HYDROGEN AND FUEL CELL TECHNICAL ADVISORY COMMITTEE

MEETING MINUTES

December 18-19, 2007
Crystal City Marriott, Arlington, VA

Agenda in Brief/Table of Contents

DECEMBER 18, 2007

1. *Call to Order, Agenda Review*

Chairman Alan Lloyd called the meeting to order at 1:00 p.m. EST. Seventeen of the 25 HTAC members were present (list of attendees and absent members, page 43). Dr. Lloyd reviewed the agenda for the meeting. Dr. JoAnn Milliken provided the Committee with a

Hydrogen Program budget update, since an omnibus funding bill was passed by Congress on December 17 (and subsequently signed by the President on December 19). Dr. Milliken reported that the omnibus bill provided a $213 million budget for the Energy Efficiency and Renewable Energy (EERE) part of the Hydrogen Program, which is equivalent to the Department of Energy (DOE) request. She noted that a final tally of the congressional earmarks had not yet been completed, but they appear to be in the range of $16-25 million. However, funding for the earmarks is provided as a "plus-up" to the budget, so the earmarks are not expected to impact the $213 million EERE budget. Dr. Milliken reported that the omnibus bill provided $10 million for the Nuclear Hydrogen Program, $12.6 million less than the DOE request of $22.6 million. The bill provided $25 million for the Coal to Hydrogen Program, which is $15 million more than the DOE request of $10 million. While Dr. Milliken did not have a final report on the funding provided for the DOE Office of Science, she understood they sustained some reductions in their budget request. She noted that hydrogen is not a separate line item in the Office of Science budget, so the impact on hydrogen funding is still unclear; the preliminary indication is that the budget will remain the same as the 2007 level ($36 Million), rather than increasing to the DOE 2008 request level. Mr. Bob Rose added that the Solid State Energy Conversion Alliance (SECA), a solid oxide fuel cell program funded by DOE's Office of Fossil Energy, lost about $6 million, or 10 percent, of its budget request. Dr. Milliken concurred, and noted that language in the omnibus bill directs EERE to support research and development (R&D) on solid oxide fuel cells for small distributed energy applications, which is a deviation from previous years, in which this solid oxide fuel cell work was funded strictly through the DOE Office of Fossil Energy's SECA program.

2. ***Report on Hydrogen and Fuel Cell Interagency Task Force Meeting***

Dr. Lloyd, Dr. Milliken and Mr. Rose attended the December 18, 2007, meeting of the Hydrogen and Fuel Cell Interagency Task Force (ITF) and reported to the HTAC on the meeting and their impressions. The ITF meeting was chaired by Mr. Steven Chalk, EERE Deputy Assistant Secretary for Renewable Energy. Dr. Lloyd reported that EERE Assistant Secretary Andy Karser had just returned from the climate change conference in Bali, but was able to attend the first part of the ITF meeting and provide some remarks. Dr. Lloyd noted that the focus of the meeting was on the federal government as an early adopter, and he was encouraged to see the emphasis on deployment. He commented that most of the agencies represented in the Task Force seemed very interested in moving ahead and trying to deploy some of these products, as appropriate. He went on to report on the presentations given at the meeting:

- Mr. Chalk opened the ITF meeting by describing some successes and opportunities for federal agencies to deploy alternative energy technologies, and noted that this deployment will be important in achieving the federal agencies' goals for energy and emissions reduction.
- Mr. Karsner challenged the ITF to consider the products that are commercially available and the various ways that government can help in deploying these products, citing examples at Nellis Air Force Base and the National Renewable Energy Laboratory, both of which have recently made investments

in procuring photovoltaic energy under long-term purchasing agreements with private sector power providers.

- Mr. Bob Rose, on behalf of the U.S. Fuel Cell Council, presented the catalogue of fuel cell products that are commercially available today and how they might be utilized.
- A number of different fuel cell users reported on their experiences, including:
  i. U.S. Postal Service: installation of a 250kW fuel cell system and a photovoltaic system to provide distributed power for a processing and distribution facility.
  ii. Federal Aviation Administration: installation of 25 small fuel cells for back-up power at smaller regional airports, citing high reliability and availability of fuel cells as a key advantage versus conventional engine generators
  iii. Defense Logistics Agency: deployment of close to 90 fuel cell-powered forklifts in a number of DOD installations around the country, with more forklift procurements planned.
- Dr. Milliken presented a process and framework for a proposed interagency action plan for deployment of fuel cells. The goal is to have a draft ready for presentation and review by the ITF in the March-April timeframe, and a final plan by summer of 2008.

Dr. Milliken reported that some of the Task Force members challenged the Hydrogen Program to provide more information on the value proposition and on the impact of early deployment efforts. Mr. Dan Byers from the Office of Science and Technology Policy pointed out that the program needs to show how early adoption efforts will lead to larger volume deployments and, eventually, to fuel cell vehicles. Mr. Byers wanted to know how the deployments will help lower costs and advance the state of technology. Dr. Milliken agreed that the program needs to do more quantitative analysis on this and offer some concrete examples. She reported that Commander Brad Hancock, designated ITF attendee for the Assistant Deputy Under Secretary of Defense, stated that he did not see a value proposition right now for fuel cells in the Defense Department. He does not see how fuel cells will help to achieve DOD's goals for reducing energy consumption and does not think they are economically viable now. Dr. Milliken noted that this is another area in which DOE will need to do some analysis and present to the Task Force.

Mr. Rose commented that he was impressed by the number of units that are already in the field under federal auspices. He noted that users reported very positive operator experience: the FAA reported 98% availability of their fuel cell back-up power systems, much better than conventional diesel powered generators. He explained that forklift operators also appreciate fuel cells because they do not have to deal with batteries and all the problems with switching out batteries, leaking battery acid, and so on. Mr. Rose recalled that most of the ITF meeting's discussion centered on financing and cost, noting that there was a lot of dialogue on various financing mechanisms--how different contracting mechanisms might facilitate (or hinder) the installation of units or the provision of power. Mr. Rose noted that while Assistant Secretary Karsner strongly advocated the DOE loan guarantee program as a potential financing mechanism, it

remains to be seen how the guarantees can fit in the context of small-scale systems in smaller markets. He expressed his impression that when it came time for all of the agency people around the table to talk about what they were going to do next, there was a lot of "when in doubt, mumble" kind of discussion, punctuated by the occasional "These things are too expensive." Mr. Rose pointed out that if fuel cells were available at a market clearing price, these meetings would not be necessary. He stated that something more needs to be done to help communicate the difficulties faced by these emerging technologies and the strategic importance of this transition, adding that a non-monetary message needs to be conveyed.

Dr. Shaw asked if most of the members of the ITF are presidential appointees. If so, he inquired about the continuity of the task force as it goes forward after the November 2008 elections. Dr. Milliken agreed with this concern, and noted that this is something that DOE has been considering. She explained that this subject has not been formally addressed with the task force, though she has spoken with a few ITF members about it. She noted that a good number of the ITF members are political appointees, but some are career civil servants. She also noted that almost all the political appointees have a delegate or a backup person who is a career civil servant. She pointed out that some of the appointees have expressed an interest in moving forward quickly because they recognize that they are only going to be in the position for another year, which could be a positive point. She expressed her hope that the delegates and backup personnel will get the ITF through the political transition period.

HTAC Co-Chairman Robert Walker mentioned that the Department of Transportation (DOT) held a meeting on December 17, 2007, on the subject of hydrogen; he asked Mr. Chernicoff to report to the HTAC on that meeting. Mr. William Chernicoff reported that the DOT has developed a draft Transportation R&D Plan, which focuses on transportation logistics and what DOT needs to do to enable industry to bring hydrogen to market. He explained that the document is still under development, and that it includes a lot of outside input, including interviews with members of industry, non-governmental organizations, DOE, and DOD. He stated that the R&D plan is a joint effort between DOD and DOT, who have common interests on the logistical aspects of moving large quantities of hydrogen. He explained that the December 17 meeting included an open comment and discussion period, and that DOT is working on finishing up the document, with the hope of having it ready in late January.

Congressman Walker mentioned that the new Administrator of the DOT's Research and Innovative Technology Administration (RITA), Paul Brubaker, has made hydrogen one of his top three priorities—something that he wants to move ahead on strongly so that it will be viewed as an ongoing program in DOT. Congressman Walker stated that he has been meeting with Mr. Brubaker fairly regularly, and recently met with Mr. Brubaker and the DOT Deputy Secretary, who he reported is also an enthusiast for hydrogen. Congressman Walker noted that he is encouraged by the work beginning at DOT, which will complement the work done by DOE in this area.

3. ***Report on the Meeting with Secretary of Energy Samuel S. Bodman on the HTAC Biennial Report to the Secretary***

HTAC Co-Chair Walker reported on his meeting with Secretary Bodman, which he believed should reassure HTAC members that the Committee's work is receiving high-level attention at DOE. In addition to the Secretary, the meeting was attended by the new Undersecretary of Energy, Bud Albright, and EERE Assistant Secretary Andy Karsner. Congressman Walker reported that there was a very good discussion about the HTAC report and hydrogen policies in general.

Congressman Walker relayed that Secretary Bodman stated that he had been a "skeptic on the hydrogen program" when he came into his position at DOE, but "he knew he had an assignment from the President to move hydrogen and fuel cells forward, and he was determined to do that, but he was not fully convinced that the technology and investment dollars were going to produce very much in the near term." A trip to the General Motors research facility in Rochester, New York changed his opinion. Secretary Bodman came back from that trip with an understanding of how far industry had come, saw the potential of hydrogen and became an advocate for this program inside the Department. The Secretary is particularly interested in where the hydrogen option fits with the nuclear option, since part of his focus is moving the nuclear option forward, and the combination of nuclear and hydrogen is of great interest to him. Under Secretary Albright also expressed an interest in helping to move the hydrogen program forward over the next year. Assistant Secretary Karsner urged a demonstration of progress in the short term and the identification of places where hydrogen is either in the market, or coming into the market soon, so that we can show that the work being done by the government is producing real results.

Congressman Walker reported that the *HTAC Biennial Report to the Secretary of Energy* was accepted enthusiastically by the Secretary, Under Secretary, and Assistant Secretary. He believes they understand the Committee's comments on the evaluation of the program and are interested in the items the Committee outlined for assuring a positive path forward. Congressman Walker summed up by saying that he thought it was a very good meeting with a lot of good dialogue, and he came away very pleased with the leadership's position on the overall program. Dr. Shaw asked whether the Secretary or others gave an indication of where they would next like the HTAC to focus. Congressman Walker thinks it is clear that Assistant Secretary Karsner believes the Committee needs to be as close to the cutting edge as possible—that he would like the HTAC to focus on fostering near term actions that can help pull the technologies forward as much as possible. Congressman Walker noted that they praised the fact that HTAC is a diverse group that is providing good feedback. He concluded that the Committee should, therefore, continue to be good stewards of the program, but also intelligent critics, so that the HTAC provides the DOE leadership with the balance that they need.

Dr. Milliken noted that at the Hydrogen Program level, the HTAC report has been discussed, a response has been drafted, and some of the recommendations have begun to be implemented. She stated that the Secretary's response to the HTAC report is currently

in the DOE concurrence chain, and should be delivered on time with the announcement of the 2009 budget request in February 2008. She added that the Committee will be provided an advance copy of the Secretary's report.

In an aside, Dr. Lloyd asked about the status of DOT regulations on air transportation of small hydrogen storage devices (e.g., in personal electronic devices such as PDAs or laptops or small hydrogen canisters for video cameras, etc.). Dr. Shaw noted the Canadian government's recommendations to the International Civil Aviation Organization (ICAO) as a very positive step forward. These limits are 120 milliliters in a device and another 120 milliliters in a backup canister in an airplane passenger compartment. Dr. Shaw asked whether ICAO acceptance would mean that DOT would also adopt this standard. Mr. Rose replied that DOT has to make a separate rulemaking. Asked about the status of ICAO and DOT rulemakings on air transport of hydrogen fuel, Mr. Chernicoff replied that he would need to check with his colleagues in the HAZMAT and FAA offices of DOT. Mr. Chernicoff added that if HTAC considers hydrogen transportation regulations to be high priority and adds this topic to a future meeting agenda, he will arrange briefings from DOT staff who are directly working on the air transport regulations. Mr. Larry Bawden recommended that HTAC make hydrogen air transport regulations high priority, noting that if the Committee is looking for "wins" on near-term applications of hydrogen, portable devices are in that category. He noted that these portable fuel cell devices are selling at market prices and solving customer's problems. He asserted that the only barrier left to get these devices to market in larger volumes (thousands to tens of thousands), is the passage of air transport regulations, which may be two or more years away in the current DOT process.

4. ***Briefing: Electricity Technology in a Carbon-Constrained Future, Revis James, Director of Energy Technology Assessment Center, Electric Power Research Institute***
   >>see also presentation at http://www.hydrogen.energy.gov/advisory_htac.html

Revis James is the Director of Energy Technology Assessment Center for the Electric Power Research Institute. He spoke on a study his group conducted on carbon emissions from the power sector.

