

MINUTES OF MEETING OF HYDROGEN AND FUEL CELL TECHNICAL ADVISORY COMMITTEE

October 2-3, 2006

Arlington, VA (Crystal Gateway Marriot)

October 2, Morning Session

The meeting was called to order around 11:00 a.m. EDT by JoAnn Milliken, Acting Program Manager and Chief Engineer of the Department of Energy Hydrogen Program. Dr. Milliken introduced herself and Kathi Epping, the Designated Federal Officer for the Hydrogen and Fuel Cell Technical Advisory Committee (HTAC), established by Section 807 of the Energy Policy Act of 2005 (EPAcT). Ms. Epping is a technology development manager on the fuel cell team of the DOE Hydrogen Program.

Introductions and Review of Agenda

The members of HTAC introduced themselves. Twenty-three of the 25 HTAC members were present (list attached); members Mr. Gregory Vesey and Mr. John Hofmeister were not in attendance. Members of the public in the audience also introduced themselves (list attached). Dr. Milliken identified the four offices of DOE involved in the Hydrogen Program: Energy Efficiency and Renewable Energy (EERE), Fossil Energy (FE), Nuclear Energy (NE), and Science (SC). (List of government attendees attached). Ms. Epping reviewed the agenda of the meeting.

Review of Charter

Ms. Epping described the purpose and structure of HTAC and the deliverables that are expected from the committee over the next 20 years. HTAC is charged by EPAcT Section 807 with:

- reviewing and making recommendations on the DOE programs and activities in Title VIII of EPAcT;
- making findings and recommendations regarding the safety, economic, and environmental consequences of production, delivery, storage, and use of hydrogen and fuel cells;
- reviewing and commenting on the Hydrogen Posture Plan required by Section 804 of EPAcT.

HTAC will provide recommendations to the Secretary of Energy, who must consider the recommendations. The Secretary is required to transmit biennial reports to Congress describing recommendations made by HTAC and DOE's response along with the Budget submission. The report will describe how the Secretary is implementing HTAC recommendations or an explanation of the reasons any recommendations will not be

implemented. Many people with excellent credentials were nominated to become HTAC members, and after a rigorous selection process, the Secretary appointed 25 members (the maximum statutory limit) with terms of one, two, or three years, with opportunity for renewal. The Department of Energy is the agency responsible for providing the necessary support for HTAC. Ms. Epping pointed out that HTAC could establish subcommittees to look in depth into specific areas covered by the Act and propose recommendations to the full Committee. Such subcommittees could include non-HTAC members, like nominees who volunteered to work on HTAC but were not selected to be members of the full Committee. She anticipated that HTAC would meet about twice yearly but could do so more frequently than that.

Responding to questions from HTAC members, Dr. Milliken stated that HTAC is very important to the Department of Energy and the Secretary. Ms. Epping agreed to investigate whether subcommittee members would be reimbursed for travel expenses. [Note: Travel expenses of HTAC members and non-HTAC members of subcommittees are reimbursed by DOE.]

Presentation on Former Committee, Hydrogen Technical Advisory Panel, by Alan Lloyd, former member

Dr. Alan Lloyd, of the International Council on Clean Transportation, one of the former Chairs of the HTAC predecessor body – the Hydrogen Technical Advisory Panel (HTAP) – gave a slide presentation on the experience of HTAP. Dr. Lloyd expressed encouragement that HTAC’s work would encompass both hydrogen and fuel cell activities, as HTAP focused only on hydrogen activities. He stated he’s also encouraged that the current visibility of the Hydrogen Program, with the President’s support, has attracted high-caliber individuals to serve on HTAC. He said that HTAP had helped the DOE Hydrogen Program increase its visibility and achieve a balanced research, development, and demonstration portfolio. During the life of HTAP (1992-2003), hydrogen funding increased nearly a hundredfold from \$0.5 million to \$45 million. (Dr. Milliken pointed out that the earlier numbers did not include fuel cell research, which had a similar level of funding.) The funding for programs HTAC will review is four times greater than the funding for programs reviewed by HTAP. Dr. Lloyd showed a list of the members of HTAP and a timeline of HTAP activities, including subcommittees formed under each of the committee chairs, achievements and deliverables. He enumerated the visions of HTAP and described some of the deliverables of the committee and recommendations that were made. He pointed out that DOE acted to implement a majority of the recommendations made by HTAP. Prior to 2003, DOE’s focus was on-board reforming of gasoline and other liquid fuels (e.g., methanol or ethanol) to produce hydrogen. The thinking was that this approach would accelerate the commercialization of fuel cell vehicles (which would use the fuel more efficiently) by enabling use of the existing liquid fuel infrastructure. A major recommendation made by HTAP in 1999 was that DOE should de-emphasize on-board reforming research in favor of direct hydrogen in transportation applications. In 2003, DOE established an independent panel to assess on-board reforming technology; and in 2004, that panel recommended the

discontinuation of R&D in that area. Subsequently, DOE dropped work on on-board reforming.

Dr. Lloyd also shared some perspectives he had gained from his HTAP experience: 1) Demonstration programs for sub-optimal vehicles are of limited value. 2) Putting more of U.S. energy supply in distributed systems would make the nation less vulnerable to the disruptions of recent years. 3) As the program becomes more visible, earmarks become more of a problem. 4) Subcommittees were very important to getting the work done because not much could be accomplished by the main committee alone, especially with meetings only twice a year. One concern expressed by Dr. Lloyd is that the demarcation of responsibilities between HTAC and the National Academy of Sciences (NAS) under Section 811 is not clear.

Dr. Robert Shaw, of Aretê Corporation, asked Dr. Lloyd to summarize what had worked with HTAP and what hadn't. Dr. Lloyd said that a major frustration was in getting access to the right level decision makers at DOE, pointing out that with President Bush's emphasis on hydrogen, this may no longer be an issue. He emphasized the importance of developing an understanding of and relationship with the DOE Hydrogen Program, as well as knowledge of competition and relevant activities in the private sector and academia.

The Honorable Robert Walker, of Wexler & Walker Public Policy Associates, asked how often HTAP's leaders had testified before Congress. Dr. Lloyd opined, "not often enough," suggesting that it had been 2-3 times per year. Mr. Walker suggested that HTAC provide the Congressional committees a "roadmap" of HTAC activities.

