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Development and transfer of technologies

Report on options to facilitate collaborative technology research and development

Note by the Chair of the Expert Group on Technology Transfer

Summary

This document presents options elaborated by the Expert Group on Technology Transfer to facilitate collaborative research and development relevant to environmentally sound technologies to enhance action on mitigation and adaptation, based on the review of existing collaborative technology research and development activities.

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I. Executive summary

1. The Subsidiary Body for Scientific and Technological Advice (SBSTA), at its thirty-second session, endorsed the terms of reference for a report by the Expert Group on Technology Transfer (EGTT) on options to facilitate collaborative technology research and development (R&D).[1] The SBSTA requested the EGTT, in preparing this report, to focus on collaborative technology R&D to enhance action on mitigation and adaptation under the Convention, and how collaborative technology R&D activities outside of the Convention can support this action.

2. Accordingly, the main objective of this document is to identify options for facilitating collaborative R&D, paying attention to activities both under and outside of the Convention. The document uses literature review, a practitioner survey, case studies and an illustrative inventory of international R&D collaborations to arrive at the options.

3. The importance of technology in addressing the challenge of climate change cannot be overstated. It is also well recognized that limited technological capabilities within developing countries restrict their ability to take effective action to address climate change. R&D is viewed as a means of contributing to promoting the development and transfer of technologies for adaptation and mitigation and is referred to in decision 3/CP.13 as an activity that could enhance the implementation of the framework for meaningful and effective actions to enhance the implementation of Article 4, paragraph 5, of the Convention (the technology transfer framework).

4. North–South, South–South and triangular approaches to collaborative R&D, as opposed to more traditional R&D efforts, may:

(a) Enable a suite of technological solutions to be made available more quickly and more cost-effectively to meet adaptation and mitigation needs;

(b) Effectively engage the private sector;

(c) Reduce overlaps and increase complementarity between efforts and fill gaps that would otherwise remain unaddressed;

(d) Help to build the capacity to adopt, adapt, develop, deploy and operate technologies for adaptation and mitigation effectively within specific local contexts, which has long-term benefits in terms of addressing both climate and development challenges.

5. As a general proposition, collaborative R&D is not new; countless collaborative activities have already occurred or are ongoing for different purposes in both the public and the private sectors. These collaborations are motivated by common benefits pursued by individual participants. The scholarly literature on collaborative R&D across a range of sectors, industries and countries, as well as very limited feedback from a practitioner survey on climate-relevant collaborative R&D, indicate that these benefits include improving competitive positions through spreading the costs and/or risks of R&D, providing access to technologies, know-how and/or markets. Challenges to collaborative R&D include risks of sharing knowledge, limited innovation capabilities and R&D-related national regulations and policies. Therefore, in order to be effective, collaborative R&D activities should be structured and designed by participants to ensure that they benefit all partners.

6. While there are a large number of climate-related international collaborative activities, a preliminary survey of the landscape indicates a number of large gaps. First, most existing initiatives are focused on enabling frameworks and facilitating deployment.

[1] FCCC/SBSTA/2010/INF.4.

Second, mitigation technologies (and within that, energy technologies) dominate; there is relatively limited focus on adaptation. Third, most of the collaborations between developed and developing countries are targeted at or take place with the major developing economies.

7. Taking a broad perspective on the objectives of collaborative R&D in the climate arena, this paper suggests that three key goals relevant to developing countries need to be addressed, namely:

(a) Adaptation/modification of existing technologies/products for local conditions and contexts;

(b) Development of technologies and products, including endogenous technologies, for unaddressed needs that are specific to developing countries;

(c) Long-term R&D.

8. Even as collaborative R&D models are explored so as to ensure effectiveness on meeting these objectives, developing countries have very varied technical needs and capabilities. Therefore the relevance of a collaborative R&D option will depend on both the objective of the collaborative R&D and the country where it is implemented.

9. It is important that those entities engaging in collaborative R&D activities pay attention to key features, including focus, R&D actors (firms, government organizations, academia, non-profit organizations), organizational models (two-actor, multiple-actors/consortia, networks), as well as funding sources (public, private, philanthropic) and models (project-centred or programmatic).

10. Table 1 outlines the types of collaborative R&D models (and their key features) that could be relevant to the three goals referred to in paragraph 7 above. For short-term objectives, industrial actors may play a key role in ensuring that technologies and products are available to satisfy local customer and market needs; here public funds can guide and stimulate R&D activities. As the time horizon becomes longer, the role of public funds as well as research actors becomes more prominent, although the private sector is still likely to be involved in pre-commercial R&D. In the short term, targeted activities – such as the product development partnerships or sectoral consortia that are aimed at solving specific problems or challenges – are more likely to be effective than broad general-purpose collaborative R&D programmes. Capacity-building is an important benefit of these collaborative activities and therefore explicit attention should be paid to this dimension.