Over the last several years, many companies that fund EPRI (mostly utilities) have concluded that some type of emissions reduction policy will likely pass. This study evaluated what the electricity sector might do to reduce emissions, using a scenario analysis based on changing the deployment of various technologies.

The analysis is organized into three basic parts, which address the following three goals:

- Estimate the potential to reduce carbon emissions from a technical perspective, absent any political or economic constraints (assuming the freedom to deploy whatever technology we wanted in whatever proportions we wanted).
- Assess the economic impact of deploying various combinations of technologies aimed towards reducing carbon emissions.

- Identify the type of technology development pathways that are needed, between now and the future, in order to develop the technology performance and deployment capabilities that would enable the estimated emissions reductions.

The study was approached from an engineering perspective, and picks technologies that allow the electricity sector to maximize emissions reductions with the combination of technologies that have the lowest economic impact.

The study's first step, determining the "technical potential," was to conduct a bottom-up calculation, by taking an array of technologies, individually calculating the potential contribution to emissions reductions, and adding them up to see if the emissions profile was desirable or undesirable. EPRI began by looking at the projections for the U.S. electricity sector in the Energy Information Administration 2007 *Annual Energy Outlook* (EIA/AEO), which has a time horizon of 2030. EPRI developed some different assumptions and technology deployment targets for nuclear, advanced coal, renewables, carbon capture and sequestration (CSS), plug-in hybrid electric vehicles (PHEV), and distributed generation—the comparison with the EIA/AEO assumptions and targets are described in the presentation. Generally, EPRI's targets for these technologies are more aggressive, since their approach was to develop targets based on an estimate of how much the different assumptions could be stretched, purely from the perspective of what can technically be done to reduce emissions, without policy or economic barriers.

EPRI's assessment of nuclear potential was based on an Idaho National Laboratory/EPRI technology roadmap that lays out the potential for deployment of nuclear power through 2100. This roadmap projects the potential deployment at about 100 gigawatts by 2030. EPRI's analysis assumes about two-thirds of this value (64 GWe by 2030 vs 12.5 GWe in EIA/AEO). EPRI's analysis took into account the existing nuclear sites in the United States, estimated the number of units that could be built on these existing "brownfield" sites (about a 50 percent increase in the number of plants), and assumed a 1,400 megawatt plant size, the typical size for an advanced light water reactor.

The EPRI study assumes higher efficiencies for coal power plants over the next 25 years (49% new plant efficiency by 2030 vs 40% in EIA/AEO), and assumes 150 GWe of existing coal power plant upgrades (vs none in EIA/AEO). The basis for these assumptions is a joint EPRI/Coal Utilization Research Council technology roadmap, which has laid out a series of five-year milestones for improved thermodynamic performance of coal plants and for improved performance on CO_2 capture. A very big assumption of the EPRI study is that carbon capture and sequestration (CCS) will be widely available and deployed after 2020 (EIA/AEO assumes no CCS by 2030).

EPRI's analysis of technical potential also assumes wider deployment of non-hydropower renewables (70 GWe by 2030 vs 30 GWe in EIA/AEO), based on a 2006 assessment that EPRI conducted of state renewable portfolio standards (RPS). EPRI assumed that all of the RPS standards would be met using non-CO_2 emitting sources, and projected a growth rate from there.

In terms of efficiency, EPRI assumes higher levels of energy conservation (based on analysis of efficiency programs and technologies), translating to a 20% reduction in electricity intensity. This assumption yielded a projected load growth of about 1.1% per year, compared with the EIA/AEO assumption of 1.5% per year. EPRI did not have good background analysis for distributed (non-utility owned) power generation (including distributed solar). They decided to choose a number that was a lot higher than what EIA assumed (5% of base load by 2030 vs less than 0.1%), with the objective of determining if that assumption would make a large impact or a small impact on the analysis. It was further assumed that the distributed generation capacity would have an emissions profile equivalent to natural gas (about half as CO_2 intensive as coal).

Finally, the EPRI analysis assumed that plug-in hybrid electric vehicles (PHEVs) would comprise about 30% of new vehicle sales by 2030. (The analysis further assumed that a PHEV runs 60 percent of the time in internal combustion engine mode and 40 percent of the time in electric mode.) While it could be argued that the emissions reductions from PHEVs should accrue to the transportation sector and not the electricity sector, EPRI included PHEV penetration in its analysis to answer two questions: 1) if PHEVs enter the automotive market in significant numbers, what would the added electricity load be, and 2) would a large deployment of PHEVs result in such large *net emissions reductions* (tailpipe emissions minus emissions from increased power load from recharging the vehicles) that this would obviate the need to achieve large emissions reductions in other areas. The increased power load from 30% PHEVs was estimated at 100-200 terrawatt hours, compared to a total projected U.S. consumption of 5,400 terrawatt hours in 2030.

EPRI has drawn two key conclusions from this analysis of technical potential. First, the CO_2 emissions curve from the U.S. power sector can be turned downward by implementing all of these technologies – from an EIA/AEO base case 2030 projection of about 3,400 million metric tons of CO_2 to about 1,600 million metric tons of CO_2. (The contributions of each technology area are shown in the presentation.) The second key conclusion is that all of the technology options contribute in a fairly big way, and that taking away any one of them will require even more reductions from another area to make up the difference. Thus a "portfolio approach" will be needed.

The next question addressed by the analysis is how much implementation will cost and is it economically feasible? To answer this question, EPRI used a general equilibrium integrated assessment model (the "MERGE" model). MERGE models the global economy, the U.S. economy (in more detail), and the interactions. For the analysis, EPRI assumed a policy-driven emissions constraint that caps CO_2 emissions at 2010 levels until 2020, and then requires a 3% annual decline in emissions from 2020 to 2050. Given this general constraint on emissions, EPRI used the MERGE model to answer the question: for a given array of technologies with costs and projected future costs, what's the lowest cost combination of technologies needed to meet this constraint and supply the necessary energy.

EPRI's economic analysis evaluated two different scenarios. The first scenario uses a limited technology portfolio that somewhat simulates the EIA base case -- no Carbon

Capture and Sequestration (CCS), limited growth in nuclear, some reduction in the cost of renewable power, some improvements in coal and gas efficiencies, no PHEVs, and efficiency improvements at more or less the historical rate. The second scenario simulates EPRI's technology deployment targets and assumptions, described above. Mr. James noted that EPRI's assumption for efficiency improvements is fairly aggressive: efficiency in this analysis means the energy intensity of the U.S. economy (unit energy per unit gross national product), and is about 50% higher than the EIA/AEO base case.

In the limited portfolio scenario coal use is phased out, gas use increases, biomass use increases, and overall electricity use must significantly decline. The analysis concludes that, from an economic standpoint, achieving the emissions reductions in this scenario might theoretically be possible, but this would be "very disruptive" since gas prices would react strongly to increased consumption. In addition, large reductions in electricity use would be required if the carbon intensity of the electricity supply is not decreased. In the "full technology portfolio" scenario, coal powered-generation increases (as CCS comes into play, even though it is expensive), nuclear capacity grows significantly, gas use decreases, hydropower remains about flat, and wind power increases. Some reduction in electricity demand would also be required to meet the emissions constraint in this scenario.

The economic analysis then looks at the total cost to the overall economy of the two different scenarios, considering the deployment cost of the technologies and the indirect impacts of prices and other effects on the rest of the economy. According to EPRI's analysis, the cost to the economy of the limited portfolio scenario is $1.5 billion and the cost of the full portfolio scenario is about $500 million. EPRI concludes that while achieving the full portfolio scenario would not come without some investment in RD&D, the pay-off, in terms of overall cost to achieve emissions reductions, would be substantial. The EPRI analysis also concludes that even in the full technology portfolio, there will be an increase in electricity prices (about a 45% increase by 2030). Mr. James noted that this outcome is contested by some other studies that assume zero or low cost to change consumer behaviors and incentivize conservation; EPRI assumes the opposite, and includes a fairly significant cost for changing consumer behavior and incentivizing conservation. More details on the economic analysis can be found in the technical paper "The Value of Technological Advance in Decarbonizing the U.S. Economy," by Richard Richels and Geoffrey Blanford (Working Paper 07-19, November 2007, available at www.aei-brookings.org).

The EPRI analysis goes on to lay out "technology pathways" in four areas, which present the R&D needed to achieve the full portfolio:

1) Distribution Enabled Technology Pathway (efficiency, distributed generation, and PHEVs)
2) Grid Enabled Technology Pathway (renewables integration and transmission and distribution efficiency improvement)
3) Nuclear Technology Pathway
4) Advanced Coal with CCS Technology Pathway

Mr. James reported that EPRI has presented this analysis, which was completed in February 2007, to a large number of different parties, including members of Congress and their staff, congressional committees, government agencies, non-governmental organizations, media groups, and trade associations. More information on the EPRI study "Electricity Technology in a Carbon Constrained Future" can also be found on the Energy Technology Assessment Center's website at www.epri.org.

Questions and Answers:

- EPRI was asked whether they had compared their assumptions and results with similar analyses conducted in European countries. Mr. James replied that several studies have been conducted in Europe; he noted that the "Global Climate Impact Abatement Map," prepared by Vattenfall and McKinsey & Company, receives a great deal of attention. The international studies have produced the same qualitative results (i.e., the need for a portfolio approach and the ability to turn the emissions curve down through the use of technology); however, the EPRI study does not include policy assumptions (other than a carbon constraint), whereas the European studies generally do include policy assumptions that foster use of renewables or other non-emitting technologies. Another key difference in the Vattenfall report is that the study does not include a cost to incentivize changes in consumer behavior (e.g., getting a builder to build a higher-cost energy efficient building; or a consumer to pay more for the energy efficient building). This leads to a "negative" cost for achieving some emissions reductions, which are then applied against costs for further reductions. EPRI disagrees with this approach, and believes that incentive programs are needed and are fairly costly. The European studies also tend to place a higher emphasis on efficiency and renewables, a lower emphasis generally on fossil fuels, a little bit less emphasis on nuclear, and a little more reliance on natural gas. Mr. James is not aware of any detailed macroecomic models developed to analyze these types of questions in the Indian or Chinese economies; though he thinks there may be a study on India underway at Stanford University's Program on Energy and Sustainable Development.

- Asked about how the CO_2 price (or avoided cost) is calculated, Mr. James replied that it is derived by the interactions within the MERGE model. There is no cap set on how high the price could go. EPRI did not make an assumption of a market structure (tax, cap and trade, etc.). The model calculates an emissions allowance value on the basis of what is most economical for any entity that must reduce emissions (either by paying for an allowance reduction by someone else or spending money for technology to reduce their emissions). Mr. James granted that this approach is fairly simplistic and leaves many questions about market dynamics and interactions unanswered. However, it served the purpose of answering EPRI's basic question: can technology be cost-effectively

implemented to turn the U.S. emissions curve down? (Or do we just need to focus on the developing world?)

- Asked about how hydrogen factored into the EPRI analysis, Mr. James replied that it largely did not factor in at all. However, EPRI does recognize that hydrogen can potentially play a very big role in the electricity sector as a storage medium. He noted that storage will be especially important for increasing grid control and the use of renewables as a power source. In addition, with a large storage capacity (on the order of 10-20%), it would be possible to decouple power generation and power consumption and better optimize overall system operation and lifetime. However, Mr. James is not aware of any analysis that quantifies this potential. Dr. Milliken noted that DOE is working on this analysis: DOE and the National Renewable Energy Lab are working with the Hydrogen Utility Group, which includes a number of utilities and an EPRI representative, to analyze the synergies between hydrogen and electricity. The group expects to issue a report in the next several months. Mr. James noted that it would be very useful if the report could provide EPRI with a cost number that can be used to represent hydrogen storage as an option within the MERGE model. Mr. Sink noted that the Nuclear Hydrogen Initiative is also evaluating ways to store large quantities of hydrogen since their technology would produce very large quantities of hydrogen.

- The emissions reductions achievable in the EPRI "full technology portfolio" may still not be enough to achieve the goals established by the IPCC or other organizations. Mr. James asserted that this underscores the need for the U.S. to greatly increase its technical capability to reduce emissions. He also noted that there will be a need to get significant emissions reductions from developing countries, and a model is needed to explore how that might happen, and the value of different options (for example, the value of spending a dollar to reduce a ton of emissions in the U.S. versus spending a dollar to diffuse technology to another country, which might have a multiplicative effect on reducing emissions over time).

- Asked about what limited the projected penetration of renewables, Mr. James replied that 70 GWe was a derived number—not one that was calculated by the model. EPRI derived the number by summing the amount of power that would be in place if all the state-level renewable portfolio standards existing as of November 2006 were implemented. It could be argued that this is a conservative approach, but EPRI engineers felt that this level of deployment was about the limit of what the grid system could absorb from a system engineering standpoint. EPRI also included a "braking factor" in the model to slow the growth rate of renewables if it got to be too fast in some scenarios.

- There was no effort to reconcile this analysis with IEA projections for oil and gas development. Mr. Hofmeister reported that the IEA forecasts spending on the order of $20 trillion in this area, and an increase in production from about 85

million barrels per day to 120 million barrels per day, which is over and above the figures shown in EPRI's analysis.

