Summary Document
International Energy Agency (IEA) Ad-Hoc Group on Science & Energy Meeting
Scientific Breakthroughs for a Clean Energy Future
6-7 May, 2008
IEA Secretariat, Paris, France

Background

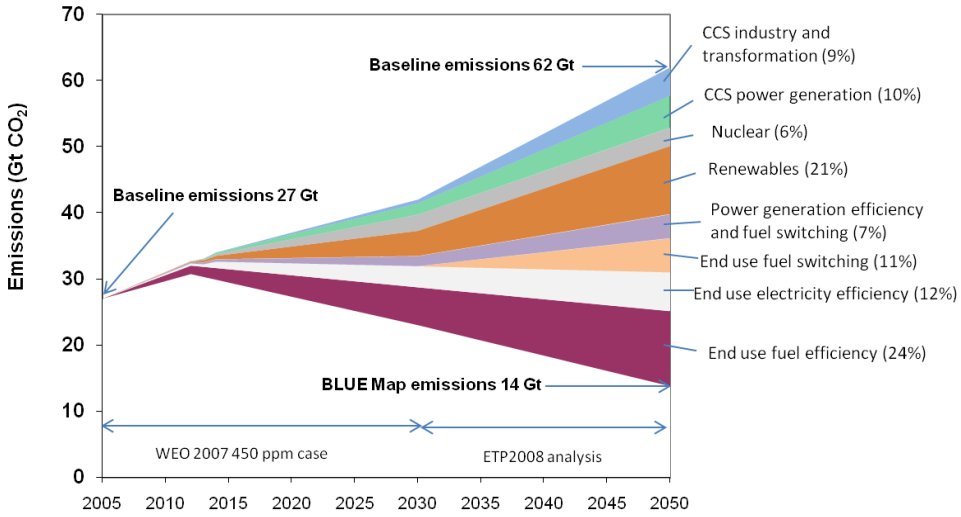
The International Energy Agency (IEA)'s Ad-Hoc Group on Science and Energy Technologies (AHGSET), which is part of the IEA's Committee on Energy Research and Technology (CERT), has been working to bridge the gap between the basic science and applied energy communities since 2005 through information exchange and outreach. For more information about the AHGSET, visit http://www.iea.org/about/ahgset.asp. With the aim of addressing energy breakthroughs for the future by engaging the IEA's Implementing Agreements, the IEA hosted a meeting on 6-7 May that included over 45 experts from government, industry and academia, as well as a number of Implementing Agreement representatives. Participants discussed the need for increased collaboration and information exchange in the area of basic science and applied energy research.

This Summary Document attempts to capture the main points of discussion, with a particular emphasis on the brainstorming discussion session that was held at the end of the workshop. Comments on this document are welcome; please contact Tom Kerr at tom.kerr@iea.org to provide feedback.

Scene-Setting Panels

The IEA's Executive Director Mr. Nobuo Tanaka opened the workshop by explaining global energy and environmental challenges with an urgent call to action. Citing the IEA's analysis from its forthcoming *Energy Technology Perspectives 2008* publication (to be released early June 2008), Mr. Tanaka called attention the need for an energy revolution to achieve climate change stabilization goals. Fig. 1 below highlights the rapid growth in the use of a portfolio of energy technologies that will be required to achieve international climate goals by 2050. While many technologies are available today to begin to reduce emissions, Mr. Tanaka highlighted the need for energy breakthroughs to achieve the 2050 scenarios shown below.

Figure 1. A New Energy Revolution: Cutting Energy-Related CO_2 Emissions



Source: *Energy Technology Perspectives*, OECD/IEA, Paris (2008).

Mr. Tanaka also stressed that while technology breakthroughs were a challenge, the most important challenge is the lack of time, as nations need to rapidly ramp up investments in energy-related research & development (R&D) today to achieve energy technology goals for the future.