Table 1
Potential collaborative research and development models by goal, and key features of the model

Goals	*Innovation stage*	*Research and development partners*	*Collaboration model*	*Funding*	*Location*
Adaptation/modification of existing technologies and products	Middle stage; market-oriented	Industry, dedicated laboratories (some universities and national laboratories)	Industry–industry (horizontal and vertical)	Public and/or private	Country/region-specific
			Industry–national laboratories/universities	Public and/or private	Country/region-specific
			CGIAR-type	Public	Globally

Goals	*Innovation stage*	*Research and development partners*	*Collaboration model*	*Funding*	*Location*
			networks		distributed
New technologies and products for unaddressed needs	Middle stage (and some early stage); end-user oriented	Industry, dedicated laboratories, universities, national laboratories, NGOs	Product development partnerships	Public	Global/regional-specific
			CGIAR-type networks	Public	Globally distributed
			Innovation prize or advanced market commitment induced collaboration	Public, philanthropic	Globally distributed
			Industry–national laboratories	Public and/or private	Country/region
Long-term R&D	Early stage	Universities, industry, dedicated laboratories	University–university collaboration	Public (climate financing; bilateral, multilateral, philanthropic) private	Country/region
			University–industry collaboration		Country/region
			Industry–industry consortium		Country/region
			CGIAR-type networks		Globally distributed
			Global facility		Single location

Abbreviations: CGIAR = Consultative Group on International Agricultural Research, NGOs = non-governmental organizations, R&D = research and development.

11. The secretariat could play the role of facilitator of these collaborative R&D activities rather than overseeing or managing these activities. By far the most collaborative R&D would be undertaken at the international and national levels through a variety of public and private entities. For example, the secretariat could facilitate these activities after the identification of key gaps through a top-down analysis of existing activities and programmes; at the same time, the process should also be responsive to a bottom-up identification of needs through technology needs assessments (TNAs), nationally appropriate mitigation actions and other existing activities.

12. The options presented in this document and in table 1 highlight general features that can be considered by potential partners before engaging in R&D activities on technologies for mitigation and adaptation both under and outside of the Convention. But given the

extent of data availability considered, further analysis on a range of issues may be very helpful in the design of effective operational options and activities.

II. Introduction

A. Mandate

13. The SBSTA and the Subsidiary Body for Implementation, at their thirty-first sessions, endorsed the two-year rolling programme of work of the EGTT for 2010–2011,[2] including an activity to prepare the terms of reference for a report to facilitate collaborative R&D on environmentally sound technologies for consideration by the SBSTA at its thirty-second session.

14. The SBSTA, at its thirty-second session, endorsed the terms of reference for a report by the EGTT on options to facilitate collaborative technology R&D.[3] It requested the EGTT, in preparing this report, to focus on collaborative technology R&D to enhance action on mitigation and adaptation under the Convention, and how collaborative technology R&D activities outside the Convention can support this action.

15. The terms of reference require the EGTT, in undertaking the elaboration on options for facilitating collaborative R&D, to take the following into account:

(a) The need for collaborative R&D relevant to technologies both for mitigation and for adaptation, paying special attention to technologies for adaptation;

(b) The varying R&D-related priorities and needs, and national circumstances, of all Parties, paying particular attention to developing country Parties, especially least developed countries, African countries and small island developing States, bearing in mind that many developing countries do not currently have in place R&D programmes specifically related to technologies for mitigation and adaptation;

(c) The diffused and distributed nature of R&D relevant to technologies for mitigation and adaptation, spanning a wide range of technological sectors, small, medium and multinational businesses, and a variety of public institutions and existing collaborative arrangements;

(d) The primary objective of collaborative R&D, including North–South, South–South and triangular approaches, which is to build up the endogenous technological capacity of developing country Parties and to enhance the development and transfer of technologies;

(e) Opportunities to enhance collaboration between the public and private sectors;

(f) That an important motivation for engaging in collaborative R&D is the meeting of mutual needs and the achievement of mutual gains;

(g) That engaging in collaborative R&D requires the presence of basic innovational structures and capabilities, and that one objective of facilitating collaborative R&D should be to ensure the presence of appropriate innovational structures which can support and enable collaboration;

[2] FCCC/SBSTA/2009/8, paragraphs 22 and 24.
[3] FCCC/SBSTA/2010/INF.4.