- Mr. Hofmeister noted that EPRI's projected number of nuclear and coal/CCS plant build-outs is very aggressive, considering commodity availability and price, people and skill availability, inflation adjustments to account for demand, permitting requirements, etc. Mr. James agreed. He noted that the model includes a braking factor for nuclear plant builds to curb growth as the acceleration of nuclear grew. The model did not, however, include build rate caps for different technologies based on analysis of the supply infrastructure. The model uses EPRI's most recent data (collected from surveys and industry interviews) on realistic build rates, build costs, build times, financing terms, etc. Mr. James added that while the projected build rates of 2-3 plants/year are aggressive, they are not thought to be impossible given appropriate demand and price pressure.

- Mr. Rose noted that EPRI's analysis of PHEVs shows the *net* carbon savings that would accrue from a 30% penetration of PHEVs into the light duty vehicle market. He asked why fuel cell vehicles (using hydrogen generated via electrolysis, nuclear, or distributed renewable power) were not included in EPRI's analysis, since they would have the same effect as PHEVs. Mr. James agreed that in this case fuel cell vehicles would serve the same purpose as PHEVs. Mr. Rose asked whether EPRI could include an analysis of fuel cell vehicles (FCVs) and include the results in the summary chart that shows the potential contribution of each technology to CO_2 reductions. Mr. James replied that the chart has already been widely published and he "probably won't change this chart now," but agreed that he would verbally communicate this message in his future presentations on the report. Mr. Rose pointed out that the emissions reduction contribution from FCVs could be much larger than PHEVs, since FCVs operate in a zero-emission mode and hydrogen production via nuclear or some renewables would also be non-emitting. Mr. James agreed with this assessment, noting that FCVs could make a "significant contribution" to emissions reduction.

5. ***Briefing: Nuclear Energy and Production of Hydrogen, Dan Keuter, Vice President of Planning and Innovation, Entergy Nuclear***
>>see also presentation at http://www.hydrogen.energy.gov/advisory_htac.html

Mr. Dan Keuter, HTAC member and V.P. of Planning & Innovation at Entergy Nuclear, presented an overview of nuclear energy and hydrogen production. His presentation was divided into three parts:

- Producing hydrogen from nuclear power
- Discussing common misconceptions about nuclear power.
- Building nuclear power plants today (what has changed)

Entergy is the fourth largest utility in the United States and the second largest operator of nuclear power. Entergy has identified four key drivers towards nuclear and hydrogen energy: 1) the world needs more energy; 2) the supply of oil and gas is finite; 3) environmental regulations are stricter; and 4) America needs energy security/diversity. There are three main ways to produce hydrogen from nuclear power: conventional electrolysis, high-temperature electrolysis, and thermochemical water splitting. The simplest method is low temperature, conventional electrolysis; however it is also the least efficient method (only 25% efficient, since most of the energy to split the water comes from electricity). High temperature electrolysis is projected at 50% efficiency and thermochemical water splitting is projected at greater than 50% efficiency. All of the processes produce very high purity hydrogen and oxygen (although the possibility for carry-over of small amounts of iodine and/or tritium is being explored).

Mr. Keuter reviewed R&D on high temperature electrolysis at Idaho National Laboratory (INL). Mr. Carl Sink, with DOE's Nuclear Hydrogen Initiative, provided an update on the INL progress:

- January-February 2006: tested a 25-cell stack – the stack ran for 1,000 hours with average hydrogen production of 60 liters per hour
- June-September 2006: 120-cell module developed for integrated laboratory scale experiments – ran 2,040 hours with average hydrogen production of 627 liters per hour
- September 2007: initiated operation of integrated lab scale experiment, using two 120-cell modules – the 240-cell unit ran for 420 hours, with peak hydrogen production of 2,000 liters per hour
- Planned for FY 2008: operate three 240-cell modules with target production level of 5,000 liters per hour

Thermochemical water splitting requires temperatures above 800^{o}C, which can be achieved with both nuclear and solar energy. The most promising process is the Sulfur Iodine (SI) process; research on this process is underway in the U.S., Japan, and France. Mr. Keuter reviewed the SI process and Mr. Sink provided an update on R&D:

- Bench-scale tests have been completed in Japan in glassware
- An integrated laboratory-scale experiment of the SI process is being built at the General Atomics facility in San Diego – three modules are currently operating independently in "shake down" testing. Plans for FY 2008 are to operate the three modules in an integrated fashion.

A study by Savannah River National Laboratory (SRNL) compared the economics of hydrogen production via natural gas (steam methane reforming) and the nuclear SI cycle. The SRNL analysis concluded that at natural gas prices above $6 to $8 per million BTU, the SI process is potentially a lower cost hydrogen production method (at $1.36 to $1.65/kg at the plant gate, depending on the value of the oxygen by-product from the SI process). The SI process also has the advantage of being carbon-free.

High-temperature gas nuclear reactors are being developed in the U.S. and internationally. The "Freedom Reactor™," under development by General Atomics in

the U.S. to produce hydrogen and electricity, is cooled with hydrogen instead of water. Some features of this reactor design include:

- Smaller reactor -- 288 megawatts electric
- Produces up to 200 tons of hydrogen per day per unit (with a proposed design of four units per site)
- Reactor is below ground, which is safer (dissipates heat to the ground) and more secure from terrorist threat
- Less than 3-year construction time (not including permitting and licensing time)
- Capital cost of $1,000 - $1,400/kW (based on old data for steel, concrete, labor)
- Low staffing needs
- Low decommissioning costs (does not have the same corrosion products as with a light water reactor)
- Proven technology – high-temperature gas reactors have been operating in the U.S. (Colorado), Japan and China
- Proliferation resistant – design of the fuel makes it very hard to take any of the plutonium or other products out of the fuel

EPACT 2005 authorized $1 billion for construction of a demonstration-scale "Next Generation Nuclear Plant" (NGNP) at Idaho National Laboratory. The proposed NGNP demonstration includes a reactor that produces electricity, a high temperature electrolysis demonstration, and a thermochemical water splitting demonstration, with the goals of validating the design, the capability to produce electricity and hydrogen economically, the costs of operation, and the benefits of waste production and fuel flexibility. Mr. Sink noted that the recently passed FY 2008 budget bill cut the budget for DOE's Nuclear Hydrogen Initiative (NHI) program from $22.6 million to $10 million. However, the NGNP program received a large plus-up. He surmised that these budget actions may result in even closer coordination between the two programs and more collaboration on work efforts. The NHI has been evaluating ways to produce hydrogen from all types of reactors, but the budget actions may compel the program to focus on high-temperature gas reactors.

Mr. Keuter concluded this section of his presentation by citing what he sees as three key advantages for hydrogen production from nuclear power: 1) capability for high volume, low cost production of hydrogen; 2) CO_2 emission free; and 3) stable, domestic fuel supply.

Mr. Keuter went on to describe a number of "myths and truths" about nuclear energy, including issues related to the following areas. These are described in more detail in the presentation:

- Safety
- Chernobyl
- Aging plants
- Cancer
- Terrorist targets
- Nuclear weapons
- High operating cost
- New plant cost
- Low reliability
- Environment
- Greenhouse gases
- Nuclear waste
- Waste transportation
- Renewables
- Environmental support
- Popular support

Mr. Keuter noted that there are 23 nuclear power plants under construction worldwide. He next addressed some lessons learned about building, operating, and permitting nuclear power plants. He described past and present conditions for the nuclear industry in 5 areas: 1) nuclear regulation, 2) plant design, 3) plant construction time and cost, 4) plant ownership and operations, and 5) economics. More detail on the status of these five areas, "then versus now," can be found in the presentation.

Questions and Answers:

- Mr. Keuter agreed that it could be challenging to get the personnel and expertise needed to design, build, and operate new nuclear plants, but that this problem is not unique to the nuclear industry. He asserted that many of the plant parts and components will be constructed overseas, that demand will stimulate supply in the job market, and that, in the future, less manpower will be needed to construct and operate nuclear plants.
- Mr. Keuter replied that the U.S. has known domestic reserves of uranium that would last at least 50 years. There has not been much effort to explore in the U.S. for uranium in the last 20 years, since there has been a uranium glut on the world market and more than half of the uranium used in the U.S. today comes from decommissioned nuclear weapons. The use of breeder reactors could increase uranium supply by a factor of 50 to 100. Globally, there are many thousands of years of uranium supply. Thorium can also be used in place of uranium for fuel, and there is three times more thorium in the world than uranium.
- Asked about the state of breeder reactors, Mr. Keuter stated that breeder reactors have been demonstrated in the United Sates in the Fast Flux Test Facility. There is also an international effort within the Global Nuclear Energy Partnership to build breeder reactors. The technology is there, but there has not been high enough demand for uranium to justify the cost.
- When asked why nuclear power is still in a stall, given "two to one public support and an impressive list of federal financial incentives," Mr. Keuter pointed to the lengthy regulatory process, noting that it took Entergy forty-four months to get an early site permit for a second reactor at an existing nuclear power plant. He added that the price of natural gas and other energy sources drives the economics for nuclear – at low natural gas prices, it is not economical for utilities to pursue nuclear power plants. Since 2002, when the price of natural gas has risen dramatically, there have been regulatory filings for around 30 new nuclear reactors in the U.S.
- Mr. Keuter responded to a question about the Price-Anderson Act and how the industry would react if this legislation was not in place. He noted that the federal government provides similar risk insurance for other large public projects (e.g., dams). He agreed that the industry would react negatively to the loss of Price-Anderson, even though it has been in effect for 30 years and there has never been a claim against the government-backed insurance. He explained that under Price-Anderson, the first $10 billion in damages for any claim would be paid by the utility industry. The insurance is there to cover any damages over this amount, and acts as a cap to limit the industry's liability and ensures that all damages from

a catastrophic event get paid. Mr. Keuter agreed that without this liability cap, the utility industry would not build nuclear power plants in the U.S.

- Asked about the amount of land required to build a new (greenfield) nuclear plant, Mr. Keuter responded that that amount of land required is not set by regulation, but by the company building the plant, and that it varies plant to plant. He said that the actual land requirement for a plant is about a third of a square mile; on the basis of a probabilistic risk assessment, the site boundary can be less than half a mile around the site.
- In response to a question abut the source of uranium used in the United States, Mr. Keuter replied that fifty percent comes from the decommissioning of Russian nuclear weapons with the remainder coming from Canada and Australia. Mr. Keuter noted that U.S. uranium mines have mostly been shut down because it is cheaper to get uranium from these other sources.
- Asked whether waste storage presents a barrier to siting more nuclear plants, Mr. Keuter responded that Yucca Mountain provides the technical solution for waste storage; the barrier is really political. He added that nuclear plant operators can continue storing spent fuels on site, as they have in the past, so waste storage is not a barrier for now.
- Mr. Keuter noted that skepticism from Wall Street is a barrier, at least for the first few plants. Financers are reluctant to provide financing for new nuclear plants, since there are uncertainties about permitting time, construction time, and costs. He explained that federal incentives are therefore needed for these first few plants.
- Mr. Keuter was asked about the claim that 68% of Americans "favor nuclear energy," and whether the answer would be the same if the question was "are you in favor of having a nuclear plant built in your neighborhood?" Mr. Keuter replied that survey questions like this have been asked to get at the not-in-my-backyard (NIMBY) issue, and he was surprised that people responded more favorably to a nuclear plant than to a coal plant or a refinery. He noted that if you ask this question of people living near an existing site, you will get close to 90% support for building another unit on that site. He agreed that NIMBY is an issue and that is one reason why the industry is focusing on existing sites.
- Asked about the expected length of the regulatory process, Mr. Keuter replied that:
    - It took Entergy 44 months to get the first (in many years) early site permit for a new nuclear unit (on an existing site)
    - Companies applying for early site permits since then are experiencing about a 24-month process
    - Entergy anticipates a 48-56 month process for getting the first combined construction and operating license; they expect this time period to shorten with successive licenses.

6. ***Briefing: Hydrogen Production from Coal and Carbon Dioxide Sequestration, Lowell Miller, Director, DOE Office of Sequestration, Hydrogen, and Clean Coal Fuels***
   >>see also presentation at http://www.hydrogen.energy.gov/advisory_htac.html

Mr. C. Lowell Miller, Director, Office of Sequestration, Hydrogen, and Clean Coal Fuels, Office of Fossil Energy, Department of Energy, spoke on DOE's RD&D directed towards hydrogen production from coal and carbon dioxide sequestration. He stated that the Hydrogen from Coal program budget received a large increase in 2008 (from a request for $10 million to an appropriation of $24 million), and explained that Congress had directed this funding be applied towards alternative fuels (e.g., liquid fuels from coal and biomass) as well as coal-to-hydrogen.