Professor Mildred Dresselhaus, of Massachusetts Institute of Technology, asked why HTAP ended. Dr. Milliken and Mr. Walker replied that as a result of the increased emphasis on hydrogen in the Administration and in the energy bill that was being developed by Congress, both Congress and DOE felt it was necessary to revamp and expand the advisory committee to include a greater diversity of perspectives.

Dr. Mike Ramage, formerly of ExxonMobil Research & Engineering, who chaired the NAS committee that reviewed the DOE Hydrogen Program, stated that if HTAC could address the earmark problem that might be the single most important thing HTAC could do. He also stated that hydrogen in the power sector should be addressed since the NAS committee did not have the time/scope to do so. The NAS committee had focused on transportation.

October 2, Afternoon Session

Presentation of EPACT 2005 HTAC Deliverables and Timeline

Ms. Epping gave a presentation elaborating on Title VIII of EPAct 2005 and HTAC. She showed the pertinent sections of the Act, focusing on Section 807 that creates the Committee and describes its purpose, membership and system for chair election among

committee members, duties and deliverables. She outlined the other sections in Title VIII, including the Section 804 plan (also known as the DOE Posture Plan), the DOE hydrogen programs under Section 805, and the DOE reports required by Section 811. She also presented a matrix of EAct activities and deadlines that relate to the DOE Hydrogen Program (including those outside Title VIII). There were a number of questions regarding the subject matter, which gave rise to discussion.

Mr. Walker asked which budget request HTAC's initial recommendations would impact. It was indicated that DOE is pretty far along in its development of the FY 2008 Budget Request, and that realistically, following a normal process for getting HTAC organized and functioning, the earliest budget request the Committee could affect would be FY 2009. Based on that timeline, the Secretary's first biennial report to Congress would be in February 2008 (accompanying the 2009 Budget Request), requiring HTAC to submit their initial recommendations at least six months before that so that the report can go through the formal DOE approval process. Mr. Wooten suggested that the HTAC recommendations would need to be submitted by June/July of 2007 if they are required to go through Office of Management and Budget (OMB) review along with the budget. Mr. Walker pointed out that the FY 2009 budget will be implemented by a new Administration; thus, if recommendations are not made until that time, they may not take advantage of the momentum for hydrogen established by the current Administration. Dr. Lloyd pointed out that the terms for some of the members of the committee will expire in one year and that their contributions might be maximized by providing recommendations during their term. Some members expressed a sense of urgency in taking action to have earlier impacts, possibly to include one or two recommendations to be made within the next few weeks (discussed again, later in meeting), which would then be considered in planning the FY 2008 budget. The suggestion was made to hold three meetings rather than two during the first year.

Dr. Shaw asked for some explanation and discussion of HTAC's mandate in the context of the breadth of EAct Title VIII, as enumerated in Sec. 802, using the example of purpose: "(5) to create, strengthen, and protect a sustainable national energy economy." He noted that Title VIII goes beyond what government R&D programs could be expected to accomplish, noting that this raises the question of just what level of recommendations HTAC should consider making. He noted that he would prefer to avoid program evaluation at the working level. Dr. Milliken responded that there was a separate DOE process of detailed technical peer review, and that any program evaluation undertaken by HTAC could be high-level in nature. She cited Under Secretary Garman's statement during his lunchtime remarks to the group that HTAC should set its own boundaries.

There was also discussion of the importance of the U.S. taking the lead in hydrogen technology so as to avoid erosion of the overall U.S. competitive position. Dr. Roger Saillant, of Plug Power, commented that fifty years hence we could be importing technologies rather than oil. He opined that recommendations should span short-, medium- and long-term horizons. Dr. Lloyd and Dr. Milliken noted that DOE recently commissioned a study on the impact of the hydrogen economy on job creation, the report on which is due to Congress in February 2007.

Mr. Walker stated that a bipartisan political consensus is emerging as to the need for the U.S. to achieve energy security, suggesting that the issue of energy security should play a role in the deliberations of HTAC.

Questions were raised as to whether HTAC's scope was limited to transportation applications of hydrogen, as indicated by numerous references to light-duty vehicles and heavy-duty vehicles in EPCA, and whether transportation applications considered under Title VIII include aircraft and other non-road vehicles. DOE representatives confirmed that HTAC has the authority to cover aviation, portable, and stationary applications, which are also part of the statute, if desired.

Larry Bawden, of Jadoo Power Systems, noted that to promote achievement of the statutory purposes, HTAC would have to address more than just DOE programs, noting problems of codes, regulations, and lack of knowledge or consistency in government agencies and regulatory bodies. Dr. Shaw pointed out that international bodies also need to be considered. Mr. Bawden stated that such problems effectively prevent the sale of portable fuel cells, citing Fire Marshal problems and the Department of Transportation prohibition against carrying these hydrogen-powered devices aboard aircraft. Even if the broad goals in the statute were met, it might still be impossible to sell fuel cells. Mr. Rand Napoli, of the Florida State Fire Marshal's office, agreed, pointing to a need for a unified program to educate the public, code drafters and enforcers, first responders, and others about hydrogen production and use.

Dr. Ramage pointed out the breadth of federal programs related to hydrogen, including related programs going on in the Department of Defense, and suggested that it would be a challenge for HTAC to collect information on all that is being done. Dr. Milliken suggested that the DOE-led Interagency Task Force, i.e., the Interagency Working Group formed in 2003, shortly after the President announced his Hydrogen Fuel Initiative, could help provide information on the activities of various agencies. Dr. Shaw stated that the members of HTAC may collectively have a better grasp of what is going on in those sectors than any other entity.

The question was raised as to the role of the HTAC in addressing hydrogen safety, codes and standards. Dr. Milliken pointed out that Section 806, which authorized work toward uniform hydrogen codes, standards, and safety protocols, referred to the Interagency Task Force, but stated that HTAC could also make recommendations in this area. This led to a discussion of the Interagency Task Force and the roles of and relationship between HTAC and the task force.

