Findings:
A Review of International Collaboration Of Technology R&D to Prevent or Mitigate Global Climate Change

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Executive Summary

Under the auspices of the CTI, researchers reviewed the international collaborations that currently exist for technology R&D with respect to climate-friendly technologies. The review focused on Australia, Canada, New Zealand, United States, and Europe. The purpose is to assist the CTI in developing an international collaborative program to promote research, development, demonstration, and diffusion of such technologies. The study found that, for most of the organizations that participated in the review, less than 25 percent of their climate change relevant research is being conducted as part of an international collaborative arrangement. Overall, the institutional arrangements that currently exist for the development of greenhouse gas mitigation technology work well. Especially noted was the IEA. However, the focus of the current institutional collaborative efforts is in among the developed nations. Especially lacking was such collaborative efforts in Asia and Africa. Suggestions to the CTI include (1) becoming a focal point for climate change relevant R&D across all areas; (2) assisting the developing countries through training and disseminating information; and (3) encouraging greater private sector involvement in all stages of research.

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Introduction

Technology is increasingly expected to play an indispensable role in curtailing the concentration of greenhouse gases in the atmosphere. The wider adoption of current climate-friendly technology, as well as the development and deployment of improved and innovative technology, are important aspects of the global response to climate change concerns.

The Climate Technology Initiative (CTI) acknowledges the crucial role that technological advances will play in the mitigation of greenhouse gas emissions. Recognizing that no single country can make technological progress better by itself than with the cooperation of others, the CTI aims to foster cooperation and new partnerships in the development, demonstration, and diffusion of technologies designed to prevent or mitigate global climate change.

Under the auspices of CTI, Japan's New Energy and Industrial Technology Development Organization (NEDO) and Japan External Trade Organization (JETRO) initiated a review of the international collaborations that currently exist in the research and development of technologies to mitigate greenhouse gas emissions in Australia, Canada, New Zealand, United States, and the European Union. The purpose of the study is to provide information for the CTI to use in its efforts to create a viable and vibrant international collaborative program to promote the research, development, demonstration and diffusion of climate-friendly technology.

The review of the institutions engaged in research and development of climate-friendly technologies was carried out in Canada, Australia, and New Zealand (collectively referred to as CANZ) and the United States by Battelle Memorial Institute in Washington, DC, under contract to NEDO. For Europe, the Environmental Resource Management (ERM) in London conducted the review, under contract to JETRO.

Methodology

Battelle and ERM each identified approximately 50 relevant institutions in the respective regions, across the US and CANZ and 17 European nations. The targeted institutions were those identified as conducting R&D of technologies that are primarily being developed for climate change mitigation. About 50 percent of the targeted institutions responded to the queries (23 in the US and CANZ, about 25 in Europe).

The organizations were selected through an extensive network of contacts already known to Battelle and ERM through their ongoing work in the field of climate change. There

was not sufficient time to map out the network of contacts cited by the participants for a thorough determination of the patterns that exist in international cooperative activities being undertaken currently in the US, CANZ, and Europe. By design, nearly all of the organizations selected were either government agencies or government funded, with very little private industry participation.

Initially, the review attempted to target those organizations that are conducting R&D of climate-friendly technologies that are specifically *motivated* by climate change concerns, such as geological or ocean carbon sequestration. This definition, however, proved too restrictive. Thus, the approach was modified to encompass a broader definition of climate-friendly technologies that would include organizations involved in international collaborations in the R&D of technologies that are *relevant* to climate change. R&D efforts being undertaken in energy efficiency and alternative energy sources, such as nuclear and renewables, were thus included in the review, although these efforts are often motivated more by energy availability concerns than concerns about climate change.

Battelle developed the semi-structured interview protocol to be administered to individuals in each organization who were identified as being knowledgeable about the organization's climate-friendly R&D efforts, its collaboration with others, and its long- and short-term technology strategy, if any. The protocol questions were chosen to ascertain the form and structure of the existing international collaborative arrangements and to discover what factors have contributed to their success or shortfall. In addition, the protocol was designed to reveal the magnitude of the R&D collaborative efforts that already exist at the target institutions and to ascertain the extent to which each institution has a technology strategy to meet future challenges facing climate change mitigation. The same interview protocol was used (with minor variations for the European application) for the purposes of collecting the data from the US and CANZ as well as the European nations.

Limitations

Due to the limited scope of the review, the findings are preliminary and should be viewed as providing only a sketch of the current collaborative arrangements rather than a comprehensive and detailed picture. The limitations of the review are as follows:

- Not a comprehensive survey;
- No follow-up inquiries due to time restrictions;
- No clear definition of what constitutes climate change mitigation technology; and
- Lack of private-sector representation.

Major Findings

This section highlights the major findings of the study. For a more comprehensive view of the findings, see the interview results in Appendix A.

For most of the organizations that participated in the review, less than 25 percent of their climate change relevant research is being conducted as part of an international collaborative arrangement. This lack suggests that there are opportunities for increasing international collaboration in this area, particularly since many of the respondents indicated that they would like to see more collaboration in the future. This lack also suggests that there may be research redundancies in the system, if many nations are conducting similar research independent of each other, for whatever reason.