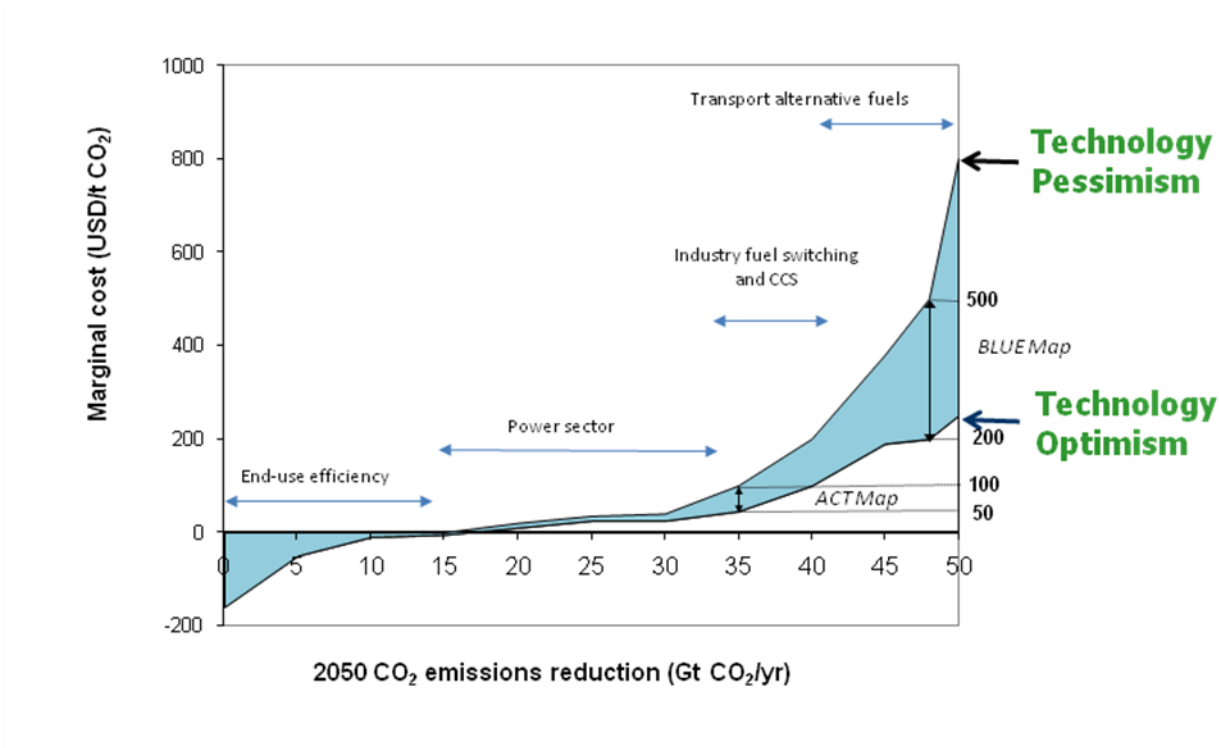
Mr. Tanaka was followed on the opening panel by Dr. Harriet Kung of the U.S. Department of Energy's (USDOE) Office of Science, who highlighted the U.S. government's efforts to systematically link basic science with applied energy research and deployment of technologies. Dr. Kung discussed recent USDOE workshops and strategic planning exercises on 37 different energy research paths, and presented the USDOE's efforts to call attention to the "top 10" grand energy challenges facing the United States. She felt there was more that the international community could do to share these examples, to respond to joint funding opportunities, and to increase energy research and development collaboration.

Mr. Robin Batterham of Rio Tinto, who was formerly the government of Australia's Chief Scientist, was the next speaker. Mr. Batterham highlighted the need to focus on existing, and not just breakthrough technologies, due to the lock-in of capital that naturally occurs as a result of the investment cycle. He also suggested perhaps there was room for a global research alliance or some other entity that allowed for greater collaboration, and invited the IEA to explore its role here. He closed by highlighting a key challenge for new technologies: overcoming the increased risks and costs that are faced by new technologies when they attempt wide-scale deployment. He stressed the need for governments to focus on accelerating technological change to "push" technologies through this difficult period, perhaps through simple incentives like accelerated depreciation.

Finally, Mr. Hiromichi Yanagihara of Toyota Motor Europe closed out the panel. Mr. Yanagihara explained the private sector's search for innovation in its energy research, and highlighted Toyota's efforts to work collaboratively to foster innovation and to address future customer needs and wants, rather than working in isolation.

This opening panel was followed by a second scene-setting panel, which provided additional background on the IEA's work, its Implementing Agreements, and the AHGSET effort. The Director of the IEA's Energy Technology Office, Mr. Neil Hirst, pulled findings from the IEA's *Energy Technology Perspectives 2008* to point out the size of the challenge associated with reducing CO_2 emissions, the magnitude of the investment that is needed and the uncertainty surrounding CO_2 reduction costs, particularly in the coming decades where technology breakthroughs are needed (see figure 2). Mr. Hirst went on to discuss the key technologies that are needed to achieve these reductions and the roadmap work that the IEA is undertaking for 17 energy technology areas featured in the *Energy Technology Perspectives* report. He also highlighted other key challenges, including the need for greater international collaboration on science and energy research.

Figure 2. A New Energy Revolution: The Challenge to Cut CO_2 Emissions



Source: *Energy Technology Perspectives*, OECD/IEA, Paris (2008).