Dr. Saillant questioned the extent to which the activities of different agencies and advisory committees would be integrated together and what entity would have ultimate authority to mesh them into a logical sequence, or to prioritize the recommendations from the various committees and DOE reports. Dr. Shaw pointed out that other agencies such as the Department of Defense have their own programs and priorities for hydrogen work as it relates to the missions of those agencies. Dr. Milliken suggested that there is no

single overarching national hydrogen agenda, but the Interagency Task Force as well as the White House Office of Science and Technology Policy (OSTP) and other entities play a role in integrating activities. Mr. John Wooten, of Peabody Energy, pointed out that under Section 807 language, HTAC has purview over all Title VIII programs, not merely DOE or transportation programs. Dr. Uma Chowdhry, of DuPont Central Research & Development, pointed out that Under Secretary Garman has requested that HTAC make recommendations regarding policy, reaffirming that this Committee's work could extend to programs by other agencies.

The discussion then proceeded to Sections 782 and 783, which authorize DOE to promote acquisitions of fuel cells and vehicles by other agencies while sharing the difference in costs (assuming that appropriations are made). It calls for the involvement of both the Interagency Task Force and HTAC in deciding whether and how to do this. Dr. Milliken confirmed that HTAC has purview over all of Title VIII, which includes activities of other agencies, and stated that getting interagency response takes time. Thus, any such recommendations of this Committee involving the activities of multiple agencies should be made with adequate lead time.

Overview of the DOE Hydrogen Program

Dr. Milliken gave a presentation on the DOE Hydrogen Program, including a summary of DOE's technical and cost goals for transportation, pointing out that the goals were established in collaboration with industry through the FreedomCAR and Fuel Partnership:

- Hydrogen Storage: Range > 300 miles
- Fuel Cell System Cost: \$30/kilowatt (kW) (though even \$50/kW might be competitive)
- Durability: 5000 hours (approx. 150,000 miles)
- Hydrogen Cost (independent of production pathway): \$2-\$3/gasoline gallon equivalent (gge)

Questions were raised as to whether the \$2-\$3 hydrogen cost included profit. Dr. Milliken, Ms. Epping and Dr. Sigmund Gronich (the leader of the Technology Validation element of the DOE Hydrogen Program, who was in the audience) answered that they believed no profit to be included but would check and report back. [Note: The cost goal includes a 10% return on investment.]

Specific program activities were described, and the DOE technology development managers present were introduced. The history of the budget for the Hydrogen Program was shown, along with how it is divided among offices and key activities, and how the funding is distributed among universities, national labs, and industry.

Dr. Milliken pointed out that the program's goal is to enable hydrogen production from a variety of diverse domestic resources including fossil resources (distributed natural gas in the near-term, centralized coal with carbon sequestration); renewables (biomass,

wind/geothermal-based electrolysis); and nuclear, photoelectrochemical, and biological in the longer term. Mr. Walker initiated a discussion of the interface between government-funded hydrogen programs and the existing “hydrogen economy.” He asked to what extent the existing infrastructure could be used to get commercialization off the ground. Dr. Milliken stated that current H₂ production is nine million tons, or enough to fuel 34 million fuel cell vehicles. About 700 miles of pipelines exist, mostly around refineries. That infrastructure would have to be expanded to support a nascent hydrogen economy. Dr. Shaw asked whether the nine million tons included hydrogen that was produced within a facility exclusively for use in the operation of the facility. Mr. Katsaros, of Air Products and Chemicals, Inc., offered to find out how much of the nine million tons of hydrogen was “outside the gate,” or used outside of the facility where it was produced, and he said he would report back to the Committee.

Dr. Shaw asked how extensively the DOE interfaces with the private sector and the international hydrogen community. Dr. Milliken cited the FreedomCAR and Fuel Partnership, a formal partnership that includes DOE, USCAR, and five major energy companies. She also cited the International Energy Agency and the International Partnership for the Hydrogen Economy. Dr. Gronich discussed some of the interactions that have taken place between the DOE and private sector hydrogen producers through DOE’s technology validation efforts.

Mr. Walker stated that government programs seem to be waiting for technology to be perfect before putting it to use, while there are many existing applications that fuel cells could serve. Professor Geraldine Richmond, of the University of Oregon, pointed out that the R&D is needed so that the hydrogen economy will not be dependent on hydrocarbon-based fuels.

Dr. Milliken continued with the presentation, reviewing historical progress, status of technology development and validation, milestones reached, and milestones being pursued. Some of the milestones have slipped due to funding shortfalls and earmarks. She discussed five technology areas on which the program’s applied research is focused: hydrogen production, hydrogen delivery, on-board hydrogen storage, automotive fuel cells, and technology validation. She also identified the priorities of DOE’s basic research program, which solicited new projects in FY 2005 on novel materials for hydrogen storage; membranes for separation, purification, and ion transport; design of catalysts at the nanoscale; solar hydrogen production; and bio-inspired materials and processes. About 20% of the total program funding is earmarked, mostly in the EERE program. Most of the earmarks address hydrogen technologies, but fuel cell earmarks are increasing.

Hydrogen delivery costs are currently estimated at \$2/gge by pipeline and \$3.50/gge by other means. The target is to get those costs down to \$1/gge, probably by pipeline. The theoretical limits of storage by liquid and compressed hydrogen are being approached, showing a clear need to move to materials-based storage. Since 2002, R&D progress has brought the estimated costs of fuel cells, based on projected high-volume production, down to \$110/kW from \$275/kW.

Dr. Milliken briefly described some of the safety, codes and standards programs underway, including web-based first responder training, a best practices manual, and research on hydrogen behavior to facilitate development of codes and standards. These activities are coordinated with the Department of Transportation.

Dr. Milliken also described how DOE was doing systems analysis, including well-to-wheels analysis, pathway analysis, and scenario analyses. DOE has examined an NAS-proposed scenario as well as more conservative ones, and compared those to hybrid penetration rates in the marketplace. Dr. Milliken stated that hydrogen quality – the purity of the H₂ delivered to the fuel cell from production/delivery/storage – is an important cross-cutting issue in the Program.

Mr. Mark Chernoby, of DaimlerChrysler, Corp., stated that in the U.S. Cooperative Automotive Research (USCAR) and FreedomCAR programs, a goal of technological “value neutrality” has been set. If value neutrality with conventional technologies could be reached, there would be mass market pull for the fuel cell systems, and infrastructure investments would follow to support these fuel cells. But at various points along the timeline to value neutrality, some more limited types of implementation could be possible. The earlier commercial products are offered, the more trade-offs there are to the consumer and the more policy is needed to offset the consumer value deficits. Dr. Gronich was asked to comment (based on scenarios considered in the scenario analyses), and said that to reach the NAS target for 10-12 million vehicles in ten years, 8,000 refueling stations would be needed. To reach penetration equivalent to today’s hybrid penetration, 4,000 stations would be needed. He concluded that policies would be needed for both the vehicles and infrastructure.