For many of the US and CANZ organizations, their collaborative efforts are primarily in the planning and research stages, with some in the development stage. Less than 10 percent of the organizations interviewed are engaged in technology deployment as a part of their collaborative research programs.

Organizations that collaborate in the demonstration and deployment of climate-friendly technology represent a smaller portion of the US and CANZ organizations compared to those interviewed in Europe. Only a few of the US and CANZ organizations' collaborative arrangements have resulted in the joint development or deployment of climate change mitigation technology, although some organizations stated that the deployment of technology remains a long-term goal. Among the exceptions to the organizations focusing primarily on planning and research is one Canadian organization, which specifically gears its collaborative programs toward the development and deployment of technology with the latter phase being handled by its industrial partners.

One reason that many organizations focus their international collaborative efforts in the planning and research stages, rather than in development and deployment, may be a reflection of the fact that funding for these efforts comes mostly from government, with little or no industry support or participation. Another, perhaps more important, reason may be that some of the obstacles, such as intellectual property concerns, are not as formidable barriers in the planning and research stages as they are in the development and deployment of technology.

In Europe, a large number of collaborations are initiated, and partners recruited, through international institutions, such as the International Energy Agency or the European Commission. Use is also made of existing research networks, such as the European Energy Network. In comparing the responses from Europe with those from the US and CANZ, the former tends to rely more on existing research networks in initiating international collaborations while the latter two show more of a mix. In the US and the CANZ, organizations make use of existing networks, but they also rely on bilateral arrangements independent of the existing networks, as well as projects that are initiated by individual researchers themselves.

The respondents cite the following measures of success in the international collaborative efforts in which they have participated. One is the creation of research networks with the potential for future collaboration. Another is the research products that came out of the collaboration, such as publications, models, new data and methodologies. Further

measures of success are the data exchange and the use of complementary knowledge and expertise, the generating of new research, as well as cross-fertilization of ideas.

The most often cited challenges relate to bureaucracy, legal and funding issues. Lack of standardized contracts or other umbrellas to ease the initiation of collaborative arrangements, as well as concerns over proprietary data and intellectual property rights over technology developed collaboratively, are seen as major barriers. Other challenges concern issues of culture, communication and logistics. Such issues as developing a common frame of reference and research plan, reaching an understanding across scientific group with myriad backgrounds, and keeping international collaborators informed and engaged across distances are seen as barriers to be overcome.

What are the factors that contribute to successful collaborations? One is a framework that eases bureaucratic and legal hurdles for those seeking collaborative arrangements. Making available such mechanisms as standardized contracts or memoranda of understanding could vastly reduce the time involved in working out legal hurdles. Having smaller administrative bodies could also cut through some bureaucratic red tape.

Another factor is the coordination of project goals and requirements by funders at the outset. Participants in international collaboration often face multiple funding sources, each with its own priorities and project requirements. A mechanism that brings funders together at the start to jointly agree on goals and requirements would greatly facilitate collaboration.

Further factors for successful collaborations involve an ability of the participants to communicate effectively and to reach a common understanding as well as having a clear delineation of responsibilities.

Role for the CTI

Overall, the institutional arrangements that currently exist for the development of greenhouse gas mitigation technology work well. Especially noted was the IEA. As one participant commented, all the key players are around the table—groups of people with expertise and common interests. The IEA thus provides a mechanism to bring different elements together to work on energy related climate change mitigation technology projects. In terms of project-by-project implementation, the IEA Implementing Agreements remove bureaucratic hurdles and may facilitate transfer of funds across borders.

The CTI offers value as an umbrella organization, a clearinghouse that brings together all the projects that are relevant to climate change mitigation, with or without an energy focus. CTI could provide a focal point for climate change relevant research and provide a bridge between IEA and the parties to the United Nations Framework Convention on Climate Change, drawing upon existing and future IEA projects. While the CTI was created to specifically address climate change issues, the IEA was created in response to

the energy crisis and has a somewhat different mission. Thus, the CTI may be a better mechanism to directly address climate change issues.

The CTI could also assist nations in coordinating research strategies for meeting UNFCCC obligations and objectives, thereby reducing research redundancies.

There is currently a lack of collaboration with countries in Asia and Africa. The CTI could help to bridge this gap by establishing research networks with those regions. Similarly, the CTI could assist developing countries through training and dissemination of information.

The CTI could encourage greater private sector involvement in all stages of research through encouragement of innovative handling of funding and intellectual property issues. Cooperative research co-financed by government and industry represents an important link between long-term research and the implementation of research results. For technology transfer and the application of know-how, it helps to have industry partners in at the beginning of a project. Involvement of industry and other market actors is key to technology implementation.

Conclusions

Overall, international collaborative efforts represent a small proportion of the climate change relevant R&D being conducted at organizations in the US and CANZ and in the European nations. This gap suggests that there may be unnecessary redundancies in research if nations are engaged in similar R&D activities unilaterally. It also suggests that there may be room to increase international collaborations. CTI may have a role to play in promoting joint research planning or funding frameworks.