Current AHGSET Chair Dr. Jim Skea of the UK Energy Research Centre then provided background on the AHGSET effort, including:

- The roles of AHGSET include: advising decision makers, creating a forum in which scientists and engineers in basic and applied science can come together to share information, and promoting international collaboration;

- The work that AHGSET has done to date, including a series of workshops that have helped to fill the gap between basic science and applied R&D, but the effort needs to be extended;
- To date, AHGSET has been a volunteer activity, and perhaps has not received the support that it needs; and
- A reflection on the conclusions from the 2005 AHGSET Oak Ridge workshop, including that an increase in R&D is critical to achieve energy goals.

He suggested that perhaps the idea of 'mining' basic research for energy applications may not be the best approach, and that it may be more productive if governments and industry conduct basic science research with energy applications in mind.

Dr. Peter Rohlin from the Swedish Energy Agency then closed this panel with a discussion of a recent consultation of the IEA's Implementing Agreements (IAs) about AHGSET and basic science research activities. He explained how at least 18 of the IAs have expressed an interest in increased information about AHGSET, possibly including sharing information and even common research or other ideas. He also discussed the European Union's INNER ERA-NET, which is quite similar to AHGSET in its goals and structure, while only covering the EU.

The discussion after this panel highlighted challenges to increased international collaboration. Participants felt that patent and intellectual property issues were particularly challenging. It was also suggested that while collaboration was one goal, it would actually be more productive if governments provided a small amount of targeted funding up front to help science researchers to come together in specific areas to identify additional opportunities for future collaboration. If opportunities are located, real productive research can then follow, using traditional R&D funding resources. Finally, it was suggested that in addition to increased funding, there was a need to ramp up scientific educational and training efforts to ensure that there is a qualified next generation of scientists to conduct all of this necessary work.

Substantive Panels

The next three panels presented a more detailed look at three different research areas that have basic science/applied energy linkages. The first panel explored advanced materials and energy storage (electrical and heat), and highlighted the work of the high temperature superconductivity (HTS) IA, the energy storage programme, and electrochemical storage and conversion. HTS issues were presented by René Flükiger, of the University of Geneva, including an overview of completed and in-progress projects, the transition from first to second generation conductor tapes and the eventual cost-effective replacement of copper, and the potential of HTS devices (cables, fault current limiters, energy storage flywheels, and transformers) to reduce cost and increase efficiency and reliability. The work of the energy storage programme was discussed by Andreas Hauer, from ZAE BAYERN, with a focus on thermal energy storage, including the impact that thermal demand can have on the electric grid for cooling and heating, a discussion of the three principle storage technologies (sensible TES, latent TES, and thermochemical reactions), and a case study of how these technologies can be implemented in common household items, like a dishwasher. John Kilner,

of Imperial College London, highlighted the role of material informatics and combinatorial materials science play in accelerated materials development, in addition to outlining the long development times for novel devices and the need to bring more young people into the field.
The second panel discussed advanced modeling/computing and mathematics, and included a sampling of diverse work in fuel cells, solar PV, CO2 geologic sequestration, and fluidized bed combustion that is underway. Olle Inganäs, from BIORGEL, delivered a presentation on polymer solar cells, including their potential for cost-effectiveness and a moderate efficiency level, while also noting that modeling is extremely helpful by saving lab time and supporting hypothesis testing. Benoit Noetinger, of IFP, France, presented on subsurface simulation, including computational issues involved with reservoir exploitation and CO2 storage, a study of a deep offshore project, and the importance of geosciences, intensive computational resources and applied mathematics to address existing problems. Mario Ohlberger, from University of Münster, spoke on mathematical challenges in modeling PEM fuel cells and focused on three principal challenges: multiscale problems, efficient numerical methods, and model reductions; noting that advanced computational models yield deeper insights, reduce R&D costs, and optimize device efficiency. Clas-Otto Wene, of Wenergy, discussed experience curves and that to utilize them as a valuable tool for energy technology policy will require a greater level of theoretical understanding of technology learning. Mr. Wene offered as a starting point a theoretical approach based on cybernetic concepts. Franz Winter, of the Vienna University of Technology, Austria, delivered a presentation on the mathematical modeling and simulation of solid fuel conversion in fluidized bed combustors, discussing the work that has taken place to date as well as existing future challenges, including simulation, fuel particle size formation, the interaction of reacting particles and flow, and the diversity of local conditions.

The final substantive panel focused on bio-based technology for energy, and included discussions of microalgae, H2, and CO2; the work of the IEA Bioenergy IA; and biomass conversion to gas and liquid fuels. Peter Lindblad, from Uppsala University, presented on photobiological biofuel/H2 production, including microalgae for biodiesel, photobioreactors, and the potential for photobiological production of H2. Kees Kwant, from SenterNovem, discussed the work of the IEA Bioenergy IA, including forestry, energy crops, gasification, R&D needs, biorefineries and sustainability issues. Serge Guiot, from the Biotechnology Research Institute, Canada, talked about biomass conversion, focusing on digestion, the microbial fuel cell, syngas bioconversion, and synfuel, with highlights of the research needs for each.