(h) The R&D-related needs across the technology life cycle, with the objective of accelerating the adoption, adaption, deployment and diffusion of new and existing technologies.

16. The terms of reference also require the EGTT to address the following:

(a) The objectives and benefits of and rationale and incentives for facilitating collaborative R&D;

(b) The collaborative R&D activities that are most effective in accelerating the deployment and diffusion of technologies for adaptation and mitigation;

(c) North–South, South–South and triangular models of collaborative R&D;

(d) Success stories and lessons learned from international collaborative R&D under other multilateral processes;

(e) The barriers to and enabling factors for collaborative R&D, including the long-term capacity-building, skills development and human resources required to significantly scale up collaborative R&D activities;

(f) Effective ways of mobilizing funding to help developing country Parties to participate in collaborative R&D, including innovative sources of financing;

(g) Models and policy options for enhancing private-sector participation in collaborative R&D in developing countries;

(h) The specific role that the Convention may play in catalysing and supporting initiatives and activities outside of the Convention;

(i) Opportunities to integrate collaborative R&D into existing and new pathways under the Convention for the provision of capacity-building, technological and financial support to developing country Parties.

B. Background

17. Collaborative R&D is viewed as a means of contributing to promoting development and transfer of technologies for adaptation and mitigation and is an obligation under the Convention covered by various decisions of the Conference of the Parties (COP), in particular decision 3/CP.13.

18. Article 4, paragraph 1(c), of the Convention states that Parties shall “Promote and cooperate in the development, application and diffusion, including transfer, of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol in all relevant sectors, including the energy, transport, industry, agriculture, forestry and waste management sectors.”

19. Article 4, paragraph 5, of the Convention states that “The developed country Parties and other developed Parties included in Annex II shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention. In this process, the developed country Parties shall support the development and enhancement of endogenous capacities and technologies of developing country Parties. Other Parties and organizations in a position to do so may also assist in facilitating the transfer of such technologies.”

20. The COP, by its decision 3/CP.13, endorsed the recommendations for enhancing the implementation of the technology transfer framework, including actions with regard to the promotion of collaborative R&D on technologies (annex I, para. 23), and the promotion of

endogenous development of technology through provision of financial resources and joint R&D (annex I, paras. 21–22).

21. Furthermore, the COP, by its decision 1/CP.13, recognized the need to consider cooperation on research and development of current, new and innovative technology, including win-win solutions, when addressing enhanced action on technology development and transfer to support action on mitigation and adaptation, as part of an agreed outcome to enable the full, effective and sustained implementation of the Convention through long-term cooperative action, now, up to and beyond 2012 (para. 1 (d)).

C. Scope of the note

22. The main objective of this document is to identify options for facilitating collaborative R&D, paying attention to activities both under and outside of the Convention. While this document provides guidance on collaborative R&D options that may be more suited to specific objectives, it does not prioritize or recommend options, nor does it preclude a decision on whether and how options should be managed, encouraged or facilitated under the Convention.

23. To this end, the report analyses the role of collaborative technology R&D in addressing climate change and the specific needs of developing countries and provides insights into the benefits, challenges and major influential factors of R&D collaboration activities (chapters IV and V). It then identifies key features and possible gaps by reviewing the existing collaborative R&D options (from the climate change as well as some key non climate change domains) (chapter VI). The report develops a categorized list of options for facilitating collaborative R&D relevant to technologies for mitigation and adaptation both under and outside of the Convention, and criteria to evaluate options which could also be used to help guide decision making for funding (chapter VII). Finally, the report outlines possible next steps that may need to be undertaken to further elaborate operational options (chapter VIII).

24. It is understood that collaborative R&D, although a necessary requirement for addressing climate change in a cost-effective manner, in itself is not enough to address climate change. R&D collaboration needs to be facilitated by a climate change policy framework. Some degree of local scientific and technical capacity is necessary for R&D collaboration, even as the collaboration itself can enhance this capacity. Much R&D on climate technology is already being carried out within countries. International R&D collaboration should not duplicate, but build on such domestic programmes. In addition, industry and other private-sector actors conduct R&D on their own. However, these valuable efforts are not sufficient to fill the gaps in climate technology R&D; public-sector intervention is still needed to enhance international R&D collaboration, including in the private sector.

D. Possible action by the Subsidiary Body for Scientific and Technological Advice

25. The SBSTA may wish to consider the options to facilitate collaborative R&D relevant to environmentally sound technologies presented within this document and determine any necessary further action, as appropriate.