Moreover, organizations involved in IEA collaborative projects report that these projects are valuable and effective, that they are "working well." This finding suggests that whatever role CTI has to play may be in the context of existing structures.

The CTI needs to clearly define where it wants to go from here and where it will focus its resources. The preliminary findings from this review suggest that perhaps the most fruitful areas may be as (1) a clearinghouse for all climate change mitigation technology research, building on existing mechanisms, (2) a link between the IEA and the parties to the UNFCCC, (3) a training provider, and (4) a bridge between OECD and non-OECD countries in climate change mitigation efforts.

APPENDIX A

International Collaboration on Science and Technology R&D To Prevent or Mitigate Global Climate Change

FINDINGS

This appendix highlights the research findings of the interviews conducted and includes discussion of the nature, formation and structure of the collaborative arrangements, common successes and challenges, additional options for collaborative arrangements, and research and development (R&D) planning.

Battelle contacted 47 organizations in the Australia, Canada, New Zealand and the United States and received 23 responses, as of the date of this report. ERM contacted 50 organizations in the European Union and received approximately 25 responses.

Organizations Contacted

Country/Region	*# of Organizations Contacted*	*# of Responses*
Australia	5	3
Canada	11	7
New Zealand	7	3
United States	24	10
Europe	50	25

Definitions of Terms as Applies to the Questionnaire

Climate Change Relevant R&D:
Research, Development, Demonstration, and/or Deployment on technologies that will impact net Carbon or reduce other greenhouse gases, but which may or may not be driven specifically by climate change concerns.

Climate Change Motivated R&D:
Research, Development, Demonstration, and/or Deployment on technologies that will impact net Carbon or other green house gases and which is driven specifically by climate change concerns. Examples of both climate change relevant and climate change motivated R&D include development of low or no carbon energy sources, carbon capture and sequestration by artificial or natural means, energy efficiency, reduction of methane emissions.

International Collaborative Arrangements:
Bilateral or multilateral relationships that are more formal than telephone contacts or occasional information exchange; relationships that are repeated or continual, e.g., joint program development, formal memoranda of understanding (MOU), sharing of data on a

repeated or continuous basis, exchange of researchers.

Enabling Mechanisms:
The means by which international collaborative efforts are implemented, e.g., contracts, grants, MOU, collaborative research and development agreements.

R&D Strategy:
Planning conducted by an organization which examines any or all of the following – selection of most viable technology research areas, the economic/social/political factors which will affect or be affected by the technology, how the technology will move from the R&D stage to acceptance in the market. R&D strategies will vary by time frame and geographic focus.

Following are the main findings from the questionnaire research. In some instances, the question from the questionnaire is included in italics. For a complete version of the questionnaire, please see the appendix.

General Nature of the Collaborations

Arrangements and Mechanisms

Of your organization's climate change relevant research, what proportion is conducted as part of some international collaborative arrangement?

For most of the organizations contacted, less than one-fourth of their climate change relevant research is conducted as part of an international collaborative arrangement. Of the exceptions, one Canadian, one US, and seven European organizations conduct around one half of their climate change relevant research as part of international collaborative arrangements. Overall, this research involves energy efficiency and renewables or scenarios, modeling and energy system analysis. The other exception is the European Commission, which, by definition, conducts 100% of its research through international collaborative arrangements.

What type of arrangements do the international collaborations entail?
What type of mechanisms enables the collaborations?

Types of Collaborative Arrangements and Enabling Mechanisms

Arrangements	*Europe*	*Australia/New Zealand*	*Canada*	*US*	*Total*
Joint program development	21	5	4	7	37
Sharing of data on a repeated or continuous basis	17	4	4	7	32
Professional exchange of researchers	8	2	3	5	18
Other	3	1	1	1	6

Mechanisms	*Europe*	*Australia/New Zealand*	*Canada*	*US*	*Total*
Contracts	16	2	2	7	27
Grants	14	4	0	3	21
Memoranda of understanding	11	1	3	3	18
Collaborative research and development agreements	22	1	2	4	29
Other	3	2	2	4	11

- Almost all the organizations contacted engage in joint program development, as well as sharing of data and, to a lesser extent, exchange of researchers.
- Based on the data received, contracts, grants and cooperative research agreements appear to be the most widely used mechanisms. Respondents who selected multiple mechanisms were not asked, however, if certain mechanisms predominated.
- In addition to memoranda of understanding, contracts, and cooperative research agreements, informal mechanisms are also used to enable collaborations.
- Joint ventures were used by only one of the organizations we contacted.
- The distribution of mechanisms used may reflect the fact that the majority of the organizations contacted were linked to governments or universities and, for the non-European organizations, were more likely to be engaged primarily in research, development and demonstration, rather than in deployment of technologies.

Research Topics
Collaborative programs represent broad and diverse array of research topics, including:

- efficient end-use
- alternative transport
- CO_2 sequestration
- renewable energy
- efficient combustion
- fuel cells
- alternative and biomass fuels
- recovery of fossil fuels

- ocean sequestration of CO_2
- CO_2 sequestration in coal seams
- carbon sequestration through managed forests
- land surface/vegetation-atmosphere carbon exchange
- reduction of green house gas emissions through land management
- forest fires and the ecosystem impact of biomass burning
- atmosphere-biosphere interactions
- ecosystem modeling

- economic and sociotechnical issues related to climate friendly technologies
- analysis of energy efficient technologies and policies
- determinants of energy demand
- climate change impact assessment and modeling

Stages of Research and Deployment of Technology

What stages of research does your collaborative arrangement focus on?