Dr. Milliken described the annual Hydrogen Program Review meeting. A report is published summarizing the scores and reviewers’ recommendations, and the evaluations are considered in funding decisions. The review meeting also provides an opportunity for basic science researchers and applied science researchers to interact.

Dr. Milliken then described the Program’s interactions with industry through the FreedomCAR and Fuel Partnership and with international partners through collaborative projects such as an international storage conference that was held last year. She identified states that have active programs, including California, South Carolina, and New York, to name a few.

Dr. Shaw asked how much of the total budget is spent on program planning and management. Dr. Milliken replied that the percentage spent on program planning and management is about 8%, and may go higher to meet the EPAct analysis and reporting requirements. That includes EERE cross-cutting activities. John Bresland, of the U.S. Chemical Safety Board, asked if the earmarks were appropriated in addition to the Department’s budget request, or if earmarks were funded out of the budget. Dr. Milliken replied that funding for most hydrogen-related earmarks to date came out of the budget

request, but Congress has the option to write language in the appropriations to provide additional funding for earmarks.

Mr. Jan van Dokkum, of UTC Power, asked how the Hydrogen Program funding of \$300 million compared to other DOE programs. Some examples were given such as \$400 million for coal research and \$300 million on fusion energy. Mr. Walker noted that some of these programs are legacy programs that have had high funding over a number of years, whereas the funding for hydrogen program has increased substantially over the last few years, from \$3 million in the early 1990s.

Consumer Acceptance, Early Penetration Factors, and Competitiveness

Professor Dresselhaus raised concerns about consumer acceptance of high-pressure on-board storage of hydrogen since the properties of hydrogen are different from those of other fuels. Dr. Byron McCormick, of General Motors, noted GM's experience so far has been that people are willing to accept the vehicles knowing that the OEMs conduct a large number of crash tests to ensure the safety of the vehicles. Mr. Bawden stated that there are currently 40 or 50 companies working on non-hydrocarbon storage technologies, and that some of these technologies may be ready for commercialization in the portable power market, but the lack of codes and standards may prevent them from being commercialized.

Dr. Shaw talked about the tendency of institutions to try to make technology perfect before introducing it to the market, in contrast to private industry. He cited examples from personal computers and the Ford Model T. He suggested stationary and portable applications are the near-term commercial applications for hydrogen technologies. Dr. Milliken mentioned that hydrogen forklifts are starting to come onto the market but that DOE's role in commercialization timing is limited to such activities as identifying federal agencies that might purchase the technologies. Dr. Milliken pointed out that hydrogen production from natural gas is not a perfect approach because of the need for natural gas in stationary power generation and the volatility of natural gas price. Yet the Department is promoting it as an approach to jump start hydrogen infrastructure because it is the most economical production pathway. She also stated that the Program's goal is to reduce dependence on oil. Since that can only be accomplished in the transportation sector, the Program's efforts in stationary and portable fuel cells are relatively small. And she said that the fuel cell materials and component R&D are applicable to all PEM-based fuel cells, regardless of the application.

Professor Dresselhaus stated that European countries and Japan are introducing hydrogen-powered computers and electronics and suggested that might be a way to develop experience with hydrogen at relatively low cost. Dr. Milliken pointed out that the Program supports portable power fuel cells, although to a small extent.

Mr. David Friedman, Union of Concerned Scientists, stated that we need to do lifecycle analysis to understand hydrogen fuel pathways compared to other fuels relative to petroleum reductions and emissions reductions, including carbon - that there is a role for

DOE to play in terms of certifying fuels on a well-to-wheels basis. Dr. Milliken pointed out that the Department has conducted such well-to-wheels analysis, and that she would provide the results to the Committee.

Dr. Chowdhry stated that private industry could not wait for 30 years to generate cash flow. It has to put things on the market even if imperfect and has to start with small devices if necessary. Asia is moving faster than the U.S., and DuPont gets more contracts from Asian clients than U.S. ones. If HTAC is concerned about U.S. competitiveness, it should make bold policy recommendations to spur commercialization.

Dr. McCormick made an analogy to implementing hydrogen energy infrastructure to how the rural electrification project was implemented to service the rural public despite imperfections in the technology and planning. The lesson is that it is possible to get a system up and running, while working out the bugs as the system starts to operate. Dr. McCormick made the point that we don't turn off the lights to reduce natural gas use, and we shouldn't halt commercialization of fuel cells rather than use natural gas. Dr. Milliken agreed, citing analyses showing that early fuel cell market penetration would increase natural gas demand by less than 3%.

Dr. Ramage cited the need to focus on the best ways of meeting the goals relating to the national interest rather than being driven by private interests of companies, some of which might be represented on HTAC. Big companies require something approaching "perfection," e.g., 300-mile range, before they will invest in new technologies because they are concerned with competitiveness at the mass-market scale, and they need to be sure that there will be a cost-competitive fuel source before a major investment for large infrastructure can be made. He stated that the role of government policy is to help move toward those conditions for the good of the country. The program has to aim at reducing oil imports, reducing carbon emissions, and moving the country away from a hydrocarbon-based economy because of energy security considerations.

Dr. Shaw expressed a differing viewpoint, pointing out that new products are often brought to market not by established giants but by small start-up companies. One example is computers. Another is photovoltaic (PV) technology, which reached market penetration largely through the incentive program of Germany, even though Germany was one of the worst places for PV implementation from a solar resource viewpoint. The nation simply made a decision that it wanted to implement it and made PV competitive by paying \$0.63/kW ("feed-in tariff"). In Canada, the subsidy is about \$0.33/kW. Dr. Ramage stated his appreciation for the importance of venture capital but still believes HTAC should formulate recommendations in terms of national interest goals. Dr. Shaw agreed.

Professor Dresselhaus questioned whether the German/solar analogy was apt since the Germans believed that solar technologies were subject to economies of scale. The scientific community has questions as to whether hydrogen systems are similarly scaleable. If investment is made in infrastructure and economies of scale are never reached, the investment is wasted. Dr. Shaw stated that in the PV example cited, scale is

critical for investment decisions, as Hewlett-Packard Development, L.P. found in a study it did for the National Renewable Energy Laboratory for super-large-scale manufacturing PV modules.

