Coverage, Strengths and Weaknesses of Existing Models for International Technology Cooperation and Collaboration

Workshop Summary

Experts' Group on R&D Priority Setting and Evaluation

International Energy Agency

Based on its workshop

"Enhancing International Technology Collaboration"
12-13 November 2008
Washington, DC, United States

About the International Energy Agency

The International Energy Agency (IEA) is an autonomous body established in November 1974 within the framework of the Organization of Economic Co-operation and Development (OECD) to implement an international energy programme.

It carries out a comprehensive programme of energy co-operation among 26 of the 30 OECD member countries. The basic aims of the IEA are to:

- Maintain and improve systems for coping with oil supply disruptions.
- Promote rational energy policies in a global context through cooperative relations with non-member counties, industry, and international organizations.
- Cooperate in maintaining a permanent information system of the international oil market.
- Improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use.
- Assist in the integration of environmental and energy policies.

The IEA member countries are Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, Germany, Hungary, Ireland, Italy, Japan, Republic of Korea, Luxembourg, Netherland, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States. The European Commission also participates in the work of the IEA.

About the IEA Experts' Group on R&D Priority Setting and Evaluation

Research and development (R&D) of innovative technologies is crucial to meeting future energy challenges. The capacity of countries to apply sound tools in developing effective national R&D strategies and programmes is becoming increasingly important. The International Energy Agency's Experts' Group on R&D Priority Setting and Evaluation was created to promote development and refinement of analytical approaches to energy technology analysis; R&D priority setting; and assessment of benefits from R&D activities. Senior experts engaged in national and international R&D efforts collaborate on current issues through international workshops, information exchange, networking and outreach. Nineteen countries and the European Commission participate in the current programme of work. The results and recommendations support CERT, feed IEA analyses, and provide a global perspective on national R&D efforts. More information is available on the website: http://www.iea.org/about/experts.asp

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EXECUTIVE SUMMARY

The Experts' Group on R&D Priority Setting and Evaluation convened a workshop to discuss successful methods of international collaboration on advanced energy research and development. The group met at the United States Department of Energy in Washington D.C. on November 12 and 13, 2008. They received an update on the roadmapping initiative that is an extension of IEA's *Energy Technology Perspectives 2008* (ETP 2008), as well as expert presentations on a variety of successful international collaboration activities currently in place.

> ***Cooperation vs. Collaboration***
>
> *Cooperation is simply a sharing of information and plans about how to move forward, while collaboration is an actual sharing of the workload and financing.*

This document summarizes that workshop and provides recommendations to the IEA Secretariat and IEA Member Countries. The workshop examined existing international technology collaboration among countries, and discussed the coverage, strengths and weaknesses of each mode or model. These discussions are a first step to identifying effective means to advance technology R&D through international *co-operation* and *collaboration*. A selection of prominent existing efforts are catalogued and discussed below, and further expanded upon in the remainder of the document.

Energy Technology Roadmaps

Workshop participants discussed the international roadmapping efforts that are included in IEA's Technology Roadmap Initiative, ETP 2008, and Japan's Cool Earth Innovative Technology Program. An analysis of these two roadmapping efforts, along with the EU Strategic Energy Technology Plan, and the US Climate Change Technology Strategic Plan suggests that close coordination of the various RDD&D mapping efforts could increase their value and benefits. Creating international roadmaps on specific technologies would be facilitated by harmonizing these efforts to increase the potential for learning from others.

Bilateral Science and Technology Agreements

Bilateral Agreements are by definition agreements between two countries to cooperate or collaborate on a specific issue. They can provide the necessary framework conditions to create synergy and critical mass for the research communities, pool funding for common projects and share expensive research infrastructure. These agreements can be arranged in many formats, scopes, and sizes, but their effectiveness is often dependant on the political will of the countries involved and complemented by the dedication of high-level policy and technical experts. Communication is key to successful implementation of any agreement, particularly in broad agreements involving multiple ministries or agencies in each country.

Multilateral Technology Initiatives

IEA Implementing Agreements (IAs) provide a mode for enhancing facilitating countries' efforts to cooperate and collaborate on energy technologies with other countries and private entities. IAs have been created that cover a wide range of energy supplies and end-uses, and include IEA member countries and non-member countries. The IA on Energy Conversation in Buildings and Community Systems demonstrates the potential for many countries to contribute to meaningful technology development and deployment by utilizing the Annex framework of IAs as well as the cost sharing structure. IAs can be implemented for both international co-operation and collaboration, although greater capital resources and member engagement are necessary for meaningful R&D collaboration.

Involving Developing Countries in Technology Collaboration

Several means from financing and project management to technical assistance and best-practices instruction are employed for involving developing countries in technology R&D. The World Bank is exploring a number of investment vehicles to deliver clean energy technologies to developing countries, though intermediate countries such as South Africa and India provide excellent initial opportunities. Similarly, the Asia Pacific Partnership (APP), through technology focused task forces, promotes best practices and clean energy solutions in several developing countries. Both these programs have the potential to develop small scale projects with a high level of sophistication, but working closely with local authorities is key.

Regional Collaboration Models – Europe

Many regional collaboration models of various scales exist in Europe, and these are closely related to the development of an integrated European Research Area introduced in 2000 to build a knowledge-based competitive economy. The majority of research activities is funded and implemented at the national level, while only a small portion is funded at the European Union level. International co-operation is often developed over time beginning with the exchange of experience and expertise and expanded through cost and task sharing to reach common research goals. Different modes of regional collaboration include the EU Framework Programmes (FPs), European Research Area Networks (ERA-Nets), and Nordic Energy Research. Regarding the scale and authority of these regional collaborations in Europe, the EU FPs are included in the overall EU legislative scheme, while ERA-Nets and Nordic Energy Research are embedded in smaller intergovernmental schemes. In either case, the regional collaboration works best when the goals are closely aligned with the national priorities and activities of contributing members.