Stages of Research

	Europe	*Australia/New Zealand*	*Canada*	*United States*	*Total*
Planning	12	3	4	5	24
Research	18	5	5	9	37
Development	15	4	3	4	26
Demonstration	16	1	1	2	20
Deployment	4	1	1	2	8

- For many of the organizations interviewed, their collaborations involve planning and research, with some development as well.
- Demonstration and deployment represent a smaller portion of collaborative activities.
- Organizations engaged collaboratively in demonstration and deployment of climate change friendly technologies represent a smaller portion of US and CANZ organizations as compared with those interviewed in Europe. Six organizations are engaged in demonstration and deployment in the US and Canada and one in Australia, as compared to Europe, where sixteen are engaged in demonstration and an additional four organizations are engaged in demonstration and deployment.

Have any of your collaborative arrangements led to the joint development or deployment of climate change mitigation technology?

- Few of the US and CANZ organizations' collaborative arrangements have led to the joint development or deployment of climate change mitigation technology, although some organizations stated that they are moving in that direction and that deployment of technology represents a long-term goal.
- One Canadian, one US, and one Australian organization specifically stated that their collaborative arrangements have resulted in the joint deployment of climate friendly technology. (Information on this point for European organizations was not available).
- The Canadian organization, Alberta Research Council, specifically gears its collaborative programs to lead to the development and deployment of technology, with the latter stage being handled by its industrial partners.
- The US organization, Lawrence Berkley National Laboratory deploys, for example, energy efficiency refrigerators and lighting in China, as part of the Laboratory's energy efficiency programs.
- Australia's Department of Primary Industries and Energy has deployed a range of technologies in developing countries, particularly in the Asian region.

Sources of Financial Support

What is your organization's main source of financial support for the collaborative climate change research?

Financial support for collaborative climate change research is mostly government based, although some programs are also funded by private industry.

Source of Financial Support

	Europe	*Australia/New Zealand*	*Canada*	*United States*	*Total*
NGO	0	0	1	0	1
Private industry	1	1	2	4	8
Government	21	4	5	7	37
Other	2	1	0	1	4

Development and Formation of Collaborative Arrangements

Recruitment of Partners

How did this global climate change research collaboration develop?

International collaborative arrangements are initiated in a wide variety of ways:

- Collaborations are supported by existing interagency agreements, such as the Memorandum of Understanding (MOU) between Natural Resources Canada (NRCan) and United States' Department of Energy (DOE), or through other longstanding bilateral agreements.
- Support and impetus for collaboration also arise through international energy or climate change oriented organizations, such as the IEA.
- In Europe, a large number of collaborations are initiated, and partners recruited, through the International Energy Agency (IEA) and the European Commission (EC). For example, European organizations interviewed conduct projects under the IEA's Greenhouse Gas Programme. EC sponsored programs include JOULE-THERMIE, which encourage energy R&D and the demonstration and eventual deployment of energy related technologies. In Europe, use is also made of existing research networks, such as the European Energy Network (ENR).
- Europeans tend to rely on existing institutional networks. In the US and CANZ, however, many projects are initiated by individual researchers, in addition to those projects developed using existing institutional networks.
- Collaborations also arise between organizations because of their similar missions and complementary capabilities, such as that between the US National Aeronautics and Space Administration (NASA) and the Canadian Center for Remote Sensing.
- Other collaborations are initiated by individual scientists with strong interest in a particular topic area. Often these projects are supported by an organization with international ties, such as the International Institute for Applied Systems Analysis (IIASA).

- In addition, collaborations develop through personal and professional contacts, workshops (some specifically initiated to promote collaboration, some not), and/or through requests for proposals.

- While many international collaborative projects originate at the international level, a number also are initiated and funded at a national or sub-national level. These projects later expand internationally, often seeking partners through the IEA or other international organizations.
- For those projects geared towards technology development, specific mechanisms are employed to bring in private sector organizations or organizations with needed expertise. For example, the Coal Bed Methane Project initiated by the Alberta Research Council (ARC) and Sproule and Associates, Ltd., recruited private sector Canadian partners through the Coal Bed Methane Forum, an organization run by Sproule and Associates.

Involvement of Intergovernmental Institutions

What specific intergovernmental institutions, if any, have been involved in putting the collaborative effort together?

European organizations involved in international collaborations on climate change relevant research work in large part through the European Commission (EC) and the International Energy Agency (IEA). While many of the US and CANZ organizations also work through the IEA, a much larger portion of their collaborations involve bilateral or multilateral arrangements unsupported by any intergovernmental organizations. One exception is work through the Energy Working Group and Energy Efficiency and Conservation Expert Group of the Asia-Pacific Economic Cooperation (APEC) agreement.