Mr. Michael Mudd, of FutureGen Alliance, suggested getting back to the HTAC charge. He expressed a desire to know about DOE's overall goals for hydrogen and fuel cells in more depth. A suggestion was made that the DOE technology development managers present more detail to the committee about what they are doing to overcome the barriers.

Professor Richmond acknowledged that producing hydrogen from hydrocarbon fuels is important in establishing a distribution infrastructure for early market penetration, but she would not have highlighted reducing the cost of hydrogen from natural gas as being a major accomplishment of the program as it could overshadow the long-term efforts to make hydrogen from renewable sources viable. She sees the cost reductions for the non-hydrocarbon hydrogen production pathways as a greater achievement than meeting the target of producing H₂ from natural gas at \$3/kilogram. Dr. Milliken explained that part of DOE's strategy is to enable the early infrastructure for hydrogen by using distributed production of H₂ from steam methane reforming - currently the most economical method. This would allow vehicle and refueling technologies to be developed and implemented. This would hopefully create a subsequent market for hydrogen from centralized production at larger scale from other feedstocks, including renewable-based.

Nominations for Chair and Overview of Plans for Day 2

HTAC then moved on to consideration of nominations for the position of Chairperson. Each member was asked to describe his/her background and relationship to hydrogen. The floor was opened for nominations. Dr. Robert Shaw, Dr. Alan Lloyd, The Honorable Robert Walker, and Dr. Kathleen Taylor, retired from General Motors, were nominated. Dr. Shaw said that he would prefer to serve as Co-Chairman or Vice Chairman rather than as the sole Chairman. The other three candidates accepted the nominations.

The Monday session was then adjourned at 6:03 p.m. EDT.

October 3, Morning Session

The meeting was called to order around 8:30 a.m. EDT.

Copies of well-to-wheels analysis of hydrogen use from various production pathways (Appendix B of the Posture Plan) were provided and a brief presentation was made, including participation by DOE's Patrick Davis, Acting Hydrogen Production Team Leader.

Election of the Chairperson

Ms. Epping opened the meeting by asking for additional nominations for the post of Chairperson. There were no additional nominations. There was a discussion of whether to have co-chairs or a chair and vice chair. It was decided by apparent consensus to have a Chairman and a Vice Chairman. Ms. Epping suggested taking a single vote with the highest vote-getter becoming Chair and the second highest becoming the Vice Chairman. Based on the vote tally, Dr. Lloyd was elected Chair and Mr. Walker elected Vice Chair. Dr. Lloyd accepted the election pending confirmation that the International Council on Clean Transportation (ICCT), for which he works, does not have any objections nor believe it presents any conflicts. [Note: ICCT did not object to Dr. Lloyd assuming the 2006-2007 Chairmanship of HTAC.]

As the votes were being counted, a discussion was begun on the subject of a possible recommendation regarding the Interagency Task Force – to elevate the group to at least the level of Assistant Secretaries, with perhaps the existing Interagency Working Group providing support for and reporting to the elevated Interagency Task Force. It was pointed out that Section 806 of EPAct 2005 calls for the Secretary of Energy to Chair the Hydrogen and Fuel Cell Technical Task Force, which could be interpreted to mean that it should meet at the cabinet level.

HTAC Structure and Subcommittees

The next item on the agenda was to discuss the Committee structure. Dr. Ramage and others stated that they thought the Committee should begin work as a whole toward possibly making some early recommendations and that subcommittees should be established on an ad-hoc basis as needed to support the issues identified by the full committee. Mr. Walker suggested that he and Dr. Lloyd have some meetings with key decision-makers at DOE, and that they share the insights from those meetings with the full committee. Work could proceed from there, possibly with the formation of subcommittees.

The idea of a visit of the HTAC members to some sites where progress was being made on hydrogen and fuel cell R&D (such as the GM Rochester facility, Plug Power, and UTC) was raised, with reference to a similar suggestion by Under Secretary Garman. Dr. Shaw suggested that if such a visit was made, it could be combined with an HTAC meeting at the site.

Mr. Mudd raised the question of whether HTAC should start with a blank slate in formulating recommendations or should start by reviewing recommendations made by other groups, explanations by the Congressional committees of what they intended in the legislation, and consultations with the DOE technology development managers of what their goals are and what activities they can undertake at various funding levels. HTAC could then identify gaps and flaws in the DOE Program and barriers to the goals with

recommendations flowing from those findings. Dr. Shaw added that HTAC should hear presentations detailing what activities are in progress within the private sector and make recommendations in that regard as well. Mr. Walker added that developments in other countries should be included and also suggested getting other viewpoints from people who have written books either supporting or doubting a hydrogen economy. This suggestion met with general approval; Jeremy Rifkin and Joseph Romm were mentioned as possible invitees.

Dr. Taylor suggested that, while background information would be interesting, generally HTAC should keep its focus on its charter to make recommendations regarding implementation.

Professor Dresselhaus stated that she would like to hear presentations from chairpersons of other DOE advisory committees working on related projects to coordinate efforts.

Mr. Wooten raised the question of where HTAC's review fits into the process of the DOE Hydrogen Posture Plan, including the existing 2004 plan and the plan currently being developed. Dr. Milliken explained that the draft plan going through the concurrence process is an updated version of the 2004 plan and that HTAC's review comes after the DOE concurrence process. The Secretary will consider HTAC's recommendations subsequent to submission of the Posture Plan to Congress, including recommendations resulting from HTAC's review of the Posture Plan.

Dr. Saillant and Mr. Chernoby both stated that they thought that the question of interagency accountability should be addressed without waiting for the broader process of the committee's educating itself and formulating a package of recommendations. Dr. Lloyd agreed and also suggested that conference calls might be used between formal HTAC meetings as a bridge to keep action moving.

Mr. Walker suggested that HTAC might want to approach the Congressional hydrogen caucuses and committees and asked if it was precluded from doing so. Ms. Epping said she does not believe the Federal Advisory Committee Act precludes such action. Dr. Ramage suggested that HTAC should get a better sense of what it wants to accomplish and how to do it and should make sure that it is not duplicating the work of other bodies. He also said HTAC needs to decide before planning contacts with Congress if it is going to speak with one voice in such meetings or have individual opinions from members voiced. Mr. Walker said that his suggestion was really to gather intelligence from members of Congress, not to advocate positions.