Mr. Miller noted that the Hydrogen from Coal Program takes its roots in DOE's RD&D aimed at developing clean power and transportation fuels from coal. He pointed out some of the findings of the National Academies 2004 report "The Hydrogen Economy," including the recognition of large U.S. coal reserves, the potential affordability of coal-based hydrogen, the need for sequestration to control coal-based carbon emissions, and the use of coal-based hydrogen as a bridge to renewable-based hydrogen. He explained that the DOE Fossil Energy program integrates and coordinates programs conducting research into producing a variety of different products from coal, including liquid and gaseous transportation fuels, hydrogen, and power. These programs include the Hydrogen Fuel Initiative, FutureGen, Gasification, Fuel Cells and Turbines, and Carbon Management and Sequestration.

Mr. Miller described the key technology pathways DOE is exploring for energy production from coal. The "central pathway" focuses on gasification of coal to produce high-purity hydrogen for fuel cell applications. The goal of the central production pathway is, by 2016, to prove the feasibility of a 60% efficient, near zero-emission coal fueled hydrogen and power cogeneration facility that reduces the cost of hydrogen by 25% compared to current coal-based technology. The "alternate production pathway" focuses on producing high-hydrogen content liquids or syngas that can utilize existing fueling infrastructure and be reformed into hydrogen. The goal of the alternate pathway is, by 2014, to make available an alternative hydrogen production pathway, including a product reforming system, for decentralized hydrogen production from high-hydrogen content liquids and/or syngas. He explained that the Program's initial guidance (based on the budget request) was to focus mostly on the central pathway and the challenges related to water-gas shift, hydrogen separation and purification, and process intensification. The additional appropriations in FY 2008 will likely result in more emphasis on the alternate fuels pathway, though the final decisions have not been made. As shown in the presentation, the budget has risen from $5 million in FY 2004 to $24 million in FY2007; currently the program is funding a total of 38 RD&D projects in 11 different areas.

Mr. Miller went on to provide an overview of CO_2 sequestration technology and DOE RD&D in the area. He related the multiple ways to manage carbon emissions: reduce carbon intensity by switching to less carbon-intensive fuels, improve energy efficiency,

or sequester the carbon. DOE's Carbon Sequestration Program has established a goal to develop fossil fuel conversion systems that offer 90% CO_2 capture with 99% storage permanence at less than 10% increase in the cost of energy services by 2012. The program is currently focused on geological (underground) storage options (depleted oil and gas reservoirs, unmineable coal seams, and saline formations). Other possibilities for CO_2 storage include conversion to solid materials, storage in biomass, or dissolution in deep oceans. Sequestration technology must be safe (no sudden CO_2 discharges), environmentally acceptable (leaving no legacy for future generations and respecting existing ecosystems), verifiable, and economically viable.

The EPA is working on an accelerated schedule for a rulemaking on underground injection of CO_2. The regulations will be issued under the Sage Drinking Water Act Underground Injection Control (UIC) Program. A Proposed Rule is expected to be issued for public comment in mid-2008, with a final rule expected by late 2010 or early 2011. Mr. Miller noted that this rulemaking process will have a big impact on what can and cannot be done with respect to underground sequestration. He emphasized that DOE is working very closely with EPA to provide the data and knowledge necessary to support the rulemaking process.

Mr. Miller described the key barriers to carbon capture and storage:

- Capture cost
- Lack of infrastructure
- Regulatory requirements
- Public acceptance
- Human capital resources.

The program is addressing these barriers in a multi-faceted approach that includes core R&D, technology/infrastructure development, government/industry partnerships, and international collaboration. The budget has grown from about $40 million in 2003 to an appropriation of approximately $120 million in 2008. The majority of program funding (48%) is directed towards seven regional partnerships that were initiated in 2003 to engage regional, state, and local governments and private industry in developing baseline data and information to support widespread deployment of sequestration technology. These partnerships, which involve more than 350 organizations in 41 states, four Canadian provinces and three Indian nations, receive 34% of their funding from industry cost share. (There is no regional partnership in the Northeast U.S. since this region does not use much coal.) The partnership program is divided into three phases: Phase One (Characterization) has been completed; Phase Two (Field Validation) is nearing completion; and Phase Three (Deployment), which will include large-scale injection tests in different geological formations, has just started with the selection of three demonstration sites. The projects involved in the Regional Carbon Sequestration Partnership (RCSP) are generating data on carbon sequestration capacity estimates in different regional geologic formations. These and other data have been compiled and published in the "Carbon Sequestration Atlas of the United States and Canada," available on-line at http://www.netl.doe.gov/. More information on the progress and status of the partnerships and associated data collection efforts is provided in Mr. Miller's presentation.

Mr. Miller listed 19 international projects that are already conducting geologic sequestration. One of the largest and oldest is a project by Statoil which has been injecting about a million tons of CO_2 per year into the Sleipner aquifer underneath the North Sea since 1996. Finally, Mr. Miller presented estimates of worldwide maximum geologic CO_2 storage capacity, which were generated by the international Carbon Sequestration Leadership Forum: 200,000 gigatons in deep saline formations, over 1,100 gigatons in depleted oil and gas fields, and just over 200 gigatons in unmineable coal seams.

Questions and Answers

- In the first phase of data collection on potential U.S. geologic sequestration sites and capacities (which began about 4 years ago), transportation distance and distance to population centers were not considered. This sort of analysis will take place in Phase Two.
- The EPA is, as part of the rulemaking process, is evaluating the potential for underground injection to result in CO_2 migration, leakage, chemical reactions, or movement of the rock formations themselves.
- Mr. Miller was unsure why, in the case of CO_2 injection in unmineable coal seams, between three and 13 molecules of CO_2 would be adsorbed for every molecule of methane released. He said that he would check into this and reply back to Dr. Saillant.
- Mr. Hofmeister noted that a key unknown in the estimated cost of sequestration is the cost of the infrastructure for transporting the CO_2 from where it is produced to where it is sequestered. Mr. Miller agreed, noting that lower-cost compression technology is one thing needed to lower the infrastructure costs. He stated that some of these issues and proposed solutions are discussed in the Carbon Sequestration Atlas.
- Mr. Miller noted that a small amount of R&D, directed towards the area of "breakthrough concepts," is being conducted on innovative ways to use or store the CO_2 (e.g., through algal production, conversion to solids, etc.).
- Mr. Miller stated that incidents at projects storing CO_2 in saline aquifers have led some to conclude that this may not be an acceptable storage method for the long term. However, he noted that "long-term acceptability" is hard to gauge when you are talking about geologic storage and geologic timeframes. He also noted that there are numerous projects around the world using underground CO_2 injection and storage for enhanced oil recovery, and he does not know of any incidents that have occurred at these projects.
- China and India have not been active in the area of carbon sequestration. China has begun to look at sequestration in association with their direct liquefaction facility. International pressure is on both countries to begin work on the issues.
- Issues surrounding legal liability for CO_2 sequestration are a major barrier to deployment. Mr. Hofmeister asserted that the government needs to address this at the front end. Mr. Miller noted that this is one of the main topics being addressed by the international Carbon Sequestration Leadership Forum, which includes 21 nations plus the European Union.

- Dr. Lloyd expressed doubt about whether it is realistic to assume that sequestration technology can be deployed on a large scale by the end of the decade. Mr. Miller replied that it would depend largely on what happens with the regulations. Even so, Dr. Lloyd explained, siting (including NIMBY), liability issues, cost, and other barriers will be very difficult to overcome.
- Mr. Miller acknowledged that the Carbon Sequestration Program and the Hydrogen from Coal Program receives some "top-down political direction" on down-selecting technologies.
- Dr. Dresselhaus, in her role as Chairman of the Board of the American Institute of Physics, explained that she has spoken with members of the Geophysical Union about carbon capture and sequestration. They have given her negative feedback on the potential for geological carbon sequestration. Mr. Miller reminded the Committee that geological sequestration is a major experimental R&D program that is only seven years old; the program is "just getting started on addressing the issues that are associated with this particular technology."

7. ***Closing Remarks for December 18, 2007***

Dr. Lloyd described the Committee's charge at the working dinner on the evening of December 18. He asked the Committee members to consider their top five objectives for HTAC and come prepared to discuss these in small groups during dinner. The topic of future goals and work plan for HTAC will then be taken up on the public agenda during the December 19 meeting of the Committee. Dr. Shaw asked if the prospective activities of the Committee are constrained by language in the 2005 Energy Policy Act—that is, can the Committee be proactive and come in with ideas and thoughts on how to move the hydrogen story along? Dr. Milliken replied that she thinks the HTAC can play a big role in moving the hydrogen story along, and that they might consider working with outside organizations with a mission in this area, such as the National Hydrogen Association, to leverage their efforts. She noted that DOE General Counsel may need to be consulted about specific activities proposed by the HTAC.

Dr. Roger Saillant questioned the effectiveness of HTAC in making a noticeable impact on national progress or policy on hydrogen. Dr. Shaw concurred, and expressed concern about the limited time on the December 19 HTAC agenda for discussing the future goals, strategy, and work plan for the Committee. He urged the Committee towards taking some concrete actions that will have an impact. Dr. Lloyd asked Mr. Rose for his impressions. Mr. Rose replied that HTAC is congressionally charged, and, as such, will continue to have a role in influencing national policy. He agreed with the frustration on the pace of activity and level of visibility. He suggested that the Committee focus more on crafting specific messages and taking these to Capitol Hill and the larger community. Mr. John Hofmeister commented that agitating on the subject of the policy formation is a very important role of the HTAC. He explained that "the science will be whatever the science will be and the pathways will emerge." He believes that what is mostly missing is an informed discussion on what it would take to get meaningful public policy passed through Congress. He urged the Committee to become more knowledgeable about what

policies might be sensible, realistic, and manageable, and then find ways to convey this to the right "thought leaders" as legislation is proposed or created.

Dr. Geri Richmond again raised the subject of the December 19 HTAC meeting agenda, and asked whether the agenda could be modified to allow more time for the Committee to discuss its future goals and work plan. After some discussion, it was agreed that the agenda would be modified to allow the HTAC to discuss the work plan from 8:00 to 10:15am, with postponement of the briefing on government research on climate change and carbon dioxide emissions to later in the day (the final agenda, as revised, is posted to http://www.hydrogen.energy.gov/htac_meetings.html. In response to questions about how the agenda for the HTAC is set, Dr. Milliken noted that the HTAC sets the agenda, not DOE. She requested feedback from all the Committee members on the draft agendas for future meetings, in an effort to avoid the need to make last-minute schedule changes. Dr. Richmond suggested that the future agendas include more flexibility on the second day—more time for open discussion. Dr. Millie Dresselhaus asked if it would be possible to start each HTAC meeting with a review of the agenda and an invitation for HTAC members to suggest changes. Dr. Lloyd pointed out that this would be logistically difficult, since many of the briefings are given by people who are flying in or may have other time commitments.

The December 18 meeting was adjourned at 6:04 p.m.

DECEMBER 19, 2007

1. *Opening Comments*

Chairman Lloyd called the December 19 meeting to order at 8:07 am EST. Mr. Rose asked how a quorum is established for HTAC meetings and whether a record of meeting attendance is kept. Ms. Kathi Epping replied that attendance records are kept, and that a record of attendance at each meeting is included as an attachment to the meeting minutes. She agreed to send the HTAC a compiled attendance record for all the HTAC meetings to date. Dr. Lloyd asked if the Hydrogen and Fuel Cell Interagency Task Force (ITF) meetings are public and whether comments made at the ITF meetings can be quoted. Dr. Milliken responded that the ITF meetings are not currently public, though that possibility could be considered. Dr. Lloyd asked whether the HTAC report on the ITF meeting (made during the December 18 HTAC meeting) would be part of the public record; Dr. Milliken replied that it would. Dr. Milliken reminded the Committee that someone from the DOE General Counsel's office would brief them during lunch about conflict of interest and other matters concerning the rules for Federal Advisory Committees.

2. *Discussion of HTAC Goals and Work Plan for 2008 and Beyond*

The Committee began by reviewing the results of the small group discussions held during the working dinner on December 18. A summary of each group's discussion was prepared and is reproduced below.

Group #1: Bob Rose, Larry Bawden, and Art Katsaros

- Help convince the Secretary of Energy to be an active advocate for hydrogen.
- Educate the transition team in 2008/2009 (prepare white paper, etc.).
- Recommend methods for how to make Federal procurements of hydrogen and fuel cells a priority.
- Refresh the case for hydrogen: clearly define the reasons for making hydrogen a strategic national priority.
- Benchmark the progress of the U.S. against other countries in terms of renewable energy and hydrogen as part of a renewable energy strategy.

Group #2: Alan Lloyd, John Hofmeister, Mark Chernoby, Dan Keuter, Ian Purtle, John Bresland, and Rand Napoli

Develop a vision of the end state (e.g., a hydrogen-electric future in 2050) and the migration plan for getting there, including the foundational building blocks that are needed:

- Incremental technology steps and technology portfolio
- Incentives and policies
- Education
- Codes and standards

  - Workforce development
  - Budget

Group #3: Millie Dresselhaus, Geri Richmond, Roger Saillant, Bob Shaw, Kathy Taylor, and Greg Vesey

- Develop a clear vision for what, *specifically*, can/should be achieved over the next ten years in hydrogen and fuel cell technology, and what the end state should be:
  - 1-3 years:
  - 3-7 years:
  - 7-10 years:
  - Vision of end-state:

Other Suggestions

- Hold some HTAC meetings at venues that enable side trips to visit technology installations or research facilities.
- Consider ways that HTAC can influence the Federal budget process.
- Expand vision to include the bigger energy picture and how hydrogen fits into it.
- Consider messages that convey the need for consumer behaviors and values that support sustainability.

