget
        - Five or six companies offered fuel cell systems in this class, making for "natural competition"
        - Modularity allows for scale-up to larger systems
        - This provided focus on one clear product
        - Installation in homes provided "grassroots publicity" and increased consumer interest
    - Since 2002, 3,352 1-kW residential fuel cell units have been installed, including at the Prime Minister's residence, and are currently in service (total government subsidy: ¥ 16.2 million [approximately $140,000]).
    - Cost reduction was the key goal, since a large reduction in cost was necessary for commercialization. Cost reduction has been pursued on two fronts: 1) "competition and collaboration" and 2) large-scale demonstrations to establish a real stationary fuel cell market.
    - A "Competition and collaboration" model was used to address balance of plant
        - Industry players were able to collaborate on reducing the cost of balance of plant components ("peripherals"), with strict provisions to protect proprietary information on stacks and reformer-related components.
        - The fuel cell providers and a diverse group of suppliers gradually agreed to share proprietary information on peripherals, recognizing that this cooperation was essential for success; government officials served as the neutral third parties and managed and analyzed the data and information.
        - Collaboration on peripheral components also resulted in the unification of specifications among fuel cell providers, which enabled a more focused technology development effort and helped to lower the suppliers' costs.
            - As exemplified by the experience with personal computers, "the development and commercialization of low cost, high performance products was made possible by an efficient modular architecture in which consistently

coordinated specifications enabled the clear interfaces of various modules from different parties…and led to creative competition among 'modular clusters' with an enormous number of independent, venture-backed companies."

        - Open competition among peripheral suppliers was encouraged by the Japanese government to bring new players into the technology development effort.
        - This model of "competition and cooperation" provided a visibly successful experience both for overcoming the difficult issue of cost reduction while forging useful alliances.
    - Large-scale demonstrations in residences across the country were used to establish a real stationary fuel cell market:
        - Japanese government committed to support the deployment of a large number of fuel cells in order to "establish a supply chain, including maintenance, all around the country; to validate the learning curve towards mass production; and to [improve upon] prototype systems and [create commercial] products through the kaizen method" of gradual, incremental process improvements.
        - "Consistent support by METI [for a]…semi-mass production project [provided] a persuasive tool for companies to continue R&D efforts."
        - "A demonstration project is only valid when technologies are close to commercialization. If mass production is not yet in sight, demonstration projects are [not useful]."
    - The cost reduction efforts have been extremely successful—75% cost reduction over three years.
- **1-kW solid oxide fuel cell (SOFC) residential co-generation system**
    - Project began in 2007 with a budget of ¥ 0 .77 billion [approximately $6.5 million].
    - Goal is to employ kaizen method to reduce costs and improve durability, and develop commercial residential SOFC systems.
    - Project includes a collaborative R&D activity aimed at mitigating the causes of stack degradation.
    - A large scale demonstration of small SOFCs is anticipated to occur in the near future.
    - A lesson from the phosphoric acid fuel cell experience is not to try to tackle performance and size at the same time. Smaller systems, once demonstrated, can be expanded to a larger scale.
- **Support for fuel cell vehicle development** is provided through 1) basic research on hydrogen and fuel cells and 2) limited demonstration projects.
    - Several new national laboratories have been established to pursue basic R&D, including:
        - Polymer Electrolyte Fuel Cell Cutting-Edge Research Center (FC-cubic)
            - established April 2005
            - Budget: ¥ 1.0 billion in 2007 and ¥ 1.2 billion in 2006 [approximately $8.4 million and 10.2 million, respectively]
        - HiPer-FC (High Performance Fuel Cell)
            - established in 2008

        - Research Center for Hydrogen Industrial Use and Storage (HYDROGENIUS)
            - France, Israel, Japan, Ukraine, and United States
            - founded to research less expensive, safe hydrogen materials
            - established June 2006
            - Budget: ¥ 0 1.6 billion in 2007 [approximately $13.4 million]
            - international research teams, including several top U.S. scientists
        - Advanced Fundamental Research Project for Hydrogen Storage Materials (HYDROSTAR)
            - China, Japan, and U.S. (Los Alamos National Laboratory)
            - a "virtual" R&D center to study hydrogen storage materials using large-scale facilities and scientific collaborators around the world
    - Vehicles and fueling stations deployed in various locations and applications around Japan
        - 12 hydrogen fueling stations and over 50 fuel cell vehicles country-wide:
            - Innovative station demonstrations
            - Stations performing on-site reforming of various petrochemicals including city gas, kerosene, natural gas, and others
            - One hybrid station being supplied by both on-site city gas reforming and delivered hydrogen
            - A diverse group of companies are partnered with the Japanese government, including: energy companies, industrial gas companies, tank manufacturers, natural gas utilities, steel companies, environmental management companies, and others.
    - Cost reductions of 99% needed in vehicles—technology innovation, engineering and scientific advances are necessary to meet this goal.
    - The goals for both DOE and Japan coincide; 2015 is a crucial year for both programs; Japan has a commercialization decision on fuel cell vehicles [and DOE has technology readiness decision].
- Japanese policy on "**micro fuel cells**" (direct methanol fuel cells and others) is "no subsidies; no laboratories; no demonstration projects." The focus is strictly on helping to establish international transportation standards.
- 5th International Hydrogen and Fuel Cell Expo brings together researchers from around the world: February 25-27, 2009, in Tokyo, Japan.

The Japanese are implementing a new program to fund entrepreneurs developing renewable energy technologies that is modeled after the U.S. Small Business Innovation Research funding program.

In conclusion, Mr. Ando stressed the need for perseverance in work towards a hydrogen future. He thanked his hosts in the HTAC, as well as Mr. George Hansen of General Motors, who facilitated his attendance at the meeting.

Questions, Answers, and Discussion

Chairman Lloyd thanked Mr. Ando for speaking to the group and asked the members to think of how Mr. Ando's remarks could be used to communicate the Committee's message to Congress and other influential groups.

Other questions and discussion were held until after the afternoon presentations from Mr. Ando, Dr. Bonhoff, and Mr. Mills on the global research, development, and demonstration environment.

3.2 The German National Innovation Program: Fuel Cell and Hydrogen Technology:

Dr. Klaus Bonhoff, Managing Director, Nationale Organisation Wasserstoff und Brennstoffzellentechnologie (NOW GmbH)

>> see full presentation at http://www.hydrogen.energy.gov/advisory_htac.html

Dr. Bonhoff was introduced by Dr. Byron McCormick and Mr. Mark Chernoby, who described Dr. Bonhoff as a former employee of DaimlerChrysler (now Daimler) with experience ranging from research to vehicle demonstrations, who has moved into German government to manage hydrogen and fuel cell programs. Dr. Bonhoff summarized the two messages of his talk: First, he noted that "hydrogen will play an important part in future transportation [and] in the energy system overall." Secondly, policies must foster partnerships and long-term commitments from all stakeholders (including government, academia, and non-government organizations). .

The major hydrogen projects Dr. Bonhoff addressed in his talk were:

- German National Innovation Program (NIP)
    - Funded as a ten year program (2007 –2016) to provide a longer term commitment than the typical three- to five-year programs
    - Strategic alliance (government, academia, and industry)
    - Involves cooperation and collaboration of four government ministries on one program, which is unique in German government
    - Supported by three sources of funding:
        - € 500 million (over ten years) public funding for demonstration activities and market preparation for hydrogen and fuel cell technology (responsibility: Federal Ministry for Transport, Building and Urban Development)
        - € 20-25 million annual public funding for R&D programs (responsibility: Federal Ministry of Economics)
        - industry cost sharing (assume a 50:50 cost share)
    - Total NIP budget over ten years, including industry investment: more than € 1.4 billion. Currently, the budget is divided as follows:
        - Transportation (including hydrogen infrastructure): 54%
        - Stationary (residential): 24%
        - Stationary (industrial): 12%
        - Specialty markets: 10%

- Responsible for creating a number of strategic planning documents and frameworks, including: the National Development Plan on project funding and direction, Lighthouse Project evaluation, and program management plan (NOW)
- Similar structure to the European Joint Technology Initiative

- NOW – The National Organization of Hydrogen and Fuel Cell Technologies (Germany)
  - NOW is the program management organization responsible for the implementation of NIP and the central point of contact for hydrogen and fuel cell technologies in Germany.
  - NOW's responsibilities include
    - Overall coordination of the NIP, in accordance with the National Development Plan, involving:
      - Link between demonstration and R&D activities
      - Setting of overall program direction and identification of synergies between areas
    - The implementation of demonstration activities including:
      - Initiation, prioritization and approval of projects
      - Design of lighthouse projects and facilitation of partnerships
      - Project supervision
    - Communication (general public, policies, etc.)
    - International collaboration
  - The NOW organization includes an Advisory Board (with 18 members representing industry, academia, and government) and a Strategy Council (whose members include more than 120 stakeholders in hydrogen and fuel cells in Germany).
- Transportation Energy Strategy (TES)
  - Founded in 1999 for the purpose of gathering industry stakeholders on a working level to talk about the different options for transportation fuels
  - Third TES status report published in August 2007
  - Key messages of the Transport Energy Strategy report include:
    - security of energy supply and climate protection are the central challenges in the 21st century
    - concentrate on most promising technologies (renewable hydrogen and fuel cells and second-generation biofuels) but recognize that there will be a portfolio of technologies required for energy efficiency and fuel diversification
    - increase usage of renewable energy sources in the transportation sector
    - It is important to start using hydrogen as fast as possible to learn about hydrogen and make progress towards the transition.
- Clean Energy Partnership (CEP)
  - The CEP is the largest hydrogen vehicle and fueling station demonstration project in Europe, comprising five automakers, two oil companies, and two utilities.
  - Receives funding from the NIP

    - Has logged more than 400,000 kilometers in hydrogen fueled vehicles, with more than 3,000 refuelings
    - Demonstrations have been very successful in exposing the public to hydrogen and fuel cell vehicles in Berlin.
- GermanHy
    - Analysis performed to better understand how hydrogen could become the transportation fuel for Germany
    - Concluded that:
        - A mixture of energy sources for the production of hydrogen would be required to meet the demand in Germany.
        - Hydrogen would reduce the carbon dioxide emitted from the transportation (light-duty) sector in all evaluated vehicle penetration scenarios.
        - Hydrogen is not the only answer for transportation; we must also address air, rail, and heavy duty vehicle sectors.
        - Further research would be required to meet energy efficiency targets.
- Joint Technology Initiative (European Commission)
    - Public-private partnership
    - Legal entity for public funding
    - Governing board consisting of 50% public and 50% private members
    - Industry group (64 companies from 15 countries) representing 90% of the fuel cell industry in Europe
    - Research group (50 organizations including universities and national labs)
    - 50% cost share in research
    - Committed € 1 billion [approximately $1.5 billion] in activities by 2013 (including the 50% cost share)
    - Most funding is for demonstration projects with some for "applied research, basic research and support action, [such as] codes and standards."

Dr. Bonhoff concluded by stressing the need for long-term political commitment and strong public-private structures to encourage collaboration.

Questions were held until after the afternoon presentations from Mr. Ando, Dr. Bonhoff, and Mr. Mills on the global research, development, and demonstration environment (see next section of the minutes).

4. *Global Competitive Environment*
Dr. Klaus Bonhoff, Mr. Haruhiko Ando, and Mr. Michael Mills

4.1 The German National Innovation Program for Hydrogen and Fuel Cell Technologies (NIP) and the European Joint Technology Initiative (JTI): Dr. Klaus Bonhoff, Managing Director, Nationale Organisation Wasserstoff und Brennstoffzellentechnologie (NOW GmbH)
>> see full presentation at http://www.hydrogen.energy.gov/advisory_htac.html

In his second presentation, Dr. Bonhoff spoke generally on German and European Union research, development and demonstration projects, as highlighted below.

- Germany is creating mechanisms to coordinate between research & development activities and deployment activities
- Germany "Lighthouse" Demonstration Projects
    - Basis for market preparation
    - Implementation of infrastructure and vendor systems
    - Public awareness and visibility
    - Confidence in the future of the technology
    - Combination of R&D and demonstration
    - Frame for suppliers (esp. small to medium enterprises)
    - Efficient combination of public and private resources
    - Strengthen German competitiveness
    - Long funding cycles ensure value of the 50% cost share from industry
- European demonstration projects parallel the German Lighthouse Projects in:
    - Size and scope with several hundred vehicles and refueling infrastructure
    - Inclusion of manufacturing, infrastructure, early markets, small vehicles, etc.
    - Stress on renewable hydrogen production, storage, and distribution
    - Deployment of stationary and backup power units
    - Establishment of beneficial market conditions using innovative funding schemes
        - Subsidies of the difference in cost between traditional and fuel cell systems
        - Working to get larger volumes into the market
        - Work is on market preparation and not market introduction, which would violate existing competition laws.
- Airline interest in fuel cells for onboard power
- The common timeline for fuel cell market adoption between the U.S. and the E.U.
    - Phase I, 2008 to 2010, is mostly research and development especially focused on cost reduction and reliability.
        - Hydrogen production will be mostly byproduct hydrogen and onsite natural gas reformation.
    - Phase II, 2010 to 2015, begins the market preparation phase as well as additional technical refinement.
        - Hydrogen production in Phase II and on will need to be wind, biomass, and coal.

    - Phase II, 2015 and on, will be market introduction in terms of 1,000 to 100,000 vehicles per year.
    - Phase I and II are crucial to timely market deployment.
- German Clean Energy Partnership
    - The framework for transportation activities
    - A partnership between 12 companies
    - Day to day operation of fuel cell vehicles
    - Hydrogen filling infrastructure open to all vehicle drivers and original equipment manufacturers (OEMs) in retail settings at full capacity
    - Customer fueling and payment with a special fuel card
    - Plan to expand the demonstration project
        - Increase number of vehicles
        - Introduce buses in Hamburg and Berlin
        - Connect Berlin and Hamburg (180 miles) with hydrogen fueling stations
        - Increase number of hydrogen fueling stations
- Lighthouse project for stationary fuel cell based home energy supply
    - Install 600 systems in three to five regions in Germany
    - Cooperation between manufacturers, energy suppliers, research institutes, and users
- Lighthouse Industrial Power Generation
    - 60 biomass systems
    - High temperature fuel cell, 200-700 kW
    - Combined with gas washer, ORC, heat usage
    - Cooperation of fuel cell and biogas system manufacturers with operators and energy suppliers
- Begin fuel cell market through specialty applications
    - Creates demand for thousands of fuel cells per year
    - Moves manufacturing processes forward
    - Gets fuel cell systems into the market quickly
    - Examples:
        - Specialty vehicles and cargo bikes
        - Municipal vehicles
        - Uninterrupted power supplies
        - Backup power for telecommunication or railroads
        - Boats, both commercial and recreational
        - Onboard power for ships, airplanes, trucks, and campers
        - Bodensee Lighthouse Project
            - Centered in Bodensee, Germany, a recreational and vacation area
            - Includes leisure and light duty vehicles and boats
            - A diverse group of 40 start-up to large companies

        - Fuel cells in this area are good marketing.
- World Hydrogen Energy Conference
    - Supported by NOW and EHA
    - May 16-21, 2010
    - Essen, Germany
    - http://www.18whec2010.de/

4.2 Fuel Cells/H2 R&D and Commercialization Activity in Japan: Mr. Haruhiko Ando, Cabinet Office, Japan

>> see full presentation at http://www.hydrogen.energy.gov/advisory_htac.html

Mr. Ando spoke on Japanese research, development, and commercialization activities. Highlights of his presentation are presented below (details may be found in the full presentation).

- Residential fuel cells for stationary power (1-kW PEM fuel cells)
    - Fuel cell unit manufacturers, energy enterprises, and political support are being prepared to start commercial sales in 2009
    - Created the unified group ENE FARM between various rival companies to produce 1-kW stationary fuel cell systems
    - Demonstration of residential fuel cells at Toyako Summit
- Fuel cell vehicles
    - "Start Selling in 2015" scenario was adopted by Japanese and international companies and by the Japanese government.
- Basic research
    - Four research centers established to study fundamental properties of fuel cells to achieve enhanced performance and cost
        - Advanced Fundamental Research on Hydrogen Storage Materials, or "HYDROSTAR" (AIST)
        - Polymer Electrolyte Fuel Cell Cutting-Edge Research Center, or "FC-Cubic" (AIST)
        - Research Center for Hydrogen Industrial Use and Storage, or "HYDROGENIUS" (Kyushu University and AIST)
        - Basic materials research for High Performance Fuel Cell, or "HiPer-FC Project" (Yamanashi University)

4.3 Global Competitive Environment: Mr. Michael Mills, DOE

>> see full presentation at http://www.hydrogen.energy.gov/advisory_htac.html

Mr. Mills is ending a detail at the Office of the White House and will be returning to a new position in the DOE Hydrogen, Fuel Cells & Infrastructure Technologies Program. He expressed his enthusiasm for working with the HTAC and for resuming his duties in the Hydrogen Program. Prior to his detail to the White House, Mr. Mills worked for five years with the International Partnership for the Hydrogen Economy (IPHE). His presentation to the HTAC provided an overview of international hydrogen RD&D

activities, and addressed the activities of the IPHE, independent international industrial R&D activities, and the hydrogen programs of Australia, Canada, China, Korea, Russia, and United Kingdom.