III. Methodological approach

A. Scope of collaborative research and development

26. In this document, the scope of collaborative R&D includes collaborative R&D activities that cover both emerging technologies and mature technologies. The collaborative R&D on the mature technologies is intended to help with the adaptation and modification of these technologies to fit different local conditions, and to meet unaddressed needs. The emphasis is on ‘technical’ collaboration rather than collaboration on other aspects that may promote innovation (for example, the design of policy frameworks or the building of capacity to enable and promote the diffusion of technologies).

B. Methodology

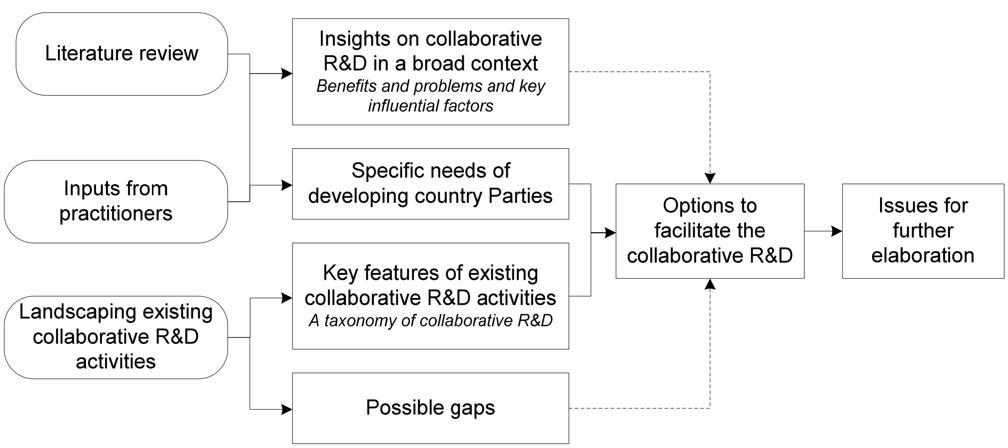
27. This document was produced through a number of steps as shown in figure 1.

28. A review of literature on collaborative technology R&D was conducted. This sought insights into a number of issues of relevance to the elaboration of options to facilitate collaborative R&D under the Convention, in particular the role of collaborative R&D in addressing climate change and the specific needs of developing countries. It also sought insights from collaborative R&D activities in a more general context, including the motivation, challenges and major influential factors that form a successful collaboration.

29. A questionnaire, as included in annex I, was used to extract key information on existing experiences of actors currently or previously engaged in collaborative R&D. The outcome of the survey was considered in the elaboration of options, which is included in annex II.

30. A review was also conducted of existing international collaborative R&D activities in mitigation and adaptation technologies, as contained in annex III, along with four detailed case studies as presented in annex IV. It sought to identify key features of collaborative R&D activities and possible gaps in the coverage of existing collaborative R&D initiatives in order to further elaborate the options to facilitate collaborative R&D on technologies for mitigation and adaptation.

Figure 1
Methodological approach of elaboration of options for facilitating collaborative technology research and development



Abbreviation: R&D = research and development.

31. From the empirical results, theoretical insights and the review of current collaborative technology R&D activities, a categorized list of options to facilitate collaborative technology R&D and a list of criteria to further elaborate these options is developed in chapter VII. Issues for further elaboration are discussed in chapter VIII.

C. Caveats and challenges

32. The information about R&D collaboration is both abundant and sparse at the same time. On the one hand, a large amount of small- and large-scale collaboration in R&D does occur; however, empirical literature on such R&D collaboration (especially between industrialized and developing countries) and independent evaluations of success and failure factors are limited. Some collaborations involving industry are kept confidential for commercial reasons. It is more likely that successful collaborations are reported in the literature than failed ones. The challenging information situation may limit the extent to which conclusions in this document can be generalized.

33. Owing to the wide scope of the topic, the findings contained in this document should be considered as preliminary. Hence, the options presented may need further elaboration, particularly in regard to their operational modalities, to ensure their effectiveness and feasibility.

IV. Role of collaborative research and development in addressing climate change in developing countries

A. The role of collaborative research and development

34. The importance of technology in addressing the challenge of climate change cannot be overstated. As the Intergovernmental Panel on Climate Change Special Report on Technology Transfer[4] notes, achieving the UNFCCC goal of stabilizing atmospheric greenhouse gas (GHG) concentrations at such a level as to avoid dangerous climate change will require "technological innovation and the rapid and widespread transfer and implementation of technologies, including know-how for mitigation of GHG emissions. Transfer of technology for adaptation to climate change is also an important element of reducing vulnerability to climate change."