Multinational Technology Focused Collaboration

Several technologies are addressed through multinational collaboration organizations such as the International Partnership for the Hydrogen Economy (IPHE), the International Thermal Nuclear Experimental Reactor (ITER), the Generation IV International Forum (GIF), and Carbon Sequestration Leadership Forum (CSLF). Each organization has its own internal structure which determines how members advance R&D in the relevant technology. Although they are essentially government-to-government organizations, various approaches have been pursued to engage the private sector. The focus on technological collaboration in ITER and GIF has driven the R&D in their respective fields. IPHE effectively manages the direction of hydrogen research by endorsing a specific portfolio of activities and coordinating many R&D efforts. In all cases, government commitment to funding the organizations is key to the continued international collaboration.

Conclusions and Outlook

The development and deployment of game-changing clean energy technologies will be required to effectively address the climate change challenge; leveraging of international resources and expertise will be required to develop and deploy such technologies. Despite the wealth of bilateral, multilateral, and regional co-operation and collaboration mechanisms, no global strategy exists to coordinate the various activities and ensure the effective and efficient use of available resources and technical expertise. Considering the number of activities underway internationally, greater coordination of these efforts on a global scale would provide major synergies. In order to advance the R&DD efforts, more focus should be put on collaboration for the development and deployment of new technologies thus expanding beyond the co-operation and information sharing mechanisms currently employed. To that end, greater focus should also be put on involving the private sector through public-private partnerships. Finally, expanded R&DD budgets are necessary both to bring forward new technologies and to reduce the costs of those already available.

INTRODUCTION

The world community agrees on the urgent need to rapidly ramp up investments in energy related research, development and demonstration (RD&D) to achieve energy security and climate goals. Effective structures for enhancing international co-operation and collaboration are essential to achieve the near-term reductions in greenhouse gas emissions required to mitigate the most severe climate impacts.

Background

In December 2007 in Bali, the Conference of Parties to the United Nations Framework Convention on Climate Change agreed on an Action Plan highlighting the critical role of advanced technology in facilitating progress toward common goals. Specifically, the Bali Action Plan called for enhanced focus on technology development, including effective mechanisms to enhance co-operation in the research and development (R&D) of current, new and innovative technology, as well as mechanisms and tools to foster technology co-operation in specific sectors.

In June 2008, the IEA was asked by member countries and G8 to develop international roadmaps for a portfolio of key energy technologies, assess the current status of international technology collaboration and explore the need to enhance these efforts. In Hokkaido a month later, G8 leaders announced, ***"We will establish an international initiative with the support of the IEA to develop roadmaps for innovative technologies and cooperate upon existing and new partnerships."***

In addition, energy ministers from G8 countries, China, India and South Korea declared that ***"…those of us interested will take the initiative to accelerate efficient and lower carbon technology RD&D by using relevant structures within the IEA and the technology roadmaps for key technologies prepared by the IEA and countries; assessing the current status of existing international partnerships for technology co-operation; and exploring the need for additional ones. Along with the IEA non-member partners and other entities and relevant partnerships, and invite interested major economies to join in these efforts."***

The Experts' Group on R&D Priority Setting and Evaluation, the IEA Secretariat and the US Department of Energy convened a workshop at the United States Department of Energy in Washington D.C. on November 12 and 13, 2008 to focus on existing international technology collaboration among countries, discuss coverage, strengths and weaknesses of different modes and models, and identify opportunities and needs for enhancing technology collaboration.

Current activities mapping the global R&D and technology collaboration (e.g., from the Major Economies Meeting Process and the IEA R&D Mapping Project) served as input to the workshop. Updates were provided by the IEA Secretariat and United States.

Partners representing existing models for international technology collaboration shared with the workshop their experiences with bilateral agreements, multilateral technology-oriented partnerships (e.g., IAs, CSLF, IPHE) and regional multi-technology frameworks (e.g., APP and the EU). The discussions at the workshop explored six key means or mechanisms by which countries are actively collaborating to accelerate progress in energy technology RD&D. Each of the first six chapters of this report summarize these approaches.

This report cannot cover all international mechanisms, yet it characterizes some of the more relevant examples that serve to illustrate the significant accomplishments that have taken place as well as the challenges in moving forward to enhance and accelerate international co-operation and collaboration on energy technology R&D. These challenges will be further analyzed in forthcoming workshops and reports by the IEA Experts' Group on R&D Priority Setting and Evaluation.

ENERGY TECHNOLOGY ROADMAPS

Chair: Herbert Greisberger (Austria, ÖGUT)

Expert presenters: Steven Lee (IEA, Energy Technology Policy Division), Atsushi Kurosawa (Japan, Institute of Applied Energy), and Craig Zamuda (US DOE, Office of Policy and International Affairs)

Development of energy technology roadmaps can be a valuable first step in enhancing cooperative or collaborative RD&D among countries. Two high-profile efforts provide some insight on this approach: IEA's Technology Roadmap Initiative and Japan's experiences in developing its "Cool Earth – Innovative Technology Program."

Summary of Current Roadmap and RDD&D Mapping Activities at the IEA

IEA's Experts' Group on R&D Priority Setting and Evaluation held a Paris workshop in May of 2008 to discuss approaches to energy technology roadmaps. In the process of developing ETP 2008, IEA had identified 17 technologies that could potentially capture a large share of the opportunities to avoid CO2 emissions. An initial, two-page roadmap was developed for each of these technologies, including nine from the supply side and eight from the demand side. Each of these technology roadmaps identify the potential contribution of the subject technology, performance targets, development timeline, key actions needed and areas for international collaboration. The G8 leaders approved these two-page roadmaps and encouraged IEA to expand the effort.

ETP 2008 Technology Options

<u>Supply Side</u>

- CCS Power Generation
- Coal – IGCC
- Coal – USCSC
- Nuclear III + IV
- Solar – PV
- Solar – CSP
- Wind
- Biomass – IGCC & co-combustion
- 2nd generation biofuels

<u>Demand Side</u>

- Energy efficiency in buildings
- Energy efficient motor systems
- Efficient ICEs
- Heat pumps
- Plug-ins and electric vehicles
- Fuel cell vehicles
- Industrial CCS
- Solar heating

Participants at the May workshop on Energy Technology Roadmaps agreed on the need to:

- Define what a roadmap is
- Ensure that any given roadmap includes all RDD&D phases
- Involve all major players in the process, including government, the private sector, industry and financial community
- Establish a clear, effective, and transparent process for bring these players together
- Identify roles and responsibilities for implementing the technology roadmap
- Encourage all stakeholders to take ownership of the technology roadmaps with IEA.