Mr. Rose pointed out that DOE will almost certainly have a new Secretary of Energy in 2009, and that regardless of party there will be a transition to a new administration. Group #1 suggested preparing for educating the "transition team." The group also would like to explore concrete ways to make the procurement of hydrogen and fuel cells a strategic necessity for the nation, and not a simple financial transaction. This will require "refreshing" the strategic case for hydrogen. The group also saw value in benchmarking U.S. programs and progress against the activities of other countries. Germany, which has a successful electricity regulatory scheme, and Japan, which has set strong national procurement goals, were cited as examples.

Mr. Rose offered another potential activity for consideration: the Committee could prepare and publish a series of "technology letters," which would be short in length but high in content, on as many topics as appropriate. These technology letters could be numbered and published as an information series.

Dr. Shaw said that he had a similar idea, which was for the HTAC to produce something like an annual "state of hydrogen technology report" to update the government and the broader audience on the Committee's impression of progress made toward a hydrogen economy and any outstanding issues. This would provide a regular, publicly anticipated deliverable from the Committee that could communicate some key messages, and provide opportunities for press releases, briefings to Congress, etc. He suggested that the report should be brief, 20 pages maximum, with key topic sentences and bullet points.

Dr. Saillant remarked that it would be worthwhile for the HTAC to try to put hydrogen in the context of a broader energy strategy for the country. He urged the Committee to

consider the energy issue systemically, and communicate how hydrogen can grow from "a sliver to a wedge" of the overall "energy pie." He endorsed the idea of producing a product that would help people attach themselves to hydrogen in whatever area they happen to be. Mr. Katsaros commented that these sorts of ideas were what Group #1 talked about under the banner of "refresh the case for hydrogen"—providing the case for hydrogen within the context of the overall energy strategy to give people a hook to grab onto concerning its importance. Mr. Katsaros also stressed the importance of meeting with Congress to communicate meaningful messages and urged the Committee to make a concerted effort to meet with/appear before the key congressional committees that are going to influence legislation.

Dr. Lloyd asked Dr. Milliken whether there was likely to be any near-term action from DOE on the Committee's recommendation for a DOE report that puts hydrogen in the context of an overall energy strategy. Dr. Milliken replied that DOE does intend to address this recommendation, but that it would take some time. Asked about the possible timeframe for this action, Dr. Milliken replied that it would require discussion and direction from DOE management, and that she could not say when such an activity would be completed. Dr. Milliken agreed to report back to the Committee on DOE's progress in addressing this recommendation. Mr. Katsaros stated that HTAC did not have to wait for DOE: the Committee could go forward and articulate its vision of how hydrogen fits in to an overall energy strategy for the nation. Dr. Milliken noted that the Hydrogen Program has identified synergies and linkages between hydrogen and the other technologies in the DOE portfolio, including plug-in hybrids and biomass programs. She stated that, if desired, DOE could assemble and share this information with the HTAC.

Dr. Lloyd reported on the discussion of Group #2 during the HTAC working dinner on December 18. He noted that there were common themes among the groups. Group 2 suggested that HTAC start by developing a vision of a future that includes hydrogen as an energy carrier, and then lay out the foundational building blocks and incremental steps as a "migration pathway" for getting there. The product should describe what is necessary to make this an attractive value proposition for all parties. Dr. Lloyd referred the Committee to informal notes from the working dinner, which captured some of the additional discussion items. He mentioned that the group believes strong policies and incentives will be needed. One suggestion was for a Federal policy that would establish priority national marketplaces for hydrogen infrastructure and fuel cell vehicle roll-outs, so that early fuel cell infrastructure and vehicle marketing can be concentrated in a few key locations rather than diluted by numerous state-led initiatives. Dr. Lloyd also drew attention to the group's suggestion to hold one or more HTAC meetings at locations that enable site trips to technology installations and research facilities. Mr. Purtle added his support for creating some sort of framework to which people can relate. Dr. Richmond agreed, but argued for flexibility in the definition since there are unanticipated technological and scientific advances that will come into play. To put the magnitude of the challenge into perspective, Dr. Lloyd asked Mr. Hofmeister about the quantity of oil demanded by today's infrastructure. Mr. Hofmeister replied that the fueling infrastructure in the U.S. currently demands 10,000 gallons of crude oil per second (21 million barrels per day).

Dr. Kathleen Taylor reported on the recommendations of Group #3. She noted that the group's overall recommendation was very similar to Group 2, but that they would like to see the pathway laid out in three timeframes, e.g., 1-3 years, 3-7 years, and 7-10 years. What does each time period look like and what do we have to do to get there? She noted that it would be expedient to start with what can/should be accomplished in the next one to three years as part of a recommended national action plan. Dr. Saillant argued for longer timeframes: e.g., 1-5 years, 5-10 years, and 10-20 years. Dr. Shaw commented that there is a common theme for a definition of an end state or vision, and what we have to do to get there. He suggested that HTAC develop the vision and lay out a timeline and the type of milestones or initiatives that have to be accomplished, and then periodically report on progress towards the milestones as a kind of ongoing mission of the HTAC. Dr. Richmond supported the idea of defining "benchmarks" or milestones for each of the timeframes. Dr. Shaw made reference to a past advisory group, the President's Science Advisory Committee (PSAC), and noted that PSAC became a very powerful force for driving science initiatives within the Eisenhower administration. He speculated that if HTAC could emulate PSAC, the Committee could accomplish a lot.

Dr. Richmond asked the Committee members for feedback on particular benchmarks or milestones for the near term (one to five year) timeframe. Dr. Shaw responded that he thinks it is important to push very hard for going to market, even at a limited scale, with what we know how to do now. He noted that on the vehicle side, Honda and GM seem to be doing that. If Honda puts 100 vehicles in Los Angeles next year, this will help people understand that (1) it is doable (2) it is safe and (3) very nice and well-performing cars can be produced using this technology. Mr. Purtle agreed, and added that by getting fuel cells into a diverse range of products in portable, stationary, and vehicle applications, people will become comfortable with the technology.

Mr. Hofmeister remarked that, over time, he has concluded the free market does not really operate "freely," and that in the case of the energy sector, it is one of the least free markets that exist. Many factors enter into the process of getting an energy product to the ultimate consumer, most of which are not market driven (e.g., regulation, policy, politics, embedded infrastructure). He asserted that if we approach the transport marketplace for hydrogen fuel cell refueling as a ubiquitous nationwide market, we will never get there. He suggested that the infrastructure build-out needs to focus on pilot markets in certain parts of the country in order to effectively test, verify, and build the infrastructure. While certain niche fuel cell products may be readily accepted by the market, Mr. Hofmeister believes the majority of hydrogen and fuel cell products will require some form of government support or intervention, at the Federal, state, and local levels. The education of potential consumers is also an important near-term priority. Mr. Hofmeister concluded by suggesting that the Committee "painstakingly draw out the lines of work that would be needed to achieve the endgame," whether the endgame is five, ten, or fifty years from now. He thinks this effort would take some time—one or two years—but that it would serve the administration extremely well.

Dr. Saillant contended that the Committee needs to consider how to influence policy makers, because he is unsure if everyone means the same thing when they refer to "policy." He asserted that it is important to "intercept" the two leading candidates (and/or their staff) before they get "entrenched in their thinking," in order to improve their understanding. There is a need to balance what is doable from an economic or practical point of view (in whatever timeframe) with the need for research funding that is aimed at achieving long-term, stretch goals. Dr. Saillant conveyed his belief that reducing the profile of consumption is critical. Efficiency, conservation, and reducing consumption per capita should be portrayed and accepted as virtues, rather than as something painful or unattractive, and the Committee should communicate this message in its zero to five year timeframe. Dr. Saillant would also like to see the Committee communicate the notion that there are/will be a mosaic of options for addressing the energy dilemma, and outline how hydrogen can grow from a "sliver, to a quadrant, to a fundamental platform" in this mosaic. Finally, he urged the Committee to consider advocating for the appropriation of funds against the $150 or $160 million that has been authorized to enable larger-scale purchases of fuel cells and hydrogen infrastructure.

Congressman Walker expressed his support for a "state of the hydrogen industry" report. He believes this would be a valuable tool for communicating key messages to policy makers and politicians. He noted that politicians and the media love numbers, so if the state of the industry report can include some kind of index that shows progress in a measurable, meaningful way, this technology could get a lot of attention. Those in Congress who sit on the Appropriations Committee have to be convinced that this report is a fundamental priority; at the present time, Congressman Walker believes they are not convinced because they see hydrogen and fuel cells as only having an impact in the long term. The funding priorities are focused on solar and ethanol because many in Congress see these technologies as here and now, and that investments in hydrogen will not pay off until much later (and therefore can be delayed). He urged the HTAC to communicate to these key members of Congress that there are hydrogen and fuel cell technologies that can be funded right now that can really make an impact on the energy equation.

Dr. Shaw concurred, and stated that this was why he made his earlier comment about the need for getting an array of products in use, even if they are not totally perfect, so that people can "touch and feel." He reminded the Committee about how Secretary Bodman's opinion on hydrogen was changed when he went to GM and actually saw for himself what was possible today.

Mr. Rose asked for clarification on the Committee's goal for the current discussion: is the purpose to define what the Committee will achieve in one to three years, or what should be achieved in the broader community? He noted that so far, the discussion had largely focused on the former. Mr. Bawden suggested that it is really a combination of the two: the Committee should establish milestones or goals for what should be achieved (e.g., 50,000 fuel cell systems in the market in the next three years), and then communicate and facilitate what needs to be done to make that happen. Mr. Rose expressed his support for Congressman Walker's suggestion to communicate what is here and now to Congress, and asked whether his presentation to the Interagency Task Force

on the fuel cell products that are available today could be appended to the HTAC meeting minutes. The U.S. Fuel Cell Council maintains a list of commercial products, and periodically conducts a survey of jobs, R&D spending and turnover in the industry. Mr. Rose noted that the idea of an index is good, but he knows from personal experience that constructing such an index is much harder than it sounds.

Mr. Hofmeister believes the Committee should adopt a position on what kind of carbon constraints the U.S. economy will operate under. He feels that one of the key drivers of hydrogen as a fuel source is its ability to play into a carbon-constrained world, where it can displace carbon-based fuels such as oil, gas, coal, etc.

Dr. Milliken appealed to the Committee to provide some specifics on the "how" as well as the "what." She said that the suggestion to "push hard to market" needs more detail. She explained that specificity—for example, Mr. Hofmeister's suggestion to focus on segmented pilot markets—will help DOE to implement the Committee's recommendations.

Dr. Lloyd amplified on Mr. Hofmeister's comment on the need to consider hydrogen in the context of policy-driven carbon constraints. In Dr. Lloyd's opinion, hydrogen has not effectively inserted itself into the carbon management picture, and does not come up often enough in discussions about what can be done to address climate change. He proposed that HTAC's "state of the industry" report make clear hydrogen's role in reducing greenhouse gas emissions, including both the power generation and transportation sectors. Congressman Walker concurred, and noted that HTAC's role as an official government committee gives the members an opportunity to have an impact by communicating a clear message about why hydrogen is important and why it needs to be a national priority today rather than in the distant future.

Dr. Saillant suggested that the Committee choose a particular carbon goal, e.g., 550 parts per million, and describe what hydrogen's role (as part of the overall energy system) could be in achieving that target, and what would be required to get there. Congressman Walker questioned whether the Committee should base its argument for hydrogen on carbon reduction, since the politics surrounding this issue may change. He asserted that the supply side of the argument will be most important for policymakers—that the real need in the 21st century is for more energy resources. Energy supply is where hydrogen can contribute, while also helping to reduce carbon emissions, etc. Mr. Hofmeister agreed with both points, but asserted that HTAC support for a carbon constraint goal is a very important "stake in the ground" because currently we do not know how to achieve that goal. He noted that the Committee could deliver a lot of numbers that show the gap that has to be closed to reach the 550 ppm carbon constraint goal and the BTU displacement that hydrogen could provide from non-carbon fuel sources. Dr. Richmond asked if Congressman Walker was implying that conservation should not be part of the HTAC's message. Congressman Walker clarified that he agrees that conservation needs to be part of the message, since it can play a huge role in bringing down the projections for energy consumption.

Dr. Shaw noted that the Intergovernmental Panel on Climate Change (IPCC) has reported that in order to stay below 550 ppm and accommodate expected growth around the world, particularly in developing nations, 17 terawatts (TW) of green (noncarbon-producing) energy sources would need to be installed by 2050. Today there are about 11 or 12 TW of energy of all types. Meeting a 17 TW goal would require installing about one gigawatt per day between now and 2050. One way to frame the index would be to measure how we are doing against meeting this 17 TW goal. While the 17 TW number seems daunting, Dr. Shaw believes this goal can be met if the will is there. Dr. Lloyd reminded the Committee that 550 ppm is a global number, and that the ability to meet this goal will be dominated by what happens in the developing world.