- International Partnership for the Hydrogen Economy (IPHE)
    - Members: Australia, Brazil, Canada, China, European Commission, France, Germany, Iceland, India, Italy, Japan, Korea, New Zealand, Norway, Russian Federation, United Kingdom, and United States
    - Broad purpose: to coordinate and leverage international RD&D resources that advance the transition to a global hydrogen economy.
    - Organizational Structure
        - Steering Committee provides overall strategic direction and is composed of senior representatives from each member country.
        - Implementation-Liaison Committee provides technical direction and manages three Working Groups: 1) Regulations, Codes and Standards, 2) Demonstration and Infrastructure, and 3) Education.
    - IPHE is not a funding organization for projects, but it does actively recognize and track 30 existing projects in a range of technical areas, including demonstration projects.
    - Over the last two years, IPHE conducted a strategic priority exercise and has established four strategic priorities going forward:
        - Accelerating market penetration and early adoption of hydrogen, fuel cells, and infrastructure
        - Policy and regulatory actions to support widespread deployment
        - Raising profile with policy makers and the public
        - Monitoring relevant technology development
    - Jointly conduct work with other international organizations, e.g.:
        - Joint IPHE-International Energy Agency (IEA) workshops to share lessons and develop visions/pathways for developing global hydrogen infrastructure
        - Encourage IPHE members to participate in IEA R&D collaborative activities.
    - Current IPHE initiatives include:
        - Developing global IPHE projects “from the ground up,” with funding provided by participating member countries
        - Fuel cell cost analysis comparison that will provide an overview of fuel cell costs in different countries around the world
        - “State of the Nation” document that will be updated consistently and provide a status report on each country's programs and activities, R&D and commercialization
        - Commercially available products list: provide links from the IPHE website to lists produced by trade groups (e.g., US Fuel Cell Council) and encourage other countries to develop and share similar lists
        - Brief for Policymakers that provides a broad overview for those who are new to the area of hydrogen fuel cells
        - Track and provide information on demonstration projects in IPHE member countries.
- Industrial Activity

- PricewaterhouseCoopers *2007 Fuel Cell Industry Survey* reviewed 26 public companies around the world whose primary business involves fuel cell production, systems integration, and/or related fueling infrastructure (not including OEMs or energy companies). The survey concluded that, compared to 2006:
  - Revenues increased 59% to $416M.
  - R&D funding remained the same at $213 million.
  - Employment increased by 10% to 3,434.
  - Market capitalization increased 20% to $3.8 billion.
  - Companies are not yet profitable; firms share net losses of $644 million.
- Fuel Cell Today, in its 2008 *Fuel Cells Commercialization Industry Review*, reported a ramp up in commercialization activity, with 12,000 new units shipped (most of which were for the APU, back-up power, or portable power/consumer electronics markets).

- World governments
  - According to the Fuel Cell Today commercialization review, world governments invested $1 billion (U.S. dollars) in hydrogen and fuel cell technologies in 2007.
  - Key contributors were US, Japan, Germany, European Commission, South Korea, China, Russia, Canada, and United Kingdom.
  - Many countries were leveraging significant private sector investment.
  - Fourteen countries have, or are developing, roadmaps or strategic plans that include hydrogen and fuel cells (U.S., Brazil, Canada, China, European Union, Germany, India, Japan, Korea, Iceland, Norway, United Kingdom, and Australia (in process)).
  - Australia
    - Developing a Hydrogen Technology Roadmap to be completed in early 2008
    - National Hydrogen Materials Alliance
      - Researching new materials to improve efficiency and economics of hydrogen generation, storage, and use
      - Brings together 11 universities, the Commonwealth Scientific and Industrial Research Organisation (Australia's national science agency), and Australian Nuclear Science and Technology Organisation
  - Canada
    - $7M in 2008 for hydrogen R&D for transportation (total budget for hydrogen and fuel cells R&D is $30 million)
    - Robust demonstrations such as BC Hydrogen Highway, Hydrogen Village, and buses for the 2010 Olympics
    - Niche market development like fork lifts and remote power
    - Canada produces the most hydrogen per-capita in the OECD [Organisation for Economic Co-operation and Development]
  - China
    - Hydrogen roadmap was published in 2006.
    - Budget for hydrogen and fuel cell R&D in 2008 is $30 million.

        - Demonstrations include the first developing country with a fuel cell bus.
    - Korea
        - Ministry of Knowledge Economy ($60 million) and private funding ($50 million) in 2007 totaled $110 million.
        - Vehicle, bus, and fueling infrastructure demonstration project includes 18 cars, 2 buses and 8 planned fueling stations.
        - Stationary demonstration includes 210 units of fuel cell residential power.
    - Russia
        - Funding of $30 million annually from 2007 to 2012
        - RD&D is becoming increasingly organized and centralized.
        - Growing number of organizations are looking into PEM, solid oxide, and molten carbonate fuel cell technologies.
    - United Kingdom
        - Creation of the UK FC Development and Deployment Roadmap
        - Over 35 groups involved in an active R&D program
            - Focused on materials, storage, integration with renewables, and socioeconomics
        - Five demonstration projects totaling $10 million
            - 10 buses and 60 vehicles in London
            - Fueling station utilizing zero-emission biomass production

Questions, Answers, and Discussion

- Congressman Walker asked Dr. Bonhoff why his presentation referenced neither nuclear nor solar energy. Dr. Bonhoff replied that nuclear was omitted for political reasons. Germany has plans to phase out use of nuclear energy by 2020, so plans beyond that date omit nuclear. Dr. Bonhoff added that nuclear energy accounts for 10 percent of Germany's primary energy. Germany could develop hydrogen energy with or without nuclear power. Germany does not have the climate for concentrated solar power and photovoltaic energy fell out of the scenario for cost reasons.
- Dr. Shaw asked if Dr. Bonhoff had seen plans from the Middle East, Saudi Arabia, the United Arab Emirates, and Libya to use their extensive solar resources to produce both electricity and hydrogen energy and ship the combination to Europe. Dr. Bonhoff replied that he had not seen specific reports. He believes that people like the idea, but that there is no specific activity at this time. Germany would also prefer domestic energy production, although he expects some energy will need to be imported. Dr. Bonhoff also did not know if energy transported from the Middle East to Germany could be economically competitive with Norwegian biomass or Scottish wind.
- Mr. Rose noted that the timetable for commercialization of fuel cell vehicles presented by Mr. Ando and a recent commercialization timetable that has gained the consensus of the California Fuel Cell Partnership are more consistent and public than they had been a few years ago. Mr. Rose observed that the timetables seemed to show growing consensus that commercial production could be achieved by 2015, and he asked for confirmation. He said it was significant because the Department of Energy "had gotten weak on its timetable in its recent material" and that this could be a message the HTAC could convey to the Secretary of Energy.

- Dr. McCormick replied that the 2015 date was conditional. A number of things need to be in place, including adequate fueling infrastructure to ensure customer mobility. He stressed that the date assumes the German program, the Japanese program, or some other program will help to put in place the "whole commercialization package," and added that the auto companies will not "just throw cars out there casually in 2015 to see if it takes." He stated that the technology path is there, but there need to be plans in place to support industry's commitment of the time and resources required to validate the cars and put the production technology into place. It is important, he stated, not to send the message "wait until 2015, and someone is going to throw cars out there." Dr. Lloyd recalled a previous statement from Dr. McCormick that "2015 really means 2011" in terms of actually putting vehicles into a showroom, which underscores the need for urgency. Mr. Hansen agreed, noting that Dr. McCormick has worked hard over the last two or three years to engage discussions about the specific support and supply infrastructure that is needed. Mr. Hansen offered that the consensus on a potential commercialization timeline allows industry, government and other stakeholders to talk about specific things that need to be done. Mr. Ando stated that the 2015 target date was still very tentative in Japan.
- Congressman Walker asked if anyone had some perspective about whether or not the Chinese have the potential to put together the type of "commercialization package" that Dr. McCormick referred to, and thereby succeed in commercializing fuel cell vehicles in a timeframe close to 2015. Dr. McCormick replied that General Motors is equally active in Japan, Germany, and China, and has created a research branch for fuel cells in China. Mr. Hansen agreed that China is preparing to play a role in this timeframe, and views fuel cells and hydrogen as a very key long-term option. Mr. Van Dokkum stated that he spends about a quarter of his time on fuel cell business in China, and that China has made hydrogen fuel cells a national priority. He noted that hydrogen fuel cells is now part of China's next five-year plan, and that Tsinghua University and Tongji University have established large campuses focused on hydrogen and fuel cells only. Dr. McCormick added that China's primary proponent of hydrogen fuel cells is Mr. Wan Gang, who is the Chinese Minister of Science and Technology. He noted that Mr. Gang (formerly President of Tongii University) has been a consistent supporter of hydrogen fuel cells, and is one of the few "real samurais" on hydrogen fuel cells in the world. Dr. Shaw added that the Committee should also remember that in less than five years, China has emerged as the dominant supplier in the solar market, outpacing the U.S., Germany and Japan. Mr. Mills added that China's is currently looking to start vehicle market entry after 2020, later than the U.S., Japan and Germany, but that they could rapidly change this schedule.
- Mr. Hofmeister stated that oil prices and carbon constraints will affect the timetable. Higher oil prices will move the hydrogen economy. If countries start pursuing a clearer direction in carbon constraints, like California, it would also support hydrogen development.
- Mr. Hofmeister asked Mr. Ando about Japanese hydrogen initiatives and the level of support for hydrogen initiatives among elected government officials. He also asked about the source of hydrogen for the residential power market and how it is delivered to the user. Mr. Ando replied that many Japanese politicians are enthusiastic about hydrogen energy. He explained that "ex-Prime Minister Koizumi is a very passionate supporter" and his support was essential for installing the two fuel cell systems in the Japanese Prime Minister's residence. Mr. Ando stated that fuel distribution for home fuel cell stationary power systems is provided through existing compressed gas, LPG, and kerosene distribution systems.
- Dr. Ogden asked Mr. Ando if the residential stationary power fuel cells in Japan's program produce any hydrogen for refueling cars, such as the home refueling concept that Honda has talked about. Mr.

Ando replied that the home refueling system is a very promising idea, as is the idea of combining hydrogen and solar using a portable (CIGS-based) photovoltaic technology. Mr. Ando confessed that Honda does not communicate openly with the government about their plans for home refueling and "does not have a samurai in this area."

- Dr. Ogden referred back to Mike Mills' review of worldwide fuel cell production and the 12,000 units produced this year, 8,000 of which were for vehicle uses, and asked if the term 'unit' referred to the fuel cell stack itself. She asked if he knew how many kilowatts of capacity are being produced. Mr. Mills could not answer her questions, but offered to follow up. Mr. Rose explained that the numbers in Mr. Mills' presentation (sourced from Fuel Cells Today) are cumulative. Mr. Rose said, "About 7,000 of these are Smart Fuel Cell (a European company) units, which are battery chargers for caravans for RVs [recreational vehicles]." He added that there are an increasing and significant number of RV units that provide either constant power or backup power, and that a substantial number of megawatt-scale systems are back ordered. Dr. Ogden asked if Mr. Rose could estimate the number of automobile fuel cell stacks that are included in the figures, and Mr. Rose estimated 600.
- Mr. Eggert asked how critical the early markets are to the eventual commercialization potential of vehicles and if the nation should be doing more to support that early market success. Mr. Rose referred to a recent study by Oak Ridge National Laboratory researcher David Greene on the contribution of small volume purchases to cost reduction for vehicles [Estimating the impacts of a government acquisition program for PEM fuel cells], and offered to forward the study to Mr. Eggert.
- Mr. Eggert asked "given what we know about the benefits of coordinated and concentrated deployment for the vehicle sector," are there enough global participants to support deployment in China, U.S., Japan, and Europe simultaneously, or if deployment will be staged. Dr. McCormick replied that some cities and even some countries will get shut out. The first generation of technology necessarily works on a constrained volume, and coordination will be necessary to ensure an adequate refueling infrastructure to support the vehicles. Mr. Hofmeister agreed, citing the difficult and challenging logistics of moving fuel and making it available.
- Mr. van Dokkum drew attention to the fact that the presentations from Japan and Germany addressed all three segments of the fuel cell market, not just transportation, as well as all the different types of fuel cell technologies (including PEM, solid oxide, molten carbonate, and phosphoric acid fuel cells). He noted that most of the programs in the U.S. have been very transportation focused, especially in the last few years. Mr. van Dokkum reiterated the important interrelationships among the different types of fuel cells in the areas of supply chain and science (such as ceramics, membranes, and catalyst development). He explained that some of UTC Power's overseas partners have started developing a much better supply chain for the fuel cell and hydrogen economy than has the United States. The United States led the effort for the last 20 years, but has lost that lead. He stressed the importance of building a supply chain in the United States so that our manufacturers do not have to depend upon the membranes being produced by China or Japan.
- Mr. Friedman asked Dr. Bonhoff and Mr. Ando about the role, use and value of advisory committees in their countries, and whether there are some lessons there for the HTAC. Dr. Bonhoff replied that NOW [Nationale Organisation für Wasserstoff- und Brennstoffzellentechnologie] was only founded as a legal entity in February 2008, so the formal NOW Advisory Board is fairly new. He explained that the NOW Advisory Board began several years ago as a "coordination group" composed of 12 people selected to represent different industry sectors, academia, and other interest groups and write the National Development Plan. [The National Development Plan defines the steps needed for

implementation of Germany's National Innovation Program Hydrogen and Fuel Cells, or NIP.] When NOW was formed, it was decided that these same individuals (plus a few others to round out the representation) should serve in an advisory capacity, to provide guidance on how to move forward, upgrade the development plan, shift priorities, and so forth. He noted that in this way, the Board members served as a working group, meeting every month to hear from dedicated speakers for the different sectors, and were ultimately responsible for writing the National Development Plan

- Mr. Ando stated that "in Japan, our advisory committee is nothing more than [an] authorizing entity; no real discussion; no real product result." He expressed his admiration for the HTAC meetings, which gather "very high level eminent persons [to] discuss various very crucial things," and stated his desire to study and learn from the HTAC model. He noted that he is hindered in this by the very strong need for secrecy among the groups with whom he works, which limits what can be discussed and who can participate.
- Mr. Chernoby asked Michael Mills about the International Partnership for the Hydrogen Economy's (IPHE) purpose statement, which says the organization is to "provide a forum for advancing policies and common codes and standards." Mr. Chernoby stated that IPHE appears to be successful in sharing information, but that it does not appear to have made much progress on "advancing policies or common codes and standards." Mr. Mills replied that IPHE has found it challenging to find the right role in the regulations, codes, and standards community. After some discussions on this issue over the last several years, the IPHE decided not to advocate specific draft regulations, codes, and standards. The organization is going to focus instead on sharing R&D related to regulations, codes and standards to help countries formulate their own positions. Dr. Satyapal added that the IPHE has a specific working group on regulations, codes, and standards, which is being co-chaired by representatives of the European Commission and the U.S. Department of Transportation. She noted that the working group has been trying to determine how exactly IPHE can help facilitate harmonization of codes and standards.
- Dr. Ogden conveyed her interest in the period between 2010 and 2015, which she called the "market preparation period," or the period of time when we would have a few hundred to a thousand or so vehicles in a particular urban area, and maybe 10 to 20 fueling stations. She expressed interest in hearing from the Committee members and the international guests on how to best support this market preparation period and position it for long-term success.
- Dr. Shaw stated he was very inspired on hearing about the importance of samurai or entrepreneurial energy in both the Japanese and German presentations. He noted that he has a lot of contact with European businesses and they are "very charged up about the opportunities." Dr. Shaw expressed his belief "that the change we need is going to come from a few really inspired entrepreneurial folks who decide to step outside the boundary of what's politically correct, or what's easy, or what the normal course of business is, and make something happen faster than it might otherwise happen." He suggested that the HTAC could become the samurai for the U.S. program, and really push to try and make something happen faster than it would if business-as-usual were the course.
- In response to Dr. Shaw's suggestion about the role of the HTAC as a "samurai," Dr. Ramage expressed his concern that the HTAC was established as an "advisory" committee not an "advocacy Committee." He suggested that the HTAC should review the Committee's charter established for the Committee by Congress to determine whether "advocacy" is within its scope. Mr. Rose stated his opinion that the HTAC charter provides plenty of leeway for offering advice on a wide range of issues. He noted that the HTAC is composed of individuals with a "tremendous amount of expertise, energy and credibility." As such, they should be able to communicate their views to the Secretary in

a way that is characterized as advice rather than advocacy. He agreed that maintaining credibility is important to avoiding the label of "enthusiast," but that there is plenty of material the Committee can draw upon (including the recent report from the National Academies of Sciences) to back up its views.