Mr. van Dokkum requested focusing on the Posture Plan and that process. He especially wants HTAC to review the plan with regard to how private industry would relate to the plan – would industry be able to implement the plan readily? Although the current draft is not available to HTAC, Dr. Milliken stated that it is not greatly different from the 2004 plan (with updated well-to-wheels analysis, updated status of activities, etc.), so HTAC could start by reviewing the 2004 plan. She said she would relay the interest of the committee in seeing the draft plan before it becomes final. Mr. van Dokkum said that he

is certain that Section 804 did not intend HTAC input on the draft but only formal comments on the final plan.

Dr. Shaw said that his interest is not just in reviewing DOE plans, but also in considering what the private sector is doing and focusing recommendations there – for HTAC to generate its own product rather than comment on the work of others. Professor Dresselhaus said that DOE will be important in implementing any HTAC recommendations and that if HTAC expects DOE to listen to their recommendations, HTAC must listen to members of the DOE staff who have been working on these issues. Mr. Wooten agreed, saying that HTAC should not assume that the DOE staff has not already considered many of the things that HTAC members want to see addressed. It was clarified that there was no implied criticism of DOE or other committees, just a desire to broaden the scope and for HTAC to define its own scope. Dr. Ramage and Mr. Friedman agreed; both expressed interest in more focus on environmental impacts (beyond CO₂). Dr. Ramage stated that the evaluations should not be based on a dichotomy of hydrogen vs. petroleum only but should look at a possible diverse fuel mix, including biofuels, and see how hydrogen fits into that mix.

Mr. Walker suggested that whatever else HTAC might undertake, it was specifically charged with: (1) reviewing implementation of Title VIII; (2) evaluating safety, economic, and environmental impacts; and (3) reviewing the Section 804 Posture Plan. HTAC will most be held accountable for those three requirements, and the requirements might suggest a division of labor for subcommittees.

Mr. Napoli suggested returning to the subject of whether HTAC wanted to try to make some recommendations in time for them to be considered within the FY 2008 budget cycle. Dr. Milliken estimated that HTAC would have at most a month to make such recommendations, noting that there was no assurance that they would make it in time for that budget submission. Dr. Lloyd wanted to try, and Mr. Walker raised the issue again of starting with a recommendation on the Interagency Task Force.

Mr. Bresland and Mr. Friedman requested presentations on where the hydrogen program fits into EAct in terms of a broad strategy involving biofuels and energy efficiency efforts.

Dr. Ramage asked about a “Strategic Plan” that has just been released by DOE – if hydrogen is a part of that plan, then should HTAC see it? Dr. Milliken agreed to provide copies.

Mr. Bresland asked about other technical advisory committees under EAct and how they operate and determine their scopes. Dr. Milliken stated that there are four other EAct advisory committees: biomass, nuclear energy, fusion, and climate change. It was agreed that DOE staff would seek more information regarding their memberships, scopes and operations to see if any guidance to HTAC could be gleaned.

Dr. Lloyd asked that members check their calendars during the break to look at conflicts so that a meeting date could be set sometime around January and suggested a possible conference call before then.

Safety, Codes and Standards Discussion

Dr. McCormick proposed that another initial recommendation would be to have the U.S. Department of Transportation (DOT) eliminate hydrogen's classification as a hazardous material. Mr. Napoli suggested that there were many issues, and he referred to Bill Chernicoff of DOT (who was present in the audience), to address those issues. Dr. Lloyd and Mr. Bresland understood the classification to be under consideration between various national and state agencies and suggested it might be expedited. Professor Dresselhaus pointed out that hydrogen is, in fact, dangerous if not used properly, to which Dr. Lloyd and Mr. Bawden agreed.

After the break, Dr. Lloyd asked Mr. Chernicoff to take the podium to address the question of hydrogen's classification as hazardous. Mr. Chernicoff explained that the hazard classifications are not discretionary or policy-based but dictated by technical standards defined by physical properties of the materials. Hydrogen falls under the hazardous classification, as do gasoline, diesel fuel, and essentially all fuels. DOT uses these hazardous materials classifications only for regulation of bulk transport of the materials, not for their use as fuels. The problems with state and local regulatory bodies could result from misunderstandings or lack of proper information, but declassifying hydrogen as hazardous is not a possible solution.

Dr. McCormick stated that whenever such problems come up, the regulatory authorities involved make references back to the DOT classification. Mr. Chernicoff referred the members to www.hydrogen.gov/regulations for a breakdown of the pertinent regulatory authorities and how they apply. Dr. McCormick stated that he believes that this problem will cause global companies like GM to implement hydrogen in other countries rather than the U.S., although this issue also comes up in other countries, which points back to the DOT classification. Mr. Chernoby stated that the California legislature has addressed the issue effectively – declaring it an acceptable fuel - without attempting to change the DOT classification, which is not the answer, and stated a belief that the problem is actually an emotional one – hydrogen phobia – rather than the DOT classification. Mr. Napoli opined that the problem could relate to the National Fire Protection Association (NFPA) and International Code Council (ICC) model codes. Mr. van Dokkum agreed and stated that a real dialog on codes and standards is what is needed. Mr. Katsaros agreed, as did Professor Dresselhaus, who again pointed out that hydrogen is different from other fuels and that education is needed about how to manage it in the range of different situations. Dr. Milliken pointed out that DOE is engaged in such educational and outreach activities under Patrick Davis and Christy Cooper, who were present in the audience. Dr. McCormick said that the resources required to change codes and standards jurisdiction-by-jurisdiction are so great that the problem might prompt GM to cut back on its hydrogen work. Patrick Davis described DOE's efforts to get adoption of workable

hydrogen codes by the 44,000 U.S. jurisdictions; DOE is currently spending about \$5 million per year on this activity. He said that once a committee is formed to draft a model code, it typically takes two years to adopt the model code and another three years to get it adopted by local jurisdictions. Model codes for H₂ are just starting to come out from the various relevant bodies, who have divided up responsibility, including one by NFPA. DOE's goal is to have all of the codes broadly adopted by 2010. When a project is proposed in a jurisdiction that has not yet adopted a code, the officials there can look to the model code as a basis for approving the project.