Participants agreed to use the following definition: "A technology roadmap is a dynamic set of technical, policy, legal, financial, market and organizational requirements identified by all stakeholders involved in its development."

A comprehensive list of necessary elements for any roadmap includes the following:

- A vision of the technology targets and when they will be achieved
- Clearly stated objectives of the innovation as well as the barriers to that innovation
- A timeline and milestones
- Identification of critical RD&D activities and the milestones needed to meet objectives
- Roles and responsibilities that players must assume in the process
- Evaluation criteria for assessing progress

In response to encouragement from the G8, the IEA is expanding the current roadmaps in manageable subsets of four or five. In selecting which technologies receive first attention in this process, the IEA applies a range of criteria, including technical and political factors and "other considerations." In this manner, the IEA plans to use a learn-by-doing approach. The first roadmaps to be expanded will address Carbon Capture and Storafe (CCS), Wind, Photovoltaics (PV), Electric Vehicles and Cement. Lessons learned from this first set of roadmaps will be applied in developing the next set, which will likely include Electric Grids and Storage, Second-Generation Biofuels, Zero Net Energy Buildings, and Nuclear Energy. The goal is to have eight to nine roadmaps completed by ETP 2010.

IEA is concurrently conducting RDD&D Mapping activities of member countries to help identify gaps in RDD&D as well as opportunities for international collaboration. IEA is working to foster international collaboration on RDD&D and compiling public data on energy R&D expenditures. This effort does not entail bibliometric or other quantitative analysis of ongoing RDD&D in IEA and non-IEA countries. The IEA is generally attempting to acquire analyses from the various governments themselves, particularly through the Committee on Energy Research and Technology (CERT), the implementing agreements (IAs) and country reviews.

One issue that may potentially hinder the success of international technology RD&D co-operation and collaboration is market competition between partners. This potential pitfall is likely to become more pronounced as technologies get closer to market. To minimize this problem, collaborations should emphasize technology RD&D projects at the pre-competitive stage of development.

Summary of the Japanese Perspective on Roadmaps

Innovative technology RD&D is believed critical to reducing emissions of greenhouse gases (GHGs). Japan's "Cool Earth – Innovative Technology Program" addresses 21 innovative technologies. Both supply side and demand side technologies are represented as well as technologies that improve energy efficiency and those that directly reduce carbon emissions. As with the technologies in ETP 2008, these key technologies are drawn from all economic sectors (power generation, transport, industry and residences/buildings) and include four cross-cutting technologies. The Japanese also recognize the importance of international co-operation on innovative technology RD&D and suggest the following supportive measures:

- Expanding RD&D investments by developed countries
- Developing and sharing technology roadmaps
- Strengthening international co-operation in each technology

The Japanese expressed concerns about the transparency of IEA criteria for selecting key technologies (e.g., cement). Further, they recommend that IEA add fuel cells and fuel cell vehicles as a priority technology and that the interim report on roadmap progress be submitted to the G8 meeting in Italy.

The Japanese have conducted a comparison of four different frameworks for coordinating RD&D on technologies to reduce climate impacts: Japan's Cool Earth, the IEA ETP 2008, the EU Strategic Energy Technology Plan, and the US Climate Change Technology Program Strategic Plan. By comparing the technologies assigned priority by in each of these efforts, they discovered that some technologies repeatedly earned a priority rank. They identified four key technologies specified as priorities in all of the four frameworks: CCS, Integrated PV, Advanced Nuclear, and Fuel Cell Vehicles. Similarly, they identified five technology areas that received priority status in three of the frameworks: Wind Power, Superconducting Transmission, Power Storage, Biofuels and High-Efficiency Buildings.

By looking across these common roadmaps for a specific technology, it should be possible to develop a common or generic roadmap for that technology. The Japanese initiated this effort for the PV technology to illustrate the process and potential benefits. This comparison of the four PV roadmaps suggests that:

- Common roadmap elements should include generic and regionally dependent elements
- Targets of generic elements should be clearly defined
- PV installations should be placed into useful sub-categories, such as grid-connected
- Generating capacity diffusion is strongly dependent on regional potential. To overcome barriers, assessments of various what-if scenarios would be useful.

The roadmap comparison yielded an outline for compiling a common roadmap across these four programs and suggestions on the process.

It is clear that close coordination of various RDD&D mapping efforts, including IEA's ETP 2010, the efforts of Japan and others, could increase their value and benefits, and that these roadmapping efforts should not be limited to the timeframe for ETP 2010, but rather be considered ongoing work. The scope of these efforts can be extremely large. However, if they are meant to assist strategic resource management, detailed scheduling of the work is necessary. Roadmap comparisons are not a simple exercise, and a harmonized effort is essential. Accomplishing this successfully will increase the potential for learning from others and make it easier to create international roadmaps on certain technologies.

BILATERAL SCIENCE AND TECHNOLOGY AGREEMENTS

Chair: Rob Kool (Netherlands, International Sustainable Development of SenterNovem)
Expert Presenters: Drew Nelson (US Department of State), Scott Smouse (US DOE, National Energy Technology Laboratory), Peter Rohlin (Sweden, Swedish Energy Agency)

Bilateral agreements for enhancing international RD&D co-operation and collaboration can take many forms. They can exist as stand-alone projects, be included in larger bilateral agreements, or utilized during the course of a multi-party collaboration. Bilateral agreements often lead to excellent results quickly, but should not be seen as a substitute for more expansive modes of engagement.

Bilateral agreements take advantage of the common interests of two parties in specific technologies in order to enhance technical performance, shorten the development cycle, and reduce costs. Political will is essential in starting the cooperative process; however, success is often determined by the quality of preparations and prior scoping of common ground by the partners. Prospects are vastly improved through the integrated application of policy and technical expertise during the preparation phase.

Creating a framework at the outset of a bilateral agreement allows technical co-operation to develop where it is most useful while reducing work at the policy level. In general, government must initiate programs that provide the necessary mechanism to develop individual projects. Effective bilateral agreements should not directly initiate individual technical projects, as this may lead to the rapid creation of more projects than the government can easily administer.