The general themes from these three panels were that there already are a number of areas where multidisciplinary research is underway, but this was really only the beginning. Much more could be done to explore linkages and to identify greater opportunities for collaboration. These panels provided good material for the closing brainstorming session about the future of AHGSET.

Brainstorming Session

The final session was chaired by Neil Hirst and Jim Skea. They explained that the goals for the session were to evaluate the value of the AHGSET effort first, and then if it was felt to be adding value, what its future priorities and activities should be. This input will then be used to shape the

future of AHGSET, particularly over the next two years. Jim Skea opened up the session by reviewing what he believed he had heard during the workshop. He highlighted the following points:

- There is an absolute need for energy breakthroughs, as evidenced by the IEA's *Energy Technology Perspectives2008* report results;
- It is possible and desirable to bring together basic science research and energy research, and benefits have already been seen from this sort of collaboration;
- It is preferable to design science research with applications in mind rather than just mining research after the fact (although there is should always be room for serendipity);
- The IEA's core audience of energy policy makers needs to be extended to the broader science ministries and other stakeholders;
- There is a need to increase the talent pool and funding for more basic science knowledge training and development; and
- These issues pose a bit of a challenge for the IEA and its member countries, as many countries have not been able to develop strong programmes linking basic science with energy research, so they may not have much to add to an international collaborative effort.

As a result of these themes, Dr. Skea suggested that there is a strong need to bring basic science and energy communities together, but this needs to be done at an even lower, more specialized level than has been done so far –perhaps even at the level of particular technologies. He also cited the need to map where the current links exist between science and energy – at the government, industry and academic organizations—to document good practice examples as well as to identify gaps that exist. Finally, he felt that there is an important role that basic science and early applied energy research can play in the IEA's energy roadmapping efforts – the 17 *Energy Technology Perspectives (see annex 1 for complete list)* technology roadmaps are being developed to show how technologies can achieve levels of performance by 2050; many of these roadmaps can and should be informed by basic scientists: their current work and their future needs.

The following summary captures the main points of discussion during the brainstorming that followed.

- The AHGSET effort has an important role in promoting collaboration and information exchange, and should continue, most likely as an advisory group under the IEA's CERT. However, the effort needs a new name that can generate greater recognition outside of the IEA network.
- AHGSET and the EU INNER efforts have important opportunities for increased collaboration and coordination, and the IEA can also help to connect to important efforts in the United States, Japan and Australia to foster truly international collaboration. Importantly, there is also a need to expand the network to engage researchers in key nations like China and India who are an important part of the global energy dialogue on climate and energy challenges.

- The IEA needs to expand from its traditional audience to bring messages to both science and energy ministries.
- There are a number of priority activities the AHGSET should undertake in the future, including:
    - Developing a "map" of what is already underway in the area of science and energy collaborative research, particularly within the member country governments. This map should identify good practice examples and gaps that exist.
    - Creating and disseminating messages about the need for increased science and energy research & development funding, urgency, and timing. In particular, messages should highlight the energy revolution and the magnitude of change that is needed for the types of breakthroughs that are being discussed. One specific idea was to follow the example of the USDOE to identify a "Top 10" list of Energy Technology Breakthroughs that are needed to achieve energy and environmental goals, and convening workshops around these areas.
    - A balance between discovery-driven science and application-driven science should be maintained, as both are needed, judging from past energy technology developments, to spur truly transformational advances and disruptive technologies.
    - Fostering a closer working relationship with the IAs to identify specific topics, perhaps in cross-cutting areas utilizing theory, modeling, and simulation; the "Top 10" areas are another area to explore.
    - Communicating the need for early "seed" funding to enable collaboration between scientists and energy technologists, while they attempt to identify opportunities for future collaboration.
    - Making linkages between science/energy ministries and education ministries to underscore the importance of the training and education of scientists.
    - Working with the *Energy Technology Perspectives* team to explore the role of basic science in the 17 technology roadmaps that are being developed.
    - Communicating these findings to the IEA's CERT at their next meeting in mid-June.

Annex 1: IEA Energy Technology Roadmaps

CCS - Power Generation
Nuclear (Gen III and Gen IV)
Wind (Offshore& Onshore)
Biomass IGCC & Co-combustion
Photovoltaics (PV)
Concentrated Solar Power (CSP)
Coal IGCC
Coal USCSC
Building Appliance EE
Heat Pump
Solar Space & Water Heating
Energy Efficient Transport
2nd Generation Biofuels
Electric Vehicles (EV) and Plug-in
Fuel Cell Vehicles (FCV)
CCS - Industry
Motor Systems