- Dr. Ramage reiterated the importance of offering credible advice. He argued that "advice" includes the negative aspects of a position as well as the positive. He suggested that the HTAC consider "what kind of advice it [should] give [the new administration] when they are facing all kinds of options."
- Dr. Lloyd asked Dr. Bonhoff about the source of hydrogen for the auxiliary power units (APUs) used aboard ships. Dr. Bonhoff replied that when Germany talks about hydrogen as a fuel, it is mostly for use in passenger cars or light-duty vehicles. The large APUs used aboard ships will provide greater efficiency than existing motors, and will use molten carbonate fuel cells (the fuel source for the APUs has not yet been decided).
- Dr. Lloyd asked whether the discussions in Europe about controlling CO_2 emissions from aircraft have led anyone to consider hydrogen-powered aircraft. Dr. Bonhoff replied that he has learned that, especially for shorter trips within Europe, aircraft turbines only operate at good efficiency for about 20 percent of the time; the rest of the time the plane is either on the ground, taking off, or landing, when the turbines run at very inefficient operating modes. Fuel cell APUs can provide efficiency advantages for power generation, especially on the ground.
- Mr. van Dokkum stated that there is still a debate in the air-framing industry about whether hydrogen can be used in aircraft. Questions revolve mostly around the energy density of hydrogen and the associated high storage volume capacities and logistics issues. However, there is a lot of interest in "offloading" some of the components that are now served by the main turbine engine to fuel cells. He noted that the APU is one of those components that runs while the airplane is on the ground, and causes much of the pollution at airports, which can be a big problem for large metropolitan areas. He noted that one key challenge to this strategy is developing reforming technology that can produce hydrogen from jet fuel.

5. ***Briefing on Activities of the HTAC Policy and Planning Subcommittee***
Dr. Robert Shaw
>> see full presentation at http://www.hydrogen.energy.gov/advisory_htac.html

Dr. Shaw (Chair of the HTAC Policy and Planning Subcommittee) invited new members of HTAC to join the subcommittee. He then reported on a July 10, 2008, subcommittee teleconference. The main agenda items of the call were:

- HTAC vision statement (discussed for the past three committee meetings)
- Annual HTAC report and progress index
- HTAC talking points

Because of the ongoing discussion on these topics, Dr. Shaw urgently suggested that anyone who does not currently read the HTAC meeting minutes begin to do so.

On the **vision statement**, the subcommittee unanimously agreed to adopt the language that was discussed at the last full HTAC meeting. The subcommittee accepted the words "universal" and "economically competitive" in the vision statement, which had been a source of debate at the last meeting. Dr. Shaw

suggested on behalf of the subcommittee that there be a motion to adopt the current language of the vision statement, and asked that the editing process for it be complete. Dr. Shaw made the motion, and the vision was adopted, as follows:

"Our vision of the future is that hydrogen will become a universal and economically competitive energy carrier, progressively substituting for carbon-based fuels over time, to meet the needs of the planet. Hydrogen will be produced from a number of sources, increasingly with the lowest possible carbon impact. To realize this vision, the nation must aggressively introduce to the market the hydrogen-based technologies that are available now and those that will be developed in the future. HTAC's role is to aid the nation in developing a policy framework that takes into account the technical, political, social, cultural, environmental and commercial requirements of the transition to hydrogen."

On the **annual report**, the subcommittee, during its teleconference, talked at length about the recommendations from the last meeting, including that the report be prepared at the end of the year, and that it be short (maximum of five pages) and focused on both progress ("steps forward") and things that still need to be done. The subcommittee agreed the annual report should include important accomplishments (including international accomplishments), how the Committee feels about them, and what still needs to be done. Dr. Shaw asked that the Committee members to provide suggested input for the annual report throughout the year by e-mailing Dr. Shaw (aretecorp@roadrunner.com) and Shawna McQueen (HTAC support staff) at smcqueen@energetics.com.

On the **progress index**, the subcommittee will first craft the annual report and then consider whether the content is more conducive to a "dashboard" presentation or a single-metric presentation. Dr. Shaw said the progress "index" will likely be more like an "indicator" (i.e., more qualitative than quantitative in nature).

Finally, the subcommittee discussed the **talking points**, which were produced as a draft for the Committee's consideration using the input from the May HTAC meeting discussion. The talking points are meant to prepare the HTAC to present to the new Presidential administration the committee's view on where the program is and how it ought to move forward in the spirit of advice, not advocacy. [The subject of how and whether the HTAC members can transmit the talking points directly to the Presidential candidates is discussed in the next section of the minutes.]

Dr. Shaw shared the subcommittee's action plan (shown on slide 5 in his presentation), which includes the following:

- Discuss the re-draft of the talking points (July meeting) and review any re-drafts coming out of that discussion.
- Get organized for a meeting with the presidential transition team.
- Meet in person as a subcommittee around the November meeting to bring together information collected so far for the annual report.
- Draft the annual report between November and January, and present a draft to the full committee at the first 2009 meeting.
- Release report to the Secretary of Energy and then the public by end of first quarter 2009.

Dr. Shaw reported that the subcommittee asked Chairman Lloyd to produce a similar action plan for the HTAC as a whole, but he may defer that task to the new (soon to be elected) HTAC Chair. Dr. Shaw asked the Committee for comments.

Question, Answers, and Discussion

- Mr. Hofmeister said he thinks the annual report will be a "learning journey as to how much content and how rich the content would be." Dr. Shaw agreed and said because the annual report would be short, the content cannot be very deep. He added that if the report communicates "where we've come in a year, what important things we have done, and what needs yet to be done…it will be quite useful."
- Dr. Ramage commented that metrics will be really important in the annual report, especially the metric of industry commitment to hydrogen. He argued that it is important to show the amount of money being spent: the amount of venture capital being spent, the amount of money automakers are spending, the commitment of integrated oil companies and industrial gas suppliers, etc. He commented that the long-term potential of hydrogen in reducing oil use and CO_2 emissions is more important than meeting fuel cell targets by a certain year. The real question, he said, is: "What is the long-term potential of this technology and what does it cost?" Congressman Walker responded that these questions were part of the idea behind the progress index, but that the Committee agreed that it is not in a position to put together an index like that. Congressman Walker agreed that without clear metrics that the news media can report on, hydrogen will get limited attention or coverage.
- Dr. Lloyd asked DOE and its contractors to prepare for the next HTAC meeting a summary of what Dr. Klaus and Mr. Ando presented so that the Committee can learn about their approaches and the money being spent, and see if there are any commonalities.
- Mr. Rose asked the HTAC to consider accelerating their proposed schedule, and expressed concern that interacting with the administration during first quarter 2009 might be too late to affect policy development. Congressman Walker responded that it is unlikely that DOE's Assistant Secretaries and others on the implementation level will be in place before then, and that is the level the Committee would prefer to interact with. Dr. Shaw suggested that the Committee try to hold several meetings with transition team staff during the period from November to January, to communicate the HTAC talking points. He added that, historically, many of those on the transition team end up in senior roles in the new administration.
- Dr. Lloyd commented that it is unfortunate that the Committee tends to focus only on carbon emissions when it discusses the environmental impacts of energy use. He asserted that there are many other pollutants (e.g., ozone, particulates) that can be reduced by using hydrogen and other alternative fuels. He urged the HTAC to take a more holistic view on pollution, especially given the problems caused around the world by things like "dirty diesel emissions" and oil spills.

6. ***Discussion of Talking Points for the Next Administration***
Mr. David Friedman

Chairman Lloyd recognized Mr. David Freidman to lead a discussion of HTAC "talking points." The talking points will serve to communicate key points about hydrogen and fuel cells to the next administration and DOE transition team. A draft talking points document (see http://www.hydrogen.energy.gov/advisory_htac.html) was developed by the HTAC Policy and Planning

Subcommittee using the Committee's input from the May 13-14, 2008, HTAC meeting. This draft was provided to the full HTAC for review and comment.

Mr. Friedman began by stating two goals for the discussion: 1) reviewing the draft talking points and 2) discussing how the talking points can or will be used by the Committee, both prior to and after the November Presidential election. Once a new President is elected, the Hatch Act (which prohibits federal employees from engaging in partisan political activity) should no longer pose any limitations on the Committee's communication with the next administration.

Mr. Friedman suggested that the Committee start by reviewing the draft talking points document, beginning with the document's structure, any major "red flags" relative to content, and then moving to more detailed issues regarding document content. He added that editorial changes might be better served by e-mail. He reviewed the document's structure, which begins with a short synopsis of the HTAC's key points as a sort of "elevator speech" to quickly capture why hydrogen is of interest and why it should be part of an energy future for the country. He noted that this opening synopsis is intentionally vague, intentionally broad, and "grandiose." The remainder of the talking points document drills down to provide more detail and includes sections on the problems the nation faces, how hydrogen can address those problems, what steps should be taken going forward (what HTAC is asking for), and the hydrogen vision. A final section provides some "quick facts" on hydrogen that are intended to make hydrogen seem more real to people—more near-term and accessible. Mr. Friedman pointed out that this is a "dense two pages," and asked the HTAC to consider whether it is too dense and whether it could be better focused. He added that one of his goals was to work towards focusing and homing the information into an even more short and powerful document, rather than expanding it further. He opened the floor for feedback from the Committee on the document structure, reported as follows:

- Mr. Chernoby: Include a brief reference to the material presented on page 2 of the draft talking points (the steps for action the Committee is recommending) in the opening paragraph. Tell them what you want to tell them, and then tell them again. Also, the steps on page 2 are not detailed enough -- a politically influential person would be left wanting some ideas. It would be helpful to provide some specific policy examples as "thought starters."
- Mr. Friedman: The material in the talking points leans towards being general for two reasons: 1) space limitations and 2) lack of consensus from the HTAC, so far, on whether or not we want to provide any detailed suggestions. One option for creating more room to describe specific examples is to delete the vision statement, which essentially repeats what is previously presented. Regarding the issue of providing detailed policy examples, one point to consider is whether that would create debate, whereas the talking points are focused on creating interest. Is that a risk that we feel comfortable taking?
- Congressman Walker: If the Committee makes the talking points more detailed, there is a clearance process that we would have to go through in order to distribute the document publicly. The Office of Management and Budget (OMB) would have to sign off. If we are speaking as "HTAC" to our audience, and we are handing out a written product as "HTAC," we cannot be "sideways" from Department of Energy or OMB policy. However, if we stick to a fairly generalized framework that emphasizes research and development and so on, we probably do not have those kinds of problems.
- Dr. Shaw asked DOE to comment on whether the HTAC would need to clear the talking points document through DOE before it is distributed. Ms. Epping Martin noted that the draft talking points document would be part of the public domain since it is a subject of HTAC business in the public

meeting and will be posted to the public website. She added that the HTAC members who have been sworn in as "Special Government Employees," may not, according to the Hatch Act, personally provide the document to politicians. Mr. Friedman stated his understanding that, as an HTAC document, the talking points would not need to go through a DOE clearance process. Ms. Epping Martin agreed to double-check this with DOE General Counsel, but said that she did not think that providing the talking points to the public is a problem.

- Mr. Friedman noted that the Committee had still not come to agreement on whether or not to recommend or provide as examples any specific policy steps in the talking points document, and asked for the HTAC to try to reach a resolution on this issue.
- Dr. Shaw: Part of the objective of the talking points is to get hydrogen "back on the table," so that people are talking about it and thinking about it. The next administration will develop their own policy initiatives; our objective is to bring the topic to their attention rather than tell them what they ought to, specifically, do.
- Mr. Chernoby: Building on Congressman Walker's previous point, details should not be in the talking points if that will start a bureaucratic process that could block the talking points or slow them down.
- Dr. Shaw: Whoever is elected has, potentially, an eight-year period in office. This is a critical period for climate change, for energy security, for international competitiveness, etc. It would be great if the next administration takes the opportunity to set a course that takes us into a new era, as opposed to T. Boone Pickens or somebody else. The vision statement is, therefore, important to communicate. I would not want to take that statement out, unless there is a very compelling reason for doing so.
- Mr. Friedman: Is it correct to say that we are not going to try to get into more detail on the steps in the talking points? Is there any other disagreement with that?
- Mr. Rose: Yes—I disagree with that, but first, a question about format. The HTAC is a technical advisory committee. The format of the draft talking points is more like a brochure. Is this the "face of HTAC?" Or should it be formatted slightly differently? Secondly, one of the things that the HTAC can do safely is refer back to the letter that the Committee already wrote to the Secretary of Energy. That letter includes some prescriptive material and has already been vetted. We may be able to find, in the context of that letter, enough to give the talking points document a certain amount of substance, which it really needs. Right now, many of the points made in the talking points could also apply to biofuels or wind or solar; the points worth emphasizing in the Committee's product are those that are unique to hydrogen and fuel cells. All economic activity creates jobs, but we have some numbers we can use. On the point regarding reduced greenhouse gas emissions, we may want to reconsider "shying away" from mentioning natural gas. Regarding the title of the talking points "Hydrogen and Fuel Cells for National Security:" is this a national security pitch, or is it something larger? Finally, the quality and nature of the debate on hydrogen versus other technologies or approaches is not about generalities. It is about some very specific, intellectual and scientific questions that are debated by learned individuals. The talking points document would be improved by referencing some of the papers and studies that support our position.
- Mr. Friedman: On the subject of whether or not to include specific policy examples in the talking points, Mr. Rose is recommending that the Committee review the HTAC's previously written letter to the Secretary to see if we want to pull in any of those policies. Is Mr. Rose also suggesting a section that would rebut/pre-but the criticisms against hydrogen?

- Mr. Rose: Ideally, the talking points document would include a reference on every subhead, but that is probably not possible. My recommendation is to include a "For more information" section that points to additional resources. These information resources could provide important background information to the administration's energy advisors.
- Dr. Ramage: The debate should not trend towards discussions of "either/or." Automakers are developing a fuel cell transportation economy on top of an electric platform. That platform will support multiple technologies – batteries, fuel cells, biofuels, etc. It is not either/or. We do not want to convey that hydrogen is the only option but instead it is part of a larger set of options. However, hydrogen does offer some unique advantages versus other alternatives. One of hydrogen's unique features is that it is a path to a sustainable energy future. It is an energy carrier that we can point to and say "if hydrogen works, and it progresses going forward, it has more potential to reduce oil and CO_2 than any of these other energy sources over some period of time." Depending on the source of the electricity, hydrogen can offer more potential to reduce CO_2 emissions. For example, what is the ability of plug-in hybrids that are charged using standard-mix grid electricity to reduce CO_2 emissions? In addition, hydrogen is not alone in having big challenges that must be overcome to realize its potential. Building the infrastructure required to deliver large amounts of ethanol will also involve laying pipelines, addressing unique metallurgy issues, etc. Why is it that only hydrogen suffers from this discussion of infrastructure obstacles? Wind energy faces challenges since the existing grid can only handle so much non-dispatchable electricity, and we do not have the kind of "smart grid" system in place to enable large amounts of wind transmission. New smart grid technology will be required to make wind a big contributor to our power supply. So hydrogen has unique features, but also some similarities and problems in common with other alternative energy sources.
- Mr. Hofmeister: The draft talking points document is very well done, and with the additional suggestions from the Committee will convey a succinct story. The real effort the HTAC is trying to undertake, however, is to get information into the hands of the people we want to have it. A better strategy might be to produce an information package that could include, for example, the two-page talking points document, a copy of the HTAC letter(s) to the Secretary, important documents that the Committee has used or discussed in its meetings, etc. It is important that both campaign committees get a briefing from the experts. The actual format is less important than the actual briefing, which includes information that the campaign committees can draw upon and extract from going forward. Both campaigns are building staff with the ability to analyze, digest, and condense information. The HTAC could work on the talking points for another month and still debate its content or its format, but at some point we need to declare victory over what we have created, and turn our attention to the actual package that is presented. That package should be materially enhanced for post-election briefings to the transition team, so that HTAC is providing "thoughtful, methodical depth" to the Secretary of Energy.
- Dr. McCormick: As I read through the headings of the talking points document, I see "The Time Is Now," and I get excited to read what will follow. However, the Steps 1, 2, and 3 that follow are just business as usual. For example, Step 3 of the talking points discusses supporting early applications. More demonstration projects are one, business-as-usual, way of supporting early applications. However, what will really drive us through the valley of death will be stable government policy that offsets the penalties of low-volume manufacturing. Policymakers need to recognize the enormous scale of the industries involved. If, for example, an automaker is losing $1,000 on the cost of a fuel cell vehicle, and we decide to manufacture a million of them, we have lost a lot of money. One

thousand dollars may not sound like a lot, but when you multiply it by a million, it is a lot of money. In addition, the headings for the three suggested next steps in the talking points document could be tweaked to make more of an impact on readers who will skim those first, before reading the entire document. We need to capture the readers' attention with the headlines and make them want to read the details.