Involvement of Intergovernmental Institutions

	Europe	*Australia/New Zealand*	*Canada*	*United States*	*Total*
IEA	17	0	4	5	26
None	2	3	0	5	10
Other	0	1	7	3	11
EC	10	0	0	0	10
World Bank	2	0	0	2	4
UNEP	1	0	1	1	3
CTI	0	0	1	1	2
IAEA	1	0	0	0	1
APEC	0	0	1	2	3
UNDP	0	0	0	1	1

Measures of Success

How well has the collaborative arrangement worked? What were the most successful parts of this collaborative arrangement?

Most cited as measures of success were the following:

- the creation of networks and the potential for future collaborations

- the products of the research, including publications, and new modeling tools, research techniques and methodologies
- data exchange and the use of complementary knowledge and expertise
- cross-fertilization of ideas and generation of follow-on research.

For the more ambitious projects, success was measured in part by:
- the ability to attract skilled, reputable partners
- the solving of analytical or technical problems relating to research
- the ability to jointly and successfully develop a research plan
- the ability to effectively manage the myriad details involved with a large-scale research project.

Challenges

What were the biggest challenges encountered? How did you surmount those challenges?

Bureaucratic and Legal

- a lack of standardized contracts or other umbrella to ease the initiation of collaborative arrangements. The framework provided by IEA's Greenhouse Gas Programme Implementing Agreement was noted for its avoidance of just such problems.
- setting and maintaining priorities, so that important goals are not lost in the bureaucratic details.
- bureaucratic delays and indecision. This hurdle may be avoided through the use of a small, dedicated project team focused on the needs of the program.
- the intellectual property status of technology developed collaboratively. Although too soon to judge its success, the Coal Bed Methane project offers a novel approach to this difficult problem. To participate in each phase of the project, collaborators must contribute a specified amount, either in dollars or in-kind contributions. These contributions are represented by "shares" in the project. Partners receive money from the licensing of technology developed through the project, commensurate with their number of shares. ARC owns the technology, which may be sold by collaborators with ARC approval. Sellers receive 50% of the sale, with the other 50% going into the shares pot, which the seller will also benefit from. Partners may also license the technology at half the cost. At the time of this report, partner companies were evaluating the shares proposal for Phase 2 of the project.
- concern with keeping data and information obtained from field work proprietary. Regulations of the Canadian government, for example, require that projects which are not registered as "experimental" must publish the results of data derived from those projects.
- building a database of information where proprietary information made researchers reluctant to contribute data.
- meeting government guidelines on collaborative projects when international partners are involved.
- the difficulty of linking organizational systems which have never worked together before.

Funding and Support

- Projects supported by different parties must meet different demands, different program objectives, and different funding priorities. There is no mechanism to bring diverse funders together, in order to develop a unified message in terms of goals and project objectives.
- obtaining funding from national organizations for foreign partners. The US NASA, for example, is prohibited from funding organizations outside the United States.
- obtaining national agency support for international work when an agency's current focus remains on domestic projects.

Culture and Communication

- developing a common frame of reference and research plan is especially difficult when the interests and expertise of the participants vary widely.
- achieving communication and understanding across scientific groups with different backgrounds and expertise.
- dealing with different working cultures.
- accomplishing open collaboration despite differences in national interests. This problem may be overcome through accurate definition of the collaboration topic and by insuring that information does not leak to competitors, although neither option is always achievable.
- dissemination of valuable information about new technologies developed, so that technologies are not left on the shelf.

Logistics

- coordinating activities, such as linking scientists working in the field.
- including international collaborators, who are physically distanced from a project site, in a way which allows them to feel involved and valued as participants.
- the logistics of moving staff and equipment to remote sites, unplanned delays taking work to the field.
- comparability/compatibility of data, as well as the availability of reliable data.
- conducting highly experimental research, such as pioneering new approaches for working with oxygen and CO_2.

R&D Planning

Project Selection

How do you define your R&D planning horizon with regards to climate change research? How are projects selected for R&D investments or development?

There are a variety of reasons cited for how projects are selected for R&D investments or development among the organizations we spoke to, but in general, the organizations in the CANZ choose their research priorities based on relevance to policy framework developed by the government. One organization in Canada, however, said that its research planning is conducted through national and international collaborative workshops. As an example, the organization viewed the Intergovernmental Panel on

Climate Change (IPCC) as a major driving force behind climate change research decisions in Canada.

In Europe, too, a number of organizations cited government as a reason for how projects are selected for R&D efforts. However, industry's interests, expertise of independent advisors, and client needs were also cited.

A different picture emerges from the US organizations, although fundability of R&D projects remains a driving force. Some US organizations stated that their R&D projects are initiated by the interest and expertise of the research staff while others establish the R&D agenda based on filling future needs as perceived by the organization itself or through inputs from industry and government.

Use of Planning Tools or Methodologies

Are specific tools or methodologies, such as energy model analysis, technology assessment analysis, and/or economic, social, or policy analysis used in the decision making process?

Slightly more organizations did not rely on specific tools and methodologies, such as energy model analysis, technology assessment analysis, and/or economic, social or policy analysis in their decision making process than those that do. Among the organizations that do rely on these tools, energy modeling was cited most often, but economic assessments also came into play. One US organization said that it uses all such tools and methodologies in its decision making process.