Financing and handling of intellectual property rights (IPR) should be clearly defined within the framework at the outset of the agreement. Funding for comprehensive collaboration is often difficult and generally depends on the governing bodies. To ensure that a program will meet expectations, program objectives must be carefully considered. Specifically, closely aligning the objectives of a bilateral agreement with national priorities helps to ensure that the investment will be worthwhile. Similarly, to protect national or individual interests, IPR issues should be considered within the framework at the outset.

Assessment of Bilateral Agreements

Bilateral agreements can take many forms and apparently can be easily tailored to the research needs and resources of the parties involved. Therefore, the formats of bilateral agreements between governments may be quite similar while the scope and content are not. Generally though, when these agreements are properly designed, approved and implemented, they can produce cost-effective, time-efficient research collaboration to accelerate development of technologies of interest to both parties.

Strengths:

Bilateral agreements can enable task and cost sharing in a way that adds value to the research activities of both parties involved. These agreements can provide the necessary framework conditions to create synergy and critical mass for the research communities, pool funding for common projects and share expensive research infrastructure. By efficiently using the strengths of each party, bilateral agreements can help to create and diffuse knowledge more effectively among parties and shorten the development cycle.

An effective bilateral agreement is grounded in a strong political will for the collaboration and complemented by refinements from high-level policy and technical experts.

Clear communication is key to the success of bilateral research agreements. The language should explicitly describe activities, accomplishments, norms and perceptions between the parties. This process can also help to identify new areas of common interest and thereby pave the way for further collaboration.

Weaknesses:

At times, bilateral agreements can become overly politicized. The process of procuring legal approval from governmental bodies may also be cumbersome and provide bureaucratic obstacles to implementation of the collaboration.

The format, scope and implementation process for each bilateral agreement must be developed on a case-by-case basis, and the challenges should not be underestimated. Indeed, the difficulty is great enough to consider a successful agreement to be a fortunate accident as opposed to a planned strategy.

Finally, broad bilateral agreements often involve various ministries. Unless these are well coordinated by one lead ministry, it may be difficult for the prospective partner to know who to contact during the important initial phases, when clear direction and management is most needed.

IEA IMPLEMENTING AGREEMENTS

Chair: Bob Marlay (US, DOE)

Expert Presenters: Peter Versteegh (Netherlands, Chair of the EU Working Party for Electricity) and Markku Virtanen (Finland, Chair of the IEA IA on Energy Conservation in Buildings and Community Systems)

IEA Implementing Agreements (IAs) offer a long-standing and fruitful mechanism for facilitating international co-operation and collaboration on energy technology R&D. Operating under the Working Parties (WP) of IEA's Committee on Energy Research and Technology (CERT), IAs form the backbone of IEA's approach in this area. Since 1974, 76 IAs have been created, and 42 are currently in effect—facilitating a wide range of R&D activities to enhance energy supply (i.e., fossil fuels, renewable energy and fusion power) and increase energy efficiency (i.e., in transportation, buildings, electricity and industry).

A broad range of international activities are carried out under the auspices of the IAs. Activities include coordination and planning of specific energy technology RD&D studies or projects. Subsequent exchange, joint evaluation and pooling of scientific and technical results are common. In addition, IAs frequently involve information exchange on national programs and policies; scientific and technological advances; and energy legislation, regulations and practices.

Participation in IAs is not limited to specific types of organizations. IEA member and non-member countries participate. Participants may include not only governments, but also energy technology companies, research institutes and universities. All told, IA participants include 39 countries and the European Commission.

The work associated with IAs is generally financed through cost or task sharing, or a combination of the two. Each approach has its benefits and tradeoffs. Through the years, the emphasis has shifted from cost sharing to task sharing or some combination.

In cost sharing, participants contribute to a common administrative fund, and the work is contracted to a general manager. The results are shared by all participants. Cost sharing provides programmatic consistency and operational flexibility. However, sustained cost sharing is often impeded by the need to reconcile international project requirements of a common fund with the independently exercised national budget controls of each country.

In task sharing, each country participant devotes specific resources and personnel to specific research projects. Task sharing envisions a division of labor, which can reduce the workload burden on the participating countries. However, with each country operating on its own, an integrated programmatic approach can be difficult to achieve.

The IEA maintains minimum requirements for operating IAs, thereby establishing a common legal approach for each agreement. This basic framework helps make the development of new IAs straightforward and more routine. Further, the IEA Executive Committee can tailor each agreement by adding specific clauses on a case-by-case basis. The minimum requirements address general principals, categories of signatories, length of terms, roles and responsibilities, reporting requirements and intellectual property and copyright protection.

Case Study: Global Collaboration on Building Technologies

The Energy Conservation in Buildings and Community Systems Program (ECBCS) is one of the oldest and most evolved of IEA's IAs. It productively involves 24 countries in energy conservation and environmental sustainability projects and serves as a model for other IAs.

The ECBCS program represents a collective effort to exploit technological opportunities to save energy in buildings and remove technical obstacles to widespread adoption of new technologies for conserving energy. Overall control of the program is maintained by an Executive Committee that monitors existing projects and identifies new areas in which collaboration may be beneficial.

Within the IA framework, ECBCS activities are governed by a series of annexes. The annexes consist of collaborative research projects with committed partners from several countries and organizations, and each partner participates on the basis of their national funding contribution. The annexes typically last three years and provide robust coordination and management to develop emerging technologies. The work currently focuses on three major areas: (1) Building Systems (i.e., electrical lighting, heat pump and reversible A/C, advanced commissioning), (2) Buildings (i.e., prefabricated energy retrofit systems, near zero energy houses, environmentally responsive elements and energy retrofit tool kit for government buildings), and (3) Communities (i.e., low-energy for communities and energy efficient communities).

The IA on ECBCS provides world-class technical products from its annexes. Close attention is paid to program outcomes in terms of technical quality and relevance to target audiences. Major steps have been taken to ensure that the technologies and techniques developed by the annexes are properly and effectively deployed. The ECBCS is also increasing its coordination and co-operation with other IEA IAs and international bodies.

Assessment of the IA Model

The ECBCS is one of many IAs that successfully demonstrate the value of this approach in fostering international co-operation and collaboration on energy technology. Workshop discussions and the experiences of gathered experts indicate that IAs are regarded as a strong model for enabling both R&D co-operation (e.g., information sharing) and collaboration (joint planning and execution of research projects). Strengths and weaknesses of the IA approach are summarized below.