- Mr. Hofmeister: Taking a cue from the presentations from Europe (Mr. Bonhoff) and Japan (Mr. Ando), one suggestion for alternative headings for the next steps could be: Step 1, Market Preparation; Step 2, Market Introduction; Step 3, Market Penetration.
- Mr. Friedman: I would argue that the three headings for next steps suggested by Mr. Hofmeister are also ambiguous, and will not pull someone in. I am going to need help on choosing the right words to get the attention while also covering the issues.
- Congressman Walker: The Committee should keep in mind that it is likely that the topic of hydrogen and fuel cells will never get more than two paragraphs in any speech made by the candidate or the President. What the Committee needs to think about is what we want those two paragraphs to say. It may be something like, "I believe by the year 2020 we can have a million fuel cell cars on the highway…and this is the reason why these cars should be on the highway….I believe that we can have distributed power….", etc., whatever it is that HTAC thinks that message should be. The Committee should formulate the talking points around the statement that we would like the new President to deliver in his first State of the Union address. The President's staff needs to be provided with enough background that they have confidence in the statement. There is a lot of good information in the draft talking points document, and it is presented in a way that makes it very readable. However, we ought not try to frame the wording that the staff will use, but to provide the staff with the confidence that "Yes, this is the future-- I want my guy to be a part of that."
- Dr. Ogden: As I read the draft talking points document, I put myself in the mind of the reader, and a couple of questions struck me. Why haven't I been hearing as much about hydrogen today as I did a few years ago? What are the opportunities to use hydrogen today? What progress has been made? We should include in the talking points some very specific bullets that speak to these questions, describe the progress that has been made, and help people to be encouraged that while there is a ramp-up process, this is not just a distant vision. For example:
    - The industry is engaged: eight top major automakers are all developing hydrogen cars, and automakers are planning to deploy several hundred of these vehicles in Southern California over the next two to three years
    - The technology has been progressing: we see a path now to a commercial vehicle by 2015; ongoing progress has been made in a steady, upward trend.
    - Fuel cells are being used today: fuel cells are being deployed for use in forklifts and other power applications.
- Mr. Narva: In relation to the structure of the talking points document, it seems like a lot of space is devoted to describing the problems (under the heading "The Cost of our Oil Dependence"). While accurate, most readers will know the problems already. The solutions (described under the heading "The Promise of Hydrogen") convey what the problems are, so perhaps the problems can be eliminated from the document either to shorten it or provide space for something else. [Mr. Eggert offered a "strong second" for this idea.]
- Dr. Taylor: Our oil use is bigger than "cars." We should try to capture some of the bigger picture.

- Mr. Eggert: With regard to describing the positive characteristics or attributes of hydrogen, a suggestion is to begin by describing the similarities that it has to other technology options in the portfolio, such as batteries, and build up to its unique characteristics. A point that is missing in the talking points is the synergy between the energy carrier (hydrogen) and the conversion technology (the fuel cell). It is not clear how those two things link together to create a potential solution. Another key point to make is the importance of "first mover advantage" in international competition. This topic will resonate among policymakers.
- Mr. Vesey: The talking points document is not about national security. Rather, it is a document about fuel diversification. What people want to know is, "what options do I have for fuel diversification?" The fact of the matter is that fuel diversification is the basic national need, and it does not matter how that goal is met. The talking points document emphasizes national security too much. I would rather see the Committee focus on what the National Petroleum Council study concluded—that we need all kinds of technologies. The document also includes too much use of the term "global warming." We should not get into the debate of science on global warming, but stick to the facts and say that this technology is an option that can reduce "greenhouse gas emissions."
- Mr. Friedman: Mr. Vesey highlighted three issues that the HTAC will have to debate. In terms of the title for the talking points document, the question is whether "Hydrogen and Fuel Cells for Fuel Diversification" is the attention-grabber we are looking for as a headline. Will people understand that? Recall that Mr. Ando's presentation was titled "Hydrogen and Fuel Cells Save the Earth." Part of the challenge is grabbing someone's attention. National security, jobs, and the environment are major issues, so referencing them grabs people. While fuel diversification is indeed the solution, that may not be the headline, and I will need suggestions for that.

  With regard to the issue of "whether to portfolio or not to portfolio," there are different opinions within HTAC about how much emphasis the portfolio issue should have. On the global warming issue, some would argue that talk about global warming does rest on strong facts. The HTAC will need to figure out how to resolve that issue as well.
- Dr. Ramage: Politicians are looking for short term fixes and they want to see an impact on reducing oil consumption and CO_2 emissions, regardless of whether it is tied to climate change, that is what energy policy needs to drive. The reality is that the impact of hydrogen will be long term, which does not mean that hydrogen is not very important for the future, nor does it mean that actions do not need to be taken today. There are hurdles, and the country needs to invest in overcoming those hurdles. We need to be careful about credibility and careful not to oversell, but, there are also misconceptions that ethanol and plug-in hybrids are short-term, which they are not. Those options also have hurdles and infrastructure issues that will take time to address.
- Dr. Shaw: I agree that solving the energy and greenhouse gas problem is a long-term issue. But at least one of our recent politicians, Former Vice President Gore, made the point that the national interest can sometimes be served by attacking long-term problems (e.g., the interstate highway system and the space program). There is nothing wrong with saying that these fixes are not short-term. There is nothing that can be done in the short term to truly correct these problems. Every real option is a long-term option. Therefore, the real choices to be made are among long-term options. HTAC is asking for hydrogen to be one of the options in a portfolio. We are not saying this is the only option, or that there are simple answers. However, this answer is one that must keep moving forward or the nation will lose a very important opportunity. If the nation is going to do something in the next

decade or two to seriously impact both of these major issues—security and CO_2, then the administration must act now. That message needs to be conveyed in the talking points.

- Dr. Shaw: While I do not object to promoting the portfolio approach per se, I am concerned about pointing to particular options (such as the specific mention of "battery-electric vehicles and plug-ins running on biofuels" in the first section of the draft talking points document. Those are two options, but there are others, and we could be criticized for mentioning those but not the others. Mr. Friedman: I believe that by acknowledging the other alternatives up front, we are heading off the debate over other alternatives. While we are focused on hydrogen, we recognize that hydrogen is part of the bigger puzzle that includes other technologies or long-term approaches. Dr. Shaw: We acknowledge the need for a portfolio approach in the talking points with the statement "We need a strong and sustained national commitment to an energy portfolio that includes hydrogen and fuel cell vehicles." Let the reader decide what to include in the portfolio other than hydrogen. Mr. Friedman: My fear is that it is "too cute, too subtle," and that it appears that we are dodging the issue. The audience may not be sophisticated enough to understand what is meant by calling out just "hydrogen" and "electricity," because people are not going to understand what is meant by "electricity." Acknowledging that there are these particular other alternatives could take the issue at least partly off the table.
- Congressman Walker: I have drafted a paragraph that might be used for a speech by one of the political candidates, as follows: "Our 21st century world will depend upon electronic and intelligent technologies. Our energy policy for the future needs to reflect that reality. In nearly every analysis, hydrogen is seen as playing a prominent role in that policy. Some may ask, 'Why has there been that emphasis on hydrogen?' Because hydrogen is abundant, clean, and safe. Its use in fuel cells provides significantly greater efficiency and allows for multiple applications in both transportation and the general use of electricity. We must develop a national policy that ensures that we lead the world in the creation of hydrogen technology."
- Dr. Lloyd: At least some of the advisors on energy and the environment for at least one of the candidates are probably not going to be a big supporter of hydrogen. At the moment, I do not see anything here that is going to change that opinion, but we do have the framework here to open that door. It often happens that when a new administration comes in they "dump" initiatives that were popular with the previous administration. If we suspect that might be true for hydrogen, then how do we convince them otherwise? I like the ideas of focusing on hydrogen's unique features and including some background information, and I agree that we need to mention some of the other options in order to have credibility with the environmental community. I think it is important to educate people. We can assemble good technical information or studies to support these ideas; in essence, these technologies are all on the same sort of timeframe, there is not a quick fix. One unique feature of hydrogen and fuel cells is that it has the potential to make "every home self-sufficient for energy and transportation fuel;" we can point to some of the enabling technologies, including distributed generation of electricity. Also, we do not have to wait until after November to transmit these messages to the candidates. Arnold Schwarzenegger talked about the hydrogen highway during his campaign, and his message "really had a lot of mileage. ….If we can give the candidates a message that reverberates, they in fact ought to implement it."
- Dr. Ogden: I am in favor of trying to explain the short-term/long-term idea and the portfolio idea. I know that it is a big job, but we have to start trying to inform policymakers this way, because that is the reality. None of these things are short-term fixes and a portfolio of options will be needed; it is

important to convey these two themes. We also do not want to support a "fuel of the year" trend, even if that approach gets attention.

- Ms. Epping Martin: Ms. Martin reported on a response from the DOE General Counsel's office, which stated "[HTAC] members, regardless of appointment [as] either a special government employee or a representative member, cannot send HTAC reports or documents to the [Presidential] candidates, because of the appearance that the Department is participating in partisan politics." In addition, there are numerous other political parties, besides Republican and Democrat, that might complain if they were not included in the mailing, not to mention the current sitting members of Congress. "In short, HTAC members should not be sending unsolicited copies" to the candidates. However, DOE counsel did say that the HTAC should post the talking points on the public website, which DOE will do. Counsel further advised that if a candidate or a candidate's staffer requests from an HTAC member a document that is publicly available (such as one that is posted to a public website), the HTAC member should forward this request to the DOE Designated Federal Official for processing.
- Dr. Schmidt: I do not know if we have defined what we really want to achieve with the talking points paper. Do we want it to be an energy policy paper, and present everything in a balanced, scientific manner, comparing options like biofuels, electricity, and hydrogen? I do not think this approach is necessary. This group is the "Hydrogen and Fuel Cells Technical Advisory Committee," not a biofuel, electricity, or other type of committee. I think it is valid that we just concentrate on what we have been asked to do. There will be another paper written for biofuels and another paper written for electricity, and I do not think we need to have a balanced paper here.

  We also need to keep in mind Congressman Walker's point that we may be aiming for only one or two sentences in a speech. We need to consider boiling this down to the one or two or three points that are really important, for example: "a fuel cell vehicle is a key enabler for freedom of individual mobility; it is energy security, improves independence, and is a key enabler to improve the energy mix; it is the cleanest energy at the point of usage. We do not necessarily need two pages with many words and sentences; maybe it is only one page, but with three easy messages." Perhaps someone with a scientific background might want to include some footnotes with references to another 20 pages with explanations and supporting material. The purpose of the talking points should be to advocate for a technology that we think is important for our future.
- Dr. Ramage: Instead of starting off by talking about hydrogen itself, it may be important to begin by putting the energy system in context in five sentences or less. First, what is the problem, which is oil and CO_2. Second, there are a number of options, and they all have a risk. Third, the transformation of the energy system will take decades, not years. And hydrogen can play a significant role in the future, and it has some very unique features. One of the unique features is that it integrates the fuel side and the vehicle side. Policymakers may not understand this long term aspect—that you would have to build hundreds of ethanol plants to provide 10 percent of the U.S. gasoline supply. "That does not mean it is bad, it just means that everything takes time, and everything has risk. The significant potential of hydrogen is that, by itself, it could remove most of the CO_2 and most of the oil from the U.S. transportation system; in combination with other technologies, we can remove all of it." Another unique feature of hydrogen is that it is a path to a sustainable energy future—it can handle renewable energy, it is an energy carrier, etc.
- Mr. Katsaros: I agree with previous comments about "trying to make this real for people." We should build on the "fast facts on hydrogen" provided at the end of the draft taking points document to help policymakers understand that hydrogen and fuels cell technology is not a futuristic pipe dream

but a real option. There are real things happening; there are real cars on the road. We could also include some bullets on what is going on internationally. There is over a billion dollars of research being done; money is being spent on demonstration projects, and we are pretty close to putting large numbers of vehicles on the road. Hydrogen and fuel cell technology is not something that has to be invented, it just has to be improved; this point is a very important.

- Mr. Friedman: There are a number of unresolved issues that will present challenges for us in producing another draft. Without more of a consensus on how to resolve these issues, we may have to have this discussion all over again. For example, what should the title be? What is the structural theme? Do we need to resolve the "global warming" versus "CO_2" issue? Dr. Shaw: for purposes of expediency, I think it is possible to take the input we have gotten and expect to get, which has about three or four major themes, and develop it into another draft that will be much closer to the mark for consensus.
- Dr. Shaw: To bring this discussion session to a close and summarize next steps:
    1) DOE will provide HTAC members with the transcripts of today's discussion.
    2) Dr. Shaw or Mr. Freidman will send the current draft talking points document to the full HTAC via email for review and comment. All comments and input received will be taken seriously. Everybody should be engaged – "if you do not comment, you lose your shot." Line-by-line commentary on the first draft is less important, since the next draft will likely be significantly different. What are most needed at this stage are general comments about the document's structure, key messages, etc.
    3) HTAC members who have useful references to support the key points should send those to Mr. Friedman. If members have additional substantive points they would like to include in the talking points, they should summarize the material and send it to Mr. Friedman.
    4) A drafting committee will assist [Mr. Friedman] in preparing the next version of the document. Drafting committee members: Dr. Shaw, Mr. Friedman, Mr. Rose, and Dr. Ogden. The Drafting committee will incorporate comments received via email, consider the comments during today's discussion, and develop another draft of the document (possibly through several conference calls and iterations).
    5) Draft 2 of the talking points will be distributed to the HTAC for review and comment some time in August.
    6) The goal is to post a polished, final document to the HTAC website prior to November, which can be referred to as a "talking points document for the transition team." The next step would be to develop a complete package for the transition team, which includes this document as a lead-in.

7. ***Briefing on the Status of Hydrogen Storage and Hydrogen Program and Budget Updates***
Sunita Satyapal, Hydrogen, Fuel Cells and Infrastructure Technologies Program, U.S. DOE

7.1 Briefing on the Status of Hydrogen Storage: Dr. Sunita Satypal, U.S. DOE
>> see full presentation at http://www.hydrogen.energy.gov/advisory_htac.html

Dr. Satyapal provided a briefing on the technical status of hydrogen storage research and development (R&D) activities in the DOE portfolio. She noted that there had been questions at the last Committee meeting about hydrogen storage and about international efforts in hydrogen storage research, and

addressed those by reviewing hydrogen storage R&D goals, objectives, and overall strategy; recent progress in materials development and the status of current research and demonstration efforts; and current frameworks for national and international collaborations in hydrogen storage research. Highlights of Dr. Satyapal's presentation are summarized as follows:

- In the North American market, consumers demand at least a 300-mile driving range, but the key challenge is to achieve that level of performance without compromising space on board the vehicle, vehicle performance, or vehicle cost.
- Industry has made significant progress with vehicle designs and early market introduction for certain vehicles, such as the Toyota vehicle (recently profiled in the press) that has been claimed to be capable of a 500-mile range using four tanks; however, manufacturers continue to identify performance, space on board, and cost as key challenges for mass market penetration.
- DOE-funded R&D complements current industry work on tanks by focusing on novel materials-based approaches and high-risk, high-potential projects to seek a low-pressure alternative to high-pressure tanks for hydrogen storage.
- The DOE learning demonstration activity has grown to include 92 vehicles and 16 hydrogen refueling stations, showing that hydrogen vehicles are ready for early market introduction, and the program's first-generation hydrogen vehicles have achieved a projected fuel cell system durability of 1,900 hours (approximately 57,000 miles) and driving range of up to 190 miles.
- Currently, no technology meets the FreedomCAR and Fuel program system targets of six percent hydrogen by system weight and 45 grams per liter.
- To complement industry and reach long-term targets, DOE launched the National Hydrogen Storage Project (NHSP), which includes about 40 universities, 20 companies, and 15 Federal laboratories and takes a technology-neutral approach, coordinating materials R&D activities among three Centers of Excellence; independent, competitively awarded R&D projects; cross-cutting testing research; and basic research conducted through the DOE Office of Science, Office of Basic Energy Sciences (BES).
- Progress against the system target of six weight percent:
    - Sorbents show fairly high capacities, but the binding of hydrogen to these materials is relatively weak, requiring low temperatures (cryogenic systems) to hold the hydrogen.
    - Some metal hydrides have very high capacities but bind hydrogen too tightly, requiring very high temperatures to release the hydrogen.
    - Some newly developed chemical hydrides are starting to come close to the performance target; however they are not reversible.
- Progress in tank development includes development of cryo-compressed tanks and assessment of high-pressure tank cost; tank cost for 700 bar tanks is still a significant issue, driven by the high cost for carbon fiber, which is produced primarily in Japan.
- Compared to a fiscal year 2008 (FY08) appropriation of $43.5 million, the fiscal year 2009 (FY09) hydrogen storage R&D budget request is $59.2 million to expand the portfolio, look at new materials and options, and increase the focus on systems engineering by establishing a new Engineering Center of Excellence as well as awarding independent projects and increasing tank R&D.
- Applied R&D under the President's Hydrogen Fuel and Advanced Energy Initiatives is coordinated among national and international organizations and includes close collaboration with industry through the FreedomCAR & Fuel Partnership, codes and standards organizations, and the DOE Technology Validation subprogram (also known as the learning demonstration); national collaboration through

inter- and intra-agency efforts (including DOE, NSF, DOT, NIST, and DOD); and a growing number of internationally funded projects. The international projects include approximately fifty organizations through the International Energy Agency (IEA) Hydrogen Implementing Agreement (Task 22, which includes participants from 17 countries and the European Commission); five projects through the International Partnership for the Hydrogen Economy (with participation from 20 countries and the European Commission.); and a memorandum of understanding (MOU) between the National Institute of Advanced Industrial Science and Technology (AIST) and New Energy Industrial Technology Development Organization (NEDO) in Japan, and Los Alamos National Laboratory in the U.S.