Questions were then raised about various alternative solutions such as accelerating the standard-setting process to six months, adopting a universal international code or set of codes and/or having Congress legislate a national code or limits on liability. Concerns were raised that the codes problem in the U.S. would put the U.S. behind other countries' implementation and cripple U.S. competitiveness. Dr. Gronich pointed out that implementation will really be at the level of technology validation through 2010, with only a few hundred vehicles in a limited number of locations, so that the large number of jurisdictions should not impede those projects. The real problems would come if the codes problem is not adequately addressed between 2010 and 2015, when companies plan to put hundreds of vehicles per year into operation.

There was some further discussion of the codes issue with concern that companies might not go forward until they have assurance that the issue will be satisfactorily resolved soon. Dr. Lloyd and Mr. Walker offered to have some further discussions with DOE and Congressional committees to gather information and explore approaches and report back to HTAC, possibly by the November conference call.

There was discussion of what the next steps should be, including immediate discussion of the Posture Plan, based on what is known about it, or of deliverables generally, and of timelines. Dr. Shaw pointed out that all R&D timelines shown by DOE from the Posture Plan go out to 2015, stating that climate change goals will not be met by 2020 if some milestones are not met prior to 2015 as technology penetration usually takes about 15 years. Dr. Ramage stated that the timelines are realistic, and that they describe not only the DOE R&D program, but also some commercialization by private industry within those periods. Dr. Milliken explained that the goal is to have the technology ready by 2015, with 3-5 years beyond that for building manufacturing capability and infrastructure, and initial mass-market penetration around 2020. This goal is consistent with the vision of the 2003 State of the Union address for a child born then to be able to drive a hydrogen car as his/her first vehicle. Mr. Friedman characterized that scenario as very aggressive, and Dr. Milliken confirmed that it was a best-case scenario. DOE is conducting analysis to determine how hydrogen fits into the broader Advanced Energy Initiative with biofuels and plug-in hybrids.

October 3, Afternoon Session

The next HTAC meeting was tentatively set for January 9 and 10 in the Washington, DC area, and it was agreed that the Committee would have a conference call in November. Due to conflicts, it was agreed that all members will send their conflict dates for the next year to Ms. Epping, who will attempt to identify the dates on which the most members will be available for the January meeting, the November conference call, and for the subsequent two meetings, likely in May and September.

A question was raised as to whether Mr. Gregory Vesey is still a member because of his recent job change. Ms. Epping replied that he still is a member, a special government employee for his knowledge and expertise, but had a conflict that precluded him from attending the first meeting.

Dr. Saillant pointed out that the meeting schedule that had been set would not allow for any input into the FY 2008 budget process. It was decided that the latest time for having any real chance of influencing that would be early November. Discussion between Dr. Lloyd and Ms. Epping clarified that DOE considers HTAC recommendations in a report that accompanies the budget request submission. Dr. Lloyd asked Ms. Epping to verify that recommendations made in November, for example, might still be considered for the report that accompanies the FY 2008 Budget Request in February. (If not, the conference call might be moved forward.) Dr. Milliken pointed out that the report must go through the concurrence chain within DOE, including the Assistant Secretaries of the four participating offices in the Program, Chief Financial Officer, General Counsel, Office of Management and Budget, the Under Secretaries and finally the Secretary, which can take months (the situation for the updated Posture Plan). She stated that there was no guarantee the report would make it through that process by February.

Mr. Walker suggested that such scheduling efforts are fruitless and that if the Committee believes it is important to make recommendations for that cycle, the Committee should agree on recommendations immediately. Members agreed to try to reach a consensus on any such recommendations and to work out precise language later by email. A number of members expressed that they do not feel comfortable making recommendations on the budget without sufficient time and information to conduct a detailed evaluation. Mr. Friedman and Mr. Walker said that it might be possible to make a few very general recommendations on which there is consensus, such as limiting earmarks and elevating the Interagency Task Force.

Mr. van Dokkum suggested that HTAC urge Congress to appropriate funding at the maximum appropriations level authorized by EAct. Mr. Wooten, Dr. Milliken, and Mr. Walker explained the relationship between authorizations and appropriations and that the former is almost always much higher than the latter. The Authorizing Committees do not have the budgetary ceilings Appropriations Committees have. The Executive Branch makes its budget requests based on priorities and program needs. There was apparent consensus not to make a recommendation regarding the overall Hydrogen Program budget or on specific program funding at this time.

There was considerable discussion of the proposal to recommend elevating the Interagency Task Force. The statute referred to the Secretary chairing the task force; however, in implementing the statute, the agencies have provided working-level staff to represent them on the task force. The idea was floated to stipulate that each agency be represented at no lower than the Assistant Secretary level (with OSTP, which co-chairs the group, to be represented at least at the Deputy Director level). The existing Task Force would become the staff working group for the statutory Task Force. The recommendation could also propose what it wants the Task Force to accomplish. Some ideas for possible language were suggested, and a motion was made, though without specific language, to have someone draft language for a recommendation to elevate the Interagency Task Force to at least the Assistant Secretary level, with the current Task Force serving as a working group under the new Task Force. Dr. Lloyd asked if there was any opposition and, there being none, he said that the details would be sent to members in an email.

Mr. Keuter suggested that there may also be a consensus that more needs to be done to accelerate progress on uniform codes and standards. Dr. Shaw, Dr. Lloyd and Mr. Chernoby felt that HTAC should learn more about the specifics before taking a position on that issue. Mr. Walker's fact-finding might be a start, with some reporting back during the upcoming conference call. Dr. Lloyd suggested that members send in their concerns to Ms. Epping in advance of the conference call. Dr. Shaw suggested forming a committee of experts on that issue. Dr. Lloyd thought the issue may be best considered within a subcommittee, though the subcommittees would not be specifically identified that day but rather could be defined in a subsequent conference call. Professor Richmond, Dr. Shaw, and Mr. Chernoby suggested that HTAC should also listen to counter-arguments on hydrogen.

Mr. Walker suggested a structure of five subcommittees to be considered for the next meeting:

- program implementation
- safety
- economy
- environment
- evaluation of the Posture Plan(s)

Dr. Lloyd suggested an additional subcommittee on national and international coordination, including looking at what the International Partnership for the Hydrogen Economy is doing.