Use of Tools or Methodologies

	Europe	*Australia/New Zealand*	*Canada*	*US*	*Total*
No	7	3	3	8	21
Yes	11	1	2	6	20
No Answer	7	1	1	3	12

Decision Making

Would you describe your decision making process to be:

Inspiration driven?
Opportunity driven?
Financially driven?
Market driven?
Regulatory driven?
Other?*

When asked to describe their decision making process, almost all of the US and CANZ organizations interviewed stated that the process was inspiration, opportunity, and/or financially driven. Some organizations answered that their decision making process was market or regulatory driven while a few said it was expert or issues driven. There were no major geographical differences in the answers to this question in the US or CANZ.

In the European countries, by contrast, organizations stated that their decision making process were primarily financial, market, and regulatory driven. European organizations cite inspiration and opportunity driven factors much less frequently than their US or CANZ counterparts.

	Europe	*Australia/New Zealand*	*Canada*	*US*	*Total*
Inspiration driven	7	2	4	6	19
Opportunity driven	11	4	4	8	27
Financially driven	11	2	3	5	21
Market driven	12	2	2	2	18
Regulatory driven	9	2	1	2	14
Other*	5	0	4	1	10

*For the US and CANZ, "other" includes: expert driven, issues driven, and requests for information. For Europe, "other" includes: politically, science, and customer driven, as well as EU policy driven.

Planning Horizon

When making your technology investment decisions, how long do you estimate it will take to go from the idea stage to deploying your technology product in the market?

In making their technology investment decision, the organizations interviewed tend to have a long view, that is, more organizations estimate that it would take either ten years or longer or between five to ten years to go from an idea stage to deployment of the technology into the market. Likewise in Europe, most of the organizations responding to the timeframe question stated that they take a long view in that they estimate that it would take either ten years or longer or between five to ten years.

The organizations with a relatively long time horizon tend to be the ones conducting basic research, such as at universities, and tend to have more government funding sources than those organizations with shorter perceived time horizons. The organizations with shorter horizons cooperate with or received at least a part of their funding from private industry.

Research Time Horizon

	Europe	*Australia/New Zealand*	*Canada*	*US*	*Total*
10 years or longer	6	3	0	3	12
5 to 10 years	9	3	3	2	17
3 to 5	2	0	1	2	5
1 to 3	1	0	2	1	4
*Other**	2	0	0	1	3

*"Other" includes project, client, and sector dependent

Collaborative Planning

More organizations in Australia, New Zealand, and the US tend not to conduct their R&D planning as part of an international collaborative research program than those

organizations that do; however, the gap is not very significant in these countries. Moreover, a few organizations that responded "no" to this question said that they are hoping to do more of their R&D planning within an international context in the future. More organizations in Canada conduct their R&D planning as part of an international collaborative research program than not. In Europe, however, a vast majority of the respondents said that they conduct their R&D planning solely within the organization, although a few said that they did so with consideration for international activities.

Future Directions

Opportunities for Expansion

Of the collaborative arrangements you're using, which do you think have the most potential for expansion? (Expansion here is broadly defined and may be in terms of the number of participating institutions, the scope of research, the geographic focus …)

Participants offered a number of suggestions as to how existing collaborative programs could be expanded.

- Newer organizations, such as CTI and APEC, could be expanded in terms of membership. Industrial members for example, may be interested in APEC or CTI sponsored projects as possible responses to potential future CO_2 emissions restrictions.
- Expansion of IEA membership to include more non-OECD countries.
- In terms of regions, there is potential for capacity building activities in China, as well as expansion into regions where there is currently little or no collaboration, such as in parts of Africa and Asia.
- Respondents foresee future collaboration opportunities with Japan and other Asian nations. Parallel projects for CTI's Coal Bed Methane project could be run in China, for example, because of the global potential of the technology being developed.

New or Alternative Collaborative Arrangements

Are there other types of arrangements that you are not using that might have potential to support international collaboration on the development of climate-friendly technologies? If so, what have been the barriers to their use?

What new or alternative international collaborative arrangements would you find useful for advancing your global climate change research?

Responses to the above two questions discussed systemic issues relating to existing frameworks for international collaboration. These issues included funding, dissemination of information, private sector involvement, national government involvement, and the respective roles of CTI and IEA.

Funding

Funding was mentioned many times during the course of our interviews. Participants complained about the exclusive nature of funding sources. They suggested the need for a funding mechanism which, recognizing the global nature of the climate change issue, transcends national boundaries. Currently, international collaborations are hampered because some funding organizations are restricted in terms of the nationality of recipient

organizations. Many US federal government agencies, for example, legally are not permitted to fund non-US organizations. As another example, the EU maintains a policy that restricts it from funding non-European organizations. For some of the collaborative projects we reviewed, IEA served as a broker by enabling funds from a variety of sources to be pooled and redistributed regardless of the nationality of the source or recipient.

Another suggestion referred the difficulties resulting from having to gather funding from multiple sources, each with its own priorities and project requirements. A mechanism that brought funders together at the start of a project to jointly agree on goals and requirements would greatly facilitate collaboration. In addition, managing funding for collaborative efforts could serve to reduce unintended duplication of activities.