Mr. Rose interjected to provide a strawman summary of proposed priorities for the Committee over the next three years, based on his notes from the Committee's discussion:

1) Document the case for hydrogen as a preferred energy choice in a carbon-constrained market
2) Assure robust funding for currently authorized programs
3) Develop publicly accessible measures of the status and progress of the transition
4) Provide adequate, affordable hydrogen to emerging markets (with focus on the passenger vehicle market in California and New York)
5) Educate the next Secretary of Energy
6) Review and revise the DOE pathway analysis

HTAC Co-Chairman Walker asked for a show of hands on establishing a Committee action to produce an annual report on the state of the industry. Seeing consensus by the show of hands, the action to produce an annual report on the state of the industry was accepted by the Committee. Congressman Walker observed that many of the points brought out in today's discussion could be included in the report. He suggested that the Committee provide input on what should be included and then engage in honing the report into its final shape.

Dr. Richmond conveyed her impression that a number of the Committee members did not want a lengthy report on the state of the industry, but rather a one- or two-pager. She suggested that the report be produced as a handout that is easy to read and understand, and can be readily modified with updated information and key messages. Congressman Walker agreed, and distributed a booklet produced by the Hydrogen Advisory Council as an example of such a product (see the "Hydrogen Handbook" at http://www.hydrogen.energy.gov/htac_meeting_dec07.html). Congressman Walker pointed out that the diversity of opinions on the Committee may make producing a "one or two pager" difficult, and Dr. Richmond agreed that discipline would be necessary. Dr. Shaw proposed a maximum of 20 pages as a goal for the report (with three to four pages perhaps being ideal), with liberal use of bullet points and graphics.

Congressman Walker went on to ask the Committee members if they want to develop an index—"some kind of measurement of where we are with regard to either hydrogen as a part of the overall energy solution or some kind of an index that gives people a chance to

view hydrogen in the context of other energy alternatives." Dr. Shaw asked to amend the suggested action to: "begin by thinking about how one might construct such an index…what would you want to measure as a first step, and so on?" Congressman Walker asked for a show of hands on whether the Committee members would like to attempt to create a hydrogen index. Congressman Walker stated that two-thirds of the Committee members raised hands in favor—he observed that this was not complete consensus, but was enough to go forward with the action. He suggested that a subcommittee begin working on ideas for an index and bring these ideas back to the full Committee for consideration and a decision on whether or not to continue on this action.

Congressman Walker noted that the next "Biennial Report to Congress from the Secretary of Energy" (a report on the Committee's recommendations) is not due for another two years. He asked if the HTAC would want to make a report to the Secretary each year, even in years that the Secretary is not required to formally respond. Dr. Shaw recommended that this be accomplished through the annual state of the industry report. He contended that the state of the industry report would be a big task in itself; thus, he suggested that the HTAC could address anything critical that arises between reports with a letter to the Secretary.

Dr. Shaw encouraged more communication among HTAC members in between HTAC meetings, and suggested two things to facilitate discussion. First, a blog that could be used by the Committee members, and second, an "executive committee" comprised of six or so HTAC members who could put in time in between meetings to work ideas and issues raised at the HTAC meetings and provide some continuity. He also proposed that each HTAC member take it upon him or herself to prepare and send bullets on any important happenings in the hydrogen arena each month—resulting in a record of progress each year. DOE responded that the HTAC members can post items like this to the HTAC collaborative website, which has already been established.

Mr. Rose repeated his proposal for the HTAC to produce a series of "technical letters," since the Committee appeared to be expressing some concern about whether they have the time and resources to produce an annual state of the industry report. An advantage of the technical letters is that they can be written to address issues as they come along, and form a credible series over time. Mr. Rose suggested that subjects for the letters could be things like how the U.S. is stacking up against foreign activity, etc., which could inform the policy debate.

Congressman Walker asked for comments. Hearing none, he suggested that the Committee move forward on the agreed-upon actions to produce a state of the industry report and an index. He advised the Committee to spend some time providing the staff with specific guidance on what should be included in the state of the industry report. Mr. Hofmeister suggested that the HTAC define the key chapters or key paragraphs that would be regularly reported on. He noted that the Committee seems to agree on key "chunks of work," eg., education of the public and special interest groups, safety and security, rule writing and regulation, supply, storage, delivery infrastructure, commercialization, connecting with decision makers.

The group proceeded to discuss guidelines and specific suggestions for the state of the industry report; the suggestions are summarized below.

- Form a subcommittee to work on drafting the report, with the help of support staff.
- Make the report a driver for progress, not just a report on progress—the report should look forward as well as back.
- Report on major accomplishments of the research community, and how many people are involved in research, etc., as benchmarks of scientific activity.
- Determine and communicate what is meant by the "industry"—fuel cells of all kinds or just fuel cells that use hydrogen? All hydrogen or just hydrogen produced for fuel?
- Communicate the different sources for hydrogen, and the quantity of hydrogen that could be available from each.

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Mr. Keuter reopened the subject of defining an HTAC vision for hydrogen and fuel cells. He asserted that communicating this vision to the administration and Congress should be a major role of the Committee and would be helpful for describing the end-state goal(s). Even a simple vision could be useful (e.g., "the U.S. should aggressively pursue a hydrogen-based economy to address global warming, energy security, and the need for additional energy…"). Dr. Richmond agreed, and stated that she assumed that the purpose of this HTAC discussion session was to develop ideas for that vision and to make decisions about priorities. Mr. Hofmeister agreed with the suggestion to create a vision, saying that the annual state of the industry report should show progress towards that vision, but he noted that it could take a number of iterative steps, and additional information, to develop the vision. He suggested that Mr. Keuter's December 18 presentation to the Committee on nuclear hydrogen production should be an essential part of the vision. Mr. Hofmeister suggested that the auto companies could inform the HTAC about what the demand for hydrogen might look like over the next 20-30 years, based on their expectations of fleet conversion and turnover. The energy companies could reflect on what kind of hydrocarbon-supplied hydrogen might be available, and the nuclear and renewable representatives could address non-hydrocarbon hydrogen availability.

After some discussion by the Committee, the following vision was developed as a draft:

> Hydrogen will become a ubiquitous energy carrier, substituting for carbon-based fuels wherever possible. Hydrogen will be produced in a number of ways, with the lowest possible carbon impact. In time, hydrogen will become the most economically competitive carrier to meet the needs of the planet. To realize this vision, we must aggressively introduce to the market the hydrogen-based technologies that are available now. HTAC's role is to develop the nation's hydrogen business plan, taking into account the technical, political, social, cultural, and commercial realities of the transition.

In the process of developing the draft vision statement, the Committee discussed a number of points that may serve as guidance in developing the final vision statement, as well as the strategy and objectives.

- Use metrics, such as:
    - Amount of hydrogen produced by non-carbon sources
    - Growth of the fuel cell industry
    - Number of people trained in hydrogen
    - Amount of oil and natural gas displaced by hydrogen
    - Amount of carbon displaced by hydrogen

- Develop a hydrogen index
    - A single number or set of numbers that simplifies conversations with media and congress
    - Serves as a numerical representation of the state of the hydrogen economy
    - Most likely includes aspects from DOE's targets and the metrics identified above

- Consider points from Dan Keuter's presentation on Nuclear Energy and the Production of Hydrogen, and possible metrics:
    - The world needs more energy (metric: quantity of hydrogen produced)
    - Supply of oil and natural gas is finite (metric: quantity of oil and gas displaced by hydrogen)
    - Environmental regulations are getting stricter (metric: quantity of carbon emissions displaced by hydrogen)
    - America needs better energy diversity / security (metric: reduction of trade deficit)
- Define the 2020, 2030, 2040 and 2050 vision of where we'll be along the pathway to a hydrogen economy, and the steps needed, beginning in 2009, to achieve a 2020 reality, a 2030 reality, and so on. This vision would constitute a "business plan for the nation."
- Describe a clear, quantitative set of actions
- Make clear that electricity and hydrogen are complementary
- Stress the need for the Government to enable the growth of hydrogen, since it will always be competing against lower cost conventional fuels
- Include conservation/efficiency in the message
- Be measurable, specific, and "aspirational."

The Committee summed up its discussion of what HTAC should accomplish over the next 3 years:

- Push hard for going to market in the near term, even at a limited scale
- Develop a brief annual report on the state of the industry
- Consider developing an index of hydrogen's progress towards the goal (BTU displacement of carbon fuel?)
- Develop a Vision Statement

The Committee agreed to form two subcommittees, with the following responsibilities:

- **Subcommittee on Policy and Planning:** draft the vision statement, strategy and objectives; draft the annual report on the state of the industry; and develop ideas for a hydrogen index.
- **Executive Subcommittee**: engage with the Secretary of Energy and members of Congress and their staff; plan and conduct site visits to industry; and prepare HTAC meeting agendas.

Dr. Richmond suggested that the next one or two HTAC meeting agendas could be devoted to presentations on different ideas for the vision statement and strategy/milestones for getting there, broken down by time period (2010, 2020, 2030…). She proposed that the HTAC select the presenters (perhaps from energy, automotive, nuclear, etc.) and develop a common format for the presentations so that they could be easily compared.

Dr. Saillant urged the HTAC to make an effort over the next few months to meet with the presidential candidates and/or their staff. One of these people will be selecting the new Secretary of Energy, and it would be beneficial to start influencing their thinking.

3. ***Briefing: Liability Issues and Options for Transitional Coverage, Representatives from AIG, Air Products, and Marsh Insurance***
   >>see also presentations at http://www.hydrogen.energy.gov/advisory_htac.html

AIG Global Marine and Energy

David Reisinger, Assistant Vice President of AIG Global Marine and Energy, Alternative Energy Practice; Thomas Bello, National Accounts Underwriting Manager, AIG Global Energy Casualty; Duncan Karcher, Senior Vice President, Business Development, AIG Consultants, Inc.; and Robert Paulukiewicz, CSP, Technical Services Manager, AIG Global Marine and Energy, AIG Consultants, Inc.

Mr. Reisinger provided an overview of issues related to liability coverage for hydrogen vehicles and infrastructure. Within this discussion, he reviewed key areas of risk. For hydrogen fuel vehicles, areas of risk are associated with the operator, fuel storage, and vehicle storage. For hydrogen refueling infrastructure, risk areas include the hydrogen generation unit, transport equipment, high-pressure operation, storage, dispensing equipment, and station design and operation. More details on these risk areas is included in the presentation.

The risk areas can be mitigated in the following ways (Mr. Reisinger explained that these measures are not required by the insurance industry, but are offered as potential ways to lower risk):

- Driver training and/or certification (including safe driving and refueling and emergency procedures)
- Leak sensors (in vehicles, garages, storage tanks, and fueling stations)
- Odorants

- Vehicle tank protection/pressure release mechanisms
- Positive crash test results
- Appropriate fire protection and security measures
- Use of trained station attendants to dispense the hydrogen
- Risk assessment completed for the site that identifies and addresses known risks
- Operation and safety plans
- Emergency response planning and training
- Adherence to standard fire and building codes (as they become available and adopted)

Another way to mitigate risk is to educate the insurance industry about hydrogen and fuel cell vehicles. Mr. Reisinger suggested several avenues for education, including making presentations at insurance industry association conferences; conducting insurance representative "open houses" at operating refueling facilities; and distributing information via websites, fact sheets, seminars, and insurance trade publications. Open houses are a common practice for insurance company representatives, and are a good way to showcase equipment, operating and maintenance practices, safety plans, etc.

Mr. Reisinger noted that the biggest factor right now causing high fuel cell vehicle insurance premiums is the high cost of the vehicles themselves. Underwriters are more unfamiliar with the refueling station technologies, especially in cases that include both the fueling station risks and the "industrial" risks associated with a hydrogen generation unit. He stated that there are no inherent risks that the insurance industry could not accommodate, although the cost of the premiums for hydrogen fueling stations will, at least initially, be higher than a conventional gas station.

Dr. Shaw asked whether AIG compares relative risks of emerging new technologies that can help mitigate climate change to the risks that could arise from climate change and adverse weather events. Mr. Reisinger replied that these relative risks would not impact the availability or cost of liability coverage for a particular hydrogen installation, unless that site was located in an at-risk area (e.g., right on the coast).

Air Products and Chemicals, Inc. (APCi)/Marsh Insurance

Edward Kiczek, Hydrogen Energy Systems Group, APCi; John Lafferty, Insurance and Risk Manager, APCi; Ann Padjen, Corporate and Finance Counsel, APCi; and Drew Eddy, Managing Director for Marsh Insurance Companies

Mr. Kiczek spoke about Air Product's experience with developing hydrogen fueling stations, and issues associated with liability and permitting. Air Products is the largest merchant producer of hydrogen in the world, with more than 50% of the market. The company has built more than 75 hydrogen fueling stations since 1993 and is approaching 50,000 fuelings in more than 14 countries. They have a range of experience with different station delivery designs, including energy park designs, low-pressure and high-pressure fueling, on-site hydrogen generation, and bulk delivered gas or liquid fuel.