- Hydrogen storage R&D was increased relatively recently (since prior to 2004, the focus was on-board fuel processing of gasoline), and the six DOE staff members on the Hydrogen Storage Team (plus Dr. Gary Sandrock, who is serving a detail from Oak Ridge National Laboratory to DOE) represent a great deal of expertise gained from industry experience.

A few questions were asked during Dr. Satyapal's presentation:

- Dr. Shaw asked for Dr. McCormick to comment on the basis for the 1,900-hour fuel cell system durability from technology validation's first-generation cars. He wanted to know if that figure was an aggregate figure representing data from the various manufacturers. Dr. Satyapal answered that the 1,900-hour figure is a composite. She explained that when DOE set up the technology validation program with four teams of OEMs and energy companies), it was agreed that the program would not disclose specific data for manufacturer or type of vehicle but instead would use composite data and show a range without any attribution to vehicles. There is a secure data room at NREL that gathers the performance data, and the program compiles the data using a very methodical and rigorous system. The IPHE has a demonstration and infrastructure working group that praised this approach, and Germany and Japan may choose to use same type of approach, get similar data, and use similar, consistent data protocols. Dr. McCormick then added that the vehicles in the demonstration program represent five- to ten-year old technology. Mr. Chernoby commented that the demonstration program represents a broad range of generations and technologies, given the timeframe in which it was established, and Dr. McCormick concurred that the demonstration program really shows where the technologies were four or five years ago.
- Dr. Shaw asked why the fuel cell system durability number is not expressed as a range of values, and asked what that range would be. Dr. Satyapal answered that the current durability figure illustrates the need to continue the demonstration program to allow additional time to collect durability data. She also echoed Dr. McCormick and Mr. Chernoby's remarks that once a project reaches the demonstration phase, it already represents technology that is a few years old. So the current durability figure represents only first-generation vehicle performance.
- Mr. Rose asked whether Dr. Satyapal could state the durability numbers for the best-performing demonstration vehicles and whether the 1,900-hour figure represented an average or median value. Dr. Satyapal answered that actual fuel cell system durability collected so far was 1,200 hours, and that the 1,900-hour figure was a projection. She stated that the data collection methodology used in the demonstration program was a success, and it will be the key to getting additional competitive data from Honda, Toyota, Hyundai, and others to update the durability figure.
- Congressman Walker asked where carbon nanotube research fits into the NHSP framework. Dr. Satyapal replied that there was a carbon-based center of excellence, but a formal go/no-go decision

process yielded a no-go decision on single-wall carbon nanotubes; as a result, the Center of Excellence expanded beyond carbon nanotubes to refocus on hydrogen sorption.

- Dr. Lloyd asked if Dr. Satyapal were to write her *Scientific America*n article today, how would she summarize the progress? Would she be more optimistic about meeting the goal? Does she have some speculation as to when the goal could be met? Dr. Satyapal answered that she would not be able to pick a favorite material, but the main point of her *Scientific American* article would be the huge increase in the number of materials that have been developed, many of which are completely new materials that are getting closer to the goal of reversibly storing hydrogen at close to room temperature. She stated that no one expected such rapid progress in identifying these materials. However, she noted that there is still a lot of work to do, to sustain momentum and resolve issues pertaining to kinetics and so forth, and she added that "there are still a lot of targets to meet."
- Dr. Shaw continued this line of questioning and asked whether Dr. Satyapal felt that the "winning" candidate has already been identified, or whether she thinks there are still new materials that will emerge from the research activities underway that will be very much better than anything that has already been identified. Dr. Satyapal answered that a large number of promising materials have already been developed and then subsequently discarded because it was determined that they will not be viable for the final approach. She stressed that "it's not trivial to tailor these materials to try to get them into this [performance] window." The tailoring process could substantially change the materials, and make them unviable. Therefore, it is too early to try to completely narrow down the set of potential materials. She noted that the effort aimed at hydrogen storage materials is really a long-term effort. There is agreement that high-pressure tanks are a viable option for hydrogen storage today. To conduct a very thorough, methodical review of the possible options for storage materials that will meet all of the targets from an overall well-to-wheels efficiency point of view will take time. Dr. Shaw followed with a question about meeting cost targets, and Dr. Satyapal agreed that there is still much work to do to meet cost targets also.
- Dr. Shaw asked about ammonia as a hydrogen carrier. Dr. Satyapal answered that DOE reviewed ammonia and published the results in a white paper on DOE's website. Ammonia has very high energy density, but also has other troublesome issues. For example, catalytic reforming of ammonia requires temperatures of more than 500 ºC. There are also issues with longevity and durability of catalysts and components. After gathering industry input and writing the white paper, a consensus was reached that a different approach was required unless a better form of ammonia reforming was developed.
- Dr. Taylor asked whether the hydrogen storage R&D program is "science idea limited," "people or expertise limited," "money limited," or "process limited." Dr. Satyapal answered that it took time to establish the Centers of Excellence and get the program working. In addition, sustaining a portfolio is always a challenge, given the budget and appropriations process. However, she asserted that the storage R&D program is now working well, with a systematic go/no-go decision process and the necessary flexibility to change R&D direction (for example, moving away from single-walled carbon nanotube R&D).
- Mr. Bawden asked whether a high-pressure storage system or a low-pressure storage system would have a more difficult time gaining regulatory approval. Dr. McCormick answered that things are coming into place for high-pressure systems, so by 2015, regulatory approval should not be an issue. He noted, however, that every time a new approach is taken, the technology has to move through a seven- to nine-year process of testing and validation in preparation for regulatory approval. Mr. Bawden then asked if regulatory concerns were an influence in selecting a final hydrogen storage

solution. Dr. Satyapal responded that there is an R&D project under IPHE involving the U.S., Japan, Germany, and Canada that is reviewing material reactivity, safety, and other issues pertaining to final safety codes and standards. As promising materials arise, that project helps determine risk mitigation strategies that could help enable regulatory approvals. The chief determining factor at the present time in selecting a potential hydrogen storage material, however, is capacity versus temperature [as well as kinetics, though all the targets must eventually be met simultaneously]. Mr. Bawden then stated that once the best material is selected, the nine-year testing and validation cycle begins, and that kind of delay is unacceptable. Dr. McCormick replied that the R&D task is to invent a new material that rests inside some sort of container. So the program is also evaluating the best materials, valving, etc., for container designs (seeking to reduce high materials costs) and beginning to perform failure-mode analysis on promising container designs. These tasks are performed in parallel to the work being done on hydrides, etc., which reduces the nine-year timetable. Dr. McCormick agreed, however, that the timetable needs to be shortened.

- Mr. Rose asked whether, given improvements in system efficiency (seen in the Honda and Toyota vehicles' improved range), the program will consider staying with or going back to 350 bar tanks. Dr. McCormick responded that the 350 bar tanks having this success are on very aerodynamic, light vehicles; however, these kinds of vehicles restrict utility in a broader variety of vehicle applications, so the focus will remain on 700 bar tanks. Mr. Chernoby added that unless the vehicles making these claims have gone through the DOE technology validation program, and therefore had third-party oversight of the performance data, the data may not be painting an accurate picture of true performance (for example, the figure might be for performance "going down a hill with my foot off the accelerator.")
- Mr. Hofmeister asked whether the studies were taking into account the potential for unintended consequences in the afterlife of the vehicle, such as destruction of the vehicle or the landfill. Dr. Satyapal replied that at this time, DOE is not working in the context of a vehicle, whole system or tank, because DOE is still focusing on the development of materials. In the materials area, the team does consider the impact of the material on the vehicle system, as well as the stability of the material [and overall well to wheels implications]. However, the primary focus has been on finding materials that meet performance targets for capacity, temperature, and reversibility. Once those materials have been identified, they will be evaluated for material reactivity, safety, and long-term impacts. This is one of the reasons why the previously mentioned IHPE project with Japan, the U.S., Germany, and Canada is important: it allows for exploration of functional aspects of candidate materials [including environmental reactivity].
- Dr. Lloyd asked why only two Japanese companies produce carbon fiber, given the worldwide demand for it. The cost of carbon fiber is a limitation; unless domestic companies become able to manufacture carbon fiber, fuel cell development will be at the mercy of an overseas supplier. Dr. Satyapal responded that this is a classic issue for emerging technologies – how to get domestic companies to invest in the infrastructure needed to supply a key component of a product that does not have an established market yet. She also noted that the FreedomCAR & Fuel Partnership has explored using low-grade carbon fiber; however, high-grade carbon fiber is required. With the aerospace industry driving demand for high-grade carbon fiber, and recent increases in demand, there is obviously concern about this issue. Dr. McCormick added that it could be possible to achieve the desired costs for carbon fiber by working with a different precursor, and some research has been done in that area. Costs also depend on volume, and a large volume (through a shared market) would be required to bring costs down (and also to spur domestic investments in carbon fiber production). Part

of the reason that there is not a blossoming carbon fiber industry is because the present market, which is currently dominated by companies like Boeing and Airbus, is "where it should be." Low-cost energy is also essential to lowering carbon fiber costs; right now, a lot of the carbon fiber made in the U.S. is made near the Tennessee valley, because of the low-cost electricity there. In addition, modularity of system design is essential for moving forward.

- Dr. Shaw asked about the possible risk of developing a hydrogen infrastructure to support vehicles with high-pressure tanks, then needing to revamp or even replace that infrastructure when new materials change the technology (perhaps 10 years from now). Dr. Satyapal made two key points in her response. First, if the initial hydrogen fueling infrastructure is geared towards high-pressure tanks, then tanks will likely still be useful even if a reversible hydrogen storage material is developed. These materials will still likely require moderate pressure to reach capacity goals, and tanks can be adapted by adding a material to the tank that can increase the capacity. Second, the market may decide to focus on distributed hydrogen production in the near term (which could delay the need for large infrastructure investments until there is a higher demand for hydrogen). During this window of time, a new liquid hydrogen carrier or storage material (such as a liquid chemical hydride) that could be transported similar to gasoline may "completely obviate the need for [large investments] in infrastructure for high pressure." Dr. McCormick added that work with liquids thus far has revealed a key problem: the liquid does not regenerate. So far, tanks remain the primary approach.
- Dr. Ogden asked about the estimated cost per kilowatt-hour (kWh) for the mass production of compressed hydrogen gas tanks. She noted that a DOE-funded study by TIAX LLC calculated $27/kWh, whereas a recent California Air Resources Board (CARB) study and an MIT study were more in the $10 to $18 per kWh range. Dr. Satyapal replied that the CARB study and a few others used an older analysis. The TIAX figure is an updated analysis showing an increase in carbon fiber cost. Dr. Ogden then asked whether estimated costs would be similar for a 350 bar tank. Dr. Satyapal responded that the figure for the 350 bar tank is approximately $17/kWh.

7.2 Hydrogen Program and Budget Updates: Dr. Sunita Satyapal, U.S. DOE

Dr. Satyapal described a major change at the organizational level within the Office of Energy Efficiency and Renewable Energy (EERE), which was approved in both the House and the Senate bills: the Safety, Codes and Standards; Technology Validation (which includes vehicle and infrastructure validation); and Education program elements, which are currently housed in the EERE's HFCIT Program, will be transferred to EERE's Vehicle Technologies Program in FY09. The move will take advantage of the synergies that these activities have with other alternative fuel vehicle programs (biofuels, plug-in hybrids, and so on). Strong coordination and stakeholder input to both offices will continue to be important. Dr. JoAnn Milliken will return to her position as Program Manager for HFCIT. (She had been detailed to serve as Acting Program Manager for Wind Technologies). Mr. Ed Wall, will take over as Program Manager for Geothermal Technologies, and Mr. Pat Davis will be assigned as Program Manager for Vehicle Technologies.

Dr. Satyapal continued with an overview of the FY09 budget bills from the U.S. House of Representatives and U.S. Senate for the DOE hydrogen programs. Highlights of Dr. Satyapal's discussion are summarized below.

- EERE Hydrogen Production and Delivery: Budget increased to $22 million in the Senate bill (from the DOE request of zero dollars) and remained at zero in the House bill.
- EERE Hydrogen Storage: Budget remained at the level of the DOE request in both bills ($59.2 million).
- EERE Fuel Cells: Budget remained at the level of the DOE request in both bills ($79.3 million).
- EERE Technology Validation: Budget remained at the DOE request ($15 million) in the Senate bill and was increased to $30 million in the House bill; $30 million will be needed in both FY09 and FY10 according to original plans for the Learning Demonstration activity to complete the Phase 1 technology validation efforts.
- EERE Fuel Processing R&D: The House restored funding for this activity ($3 million), which had been zeroed out by DOE.
- EERE Safety Codes and Standards: DOE budget request ($12.5 million) was increased to $18.8 million in the Senate bill and $15 million in the House bill.
- EERE Systems Analysis: DOE budget request ($7.7 million) was increased to $11.5 million by the Senate, and left at $7.7 million by the House.
- EERE Manufacturing R&D: The DOE budget request was increased from zero (due to budget prioritizations) to $3 million by the Senate and $5 million by the House. (The House mark is consistent with the FY08 budget for manufacturing R&D).
- EERE Market Transformation: The House bill added a new, $15.7 million activity on market transformation to address the Energy Policy Act of 2005 (EPACT) to help Federal agencies purchase hydrogen fuel cell systems for portable, stationary and transportation applications. The Department's request did not include a budget for Market Transformation.
- EERE Education: DOE budget request remained essentially the same ($4 million) in both House and Senate.
- DOE Office of Science: Budget was unclear in the Senate language; the House bill supported the DOE budget request of $60.4 million.
- DOE Office of Fossil Energy: DOE request ($11.4 million) was reduced to $10 million in the House bill and increased to $30 million in the Senate bill.
- DOE Office of Nuclear Energy: DOE request ($16.6 million) was supported in the House and reduced to $10 million in the Senate.
- With the expected continuing resolution (CR), it is unclear whether there will be any flexibility in the language; usually, with a CR, budgets fall to the lower of the two mark-ups.

Following her review of the House and Senate mark-ups of the FY09 budget, Dr. Satyapal took questions from the HTAC members, as summarized below:

- Dr. Shaw asked whether EERE will continue at last year's budget, or the marked-up FY09 budget level. Dr. Satyapal commented that, with a DOE budget request of zero for hydrogen production and for manufacturing, the program will need additional clarification and guidance [e.g., from DOE's CFO], but it is unlikely they can spend at last year's levels ($40 million) during the CR.

- Dr. McCormick commented that "a number of us are people who are taken to task in the press… for not being serious about solving energy problems," and he said that if he could "give the Secretary one piece of advice," it would be for the U.S. government to become more serious about these issues, and stop "whipsawing" the R&D budgets. Mr. Chernoby commented that the HTAC needs to channel that sentiment and "tag some data to it," data such as the National Academy of Science (NAS) analysis that shows that the "decimal point is probably two or three places off." Dr. McCormick agreed that they need to "move the decimal point," because $3 million vs. $5 million on a line item is not the heart of the issue. Dr. Satyapal reminded the group that the FY08 budget was the largest ever—$281 million—and the FY09 budget request is $267 million, approximately the same as the FY07 budget. And while the Senate and House mark-ups of the FY09 budget request are very prescriptive, the overall budget is higher than prior years.
- Mr. Eggert asked about the expectations for Congressionally directed projects (CDPs) in the FY09 budget. Dr. Satyapal answered that her office has identified some CDPs for hydrogen in the House and Senate bills. While it is unclear how the CDPs will be funded, language so far indicates that the CDPs will receive additional funding, like they did in FY08.