Dissemination of Information and Expertise, Establishing Research Networks

- Arrangements to facilitate the management and exchange of research data, with improvements in access, availability, compatibility, and preservation.
- A mechanism by which science and technology investments can be tracked, to insure that technologies move from development through to deployment. Perhaps more importantly, a means by which research investments in different countries could be coordinated, in order to avoid duplication of effort and to build on research strengths.
- Dissemination of information regarding the latest available climate friendly technologies. To a large extent such information is available through programs such as IEA's Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET), which analyses and disseminates information on energy efficiency and renewable demonstration projects, and IEA's Greenhouse Gas Technology Information Exchange (GREENTIE), which operates a global database of suppliers of technology and expertise for greenhouse gas mitigation.
- Accompanying dissemination of technology information should be training opportunities for business managers, city planners, etc., in OECD and non-OECD countries. These training opportunities would build national capacity in policy and technical skills relating to implementation of climate friendly technologies, much as the UNEP IE OzonAction Programme does for ozone-friendly technology.
- There is high value in the provision of opportunities for scientists from different countries with mutual interests to interact and exchange ideas.
- The establishment of research networks that would encourage European collaboration with organizations outside Europe.

Attracting the Private Sector

Cooperative research co-financed by government and industry represents an important link between long-term research and the implementation of research results. For technology transfer and the application of know-how, it helps to have industry partners in at the beginning of a project. Involvement of industry and other market actors is key to technology implementation.

Private sector organizations comment that international funding agencies are not nimble enough to support collaboration, so these private sector companies develop their own arrangements. They avoid restrictive program structures that would tie up their staff in

meeting bureaucratic or other, non-research related, program requirements. Other respondents commented that incentives for the private sector to participate are low, because costs and risks are high.

Involving Federal or Provincial Departments and National Governments

- In addition, they noted that they are waiting for their national government to lay out its goals/restrictions for industry. Many companies expressed an interest in moving into the field of climate change friendly technology. Governments can contribute to the creation of a framework where private industry would find it profitable to join with researchers.
- Coordination of national government involvement in international climate change mitigation research activities to encourage a focus on international opportunities and to support better allocation of national research funds.
- Some respondents commented that participation in international organization has been hampered by the tendency of their national governments to focus on local problems over the past few years.
- One way to focus national participation would be for international topic areas to be chosen and for countries to select which areas they would support. The goal then would be to seek out the best international resources to tackle the problem.
- The approval and involvement of national government research agencies would establish authority for individual researchers wishing to cooperate with researchers in other countries (i.e., a "hunting license" to pursue international collaborations).

IEA and CTI

- Overall, the institutional arrangements that exist for the development of greenhouse gas mitigation technology work well. Especially noted was the IEA. As one participant commented, all the key players are around the table – groups of people with expertise and common interests. The IEA thus provides a mechanism to bring different elements together to work on climate change mitigation technology projects. In terms of project by project implementation, the IEA implementing agreements remove bureaucratic hurdles and may facilitate transfer of funds.
- CTI offers value as an umbrella organization, a clearinghouse which brings together all the projects relevant to climate change mitigation. With regards to IEA, CTI could provide a focal point for climate change mitigation research and provide a bridge between IEA and the United Nations Framework Convention on Climate Change (UNFCCC), drawing on existing and future IEA projects. The reason for CTI to serve as a clearinghouse is that its mission is devoted to climate change concerns, as opposed to the IEA, for example, which was created in response to the energy crisis and therefore has a broader focus.
- CTI may also do road mapping in a policy sense, and assist national governments and funders in developing joint, long-term research strategies for research on climate change mitigation technology.

APPENDIX B

International Collaborative Arrangements for Climate Change Technology Research
Interview Questionnaire

Name of Organization: _____

Address of Organization: _____

Country: _____

Organization Web Site: _____

Name of Contact Person _____

Title/Position: _____

Group/Division: _____

Tel No. _____

Fax. No. _____

E-mail Address: _____

A. Background:

1. Please provide a brief description of your organization, e.g., mission and purpose. (You can fax this information to me at my fax number stated above.)

B. International Collaboration on Climate Change Mitigation Technology

Your candid assessment of the challenges your group has faced and the strategies you have used in international collaboration on climate change technology research will contribute to understanding of your program and of ways to improve international collaboration, both conceptually and operationally.

1. Of your organization's climate change relevant research, what proportion is conducted as part of some international collaborative arrangement? Collaborative arrangement can refer to bilateral or multilateral relationships that are more formal than telephone contacts or occasional information exchange; relationships that are repeated or continual; e.g., joint program development, formal memoranda of understanding (MOU), sharing of data on a repeated or continuous basis, exchange of researchers.