Mr. Kiczek emphasized that it currently takes far too long to contract a hydrogen fueling station – typically two to three years from project start to finish. Air Products believes this time could be shortened to six months, thereby saving significant costs. The lengthy project development time not only adds to costs, but slows station deployment, causing loss of momentum in developing the hydrogen economy. It is important to keep in mind that right now these hydrogen stations are not "commercial," in the sense that they are not making a profit like gasoline stations do (since the stations are underutilized), and in the sense that the technology is still developmental and there are uncertainties. Consequently, negotiations concerning liabilities, indemnifications, and warranties can become lengthy and complex. Mr. Kiczek asserted that the high cost of liability coverage can be a showstopper for some stations. He cited several examples of stations built under demonstration programs that need to transition to government (e.g., state or city) or private ownership. These stations may be forced to shut down because no one can afford to take them on as independent owner-operators. While insurance coverage may be available, it is not affordable. Mr. Kiczek also stressed the need for continuing efforts to develop finalized codes and standards.

Mr. Eddy began by explaining that Marsh Insurance, as an insurance broker, works with hundreds of insurance companies around the world to find the best carriers for their clients. He was asked by Air Products to look for insurance providers that would serve independent owners of hydrogen fueling stations. He has determined that the marketplace is highly fragmented, with no single insurance company doing any volume of these policies (although Nationwide has some volume). The insurance industry is often conservative, waiting to follow other companies into a new area. The small number of fueling stations from, which to gather safety data, makes premiums hard to set. Also, there are few reinsurers, which is one mechanism the insurance industry uses to spread risk among different organizations.

Mr. Eddy summed up by explaining the three factors that make a risk insurable:

- *Large numbers:* enough units (policyholders) to achieve a critical mass
- *Predictability of losses:* enough historical/empirical data for financial modeling
- *Ability to spread risk:* existence of a reinsurance market that will purchase the policies from the primary insurers and limit their risk exposure (currently most reinsurers exclude hydrogen fueling station policies from their portfolios because it is new technology)

Congressman Walker asked whether this situation points to a different business model for hydrogen fueling stations – perhaps one that moves away from the independent owner-operator model to one where large corporations take it on (e.g., Wal-Mart). Mr. Eddy agreed that some of the bigger companies can absorb a lot of risk under their own insurance funds, and can just buy catastrophic coverage. Mr. Kizcek commented that Air Products has done business with Wal-Mart and he believes that while they may be interested in doing a few pilot projects, they will not put out the kind of infrastructure that the transition to hydrogen needs.

Mr. Lafferty emphasized the need for government intervention with respect to reasonably priced insurance for an independent hydrogen fuel station owner. He stressed that a precedent exists for government assistance with insurance. He explained that the typical fueling station owner is, in general, an unsophisticated purchaser of insurance, lacking in financial wherewithal, and, in the case of hydrogen, lacking a current profit stream to offset insurance costs. The typical gasoline station owner buys very modest limits of insurance and owns between one and five stations.

Mr. Lafferty suggested that the government should provide near-term owner-operators with a combination of insurance premium rebates and a reinsurance "backstop" (a limit to liability for catastrophic losses, similar to what is provided to the nuclear industry through the Price-Anderson Act). He asserted that a premium rebate may be more important in the hydrogen transition, because it would provide direct relief to the fueling station owner, and it would allow the insurance industry to work out competitive pricing levels. Dr. Milliken asked if there was a precedent for the premium rebate or for state incentives to lower liability costs. Mr. Lafferty stated that he did not know of a precedent for government-issued premium rebates in the area of insurance, nor did he know of any state programs to lower private liability costs. Congressman Walker asked Mr. Lafferty to estimate how long this type of support would be needed; he replied that it would be needed until the stations began making a profit.

Mr. Reisinger stated that AIG does not necessarily endorse either of the approaches proposed by Mr. Lafferty. He agreed that there is a big "chicken and egg problem," since the hydrogen stations need large numbers of vehicles (upwards of 1,000 vehicles/day) to earn a profit, but, without the existence of fueling stations, "manufacturers won't build the vehicles and people won't buy them." He agreed that it might be necessary for government to somehow "prime the pump" to get the critical mass that is needed. Mr. Kiczek added that Air Products (and automakers) advocate concentrating the development of publicly accessible fueling stations in certain locations (e.g., southern California), in order to focus markets for stations and vehicles. Most of the hydrogen fueling stations currently located in southern California (on the order of 20-25 stations) are not open to the public, mainly because of liability issues. Mr. Rose suggested that creative approaches to ownership could be explored, for example, state or federal ownership of stations.

Dr. Saillant asked what a "catastrophe" would be in the case of an accident at a hydrogen fueling station. Mr. Kiczek explained that one example could be the explosion of a liquid hydrogen tank that caused extensive third-party liabilities. He noted that Air Products has not calculated the potential damage from this type of failure because the company is not currently exposed to this type of risk. Dr. Salliant explained that he was trying to understand the upper limit of the potential liability in the event of a catastrophic failure, and asked whether historical experience in the auto or gasoline station industry could provide any sense of the magnitude. Mr. Lafferty noted that the typical liability for gas station owners is fairly low, and that is why most of them only purchase $1 to $3 million worth of coverage. Dr. Milliken asked how much a hydrogen fueling station owner would have to pay for the same level of coverage ($1 to $3 million). Mr. Lafferty stated that he

cannot be sure, but that the policies he has seen are eight to ten times more expensive for hydrogen stations (and that these stations have a lower exposure to the public than do typical gas stations).

4. ***Briefing: Government-wide Research Addressing Climate Change and Carbon Dioxide Emissions, Robert Marlay, Climate Change Technology Program, Department of Energy***
   >>see also presentation at http://www.hydrogen.energy.gov/advisory_htac.html

Mr. Robert Marlay is a senior career official in the DOE Climate Change Technology Program (CCTP). The CCTP is a multi-agency program created to coordinate climate change R&D planning, execution, and budgets across 13 federal agencies. Approximately 85% of the Federal government's work on climate change is occurring within DOE, with the remainder at the Departments of Defense, Agriculture, and Transportation, NASA, EPA, and others. Mr. Marlay profiled the *U.S. Climate Change Technology Program Strategic Plan*, which details measures to accelerate the development and reduce the cost of new and advanced technologies that avoid, reduce, or capture and store greenhouse gas emissions over a 100 year planning horizon. This document represents a multi-agency plan for harnessing advanced technology and innovation to stabilize carbon emissions, and is available online at http://www.climatetechnology.gov. Hard copies of the CCTP Strategic Plan can also be provided to Committee members who want them. The Hydrogen section of the plan (pages 86-92) was included in the HTAC briefing book. The CCTP's counterpart organization, the U.S. Climate Change Science Program (CCSP), also has a strategic plan available, and this can be found at http://www.climatescience.gov/. The CCSP manages a federal investment of about $2 billion annually in R&D aimed at developing a better understanding of the science of climate change.

Mr. Marlay mentioned that the CCTP has compiled a "catalogue" of government-wide spending on climate change and emission reductions research and development. Mr. Marlay also described a document that summarizes each of the key activities that the Federal government is undertaking to reduce emissions.

Mr. Marlay reported that President Bush laid out his administration's approach to addressing climate change in a February 2002 document entitled "U.S. Climate Change Strategy: A New Approach." He noted that President Bush continues to reaffirm the U.S. commitment to the U.N. Framework Convention on Climate Change and the goal of stabilizing carbon emissions. The U.S. approach is to "harness the power of markets and technological innovation," to reduce emissions, maintain economic growth, and enlist global participation. For technology planners, this means there is a need to envision and develop technologies that will take us close to a zero emission global infrastructure, not just for the energy sector, but for other emissions sectors as well (agriculture, industry, etc.) The four key thrusts of the U.S. approach are: 1) near-term policies and measures, including financial incentives; 2) improved climate science; 3) advanced technologies; and 4) international cooperation.

Mr. Marlay explained that the coordination of climate change activities begins with the Office of the President and flows down through a Cabinet-level group of thirteen different agencies (the Committee on Climate Change Science and Technology Integration) and down through management and staff-level interagency working groups and offices (Interagency Working Group on Climate Change Science and Technology, Climate Change Science Program, and Climate Change Technology Program). He noted that the leadership of the Interagency Working Group on Climate Change Science and Technology, whose members are at the Deputy Secretary or Under Secretary level, rotates between the Department of Energy and the Department of Commerce.

Mr. Marlay's presentation highlighted some of the near-term actions that are underway, including voluntary programs, incentives for investments, and regulatory reforms. He reviewed a list of available tax incentives, as well as other financial incentives available though EPACT 2005. The Department of Energy's voluntary "Climate VISION" program includes business associations and trade groups representing 14 energy-intensive industrial sectors and the Business Roundtable. Each of the groups has made a commitment to improve the energy efficiency or greenhouse gas emissions intensity of its sector. In answer to a question about the "standard of eligibility for membership" in Climate VISION, Mr. Marlay replied that DOE approached trade associations representing sectors with significant emissions and asked them if they would participate. Congressman Walker observed that none of the groups involved in Climate VISION represent what might be termed the "solutions" side (e.g., the National Hydrogen Association), and Mr. Marlay agreed that the focus so far has been on involving the major emitters.

Mr. Marlay then provided more detail on the activities underway within the CCTP. The program's four goals include:

1. reduce emissions from energy end use and infrastructure
2. reduce emissions from energy supply
3. capture and sequester CO_2
4. reduce emissions for non-CO_2 greenhouse gases.

He reviewed the program's technology strategy, federal agency involvement, and a summary "roadmap" for technology development. He described the CCTP portfolio analysis and planning activities, noting that while the program is guided by many different inputs, one key source of information is the advanced technology scenario analysis conducted by Pacific Northwest National Laboratory. The September 2006 report, "Climate Change Mitigation: An Analysis of Advanced Technology Scenarios," is available on line at http://www.globalchange.umd.edu/data/publications/CCTP_Final_Report_041007.pdf. The analysis (which has a 100-year time horizon) divides the world into 14 regions that are all constrained in some way to move toward a stabilization end state over time under various technology scenarios. Mr. Marlay's presentation included results from this analysis, which yielded some key conclusions, including 1) reaching long-term goals will

require near-term actions (between now and 2040), and 2) CO_2 emissions reductions on the order of 600 gigatons of carbon/year will be required to achieve global stabilization by 2100. His presentation included a table illustrating how different technologies available today could be applied to cut just one gigaton of carbon emissions. He observed that the challenge of cutting 600 gigatons is therefore immense and that achieving all four of the CCTP's goals will be critical to reaching stabilization targets. The analysis also looked into the cost for addressing climate change, both with and without advanced technologies, and concluded that the development of advanced technology can lower the investment costs by as much as two-thirds. Therefore, a major goal of the CCTP is conducting R&D that will provide more (and more affordable) technology options.

Mr. Marlay presented the FY 2008 CCTP budget breakdown, which includes a total federal request of about $320 million for hydrogen and fuel cells R&D. He added that the CCTP sees hydrogen in a "transformative role," as an energy carrier that could play a big part in the transportation and power sectors, with synergies between hydrogen and electricity. He asked the Committee to let him know if the role of hydrogen laid out in the CCTP strategic plan is inaccurate or incomplete.

Mr. Marlay presented a CTTP portfolio assessment chart, which displayed pathways for achieving carbon reduction goals, the projected potential emissions reductions from each, and the likelihood of success. Congressman Walker asked why hydrogen production is assessed as a "maybe" on the "likelihood of CCTP goal attainment" scale, while carbon capture is assessed as "likely." Congressman Walker noted that "we already know how to produce hydrogen," whereas "we don't know how to do carbon capture." Mr. Marlay replied that carbon capture actually has a grayed-out check mark in the "unlikely" category, meaning that given the present state of technology, the likelihood for success is unlikely, but with a proposed major boost in funding to accelerate R&D, the potential could be advanced to "likely." Congressman Walker asked again why hydrogen production only assessed at "maybe," and Mr. Marlay replied that in the CCTP's assessment there are a lot of technical risks and also uncertainties on whether the source of the hydrogen will be carbon-free. Congressman Walker pointed out that there appears to be significant potential for producing hydrogen from nuclear energy at very competitive prices. Mr. Rose pointed out that the CCTP analysis also shows that hydrogen appears to be one of the highest pay-off strategies.

A chart showing international spending on energy R&D over the past thirty years (in total dollars spent) indicated that the U.S. and Japan are the two main contributors. While the chart does not show funding on a per capita (or per GDP) basis, Mr. Marlay asserted that it does point to the need for more investments from other countries.

Mr. Marlay concluded by observing that investments in science and technology are not substitutes for a comprehensive climate change policy; they are pre-requisites. Improved understanding and technology options are critical both to inform the process and to reduce the cost of compliance with policies.