Strengths:

The IA model has been demonstrated to provide a number of benefits. While no IA will necessarily deliver the entire spectrum of possible benefits, the most common include:

- Coordinated planning and co-operation
- Information sharing and networking
- Reduced cost and duplication of work
- Greater project scale
- Accelerated development and deployment
- Strengthened national RD&D capabilities
- Linking of IEA member and non-member countries

- Linking of research, industry and policy
- Harmonized technical standards

Weaknesses:

While the IA System has been effective in enhancing international co-operation, it has some potential limitations with regard to energy technology collaboration. These limitations may include inadequate financing, limited participation by non-IEA members, cumbersome consensus building processes, inadequate recognition of political factors, sluggish information flow, and narrow technological scope.

IAs often struggle with modest budgets. In moving beyond co-operation and information sharing towards meaningful R&D planning, collaboration, and joint execution of projects, real financial muscle is needed to make the IEA model effective.

In the effort to extend international co-operation and collaboration worldwide, there are difficulties in engaging adequate and appropriate representation from non-IEA member countries. Typically participation on the IA working groups is concentrated among from IEA member countries. Key non-IEA countries (e.g. China, India, etc) may not be included.

Membership on IAs is self-selecting and IEA protocols call for consensus in action. This can lead to cumbersome processes, with disproportionate influence on outcomes by participants with limited engagement or low stakes at risk on specific topics of interest.

The IAs have a bottom-up character. In some technical settings, this can be a strength. In some international settings, where ambitious agenda require strong political support, this can be a weakness, compared to some other modes examined in the workshop. Successful efforts to enhance energy technology collaboration often require enhanced engagement of both policy and technical elements. However, there is no perceived barrier to this being achieved employing the IA model.

In some IAs, administrative processes are slow, requiring extended periods for information to flow from a working group to an Executive Committee, and vice versa. The IEA Secretariat desk officer assigned to each IA may play an important role in providing soft steerage in both directions.

When it comes to a full spectrum of important climate change-related technology solutions, as opposed to a narrower focus of energy, the scope of the IEA itself, and its subordinate IAs, may be limiting. IAs typically focus on technologies for fossil energy, renewables, efficient energy end-use, and fusion. This scope neglects other technical areas believed to be important for global climate change solutions. These include civilian nuclear power, biofuels, agriculture, forestry, technologies aimed at reducing non-CO_2 GHG emissions (many with high global warming potentials), land use and others.

In summary, the IA is seen as a generally successful model for carrying out international R&D co-operation and, and to a lesser extent, R&D collaboration. To be enhanced to a grander scope and scale, as suggested, in part, by the G8 challenge of $10 billion per year, additional emphasis and leadership would be needed. This would have implications across a number of the factors mentioned above, including an enhanced level of commitment of resources, in terms of technical expertise and dollars and Secretariat coordination and support.

INVOLVING DEVELOPING COUNTRIES IN TECHNOLOGY COLLABORATION

Chair: Steven Lee (US), IEA

Expert Presenters: Jonathan Cooney (US, World Bank) and Griff Thompson (US Department of State)

The two key organizations involved in developing clean energy and energy-efficient technologies for deployment in developing countries are the World Band and the Asia-Pacific Partnership.

The World Bank is exploring a number of investment vehicles to deliver clean energy technology to developing countries. While the World Bank is not a technical organization, it provides project management and funding expertise. The new vehicles intended to bring private investors to the table and help commercialize advanced new technologies in the developing world are as follows:

- Regional Energy Innovation Centers
- Advance Market Commitment for Energy
- Clean Energy Innovation Grants
- Technology Policy Support Program

These vehicles are designed to complement the Climate Investment Fund (CIF) and the Climate Technology Fund, which is under the umbrella of the CIF.

While the poorest countries have a great need for new technologies, countries at an intermediate level of development, such as South Africa and India, represent better investment vehicles for the World Bank. For this reason, these intermediate countries are their initial targets. These countries may desire the “latest and greatest” technologies, yet the World Bank is not discounting any developed technologies from consideration for transfer. Consideration has been given to how the four mechanisms listed above could help advance CCS, concentrated solar power and small-scale biorefineries.

The Asia-Pacific Partnership on Clean Development and Climate (APP) is an innovative effort to accelerate the development and deployment of clean energy technologies. Partner countries are Australia, Canada, China, India, Japan, Korea and the United States. The Policy and Implementation Committee (PIC) leads the Partnership and acts as a steering committee, while eight Task Forces perform the more technical work. Each task force addresses one sector of the general economy. The task forces bring together relevant industries to participate in the discussion in each sector, allowing the APP to clarify challenges and identify solutions. As shown in Figure 1, APP has established task forces for clean fossil energy; power generation and transmission; renewable energy and distributed generation; and a range of energy-related sectors.

Collaboration in the APP is a strictly voluntary, bottom-up approach that is not meant to supplant the Kyoto Protocol. The APP is built from a solid foundation of participation and works to provide private funds to public projects. It promotes best practices by bringing together utility operators and other relevant parties to discuss and share best practices. In general, the APP brings international attention to local efforts.