   __ less than ¼
   __ between ¼ and ½
   __ between ½ and ¾
   __ more than ¾

2. What type of arrangements do the international collaborations entail? Please check all that apply.

__ joint program development
__ sharing of data on a repeated or continuous basis
__ professional exchange of researchers
__ other (please specify) _____

3. What type of mechanisms enables the collaborations? Please check all that apply.

__ contracts
__ grants
__ memoranda of understanding
__ collaborative research and development agreements
__ other (please specify) _____

4. What research topics do the collaborative arrangements focus on?

5. What stages of research does your collaborative arrangement focus on? Please check all that apply.

__ planning
__ research
__ development
__ demonstration
__ deployment

6. What is your organization's main source of financial support for the collaborative climate change research?

__ NGO
__ private industry
__ government
__ other (please explain)

7. Have any of your collaborative arrangements led to the joint development or deployment of climate change mitigation technology? YES NO

If YES, please describe

8. We would like to map out the collaborative network, to better understand how information and ideas are flowing. We would appreciate knowing the names of some of the institutions that you've collaborated with internationally. In the table below, please detail the international climate change research collaborations in which you have been involved within the past five years.

Climate Change Research Network				
Name of Collaborative Program	**1.**	**2.**	**3.**	**4.**
Name of Principal Collaborating Organization				
Name of Key Contact at Principal Collaborating Organization				
Country of Collaborating Organization				
Funding Source or Sponsoring Organization				
Names of Other Research Organizations Involved in the Collaboration				

Please answer questions **9, 10, and 11 for each of** the collaborative efforts you have listed in the above table

9. How did this global climate change research collaboration develop? For example,

   a) Who initiated the collaborative arrangement?

   b) How were partners recruited?

   c) Goals for the collaborative relationship?

   d) How long has the collaboration been going on?

10. How well has the collaborative arrangement worked?

a) What were the most successful parts of this collaborative arrangement?

b) What were the biggest challenges encountered?

c) How did you surmount those challenges?

11. What specific intergovernmental institutions, if any, have been involved in putting the collaborative effort together?

    __ None
    __ International Energy Agency (IEA)
    __ World Bank
    __ International Atomic Energy Agency (IAEA)
    __ United Nations Development Programme (UNDP)
    __ United Nations Environment Programme (UNEP)
    __ Other _____

    With what part of the intergovernmental organization or with whom do you work?

12. Of the collaborative arrangements you're using, which do you think have the most potential for expansion? (Expansion here is broadly defined and may be in terms of the number of participating institutions, the scope of research, the geographic focus …)

    Please explain.

13. Are there other types of arrangements that you are not using that might have potential to support international collaboration on the development of climate-friendly technologies?

    If so, what have been the barriers to their use?

14. What new or alternative international collaborative arrangements would you find useful for advancing your global climate change research?

C. R&D Planning

The purpose of this section is to understand how your organization **plans** its climate change technology research.

1. How do you define your R&D planning horizon with regards to climate change research? For example:

   a) How are projects selected for R&D investments or development?

   b) Are specific tools or methodologies, such as energy model analysis, technology assessment analysis, and/or economic, social or policy analysis used in the decision making process? If so, which ones and how are they used?

c) Would you describe your decision making process to be: (check all that apply)

__ inspiration driven
__ opportunity driven
__ financially driven
__ market driven
__ regulatory driven
__ other (please explain)

d) When making your technology investment decisions how long do you estimate it will take to go from the idea stage to deploying your technology product into the market?

__ 10 years or longer
__ 5 to 10 years
__ 3 to 5 years
__ 1 to 3 years
__ other (please explain)

2. Is any of your climate change R&D **planning** conducted as part of an international collaborative research program, or is planning done solely within your organization?

Please elaborate.

Please feel free to add any additional comments you might have. We greatly appreciate your time and help in this effort. If you would like to receive a summary of our research findings, please let us know.

Thank you.

Appendix D

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APPENDIX E

Descriptions of Organizations Involved

Battelle Memorial Institute was established in 1925 pursuant to a will of Gordon Battelle, a philanthropist who was interested in using scientific research for real-life applications. Battelle is one of the world's largest contract research firms headquartered in Columbus, Ohio, with staff working in more than 30 countries. Battelle provides science-based solutions to complex problems in environment and energy and acts as a catalyst to technology transfer between government and industry.

Climate Technology Initiative (CTI) is a voluntary initiative to foster and strengthen national and international development and deployment of climate-friendly technologies. The CTI was launched at the First Conference of the Parties to the United Nations Framework Convention on Climate Change in Berlin in 1995 by 23 developed countries and the European Commission. Countries participating in the CTI include Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, The Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States, and the European Commission

Environmental Resources Management (ERM) is a private environmental consulting company, which has been operating for about two decades. ERM aims to assist governments through its work in decision making and policy formulation in the environmental field. ERM has its headquarters in both London and Oxford.

Japan External Trade Organization (JETRO) is a nonprofit government-related organization, established in 1958. Its mission is to support trade and investment between Japan and other countries. JETRO has a network of 80 offices around the world. JETRO's activities include expanding Japan's imports, fostering industrial cooperation, and promoting mutual understanding among nations.

New Energy and Industrial Technology Development Organization (NEDO) is the administration and implementation arm of the Ministry of International Trade and Industry (MITI). NEDO was established in October 1980, immediately after the second oil crisis, to address issues related to technological development in Japan and is a unique organization in Japan, in that it works to coordinate funds, personnel, and technological strengths of both the public and private.