Questions and Answers

- Dr. Shaw noted that, on a global basis, shipping is reported to be a major carbon emitter. He asked whether the CCTP addresses maritime carbon pollution in its strategic plan. Mr. Marlay agreed that this is a gap -- maritime and aviation sources of emissions are not currently addressed within the program -- mostly because the focus has been on grid emissions and alternative energy carriers. He stated that he would look into Dr. Shaw's information on the magnitude of maritime emissions and take this back to the program.
- Dr. Richmond asked whether reducing overall consumption had a place in the emissions reduction strategy. Mr. Marlay replied that energy efficiency is a key feature in the technology roadmaps for addressing energy use in the transportation, buildings, and industry sectors. The program has only recently begun to address the "socioeconomic barriers" to developing new social norms that would lead to reduced overall consumption. Dr. Milliken noted that DOE has launched public information campaigns on energy conservation (available on line at http://www.energy.gov/forconsumers.htm). Mr. Marlay noted that his office has documented over 400 programs throughout the government aimed at promoting energy efficiency through education, awareness, etc. Dr. Richmond inquired about the effectiveness of these programs. Mr. Marlay explained that assessing performance is the purview of the U.S. Government Accountability Office, which periodically issues reports on the programs' performance.
- Mr. Marlay was asked whether the CCTP has calculated the carbon reduction benefits of hydrogen. He replied that it had not. Dr. Milliken noted that the Hydrogen Program has performed some of those calculations, and will provide information on the analysis methodologies and results to the CCTP. Mr. Marlay noted that the program is interested in a way to calculate the benefits associated with hydrogen as an energy storage medium.

5. ***Public Comment Period***

Mr. Leo Grassilli, U.S. Navy (retired)

On a recent visit to the new Department of Transportation building, Mr. Grassilli noted that everything about the building seemed to be "state-of-the-art" (e.g., the air conditioning and security), except the energy systems. He urged the HTAC to promote the idea that in the future, every time a Federal building or energy purchase is made, it should include efficiency and alternative energy. In his previous experience in construction, he observed that budgets for buildings in the public sector are inflated; therefore, he believes there is there is room for energy investments in these Federal procurements. This type of initiative should go beyond DOE, to include all Federal agencies. Mr. Grassilli also expressed frustration that auto companies have reported that they are getting very close to building hydrogen fuel cell vehicles on the order of hundreds, or thousands, or tens of thousands, but cannot do so without some help to get the fueling infrastructure in place.

Mr. Grassilli stressed the need for the Federal government to help hydrogen across the "valley of death" to marketability. DOE has worked hard on these types of initiatives, he said, but needs other agencies, especially those with bigger budgets, to participate. Dr. Milliken pointed out that helping more agencies invest in hydrogen technology is one of the purposes of the Interagency Task Force on Hydrogen and Fuel Cells. She also pointed to the DOE's Federal Energy Management Program and a variety of interagency working groups and task forces that have been formed over the last few years to foster information sharing and promote the adoption of energy efficient and renewable energy technologies in the Federal government. Mr. Rose expressed his understanding that there are not incentive programs in place within the Federal government to promote the construction of buildings with LEED- equivalent certification (the Leadership in Energy and Environmental Design (LEED) Green Building Rating System™). Mr. Grassilli replied that incentives are nice, but his suggestion is for straightforward direction from the top-down to "just do it." Mr. Rose noted that there is a bill before Congress that would require fuel cell backup power systems in all federal buildings by a certain date.

Mr. Jerry Hinkle: Vice President, Policy and Government Affairs, National Hydrogen Association

Mr. Hinkle presented four handouts to the HTAC (see http://www.hydrogen.energy.gov/advisory_htac.html):

1) A memorandum to the NHA Legislative Affairs Council reviewing the hydrogen and fuel cell provisions in H.R. 6, the *Energy Independence and Security Act of 2007*, which was signed by the President on December 19, 2007. He urged the HTAC to advise the DOE on how some of the authorized programs in the bill might be implemented. The memo lists several areas in the bill where hydrogen and fuel cells have been specifically mentioned or where there is a role for them, depending on the interpretation; these areas include vehicle fleets, vehicle technology, production of biofuels, energy storage for transportation and electric power, the H-Prize, transportation infrastructure, carbon capture and sequestration in facilities that co-produce hydrogen and electricity from coal, express loans for renewable energy and energy efficiency.
2) A letter from the U.S. Senate to Secretary Bodman, copied to Jim Nussle (Director, Office of Management and Budget). The letter points out that EPACT 2005 authorizes $872 million for hydrogen and fuel cell technology in fiscal year 2009, and "strongly encourages [Secretary Bodman] to take advantage of this authority in the FY 2009 budget request." The letter was signed by seven senators, including Senators Dorgan and Graham, who co-chair the Senate caucus on hydrogen and fuel cells, and Senator Bingaman, Chair of the Energy Committee.
3) A letter from Senator Dorgan to Mr. Guy Caruso (Administrator, Energy Information Administration) asking EIA to conduct a thorough analysis of the carbon and emissions effects of various sizes of a hydrogen economy.
4) An article, published on-line by Government Computer News, entitled "DOT sees future with vehicle integration, hydrogen fuel." The article provides some

remarks on hydrogen and fuel cell vehicles by Mr. Paul Brubaker (the new Administrator of DOT's Research and Innovative Technology Administration).

Questions and Answers

- Mr. Katsaros asked who had orchestrated the senators to write the letters. Mr. Hinkle said he did not know. Mr. Rose conveyed that members of the House and Senate are actively interested in hydrogen and fuel cells. He reminded the Committee that the Hydrogen and Fuel Cell Caucus in the Senate has approximately 18-20 members; a parallel organization in the House has about 50 members. Mr. Hinkle noted that the House caucus can often get as many as 70-80 signatures on letters in the House, illustrating that the Representatives are tuned in to these issues.
- Congressman Walker asked whether the NHA had ever discussed the possibility of becoming involved in the Climate VISION program. He suggested that the NHA, as a "solution provider," could provide a positive influence on the Climate VISION program and encouraged the NHA to pursue membership. Mr. Hinkle agreed, and said that the NHA would make some contacts in this regard.

Chairman Walker asked for further public comments, and there were none, so he moved onto other agenda items.

6. ***Discussion: Next HTAC Meetings and Formation of HTAC Subcommittees***

The Committee discussed the HTAC meeting schedule for 2008. Dr. Milliken related that the Interagency Task Force on Hydrogen and Fuel Cells (ITF) is considering holding its next meeting in conjunction with the Department of Defense Annual World Energy Conference, April 14-16, 2008, in Washington D.C. The HTAC discussed the possibility of holding an HTAC meeting during this timeframe, but could not do so due to scheduling conflicts. Dr. Lloyd asked DOE to inform the HTAC about the final dates for the ITF meetings. DOE will also provide HTAC with minutes of the ITF meetings. Dr. Shaw noted that summary reports on the ITF meetings are useful and suggested that these continue to be included on HTAC meeting agendas.

After discussion among the HTAC members present at the December 19 meeting, and reference to the available calendar dates for the entire Committee, the HTAC meetings for 2008 were tentatively set for the following dates, in the Washington D.C. area:

- May 13-14
- July 22-23
- November 6-7 (ending by 4 pm to facilitate travel to the West Coast)

Vice Chairman Walker asked when the two-year appointment term would end for the original set of HTAC members. Ms. Epping replied that the first two-year term will end in June 2008. She noted that some of the members' appointments may be renewed, but that some will expire and the Secretary will appoint new members to the Committee in

that timeframe. Chairman Lloyd expressed his hope that the next HTAC meeting in May could be scheduled to allow the two recently appointed HTAC members, Mr. Gerhard Schmidt and Mr. Philip Ross, to attend. DOE will email the proposed HTAC schedule to the entire Committee for review and approval.

Dr. Lloyd noted that the proposed 2008 HTAC schedule places a fair amount of time in between the December 2007 meeting and the first meeting in 2008, on May 13-14. He suggested that the subcommittees meet during this time and develop products or information that will be reported on at the May meeting. The HTAC reviewed the roles and responsibilities of the two new standing subcommittees, and agreed on the following:

- **Subcommittee on Policy and Planning**
  - Chair: Dr. Robert Shaw.
  - Preliminary charter: draft the vision statement, strategy and objectives; draft the annual report on the state of the industry; and develop ideas for a hydrogen index.
- **Executive Subcommittee**:
  - Co-Chairs: Dr. Alan Lloyd and Congressman Robert Walker
  - Preliminary charter: engage with the Secretary of Energy and members of Congress and their staff; plan and conduct site visits to industry; and prepare HTAC meeting agendas.

Mr. Katsaros asked DOE to send the material related to the vision and state-of-the-industry report to all of the Committee members, so that they could review it and provide additional thoughts and ideas to the Policy and Planning Subcommittee.

Ms. Epping clarified that the HTAC subcommittee members could include persons who are not members of HTAC. Mr. Rose and Mr. Walker stated that there should be a process for vetting, or HTAC approval of, any proposed subcommittee members who are not HTAC members. Mr. Rose suggested that one option would be to invite non-HTAC members to participate on the subcommittees on an ad-hoc basis, to contribute to a particular discussion or work product. Dr. Shaw asked if DOE could assign HTAC support staff to the two subcommittees, and DOE agreed to do so.

The HTAC meeting was adjourned at 2:41 p.m. EST.

Sixth Meeting of the
Hydrogen and Fuel Cell Technical Advisory Committee (HTAC)
December 18-19, 2007

HTAC Members Present

- Larry Bawden – Q1 NanoSystems Corporation
- John Bresland – U.S. Environmental Protection Agency
- Mark Chernoby – Chrysler LLC
- Mildred Dresselhaus – MIT
- John Hofmeister – Shell Oil Company
- Art Katsaros – Air Products and Chemicals, Inc. (retired)
- Dan Keuter – Entergy Nuclear, Inc.
- Alan Lloyd – International Council on Clean Transportation
- Rand Napoli – Florida State Fire Marshal (retired)
- Ian Purtle – Cargill, Inc.
- Geraldine Richmond – University of Oregon
- Robert Rose – U.S. Fuel Cell Council
- Roger Saillant – Plug Power
- Bob Shaw – Aretê Corporation
- Kathy Taylor – General Motors (retired)
- Greg Vesey – Chevron Global Power Company
- Robert Walker – Wexler & Walker Public Policy Associates

HTAC Members Not Present

- David Friedman – Union of Concerned Scientists
- Byron McCormick – General Motors
- Michael Mudd – FutureGen Alliance, Inc.
- Michael Ramage – ExxonMobil Research & Engineering (retired)
- Philip Ross – Lawrence Berkeley National Laboratory (retired)
- Gerhard Schmidt – Ford Motor Company
- Jan van Dokkum – UTC Power
- John Wootten – Peabody Energy (retired)

U.S. Department of Energy Staff

Office of Energy Efficiency and Renewable Energy

- Arlene Anderson
- Peter Devlin
- Kathi Epping
- Rick Farmer
- Monterey Gardiner
- Fred Joseck
- JoAnn Milliken
- Terry Payne

- Antonio Ruiz
- Sunita Satyapal

Office of Fossil Energy
- Mark Ackiewicz
- Lowell Miller

Office of Nuclear Energy
- Carl Sink

General Counsel
- Christina Hymer

U.S. Department of Transportation Staff
- William Chernicoff
- Mike Molloy

Members of the Public in Attendance
- Tim Armstrong – Oak Ridge National Laboratory
- Thomas Bello – AIG Consultants, Inc.
- Andrea Chew – Sentech, Inc.
- Kristin Deason – Sentech, Inc.
- Eddy Drew – Marsh Insurance Co.
- Alan Gier – General Motors Corporation
- Leo Grassilli – U.S. Navy
- Tom Gross – IF, LLC
- Jerome Hinkle – National Hydrogen Association
- Peter Hoffman – The Hydrogen & Fuel Cell Letter
- Jamie Holladay – Pacific Northwest National Laboratory
- Revis James – Electric Power Research Institute
- Duncan Karcher – AIG Consultants, Inc.
- Ed Kiczek – Air Products and Chemicals, Inc.
- John Lafferty – Air Products and Chemicals, Inc.
- Erin Lane – Plug Power
- Ann Padjen – Air Products and Chemicals, Inc.
- Robert Paulukiewicz – AIG Consultants, Inc.
- Chris Peterson - SRI
- David Reisinger – AIG Consultants, Inc.
- Bill Richards - DeltaGEE
- Mark Ruth – National Renewable Energy Laboratory
- Tom Sheahen – National Renewable Energy Laboratory
- Brendan Smith – Sentech, Inc.
- Dick Snaider - DeltaGEE
- Neil Snyder – National Renewable Energy Laboratory
- Thomas Timbario – Alliance Technical Services, Inc.
- Allison Trepod – SRI
- Kristin Whitman – Shell Oil Company

Support Staff

- Judi Abraham – Conference Management Associates, Inc.
- Anna Domask – Energetics Incorporated
- Michael Harris – TRAK Services
- Melissa Lott – Alliance Technical Services, Inc.
- Kevin McMurphy – Sentech, Inc.
- Shawna McQueen – Energetics Incorporated
- TG Powell – Alliance Technical Services, Inc.