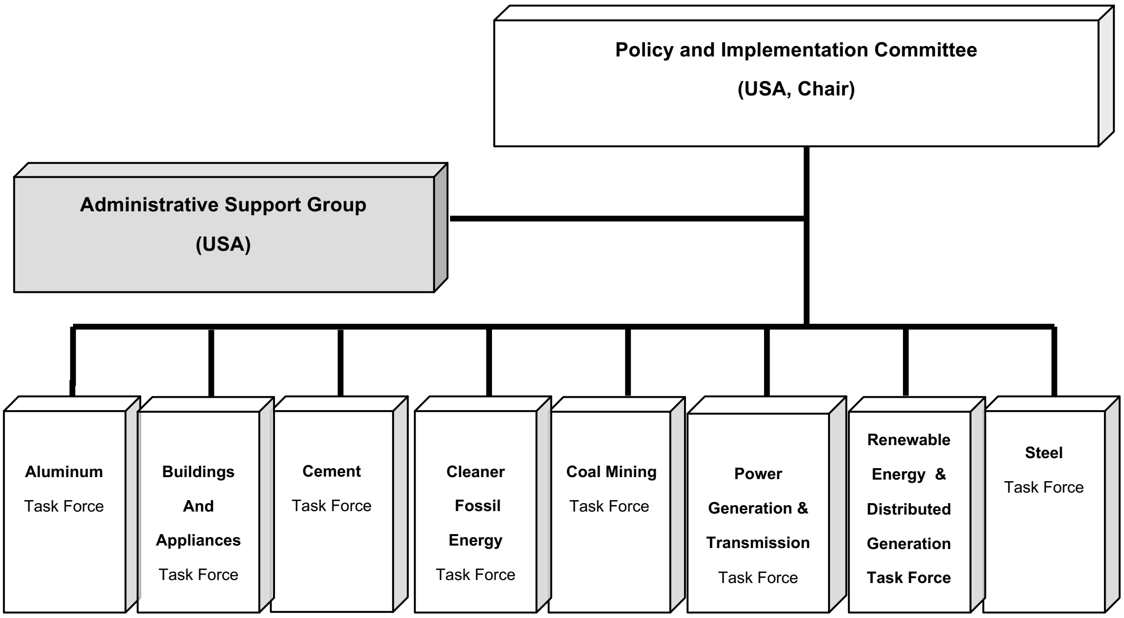

Figure 1. Structure of the Asia-Pacific Partnership on Clean Development and Climate (APP)

Assessment of Involving Developing Countries in Technology Collaboration

Adoption of clean, new technologies must occur on a grand scale in industrialized *and* developing countries to mitigate the worst impacts of climate change foreseen by IEA, IPCC and others. To that end, the APP provides a direct and largely successful effort to develop technologies for deployment in certain developing countries. Similarly, the World Bank will provide investment vehicles for private enterprises or other organizations to develop clean technologies in developing countries. Each approach naturally has its strengths and weaknesses, though one cannot deny the necessity of these and related efforts.

Strengths:

Participation in both programs is voluntary, ensuring a level of commitment that is necessary for successful projects. By utilizing expertise of the program, be it management and finance from the World Bank, or best practices and technological expertise from the APP, the different programs are able to develop small-scale projects with a high level of sophistication.

Weaknesses:

As a complement to the Kyoto Protocol, the APP should be in dialogue with the protocol. After several years in existence, there are efforts underway to assess the APP strengths and opportunities for improvement, and identify future activities.

In summary, these efforts are continuing to develop and learn from past experiences, while still proving the ability to promote and deploy needed technological improvements in developing countries.

REGIONAL COLLABORATION MODELS – EUROPE

Chair: Frank Witte (Netherlands, SenterNovem)

Expert Presenters: Stathis Peteves (European Commission, DG Joint Research Centre); Astrid-Christina Koch (European Commission Delegation to the US); Birte Holst Jørgensen (Nordic Council of Ministers, Nordic Energy Research); and Herbert Greisberger (Austria, OEGUT)

Numerous organizations exist to enhance coordination and collaboration in research by European nations and their partners. These organizations have varied structures, resources and areas of focus, including energy and related science and technology. In some cases they overlap or coordinate with one another. The organizations discussed here include:

- European Framework for International Science and Technology's Seventh Framework Programme (FP-7)
- Strategic Energy Technology Plan (SET)
- European Research Area net (ERA-net)
- Nordic Energy Research

The strategic European Framework Programme for International Science & Technology co-operation's Seventh Framework Programme (FP-7) is the EU's main instrument for funding research in Europe. It engages 27 member states and 11 associated countries[1]. FP7 is also open to collaboration with non-European countries, such as the United States, Japan, Canada, Australia, New Zealand, and Korea, as well as international co-operation partner countries. FP-7 will run from 2007 to 2013 to support research in selected areas. Energy is one of the themes and the budget for energy within FP-7 is 2,265 M€.

The international co-operation strategy of the Strategic Energy Technology (SET) Plan is under development. It is presently considered in the ongoing definition of the European Industrial Initiatives and the joint program of the European Energy Research Alliance. A prime example is the Solar Mediterranean Plan and the corresponding SET-Plan Industrial Initiative on Photovoltaics and Concentrated Solar Power.

The concept of European Research Areas (ERA) dates back to the Lisbon Strategy from 2000 on how to make Europe the most dynamic and competitive knowledge-based economy in the world by 2010. As the majority of European research activities take place at the national level, and only a minor fraction at EU level, open mechanisms of coordination are used to overcome fragmentation of efforts, align resources and create the synergy and critical mass needed to drive research and innovation in Europe. One such mechanism is the ERA-net, which is a coordinating action among national and regional research funding agencies in Europe. The aim of the ERA-net is to provide bottom-up contributions to the creation of an internal European market for knowledge. To that end, ERA-net maps ongoing and planned RD&D activities, provides opportunities to exchange experiences on national strategic programmes, reviews evaluation and assessment procedures and makes common calls for

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[1] Switzerland, Israel, Norway, Iceland, Liechtenstein, Turkey, Croatia, Former Yugoslav Republic of Macedonia and Serbia, Albania, Montenegro, Bosnia & Herzegovina are eligible for funding on the same footing as legal entities from the EU member states. More information on: ftp://ftp.cordis.europa.eu/pub/fp7/docs/third_country_agreements_en.pdf.

research proposals. ERA-net has issues 77 joint calls for projects and organized the pooling of more than 500 M€ for common research projects.

Nordic Energy Research designs and conducts transnational energy research co-operation among the five Nordic countries – Denmark, Finland, Iceland, Norway and Sweden. Nordic Energy Research co-operation started in 1985 to add value to the relatively small and fragmented national energy research communities with technology areas of common interest. Activities are organised in four-year strategic programmes for five priority areas: renewables, energy efficiency, hydrogen economy, liberalised energy markets and impact of climate change on the energy system. The organization conducts research using a common pot of approximately 5M€ per year, and since 2000 has also earmarked funds for collaboration with Estonia, Latvia, Lithuania and Northwest Russia. Nordic Energy Research is an executive partner in various energy-related ERA-net initiatives, including HY-CO, INNER (Northern European Innovative Energy) and Smart Grid. As Nordic energy technology businesses expand their activities in key markets (e.g., China, India, North America etc.), the organization explores the prospects for closer Nordic RD&D co-operation with these countries. In 2008, a top, new, five-year Nordic research programme in energy, climate and environment was approved. The programme covers six thematic areas and has an initial funding of 50M€.