Mr. Keuter suggested an alternative structure with the following subcommittees:

- production
- delivery
- storage
- conversion

Dr. Lloyd stated that in his HTAP work, he had found it useful to attend sessions of DOE's own program evaluation, which will be held on May 15-18, 2007. It was suggested that the May HTAC meeting could be timed to coincide with the DOE Hydrogen Program review meeting. Professor Dresselhaus said that the review was useful to help get the "big picture" of how the various elements tied together, including the relationship between basic sciences and applied research.

Dr. Shaw asked about a subcommittee on "outside the beltway" – surveying what is going on in the private sector – and volunteered to serve on it. Dr. Lloyd said that he intended that to be part of what he had referred to as "national/international coordination" and suggested that maybe a better descriptor could be found.

Mr. van Dokkum again raised the focus on short-, medium-, and long-term perspectives and suggested using them as an organizing principle. This includes looking at current opportunities such as the federal funding for fuel cell school buses, transit buses, and government buildings. Mr. Mudd agreed on the importance of that perspective and suggested it be part of the purview of the program implementation subcommittee. Dr. Lloyd agreed and stated that he hoped that HTAC recommendations would not be completely postponed until a comprehensive understanding was reached by the members, but that recommendations would flow relatively continuously.

Public Comment

Mr. Moyer, private citizen (not affiliated with any stakeholder organization): Mr. Moyer believes that there should be greater priority on building a prototype heavy-duty hydrogen vehicle. Once the design is achieved on a heavy-duty vehicle, it can be readily adapted to light-duty vehicles. By heavy-duty, he means semi-tractor long-haul vehicles, not buses. He also has concerns about the environmental impact of mass production of fuel cells, their recyclability, durability and affordability. He also put forward the idea of highway "trains" of semi-trailers being pulled by a single heavy fuel cell tractor. He suggested that some hybrid of fuel cell plus internal combustion engine, turbine engine or rotary engine might provide a solution if the fuel cell-electric drive train proved inadequate.

Mr. Fred Humes, Chairman of the Board, South Carolina Hydrogen and Fuel Cell Alliance: The South Carolina Hydrogen and Fuel Cell Alliance includes the University of South Carolina, South Carolina State University, Clemson University, Savannah River National Laboratory, and the Hydrogen Research Center. Its goals are to educate the citizens of South Carolina on hydrogen; facilitate the development of codes and standards in South Carolina; commercialize the technology that comes out of its member organization; address education and workforce issues; as well as sponsor and promote demonstrations. He urged HTAC to work with the states, as they bring their own perspective and a sense of urgency.

Mr. Robert Rose, U.S. Fuel Cell Council: The Council includes 120 organizations including universities, developers, suppliers, customers and non-government organizations involved in fuel cell commercialization for all applications. The council is involved in technical education, support of standards, and advocacy. He believes that HTAC should be non-partisan and should provide technical advice and support to the Interagency Task Force and Secretary of Energy with focus on what the federal government is doing. HTAC is not limited to hydrogen transportation but should cover the gamut of fuel cell applications. It is not limited to R&D, but is about technical evolution, cost reduction, public education and especially the government-industry partnership. HTAC is a consultant to the Secretary. Power generation should be a priority. The funding for the President's Hydrogen Fuel Initiative is for five years, of which next year is the last. DOE's Program focuses on vehicles, but other applications, including market entry for portable, stationary, cogeneration, back-up systems, and micro fuel cells should not be left out.

Mr. Wooten asked Mr. Rose whether his Council was actively engaged in codes and standards activities. Mr. Rose said that his Council spends more of its resources on that than on any other area. He believes that there are plenty of codes already available or being developed, but that HTAC could support public outreach and education of first responders, fire marshals, etc. Mr. Rose also stated that he or his Council members would be willing to serve on subcommittees of HTAC.

Final Action Items

Questions were then raised about reimbursement of expenses, and forms were provided. Dr. Shaw expressed concern about government databases and asked if the submission of personal information could be avoided by seeking reimbursement through his company. Ms. Epping will look into that and report back. [Note: Reimbursements can be made to either the member or his/her company.]

Next Meeting Date: Ms. Epping agreed to coordinate and report the next meeting date. Mr. Shaw offered to host the members on a visit to a hydrogen production facility under construction in Alexandria in conjunction with the next meeting. It was agreed that an agenda and the pertinent information materials would be provided at least seven days prior to the conference call. Dr. Ramage also suggested an agenda be agreed well in advance of the next meeting to avoid a rambling meeting. There was further discussion of whether and when the conference call had been scheduled, and it was tentatively set for November 17 at noon EST.

DOE staff will report back on the membership of other EPA Advisory Committees. [Draft in preparation.]

DOE staff will provide copies of the NAS FreedomCAR review and the DOE document describing responses to it.

DOE staff will look into getting early release of the draft Posture Plan to HTAC. [Topic for conference phone call – HTAC will have to wait for the release of the FY 2007 Posture Plan.]

DOE staff will look into getting a “voice box” at future meetings for members who cannot attend to participate by telephone. [Voice boxes are possible.]

DOE staff will provide all members with contact lists including phone numbers, email addresses, etc. [Done.]

DOE staff will review the meeting transcript to identify any other tasks or action items requested.

Other Actions and Tasks Identified:

- Provide HTAC more detailed presentations on DOE’s and Interagency Working Group programs and activities.
- Address structural and other barriers.
- Invite Jeremy Rifkin (proponent) and Joe Romm (opponent) to a Committee meeting.
- Invite Chairs of other four EPA Act Advisory Committees to come as a group, give short presentations, and coordinate with HTAC (Chairs should be asked to provide materials ahead of time). Similar recommendation for DOE Secretarial Advisory Committees (some members of these committees are also members of HTAC).
- Identify short-, medium-, and long-term perspectives and actions.
- Invite Congressional Caucus Members on Hydrogen to meet with the Committee and clarify expectations.
- DOE to provide HTAC members with reports on employment (jobs) and on environmental and social impacts.
- Identify unintended consequences of a hydrogen economy.
- HTAC to provide Congress a roadmap of its activities.
- HTAC to define its own boundaries.

The meeting concluded at 2:24 p.m. EDT (no formal motion to adjourn requested or made).

Approved by:



December 22, 2006

Alan Lloyd, Chair

Date