Dr. Satyapal then continued with a discussion of the materials that will need to be prepared for the transition to a new Presidential administration (including new senior management at DOE). After stating that it would be very helpful to hear HTAC feedback soon, so the feedback could be incorporated into the transition materials, Dr. Satyapal took questions from the HTAC members, as summarized below:

- Mr. Friedman asked for more information about what is being done in regard to the transition materials, because it seems like an important opportunity for the HTAC members to see and comment on the materials while they are being developed. Dr. Satyapal responded that it is still relatively early in the process, with only pre-decisional draft documents in development. Mr. Friedman responded that he thought the HTAC members could make the best use of their time, and be most useful to the process, if they could be involved at this early pre-decisional phase and could help steer some of the important decisions to be made.
- Dr. Lloyd asked Dr. Satyapal to discuss the kinds of materials being prepared for the transition. She replied that the materials were in the process of being formulated, and that her office would get more details and see what could be shared with the HTAC members. She noted that while these materials were being developed within the Department, the HTAC plays its own valuable role in advising the Secretary of Energy and having a separate, strong statement.
- Mr. Rose asked what the approval process is for the transition materials. Dr. Satyapal responded that it is too early to answer that question, but the process will likely include, as it typically does, the Chief Financial Officer (CFO) and various program offices within DOE.

The July 22, 2008 HTAC meeting was adjourned at 6:00 pm.

July 23, 2008

Chairman Lloyd called the meeting to order at 8:35 a.m.

1. ***Report on NAS Hydrogen Resource Study***
Dr. Michael Ramage
>> see full presentation at http://www.hydrogen.energy.gov/advisory_htac.html

Dr. Ramage briefed the HTAC on a National Academy of Sciences (NAS) study, commissioned by DOE at the direction of Congress, to examine what resources would be required to make a transition to hydrogen fuel cell vehicles. To conduct the study, the National Academy of Sciences' National Research Council (NRC) established a 17-person committee (with Dr. Ramage as Chair), known as the "Committee on Assessment of Resource Needs for Fuel Cell and Hydrogen Technologies." Dr. Ramage noted that the NRC committee was very balanced with members from different industries, with different environmental backgrounds, and with a range of views on hydrogen technology. He introduced three other HTAC members who also served on the committee: Mr. David Friedman, Dr. Joan Ogden, and Dr. Robert Shaw. He noted that committee members were very actively involved in conducting the analysis and modeling, and that everyone contributed to writing the report and came to consensus on the conclusions.

The committee was formed in 2007 to address the following "statement of task:"

- Establish as a goal the maximum practicable number of vehicles that can be fueled by hydrogen in 2020
- Determine the funding, public and private, required to reach that goal
- Determine the government actions (including policies) required to achieve the goal
- Consider the role that hydrogen's use in stationary electric power applications will play in stimulating the transition to hydrogen-fueled hybrid-electric vehicles
- Consider whether other technologies could achieve a significant CO_2 and oil reductions by 2020
- Establish a budget roadmap to achieve the goal.

Dr. Ramage reported that early on, the NRC committee agreed that hydrogen fuel cell vehicles (HFCVs) would probably not have a big impact on CO_2 or oil reductions in the 2020 timeframe, and decided to extend its analysis to include longer-term timeframes (2020, 2035, and 2050). The committee conducted some of its own modeling, with the help of Dr. Ogden and others, and drew heavily on the DOE scenario analysis work that is published in the report "Transitions to Hydrogen Fuel Cell Vehicles and the Potential Hydrogen Energy Infrastructure Requirements." The committee's analysis included modeling the penetration and impact of ethanol (including cellulosic ethanol), hybrid vehicles, and efficiency gains in conventional vehicles.

The NRC committee estimated the maximum practicable penetration rate of HFCVs in these three timeframes, assuming a "best case" scenario: that technical goals are met, that consumers readily accept HFCVs, and that policies are in place to support HFCVs and hydrogen production. Dr. Ramage summarized some of the study's key findings and conclusions, as follows:

- If supported by strong government policies, commercialization and growth of HFCVs could get underway by 2015, even though all DOE targets for HFCVs may not be fully realized.
- The maximum practicable number of HFCVs that could be on the road is about 2 million by 2020, 60 million by 2035, and 200 million by 2050 (which is 80% of new vehicles and 60% of the light-duty vehicle fleet in 2050).
- A portfolio of technologies, including HFCVs, biofuels, hybrids, and improved efficiency of conventional vehicles, could virtually eliminate gasoline use in light-duty vehicles in the U.S. transportation system by 2050, and could reduce fleet CO_2 emissions to less than 20% of current levels.
- To get through the transition to a point of market sustainability (that is, from 2008 to 2023), the NRC estimated that the government would need to spend a *total* of about $55 billion: $40 billion to support the incremental cost of HFCVs, $10 billion to support initial hydrogen infrastructure, and $5 billion for R&D.
- Policies designed to accelerate the penetration of HFCVs into the U.S. vehicle market must be durable over the transition time frame, but should be structured so that they are tied to technology and market progress, with any subsidies phased out over time.

To put the $55 billion figure in perspective, Dr. Ramage pointed out that if the U.S. were to meet its renewable fuel mandate with ethanol between now and 2020, the government will spend $160 billion on ethanol subsidies (not including any additional subsidies for cellulosic ethanol production, which may be required). Dr. Ramage clarified that the cost to the government for the hydrogen transition was estimated at $55 billion, as noted above. The figure of $200 billion, which was reported in some press releases, includes the *total* cost for purchasing the HFCVs (not just the incremental cost above what it would cost to buy conventional vehicles) as well as private-sector spending on RD&D and infrastructure. The majority of this $200 billion figure ($128 billion) is what would be spent anyway, to replace retiring vehicles in the fleet with conventional vehicles.

Dr. Ramage noted that substantial, sustainable, and durable policies will be required to move hydrogen through the period of technology development. The policies must help overcome the technology hurdles, handle low-volume manufacturing issues of vehicles, and initiate early hydrogen fueling infrastructure.

He emphasized that one of the report's most important messages, is "don't pick winners and losers." It is the *combination* of properly employed ethanol, advanced internal combustion engines (ICE), hybrid vehicles, and HFCVs that has the potential to have a large impact on oil use and greenhouse gas emissions in light-duty vehicles. In describing the committee's analysis of the costs for hydrogen infrastructure, Dr. Ramage explained that the committee focused on three technology options, mainly because these were considered to be the least expensive, most fully developed technologies with potential for low CO_2 emissions during the 2015-2035 timeframe. These technologies were also those for which the committee had the information it needed to develop cost estimates for building hydrogen infrastructure during the transition. The three options considered were 1) distributed hydrogen production via on-site steam methane reforming; 2) centralized hydrogen production from coal gasification with carbon capture and sequestration; and 3) centralized production from biomass gasification. Other options (like hydrogen produced using nuclear, solar, or wind-derived energy) may also be plausible in this timeframe, but the committee did not have enough data on these hydrogen supply options to cost them

out. Dr. Ramage stressed that their omission in the report does not imply that these technologies are unimportant, or that they will not play a role in the sustainable future.

Dr. Ramage reported that the committee developed three scenarios to investigate the range of possible outcomes for hydrogen (Hydrogen Success, Hydrogen Accelerated, and Hydrogen Partial Success). Scenarios for biofuels and increasing efficiency of conventional vehicles were also developed, as well as a "portfolio" scenario that combines all three. Dr. Ramage showed a number of slides that compared the impacts of a Hydrogen Success scenario (the scenario selected by the committee as the 'maximum practicable" scenario) with the reference case, based on the Energy Information Administration's projections under a high oil price scenario (*Annual Energy Outlook, 2008*). He reviewed a chart comparing the first costs of HFCVs with conventional vehicles, and noted that the break-even point, according to the NRC analysis, is 2023, when the cost of HFCVs becomes "market self-sustaining." He added that this particular date is simply a projection; the important point is that the HFCV market *does* become self-sustaining after some period of time, and government policies can then be ramped down.

Dr. Ramage also reported that the NRC analysis looked at the federal government vehicle fleet and concluded that if the U.S. government were to make half of their fleet vehicle purchases each year HFCVs (including the supporting fueling infrastructure), this would go a great distance towards building the manufacturing and supply base needed to bring the costs of HFCVs down in the transition period.

Questions, Answers, and Discussion

- In response to a question by Dr. Lloyd, Mr. Friedman clarified that the hybrid-electric vehicles examined in the study were similar to a Toyota Prius, with no all-electric range and no grid re-charging, and getting about double the fuel economy of today's vehicles. The hydrogen fuel cell vehicles were also hybrids without plug-in capabilities. Mr. Rose asked if the study's model could accommodate plug-in hybrids, since plug-ins are not likely to get better than 50 miles per gallon. Mr. Friedman replied that the model could, but that the oil and CO_2 savings might be larger with a significant plug-in range. He said that the complications associated with estimating oil savings and CO_2 emissions reductions from plug-ins were a key reason the study did not include plug-in vehicles. Dr. Ramage added that the committee explicitly excluded plug-in hybrids and light-duty diesel engines as alternatives because of 1) uncertainty over future electric battery performance; 2) uncertainty about consumer acceptance of both diesels and plug-ins and lack of confidence in assumed market penetration rates; and 3) difficulty estimating the impact of plug-in vehicles on the electricity grid mix and the subsequent impact on CO_2. He stated that the committee did not have the resources to conduct this analysis and therefore excluded these two alternatives from the study.
- In response to questions about the biofuels analysis, Mr. Friedman, Dr. Ogden and Dr. Ramage responded that the report considered a biofuels case that most people would consider aggressive. It included both grain-based and cellulosic ethanol, with cellulosic ethanol coming into the market in 2010. Dr. Shaw pointed out that the analysis clearly shows that biofuels can help to get us where we want to be, but HFCVs are needed as part of the portfolio to reach the year-2050 potential for oil savings and CO_2 reductions that are noted in the NRC report. Dr. Ramage noted that biofuels provides a greater contribution in the near-term. The biofuels case provides a 20 percent reduction in oil and CO_2 over a short period, which could be significant with tight oil supply. The key point is that there needs to be a balance between technologies with short term and longer term impacts.

- In response to a question about the assumptions for vehicle miles traveled (VMT), Dr. Ogden clarified that the analysis used the assumptions for VMT from the Energy Information Administrations' *Annual Energy Outlook 2008* (AEO 2008) and used the same VMT for every case. She agreed with Dr. Lloyd that a reduced VMT would help all cases happen faster.
- Dr. Ramage commented that this study shows the potential for a number of things to reduce oil and CO_2; hydrogen has the most long-term impact of the three studied. Ethanol can be supplied in the short term. Dr. Lloyd pointed out that to gain the long-term impact, you must start in the shorter term. Dr. Ramage agreed and said he has been asked if a carbon tax would push hydrogen vehicles into the market faster. He does not believe it would, because there are manufacturing and technical issues the tax will not overcome. The carbon tax is needed to make sure that carbon-neutral hydrogen supplies are produced.
- Dr. Schmidt inquired about how the well-to-wheel CO_2 emissions and energy efficiency compared for coal gasification versus liquid fuel from coal (Fischer-Tropsch). Dr. Ogden replied that the study did not consider hydrogen from coal unless combined with carbon capture and sequestration (CSS). Coal-based hydrogen without CSS is about equivalent to an efficient gasoline car. Liquid-based coal synfuel with or without CSS likely would look worse well-to-wheels. The carbon sequestration is not as efficient for Fischer-Tropsch liquid fuel coming from coal compared to hydrogen from coal gasification.
- In response to a question from Dr. Taylor, Dr. Ogden explained the sensitivity analysis done for oil costs. To calculate the fuel cost savings with hydrogen, the study used the AEO 2008 oil costs of $80 to $120 a barrel. A fairly complicated infrastructure model estimated the hydrogen cost. The sensitivity test looked at higher and lower oil prices and their impact on the buy-down costs. Higher prices did not really accelerate hydrogen, and there was only an impact with lower prices if oil dropped to $30 to $50 a barrel. She said that problem would be solved with a buy-down, not by putting a floor on gasoline prices. Mr. Friedman added that even if there was a floor, it would have to be very high because the majority of the cost for hydrogen is in the vehicle. A sensitivity analysis was performed on the cost of the fuel cell vehicle itself and on hydrogen costs.
- Dr. Lloyd questioned whether any of the cases show that hydrogen from nuclear would be cost effective. Dr. Ramage replied that hydrogen from nuclear is still in a research stage and was not included because costs could not be properly calculated. In addition, the NRC committee agreed that while direct water splitting with solar energy, either biologically or catalytically, could be cost effective in the long term, this method was also not considered in this study. The three hydrogen production scenarios on which the study focused were those for which the costs could be calculated.
- Dr. Lloyd commented that the NRC report seemed relatively optimistic compared to the CARB review and Zero Emission Vehicle report. Though Dr. Ramage reminded him that the study assumed a "best case scenario," Dr. Lloyd noted that some HTAC members are in a position to transfer this information to the appropriate people. Mr. Eggert added that the NRC study will help the CARB with its deliberations as it reformulates the program.
- Dr. Ramage reiterated that the big takeaway from the study is with a combination of biofuels, advanced non-plug-in ICE, and hydrogen, almost all oil can be removed from U.S. transportation usage. Eventually the U.S. transportation system must be replaced by one which does not emit CO_2 and which is not dependent on oil. To start this transition to a sustainable U.S. energy system, the government can put a relatively small amount of money toward support for hydrogen transportation. He said the study offers the ability for people to explain how hydrogen contributes over the long term, and not let it get short-sighted.

- Congressman Walker asked if he can say, based on the study, that for an average cost of less than $10 billion a year for public and private hydrogen investments between now and 2050, we can have 100 percent of the auto fleet be non-oil by 2050. Mr. Friedman said it cannot be stated exactly that way because, while the study assumes a break-even point at 2023, some policy supports may be required after this date to maintain the progress (we cannot assume that policy supports would immediately shut off at the break even point). Dr. Ramage advised saying that the study shows government spending of $55 billion over the 15 or so years will give this potential energy and transportation source a "maximum probability of happening by 2050 and reaching its full potential." Congressman Walker replied that $10 billion a year over a 40-year period is a much more manageable and attention-grabbing figure in the political realm, especially when the figure covers both public and private investment. Then, he said, you can begin to talk to the government about what specifically will be required in a certain time frame. Dr. Ramage said that statement risks implying that the government can spend just that figure and is guaranteed results. It is important that the government has a realistic view of the risk involved and understands the rewards aren't certain. He added that this is important for *any* alternative fuel technology—not just hydrogen. The ramp-up of ethanol production also has risks, and those need to be made clear. Dr. Ogden added that there are many assumptions going into the models that generate the numbers, so the message should perhaps be put it in context with other energy expenditures instead of an exact number.
- Responding to a question from Dr. Schmidt, Dr. Ogden said the main sources of hydrogen assumed in the study are coal with sequestration, some natural gas, and some biomass. Dr. Ramage added that the committee concluded the chicken-and-egg argument is no longer relevant and most hydrogen-producing technologies can be cost effective. In the early phases, small natural gas reforming appliances would be placed at filling stations. Past about two million vehicles, he said the study committee believes centralized production from coal gasification will be the viable larger source. The study committee, impressed with low-pressure biomass gasification systems, included those as well. Dr. Ogden elaborated that by 2050, about 25 percent would come from biomass gasification, about 40 percent from coal gasification, and 30 to 35 percent from natural gas distributed units. She said this distribution showed a fairly conservative infrastructure design. Dr. Shaw clarified that the committee did not discard nuclear electrolysis or high-temperature thermal decomposition of water as a potential for the future, but concluded they could not be included in the time frame of the cost analysis.
- Mr. Friedman commented that an NAS study is tricky because a scenario is picked to answer a question. The study does not represent the committee's prediction of the future fuel mix.
- In response to questions by Mr. Rose, Dr. Ogden answered that all of the study's cases are for light-duty vehicles, and that the $40 billion stimulates the purchase of about 5.5 million vehicles by covering the cost difference between the less expensive (conventional) and more expensive (hydrogen fuel cell) vehicle. She also clarified that achieving a "gasoline-free" fleet of cars by 2050 would be achieved by a portfolio of technologies that includes HFCVs and very efficient internal combustion engine vehicles or hybrids running on biofuels.
- Following requests for clarification, Dr. Ramage indicated that the report did not study past where the technology would be economically self-sustaining, but that government spending likely will need to continue beyond the time frame discussed, particularly in R&D and renewables development. Slide 17 shows total R&D spending for that time period in the U.S. alone. He added there may be discoveries or developments internationally and/or potential advances in manufacturing capabilities that decrease future costs. The study only examines U.S. budget numbers and does not consider international developments.