Assessment of the European Collaborative Frameworks

The European research collaboration frameworks are closely linked to further development of an integrated European Research Area, which was introduced in 2000 to build a knowledge-based, competitive economy. As the majority (up to 95%) of European research activities are funded and implemented at the national level, rather than at EU level, various mechanisms of coordination are used to align the resources and activities of member and associated states. ERA-net is one of these mechanisms. A comprehensive assessment of the European Research Area has led to a set of new initiatives. These include joint programming, sharing of research infrastructure, researcher mobility, knowledge sharing and co-operation and collaboration with non-European countries.

Smaller regional collaboration schemes, such as Nordic Energy Research and other successful coordination of national research activities, are important stepping stones toward an internal European market for knowledge. A fundamental difference between the EU framework programmes (FPs) and smaller regional programmes, such as Nordic Energy Research or successful ERA-net activities, is that the EU FPs are included in the overall EU legislative scheme and treaties, which have both supranational and intergovernmental components. In contrast, the smaller programmes are embedded in intergovernmental schemes.

Strengths:

At their best, the European regional programmes are embedded in national interests and priorities and focus on common interests. Such coordinated programmes allow the parties to create a common RD&D programme closely aligned with national priorities and activities.

Co-operation is often developed over time, often starting with knowledge sharing and researcher mobility schemes and developing into cost and task sharing in common research programmes and even a common legal institution.

Value for scarce money is best delivered by supporting networking activities (as opposed to technical research) and providing a common platform for focused RD&D project support with private and other national co-funding. While the main focus is certainly regional, many programmes are open to non-EU countries. By working with these groups, particularly across national borders, the direction of research can be more effectively implemented.

Weaknesses:

While the central administration is a great strength, the regional programme is often in addition to the national efforts already undertaken, and thus of lesser scale and impact compared to larger national programmes. For example, only 10% of the public RD&D money in the EU is available through the FP-7 program. Furthermore, the centrally directed programme priorities are based on consensus, which can potentially put them slightly at odds with individual national priorities.

TECHNOLOGY FOCUSED COLLABORATION

Chair: Peter Rohlin (Sweden)

Expert Presenters:: Justin Swift (US DOE, Office of Fossil Energy), Michael Mills (US DOE, Office of Energy Efficiency and Renewable Energy), John Glowienka (US DOE, Office of Science), Michael Roberts (US, Roberts International, LLC) and Rob Versluis (US DOE, Office of Nuclear Energy)

Four multinational programs focused on technology-specific collaboration have significant membership and broad support from nations around the world:

- International Partnership for the Hydrogen Economy (IPHE)
- International Thermal Nuclear Experimental Reactor (ITER)
- Generation IV International Forum (GEN IV or GIF)
- Carbon Sequestration Leadership Forum (CSLF)

The IPHE provides a unique forum for advancing policies and uniform codes and standards that can accelerate the cost-effective transition to a hydrogen economy. It has organized and implemented effective collaborative activities and projects in many areas, including joint projects with the IEA, and dozens of sponsored workshops. They have also identified common international priorities for advancing Hydrogen through the roadmap framework and helped other countries develop their own roadmaps. IPHE lacks central funding yet acts as an endorsing and coordinating organization, sponsoring projects that generally receive substantial funding from elsewhere. IPHE members include Australia, Brazil, Canada, China, the European Commission, France, Germany, Iceland, India, Italy, Japan, Republic of Korea, New Zealand, Norway, the Russian Federation, the United Kingdom and the United States.

ITER is a well-developed, long-term project to build an R&D device for the testing of fusion. It is essentially planned over a 100 year period dating back to 1958 with plans for construction, testing, and deconstruction through 2058. The negotiations that led to the project started at the technological level through the familiarity developed in bilateral programs. Through extensive negotiations at high levels of government, the ITER agreement established the ITER organization along with certain privileges and immunities and common understandings among the member nations, as well as outlining funding responsibilities of participants. ITER members include China, European Union, India, Japan, Republic of Korea, Russian Federation, and United States

The Generation IV International Forum (GIF) was established as an international collaboration in 2001 with four goal areas in which to advance nuclear energy: sustainability, safety and reliability, economics, and proliferation resistance and physical protection. This collaboration was intended to reinvigorate the nuclear R&D community to think about the next generation of power plants, and to keep nuclear energy as a viable option for the future. In February 2005, the GIF Framework Agreement was signed establishing an agreement for R&D collaboration, assignments of roles and responsibilities of the governments, protections for intellectual property, the formation of Steering Committees to manage certain projects, and support for the creation of multilateral R&D contracts that could include industry, academia, and other countries. Under the Framework Agreement, System Arrangements are developed which describe how to develop specific nuclear systems through more detailed Project Arrangements, which in turn elaborate on the specific technologies needed to advance and develop the system. The Project Arrangements are legally binding agreements between the signatories, who can be public and private entities. GEN IV International Forum members include Argentina, Republic of Korea, Brazil, Russian Federation, Canada, Republic of South Africa, China, Switzerland, EURATOM, United Kingdom, France, United States and Japan.

The objectives of Carbon Sequestration Leadership Forum (CSLF) are to identify obstacles to improved technological capacity; to foster collaborative research, development, and demonstration; to find gaps within the research and address them; and to improve the public perception of CCS. The CSLF is structured with both a policy group and technical group working beneath them. Various Task Forces operate under the direction of either the policy group or the technical group, with all reporting to the Secretariat of the CSLF. The Task Forces support and direct research focused on various CCS technologies. The Forum is open to national governments that are significant producers or users of fossil fuel and that are committed to CCS R&D, and it includes stakeholders from the private sector. CSLF members include Australia, Brazil, Canada, China, Colombia, Denmark, European Commission, France, Germany, Greece, India, Italy, Japan, Korea, Mexico, Netherlands, Norway, Russia, Saudi Arabia, South Africa, United Kingdom, and United States.

Assessment of Multinational Technology Focused Collaboration

Each of these multinational programs have their own strengths and weaknesses, though clearly, the large and encompassing nature of the programs lend themselves to enhanced collaboration and sharing of technologies among a great range of perspectives. Negotiations and agreements at an international level, though often initiated from smaller bilateral projects, provide structure for the different programs to develop.

Strengths:

The multinational nature of the organizations engenders international dialogue at minimum, as well as a sharing of technologies in the RD&D efforts. Moreover, where it has been a priority, such as in ITER and GIF, the involvement of technical people particularly in roadmapping processes gives solid foundation to the direction of the organization.

Particularly in the case of IPHE, the international scope of the effort allows it to more effectively catalogue and monitor the various R&D activities. As an umbrella organization, it can assist project development, as well as define a robust portfolio of R&D efforts.

Weaknesses:

Funding is a constant weakness, and while the legally binding nature of many of the agreements is an asset, the funding is often at the discretion of the current national governments. These projects, especially ITER, aim to break free from policy cycles as development on such a large scale takes substantial time and resources.

Stakeholder participation can be limited by the structure of the organization, as in the example of CSLF which is a government-to-government system. However, the CSLF recognizes that stakeholders form an essential component of CSLF activities and that their views and contributions are important to the success of the CSLF. Stakeholders are invited to register with the CSLF to access information on CSLF activities and meetings.

Similarly, the GIF membership is essentially by invitation only, which can leave interested parties disenfranchised. Deciding the structure of the organization, however, is crucial to acquiring appropriate private stakeholder input.

In summary, the multination organizations tend to follow a certain evolution. Initially, researchers and other interested people convene to discuss the topic of importance; they identify projects that are ongoing and move to rebrand those projects with the formation of the larger initiative. The initiative uses that portfolio to increase the political muscle behind it while it holistically catalogs the on-going research. Finally, with international membership, the group decides on future planning. The examples given are certainly in different stages of the evolution, and even advancing in multiple sections of the evolution simultaneously. In either case, this or similar evolution appears essential to organic growth of an organization.

CONCLUSION AND OUTLOOK

Several general observations can be made from the analysis of the various modes and means of international energy technology co-operation and collaboration discussed in this paper:

(1) Development and deployment of game-changing clean energy technologies will be required to effectively address the climate change challenge and this will require international leveraging of resources and expertise.

(2) A multitude of bilateral, multilateral, and regional energy technology co-operation/ collaboration mechanisms are in place, yet no global mechanism or strategy exists to coordinate the related activities and ensure the effective and efficient use of the available resources and technical expertise. Given the number of activities underway in both developed and developing countries, major synergies can inevitably be achieved through greater coordination of these efforts.

(3) There is a need to assess whether the existing mechanisms, or a modification of them, will be sufficient to adequately strengthen and accelerate international collaboration, or whether new mechanisms are necessary. An effort is needed to identify opportunities to strengthen international energy technology co-operation and collaboration in ways that are mutually advantageous and can leverage experience and expertise across countries.

(4) The IEA Implementing Agreements represent a successful model for carrying out international RD&D co-operation and to a lesser extent, RD&D collaboration. There is a need to analyze how additional emphasis and leadership may enhance the scope and scale of the IAs. The expertise and strategic potential of the IAs is already being activated in the technology roadmaps. In addition, an external assessment of the IA mode and the prospects for enhancing its scope and scale may provide valuable insight in how best to enhance this unique mode.

(5) Existing mechanisms have focused more on co-operation (i.e. exchange of technical information and expertise) and less on collaboration (i.e. projects). Greater emphasis on collaboration and the development and deployment of clean-energy technologies is critical to lowering the cost of achieving emission reductions.

(6) Research, development and deployment of low-carbon energy technologies will require a public-private partnership. Governments have an important role and international co-operation/collaboration efforts have been focused primarily on government to government partnerships, and to a lesser extent public-private partnerships. However, the majority of resources and effort will need to be provided by the private sector and greater efforts are needed to promote public-private energy technology partnerships.

(7) Current efforts appear focused on short-term investment and the transfer of existing technology more so than longer-term collaboration on clean energy options and the development of new advance technology. Expanded R&D budgets for research, development and demonstration efforts are needed.

(8) Lessons learned from more successful international energy technology R&D efforts include:

- Objectives should be closely aligned with national priorities.
- Scope of activities and timeline/milestones should be clearly defined.
- Activities should be of common interest and mutually advantageous.
- Commitments regarding resources are key to successful co-operation and collaboration.
- Timely and adequate attention should be made to overcome barriers such as Intellectual Property Rights (IPR), inadequate legal rules and procedures etc.
- Clearly defined roles and responsibilities are required.
- Success measures or evaluation criteria should be established.
- Broad stakeholder participation should be engaged.

The workshop could not cover all international mechanisms for energy technology RD&D co-operation and collaboration, yet it provides an illustrative characterization of some of the more relevant examples. These mechanisms have facilitated significant accomplishments, enhancing and accelerating international co-operation and collaboration on energy technology R&D. These mechanisms will be further analyzed in forthcoming workshops and reports by the EIA Experts' Group on R&D Priority Setting and Evaluation.

Acronyms

A/C	air conditioning
APP	Asia-Pacific Partnership on Clean Development and Climate
CCS	carbon capture and storage
CERT	Committee on Energy Research and Technology
CIF	Climate Investment Fund
CSLF	Carbon Sequestration Leadership Forum
ETP	*Energy Technology Perspectives*
EU	European Union
FP-7	European Framework for International Science and Technology's Seventh Framework Programme (FP-7)
G8	Group of Eight forum for governments of eight nations of the northern hemisphere: Canada, France, Germany, Italy, Japan, Russia, the United Kingdom, and the United States
GHG	greenhouse gas
GIF	Generation IV International Forum
IA	Implementing Agreement
ICE	internal combustion engine
ITER	International Thermal Nuclear Experimental Reactor
IEA	International Energy Agency
IGCC	integrated gasification combined cycle
IPR	intellectual property rights
PIC	Policy and Implementation Committee of the APP
PV	photovoltaic
R&D	research and development
RD&D	research, development and demonstration
RDD&D	research, development, demonstration and deployment