- Responding to a question from Mr. Eggert about how the estimate for the DOE RD&D budget (total of $5 billion) was derived, Dr. Ramage reminded the group that the figure is not a recommendation. He noted that the committee did not have access to out-year budget projections for the DOE. To get the $5 billion DOE investment number, the study took the 2008 budget, looked at how it had been increased over a period of time, and projecting forward, made adjustments where the committee estimated that there would likely be major ongoing efforts or reductions in efforts. In fuel cells, hydrogen storage, and coal gasification demonstrations, the budget numbers were increased somewhat over time; in other areas, like production technologies that meet cost goals, the budget was reduced or eliminated. He explained the $16 billion for RD&D shown in the report is the total *public and private* investment for both vehicles and fuel.
- Dr. Shaw brought up the European Union's Hyways report, which he said seemed to be consistent with this study in terms of CO_2 reduction and oil consumption. Dr. Bonhoff agreed and said that the German Hyways study builds upon the EU study. Dr. Ramage stated that a GM/Shell study was also consistent with the NAS study, and Dr. Ogden echoed that it is also consistent with the DOE scenario analysis performed by Oak Ridge National Laboratory and others.
- Mr. Chernoby noted that the NRC study estimates the industry cost for hydrogen infrastructure at about $400 billion. He asked what the NRC committee members assumed would motivate that investment? Would the vehicle policies drive the vehicles into the market place first? Dr. Ramage explained that the study assumes the $55 billion in government support would "push" the technology (vehicles and infrastructure) during the transition period, when the technologies are not cost-competitive with incumbent technologies. At the point where the hydrogen energy system becomes cost-competitive with the gasoline system, investors will enter the market without the need for government support, because they see an adequate rate of return and have the confidence that HFCVs represent a sustainable, durable market. Mr. Friedman and Dr. Ramage agreed that it will require more than government dollars to make the transition – it will require sustainable and durable policies, including carbon policy that sends a signal to the markets that this is the future. Mr. Chernoby echoed that the government support will have to have, in Mr. Ando's words, "passion and patience," and emphasized that support will need to be consistent across several Presidential administrations. Dr. Ramage added that one thing which impressed the NRC committee was the level of industry commitment to hydrogen and fuel cells (including from integrated oil companies and large automobile companies) and the amount of entrepreneurial money and venture capital that is going into hydrogen.
- Mr. Rose noted that an industry investment of $400 billion, while not trivial, is certainly manageable. He asked whether anyone could comment on the context for that level of investment over the next 15 years. He added that this investment will likely not be all new money, but a reallocation of investments. Dr. Ramage pointed out that there will a continuing need for investments in energy systems to support economic growth and maintain existing systems, but he finds it difficult to compare this future investment with what is spent today. Mr. Katsaros added that the oil and gas companies are spending $2 billion to $3 billion a year to build hydrogen plants for other applications, so getting to $400 billion over the next 15 years should not be a problem.
- Dr. Shaw summarized what he thinks are the important takeaways from the NRC report: 1) we probably cannot become oil-free and reduce CO_2 emissions without hydrogen; 2) the $55 billion government expenditure to make the technology cost competitive is not insurmountable by any government measure; and 3) the durability of government's commitment is vital to motivating industry investment, and while the cost is not large, it cannot be done in a piecemeal fashion.

- Congressman Walker observed that one message he gets from the report is that we ought to look at creating a $55 billion hydrogen trust fund as part of one of the highway bills that are in Congress now. This would take the funding out of year-to-year appropriations decisions and put it into a fund that would be available to provide the needed support over a period of time, with an established end date for the trust fund.
- Mr. Rose suggested that the HTAC write a letter to the Secretary of Energy that communicates three or four major points of the NRC report, and ask the Secretary to consider the study as part of the 2010 (and beyond) budget planning process. The HTAC agreed to this, and Mr. Rose took an action to draft a letter for review by the members.
- Dr. Ramage reminded the group to make clear when talking about the NRC report that this is a best possible case and not a projection of the future. He also emphasized that efforts have to start now to get the long-term benefits.
- HTAC members requested copies of the NRC report, and Ms. Epping Martin agreed to work with Dr. Ramage to get the draft report to the Committee in electronic and hard copy form.

2. *Elect New HTAC Chair and Vice Chair*

Chairman Lloyd explained that the current terms for HTAC Chair and Vice Chair (currently filled by Dr. Lloyd and Congressman Walker, respectively) are expiring. Ms. Epping Martin clarified that EPACT specifies two-year terms for the HTAC Chair and Vice Chair, and that members could be re-elected into those positions to serve consecutive terms. Dr. Lloyd asked for nominations for Chair and Vice Chair, which would be submitted to the Committee for a formal vote at the scheduled November 6-7 meeting. Dr. Lloyd described his experience as HTAC Chair, and explained that the position will "probably require more time" than he has been able to spend on it over the last two years, especially with all the upcoming activities. Due to constraints on his available time, Dr. Lloyd asked that his name be removed from nomination consideration. Dr. Lloyd also conveyed his opinion that it is important for either the Chair or Vice Chair to have a Washington, D.C. presence, so that he or she can attend meetings with the Secretary of Energy or members of Congress, as necessary.

Congressman Walker, on behalf of all the Committee members, thanked Dr. Lloyd for his service as HTAC Chair. He also thanked the members of the Committee for the support they have provided to him and Dr. Lloyd over the past two years. He seconded Dr. Lloyd's point on choosing someone for the HTAC leadership who has the ability to respond to requests for meetings at the Department of Energy or Capitol Hill.

Dr. Lloyd nominated Dr. Shaw, and asked if he would be willing to serve as either Vice Chair or Chair. Dr. Shaw responded that he would be happy to serve as Vice Chair, but would prefer not to serve as Chair (though would do so if elected). He explained that he would prefer the Chair to have more of a Washington presence, with a "higher level of political visibility."

Dr. Lloyd asked Dr. McCormick if he was interested in serving as Chair or Vice Chair. Dr. McCormick declined, stating his opinion that an energy or automotive company representative in an HTAC leadership position might cast doubt on the Committee's credibility. He noted that both Mr. Friedman and Mr. Rose have a Washington presence, or an understanding of the political system, and could serve the Committee well in either of the leadership positions. Mr. Friedman explained that he is mostly based in Florida now,

and is concerned that he would not have enough time to commit to the position of HTAC Chair or Vice Chair. Mr. Rose declared that he could best serve the Committee in a support role versus a leadership role. Dr. Lloyd asked Mr. Hofmeister if he would be interested in serving as either Chair or Vice Chair. Mr. Hofmeister responded that he is currently transitioning into a new job and would not have the time for this term, but would consider it in future terms if he is still on the Committee.

Dr. Richmond nominated Congressman Walker for either Chair or for a second term as Vice Chair. Congressman Walker agreed to place himself in consideration for either position.

Dr. Shaw nominated Mr. Jan van Dokkum as Committee Chair or Vice Chair. Dr. Lloyd took an action to follow up with Mr. van Dokkum to find out if he is willing to be placed into consideration for Committee Chair or Vice Chair.

Dr. Lloyd summarized the action items:

- Dr. Lloyd: check with Mr. van Dokkum on whether he is willing to be nominated for the position of HTAC Chair or Vice Chair.
- Dr. Lloyd: send all HTAC members the list of nominees (by August 1) and a request for additional nominations. Nominations received today include:
    - HTAC Chair: Dr. Shaw, Mr. van Dokkum (tentative), Congressman Walker
    - HTAC Vice Chair: Dr. Shaw, Mr. van Dokkum (tentative), Congressman Walker
- HTAC members: send any additional nominations for Chair and/or Vice Chair to Dr. Lloyd and Ms. Epping Martin by August 14, 2008.
- Ms. Epping Martin: organize a voting process for HTAC Chair and Vice Chair.

3. *Discussion of HTAC Calendar for Fiscal Year (FY) 2009*

The HTAC discussed the schedule of meetings for FY 2009. Ms. Epping Martin stated that the first meeting in FY 2009 has been scheduled for **November 6-7, 2008,** in Washington, DC. She had previously collected data on the HTAC members' calendars and suggested that the Committee try to come to consensus on the rest of the meeting schedule for FY 2009. She clarified that the HTAC charter calls for holding "approximately three meetings a year." Dr. Shaw requested that an HTAC meeting be scheduled for some time around the middle of February. He noted that if the Committee aims to publish its annual report by the end of the first quarter, a meeting in mid- or early-February should be held to review a draft. After some discussion, the Committee agreed to the following:

- Ms. Epping Martin will send a schedule of tentative dates out to HTAC members and ask members to respond with any conflicts.
    - **February 18-19, 2009** in Washington, D.C. (DC location will enable HTAC interaction with DOE transition team).
    - **Week of June 22, 2009** (or first week June as a back-up). Consider locating this meeting near facilities that the HTAC members could tour, such as the GM Fuel Cell Research Center (near Rochester, NY) and/or UTC Power (in South Windsor, CT), or the National Renewable Energy Laboratory (in Golden, CO).

4. *Open Discussion of Innovative Market Demand Strategies*

Congressman Walker opened the discussion with the topic of market strategies or technologies that would get people interested in investing in hydrogen and that would prime the pump for a hydrogen economy. He explained that he was inviting a discussion of "blue-sky" entrepreneurial ideas that would help the Department of Energy understand that there are valid ideas that may not fit exactly into current congressional mandates.

Congressman Walker clarified that the scope of the discussion should be broad, because the Department of Energy's ideas are often narrowed by the "checklist" of activities in the Congressional mandates. The HTAC intent is to help the Department understand there may be a much broader agenda that could be accomplished if they go outside of that narrow framework.

(1) Large diesel vehicles and APUs

Congressman Walker: There is a big problem at truck stops, particularly in the wintertime, with diesel trucks running all night long in order to keep the engines warm and the cabs heated. If you could replace those diesel engines with fuel cells, the fuel cells could both keep the engine warm so it could be started the next morning and at the same time provide the electricity for the trucks. You solve a pollution problem, and you end up with a process that puts hydrogen refueling capacity at every truck stop in the country, while providing an infrastructure that could be utilized well beyond the trucking industry. This strategy would require a reasonably minimal investment but would have practical applications going forward.

Mr. Rose: UC Davis did a substantial study on the truck APU marketplace.

Dr. Shaw: There are many ventures that have targeted the APU opportunity. This application almost certainly will end up being a solid-oxide system, not a PEM system, because truckers want to be able to use the fuel they have on board, and so everybody's targeting using diesel in the APU [fuel cell system] to reduce the consumption of diesel fuel. Truckers might be enticed by the noise reduction and fuel savings of using a 3–5 kW APU rather than a 12-cylinder engine all night. However, this scenario probably does not actually lead to a hydrogen infrastructure opportunity, because most of the truckers are going to want to use their existing fuel. Most would use reformers on board because SOFCs more or less self-reforms, or can be pre-reformed. Though he said he has not dismissed the idea of PEMs taking over that application in time, when he talks to the trucking industry, he hears "We've got diesel on board. That's what we're going to want to use. Please don't try to sell us an alternative fuel system for that."

Dr. Lloyd agreed, but warned that the PEM application should not be entirely written off because there is so much military work toward diesel reforming and getting hydrogen in some of those areas.

[Post meeting note: the DOE Hydrogen Program has had a small effort on fuel cell APU applications for several years.]

(2) Automobile dealers taking responsibility for hydrogen refueling capacity

Congressman Walker: The concept of automobile dealers taking responsibility for hydrogen refueling would offer a new investment strategy. An automobile dealer selling a hydrogen car would have to have

refueling capacity at the dealership anyway. Dealers could design the refueling station as a commercial enterprise that brings all brands of cars into the dealership. That strategy would serve as an incentive to dealers who are looking for ways to increase traffic into their dealerships, and so this strategy may generate investment at the front end of the hydrogen economy. If the energy industry sees this competition, it may have an incentive to invest in the infrastructure as well. Dr. McCormick noted that the automakers have discussed this idea, but the dealerships will face the same "chicken and egg dilemma" on the business case. Congressman Walker agreed that one of the key questions is how to get investment money flowing towards the build-out of hydrogen infrastructure in a way that actually then supports the fleet of automobiles.

Dr. Shaw: The National Academies' study looked at the gas stations at a dealership in the Los Angeles basin, just as an illustration of whether that was a feasible option. It is definitely feasible. On average, consumers are not further than two and one-half miles from the nearest dealership. Dealerships have more land area and the ability to professionally manage the stations. It's an entry point for the industrial gas companies, too, because then they can work with the dealers to put the stations in, own, operate, and sell the hydrogen at the station lot, and not have to be running head on into the major energy companies who may or may not want to place hydrogen at their particular sites.

Mr. Hofmeister: The major companies would likely have to pay for the up-front capital costs to install the stations, since independent dealers will not be interested nor, in most cases, be capitalized to pay these costs.

Dr. Lloyd: Is it still true that the retail gas operations make more on food and drink than they do on gasoline? In addition to coming in for fuel at a dealership, drivers will come in to look at new cars. Providing food and drinks will be an additional way to bring in more money.

Mr. Vesey: The real point is that the economic model at the service station is very tough. Even with today's prices, service stations are not making a lot of money, and they do not have investment capital to front the needed changes. A real potential difficulty in the future is going to be at the service station level. Major energy companies do not want to get involved because of the experience with traditional gasoline stations, and traditional stations do not have the capital to invest.

Dr. Shaw: Another argument for going to the dealer is that fuel cell vehicles, at least in the early days, will need some diagnostics. It is easy to envision a service station at a dealership that provides a simple plug-in diagnostic that could be performed at the same time as fueling to make sure everything is properly functioning.

(3) Material handling equipment as early market for fuel cell technology

Mr. Eggert: Material handling equipment, such as forklifts, are showing some promise and could potentially be an innovative market area, if combined with an infrastructure component to be able to provide the supporting infrastructure for mostly large-scale facilities that operate in material handling areas.

Dr. Shaw: Niche markets are not easy. Four or five companies have all struggled to try to get in the forklift market. Wal-Mart and the big box stores are not racing there for a variety of practical reasons: What about fueling? Is this really safe? Is this something we can count on for the future? The financial community is dealing with these kinds of issues in looking at business plans.

(4) Biogas fuel generation (generating both electricity and hydrogen as two viable commercial products)

Mr. Rose: One possibility with good promise is to cite a fuel cell and "put a spigot on it" and essentially have an opportunity to fill up a fuel cell vehicle but also make money selling electricity. This concept offers a power generation system with the ability to tap a stream of hydrogen off of it. A company is currently utilizing landfill gas, or biogas, not just to generate electricity but also to provide a fueling option in California. It is another way to make money while waiting for the hydrogen volume to build.

Dr. Ogden: Using biogas would be very useful in places like California, where a lot of feedstock is created from the agriculture industry, while providing a combination of power generation, heat generation, and hydrogen generation. It is a renewable resource, in a sense.

(5) Government consortium, trust fund, loan guarantee, or other funding concepts for hydrogen

Mr. Bawden: One suggestion is for the government to match every venture capital dollar that is invested in hydrogen. This strategy would take the risk off the table for the investors, especially if we can show a common roadmap we are investing towards. It might spur the investment needed in the outside markets quickly and lead to successful advancements in technology.

Dr. Shaw: It is difficult to raise money today for a hydrogen investment deal of any kind because the market was disappointed by promises made in the late nineties and even up into 2000. Many companies went public and are now bankrupt. Around $4 billion of venture money got invested in a number of small companies that have struggled mightily to get to market in a timely way. Those investing in high-risk opportunities want to see an exit in five to eight years, not 20 years. The National Academies' study said industry needs a clear, durable policy on the part of the government to push forward, or a consortium of major auto manufacturers and energy companies saying, "We're going to do this and stick with it." Without such a signal to the market, it is very hard to attract money. The market has put a high premium on solar companies, which has attracted more money to the market. Because no clear, large market opportunity in the fuel cell world exists, the venture community is saying, "I'll believe it when I see it." A trust-fund concept is needed, i.e., a 20-year contract similar to the feed-in tariff in Europe for photovoltaics. "That kind of commitment will attract capital into the marketplace in a flash."

Mr. Eggert: The concern and challenge associated with uncertainty is not unique to the venture capitalist or the business community. Politicians want to be fairly confident when they launch an initiative that they can deliver results. We are looking for where we can create policies that will survive political transitions and public scrutiny, and that will effectively support early deployment activities. Couching policies more in the context of performance might be useful—for example, a zero-emissions trust fund designated to support these types of activities.

Mr. Chernoby: Getting back to the very basics, it is critical to limit liability. This topic is not popular in Washington, but it needs to be off the shoulders of the people who are going to put the infrastructure in place and off the shoulders of the people who are going to put the hardware in place for a period of time. It is time to take the first draw down on the trust fund, and the draw down needs to make it cost neutral to put the infrastructure in place, and possibly offer a cost benefit for the people using the end product.

Mr. Friedman: Listening to the discussion, there seems to be some consensus regarding a need for some sort of a trust fund. The ideas require commitment and the necessary policies in place. It is about push. There are a lot of interesting niches where hydrogen could be introduced, but that requires a significant, sustainable, and durable commitment. One of the big opportunities for hydrogen and fuel cells may be at shipping ports, because of all the problems there, but the momentum there is not directed toward fuel cells. It would take some effort to steer ports in that direction because hydrogen was discredited somewhat by not meeting some of the early promises. It just gets back to the lesson that we need commitment.

Congressman Walker: The trust fund idea offers a long-term, sustainable policy, and there is "real money" there that can be spent. A zero-emission trust fund is a good idea, and it "fits with the political winds at the present time." For those in the political arena, this concept will resonate. It is a concrete idea that could be sold on Capitol Hill, and a number like $55 billion over 15 years is a manageable amount of money. However, we must also consider where the revenue should come from, since the revenue source for a trust fund will play a very important role in advancing this idea in a positive way.

Mr. Friedman: How do you get bipartisan agreement on a trust fund? Is it an energy independence trust fund? It will be difficult to package it when you need acceptance from multiple sides of the aisle. The politics is typically the sticking point. Is there an innovative revenue source?

Mr. Eggert: A modest carbon tax and/or a "climate user's fee" could be established to fund the trust. Congressman Walker replied that carbon taxes will generate political controversy, but the idea has potential.

Congressman Walker: Funding trust funds out of gasoline taxes at the present time is problematic. Highway usage fees are also a possibility, but that requires the technologies to make it real. So far, Congress has not been willing to invest even in the technologies for air traffic.

Mr. Friedman: The idea of user fees is gaining a lot of interest, especially in the environmental community.

Congressman Walker: It would be advantageous to get away from the tax argument with a revenue stream that makes sense to both sides of the aisle.

Dr. Ogden: A gas-guzzler tax or "fee-bate" (without the rebate) would be one way to fund a trust. Congressman Walker responded that the revenue numbers from such a tax would need to be analyzed. CAFE and other vehicle standards would negatively impact any type of gas-guzzler tax.

Mr. Rose: He asked the group if anyone had input on low-interest loan guarantees. Assistant Secretary Karsner at DOE has been enthusiastic about this initiative, and the fuel cell industry is hard-pressed to come up with creative ideas about how loan guarantees might help deploy units or support manufacturing infrastructure. Proposals are due out at the end of the year for $10 billion in loan guarantees.

Mr. Bawden: In the past, loan guarantees have been based on revenue. The fuel cell industry is not making the revenues necessary to pay the loan back. Dr. Shaw agreed, noting that many small start-ups in hydrogen are selling products to other markets to make money, since the market for hydrogen is not yet there.

Mr. Chernoby: When the word "guarantee" is used, it creates very little interest and little traction. The industry needs to think about the word and what it means. If it is not "guaranteed," but rather "low interest," it may offer more enticement.

Dr. Shaw: The example of the Rural Electrification Administration (REA) offers another model for how government can give incentives while getting paid back. The government provided low-cost loans to utilities willing to put in the expensive power lines to power farms, and the return on investment was positive. The REA went to a few farmers first, not all at once. The government incurred a start-up cost, but the numbers came out positively in the end. For fuel cell vehicles, the government could set an interest rate on a buy-down loan to consumers such that the purchase of a hydrogen vehicle would end up producing the same monthly cost to them over a reasonably extended period of time. The interest rate would be low, and the government would be paid back out of the principal and interest payments, which would serve as a regular car payment for the consumer.

Mr. Rose: The next highway policy will be debated at the beginning of 2009, and is typically a minimum of $400 billion for five and a half years. The big fight is who gets how much of the trust fund, but the policy will include revenue to finance things like we have proposed, if hydrogen has a persuasive policy and political case. An "Energy Freedom Trust" might be a possibility.

Dr. Ogden: A longer term payback period for loans might be attractive. Going beyond 2015, a few thousand or tens of thousands of vehicles a year are needed to make the market take off. There is going to have to be consensus within the auto industry that it is doable and attractive. At that point, government could go from putting hundreds of millions of dollars in the first few years to putting in billions, but with the understanding that once this becomes a money-making business ten years further down the line, the government will be paid back at some rate over time.

Congressman Walker: Is there a way that loan guarantees could go to places like GMAC to help support leases on fuel-cell cars? Then GM would be in a position of leasing the car to someone at an affordable cost, but a loan guarantee would go into the actual financing mechanism that would underwrite a lease. Honda, with the Clarity, is actually leasing the cars, but they are taking a huge hit on the actual cost of the car. Is there a way to utilize a loan guarantee program inside the financing mechanism to get the same kind of activity?

Mr. Rose: This proposal is reasonable, but the DOE loan guarantee program parameters would have to be examined. The loans also would also need to be approved by the next administration.

Dr. Shaw: The loan guarantees are project-oriented loans, which means that someone who wants to finance a project comes to the government with a power purchase agreement or an agreement to take a certain amount of ethanol, so there is a known revenue stream out of the back end of the project. For the project investors, the advantage is that they can get the financing from the debt market instead of raising expensive equity. If the project is higher risk than the normal project, such as the first one of that kind, the government basically stands behind commercial debt in the same way the International Monetary Fund stands behind international loans to projects. While he has tried to figure out how to use that model in the hydrogen business, the only idea he considers viable are loans to customers to buy down cars.

Mr. Bawden: Cars are a depreciating asset, so it is harder to get a loan against that versus a project that has defined revenue with projections.

Dr. Shaw: There are loans against cars and houses, and that difficulty could be solved with a 15-year loan against a hydrogen car. If someone sells the car, they have paid the loan during the course of the time and are transferring the loan to the next buyer. The stream of the loan continues across whatever time period is required to buy down the cost of the vehicle.

Mr. Rose: Such a scenario assumes that the vehicle will have residual value sufficient to cover the loan amount when it is sold.

Dr. Ogden: Analysis shows that once the price of the fuel cell car gets within a few thousand dollars of a gasoline car, the consumer starts to come out ahead, because the fuel price per mile is lower with hydrogen than it is with gasoline. There has to be a way to involve the fuel providers; they should be making money on this sooner than the car manufacturers, because they will get to the point where hydrogen will break even at the pump.

Mr. Chernoby doesn't think the gas tax should be mentally written off. If the markets get the sense that things are serious, then that additional gas tax would not be seen at the pump. Other financial factors might drive costs down in parallel. How do we show we're serious, and what are the near-term implications if we do?

Dr. Taylor: In January, over a year earlier, less gasoline was sold in California, but more tax was collected. There should be a gas-guzzler tax, because there is more money coming in on taxes, even while gasoline use is going down. The money is there – it's about how it is allocated.

(6) Auto companies put vehicles on the road

Dr. Shaw: What will also attract capital into the marketplace is if major auto manufacturers put vehicles on the road and people start demanding them, much as they did with the hybrids. It was a really interesting experiment that Toyota did, and other companies followed quickly.

Dr. McCormick: Once you get the economies of scale driven by the automotive companies (10,000 cars or 100,000 cars on the road), usage of fuel cell components will be enough to make all the niche markets for fuel cells work. Usage of membranes, materials, and catalysts will be enough to support the suppliers' manufacturing processes. None of the niche markets will drive this kind of volume [alone]. The key is getting into place some durable polices, like a hydrogen trust fund, so we know the business can work. Once the supply base is driven, everything else will happen at top speed.

(7) Zero-emission trucking and "mode shifting"

Dr. McCormick: One thing happening today is mode shifting. Truck cargo is more often being put on the back of trains for transportation to local distribution centers. There the drivers switch from cents per mile to dollar per hour, so there is the opportunity to switch cabs. Distribution is headed pretty clearly back to locomotive. If we mode shift the tractor side of that equation to a zero-emission vehicle, which is very clean and quiet in high-density population areas, those positive attributes drive scale. What this business needs more than anything is scale, because the manufacturing process and supply base is there.

Dr. Ogden: Zero-emission movement of goods leverages other things we want to do, in this case air quality and environmental justice around ports and in large cities in California and other places.

Mr. Eggert: Looking at ports and railroad terminals as early markets is a very good idea. These facilities are already under severe pressure to reduce criteria pollutants and are moving toward electrification and idling restrictions, so the regulatory pressure is there. It is a matter of getting the solutions in a form that can actually be delivered to the customer.

(8) Hydrogen as a home-heating alternative

Mr. Hofmeister: Home heating is a struggle for those who are not connected to natural gas. Plus, heating oil comes from the infamous "middle of the [oil] barrel," the scarcest part of the petroleum supply chain. If there were the right incentives, rules, and regulations, this area could be of great interest, particularly for those who have some means to invest in a new type of power plant in their home or in office settings.

Mr. Chernoby: Replacing heating oil is a great idea, especially given the prices that people are paying across the country.

Mr. Hofmeister: Petroleum refineries have a surplus of gasoline, that is likely to continue in the future, because the refining system of the U.S. is geared for gasoline, but the demand for gasoline is going down [relative to middle of the barrel products, by design (due to increased fuel economy and use of biofuels).

Mr. Chernoby agreed and said that is why the focus should go to those using heating oil. From a heating perspective, customers will have a clear motivation if the equipment is not only installed for them, but costs them less to operate. The industry needs to start thinking about a combination of both stationary and transportation applications to get the scale needed. City, state, and Federal government need to get together and combine efforts to develop standards.

Dr. Shaw: The financial community in the U.S. is not very excited about the home heating market. Plug Power started there in partnership with General Electric (GE), putting 7-kW units in homes. GE "ran for the hills" very quickly. Plug Power is now focused on other applications like backup power at cell phone sites, and even there they struggle to get units out. It will be difficult to get hydrogen to the places in the U.S. where heating oil is used. Customers will need converters or a cost-effective way to get small quantities of hydrogen for a home fuel cell device, but that is expensive. Cheap hydrogen is needed to make the home heating option really work. In Japan, the companies are pouring money into subsidies to try to create an entry market.

Mr. Rose: The government is also subsidizing home heating in Japan. Most homes have two boxes—a fuel cell and a reformer running on natural gas, propane, or another hydrocarbon. It is very innovative.

(9) Build up locally and expand

Mr. Chernoby: The DOE scenario analysis study conclusion is solid – we need to start locally, by building markets as large as possible in concentrated urban areas and then start expanding regionally from there. This strategy will create the ability to drive demand and make the business case for getting the infrastructure there.

(10) Interim markets

Dr. Shaw: Venture companies have financed a lot of companies to build their business in markets that have little to do with the topics in this discussion. The sales of Proton Energy Systems, a manufacturer of PEM electrolysis systems, are driven by generator cooling in the electric utility industry and by small applications like filling weather balloons. H2Gen Innovations produces small steam methane reformers and is selling those units to industrial gas companies who sell merchant hydrogen. The industrial gas companies put these reformers at some of their customer locations instead of having to deliver the hydrogen by truck. These interim markets create an opportunity today, and many of these companies are looking at these markets. In the portable power market, there are companies on the verge of putting small methanol or straight hydrogen fuel cells into cell phones and PDAs. The International Civil Aviation Organization (ICAO) has recently approved carrying these products in the passenger cabin of aircraft. These applications are going to get people to say, "My cell phone runs on hydrogen. Why should I be worried about it in my car?"

5. *Public Comment Period*

Ms. Epping Martin reported that no one from the public had pre-registered to make public comments before the Committee. Dr. Lloyd opened the floor for public comments. Hearing none, this session was adjourned.

6. *Other Business and Closing Comments*

The Committee discussed a variety of miscellaneous topics and actions, as summarized below.

- It was agreed that future HTAC meetings would include the Public Comment period as one of the first agenda items on the second day of the meeting.
- The Committee moved to approve the meeting minutes of the May 13-14, 2008, HTAC meeting, subject to clarification of a statement made by Dr. Schmidt about the CARB goal.
- Dr. Satyapal informed the Committee that the DOE is working through a joint IPHE/IEA effort to compare hydrogen and fuel cell scenario analyses being conducted in the European Union (especially the HyWays project) with scenario analyses developed in the United States (including H2A, GREET, etc.). The results of this analysis should be available soon, and the DOE could make a presentation on this topic at the next HTAC meeting if desired by the Committee.
- Dr. Satyapal also informed the Committee that Ms. Epping Martin, who has been serving as the Designated Federal Officer (DFO) for the HTAC, will be rotated out of this position. Pending appointment by the Secretary, Mr. Michael Mills will take over the role of DFO for HTAC. Mr. Mills has been involved with the IPHE Secretariat for five years, and will be returning to DOE shortly after a one-year detail to the White House.
- Dr. Satyapal announced that the hydrogen fuel cell-powered Chevrolet Equinox (currently part of the DOE vehicle fleet) was being brought to the hotel for HTAC members to test drive after the meeting. Dr. McCormick agreed with a comment by Mr. Rose, noting that the presence of a "regular" Owner's Manual for the vehicle was indeed a sign of progress, but also an example of how much must be invested to put even a hundred vehicles on the road. He pointed to the large amount of time and effort that goes into creating the manual, including all the safety certifications and legal approvals that

are required. He noted that part of GM's Project Driveway effort has been educating first responders on how to deal with hydrogen, and that about 7,000 first responders have been trained at GM's Washington and New York centers.

- Dr. Shaw suggested that DOE and HTAC need to develop and implement a formal orientation and introduction process for newly appointed HTAC members and a process for recognizing members who are departing the Committee. He and others offered several suggestions, including 1) providing sitting Committee members with detailed resumes of new appointees (if possible, in advance of their appearance at HTAC meetings); 2) providing new appointees with past meeting minutes, bios of sitting members, and a future HTAC meeting schedule; 3) providing an "orientation process" for new members, to include a conference call with the HTAC Chair and Vice Chair. Ms. Epping Martin apologized for the lack of notice and preparation for the recent new HTAC appointees, which she attributed to the fact that the new members had only been formally appointed by the Secretary a couple of days before the July 22-23 meeting. She explained that the first appointments to the HTAC were made in June of 2006. The HTAC Charter specifies that terms can be either one, two or three years, so each year the terms of some Committee members will expire. She expressed her hope that, in the future, new appointments would be made further in advance of HTAC meeting dates.
- Mr. Rose urged the Committee to think about "how we take advantage of the opportunities that we have in the short term to comment on the DOE budget in development, to comment on Congressional decision-making, and to put our thinking in front of [the DOE management] as they develop their transition plan. He stressed that this kind of input, if it is to be provided, must be developed in the next few months.

7. *Adjourn*

The July 22-23, 2008 HTAC meeting was adjourned at 12:24 p.m.

EIGHTH MEETING OF THE

HYDROGEN AND FUEL CELL TECHNICAL ADVISORY COMMITTEE (HTAC)

PARTICIPANT LIST

JULY 22-23, 2008

HTAC Members Present:

- Larry Bawden
- Mark Chernoby
- Anthony Eggert
- David Friedman
- Janice Hicks
- John Hofmeister
- Arthur Katsaros
- Alan Lloyd
- Byron McCormick
- James Narva
- Joan Ogden
- Michael Ramage
- Geraldine Richmond
- Robert Rose
- Gerhard Schmidt
- Robert Shaw
- Kathy Taylor
- Jan van Dokkum
- Greg Vesey –
- Robert Walker

HTAC Members Not Present:

- John Bresland
- Maurice Kaya
- Frank Novachek
- Philip Ross
- Kenneth Shultz
- John Wootten

U.S. Department of Energy Staff

Office of Energy Efficiency and Renewable Energy

- Steven Chalk
- Kathi Epping-Martin
- John Garbak
- Monterey Gardiner
- Nancy Garland
- Roxanne Garland
- Fred Joseck
- Mike Mills
- Grace Ordaz
- Terry Payne
- Carole Read
- Antonio Ruiz
- Sunita Satyapal
- Ned Stetson

Office of Fossil Energy

- Lowell Miller
- Wayne Surdoval

Office of Nuclear Energy

- Carl Sink

Office of Science

- John Vetrano

U.S. Department of Transportation Staff

- Sean Ricketson
- Martin Koubek

Invited Speakers:

- Haruhiko Ando – Japan Cabinet Office
- Klaus Bonhoff – Germany National Organization for Hydrogen and Fuel Cell Technology
- George Hansen – General Motors

Members of the Public in Attendance

- Joe Badin – U.S. Department of Agriculture
- Ted Biess – National Aeronautics and Space Administration
- Geoff Bromaghim – National Hydrogen Association
- Katherine Cotton – Japan Automobile Standards Internationalization Center
- Kristin Deason – Sentech, Inc.

- Leo Grassilli – U.S. Navy
- Karl Jonietz – Los Alamos National Laboratory
- Eric Mollen – Neal R. Gross & Co.
- Mark Ruth – National Renewable Energy Laboratory
- Tom Sheahen – National Renewable Energy Laboratory
- Brendan Smith – Sentech, Inc.
- Neil Snyder – National Renewable Energy Laboratory
- Ken Stroh – Sentech, Inc.
- Thomas Timbario – Alliance Technical Services, Inc.
- Linda Wennerberg – National Aeronautics and Space Administration

Support Staff

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- Kevin McMurphy – Sentech, Inc.
- Shawna McQueen – Energetics Incorporated