35. Meeting this challenge requires a focus on enhancing the technology innovation process shown in figure 2. Many strategies to enhance technology innovation have been discussed in the literature, including the need to scale up R&D and focus it on locations and sectors where it is most needed.[5] As an example, the International Energy Agency (IEA) estimates that even though energy-related R&D spending has increased slightly in recent years, it is still well below the numbers reached in response to the oil crises of the 1970s.[6] Also, energy-related R&D is skewed towards options that may only play a limited role in the mitigation portfolio. Agricultural R&D spending has increased over the years, but only a small and declining part of this is spent in least developed countries.[7]

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[4] Intergovernmental Panel on Climate Change. 2000. *IPCC Special Report: Methodological and Technological Issues in Technology Transfer*. Cambridge: Cambridge University Press.

[5] FCCC/SB/2009/2.

[6] IEA Energy Technology R&D Database available at:<http://www.iea.org/stats/rd.asp>.

[7] Pardey, PG, Beintema N, Dehmer S, and Wood S, 2006. Agricultural research: A growing global divide? International Food Policy Research Institute: Washington, DC.

36. Other strategies for enhancing technology innovation include developing better portfolios of technological solutions and improving the effectiveness of R&D and innovation activities. While most of the focus in the literature is either on a global scale or at the national level, there is a lack of focus specifically on collaborative R&D as an element of a global strategy, in particular to help developing countries to meet their needs to address climate change.

37. It should be noted that while the innovation process is generally stylized as a linear process (see figure 2), in reality it is far from that: successful innovation is characterized by multiple and deep interactions between the various stages. Clearly, activities and outcomes in earlier stages will certainly have effects on the later stages: for example, a breakthrough in a new material may lead to a completely new product redesign. But feedback from later stages can also affect earlier stages. Technical demonstration projects yield important performance information that can improve the technology. Similarly, learning from the market, through consumer feedback, can help shape product design. Stimulating the interaction among various actors is recognized as crucial to strengthening the performance of the innovation system. Collaborative R&D is one means to this end.

38. It is also well recognized that limited technological capabilities within developing countries create a common barrier to effective action to address climate change. The R&D investments of most developing countries are lower than those of most industrialized countries in absolute terms and as a proportion of gross domestic product;[8] and the capabilities of the science and technology enterprises in these countries remain relatively weak, as illustrated by various technology and innovation indices.[9] Collaborative R&D between developed and developing countries can help developing countries adopt appropriate technologies for adaptation and mitigation by providing access to complementary skills and by supplementing their own capacity.

39. From the point of view of an industrialized country partner, collaborative R&D can be helpful since such a partnership allows for a better understanding of local needs and product opportunities that can help meet these needs. The value of a partnership with developing country entities that possess complementary knowledge is already being used by firms in industrialized countries in their strategies for "open innovation".[10] Realization of the importance of developing countries' markets and the need to be close to these markets has also led to the establishment of R&D centres in these markets.[11]

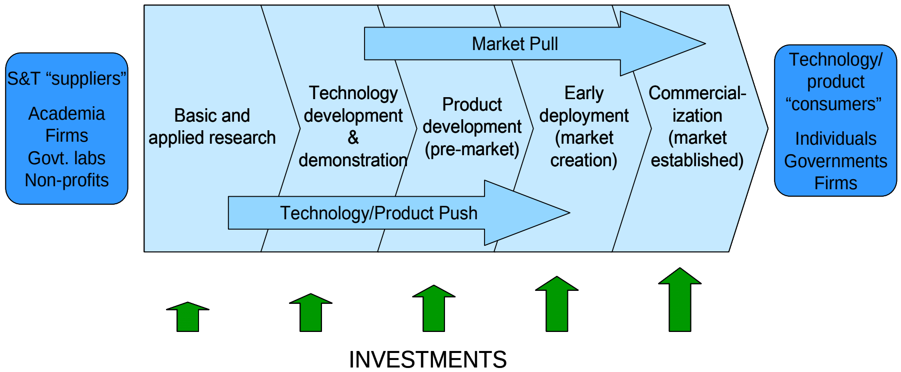
[8] For example, in 2007 (the latest year for which data are available), R&D investment in Japan and the United States of America were 3.45 per cent and 2.67 per cent of gross domestic product, respectively; the corresponding numbers for China and India were 1.48 per cent and 0.80 per cent, respectively (World Development Indicators).

[9] For example, the Global Innovation Index, published in 2009 by Boston Consulting Group and the National Association of Manufacturers, ranks China, South Africa, India and Brazil at 27, 34, 46 and 72, respectively. The World Economic Forum's Global Competitiveness Report 2010–2011 ranks these countries as 32, 59, 56 and 63, respectively.

[10] Chesbrough HW. 2003. *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Boston: Harvard Business School Press, p.xxiv.

[11] United Nations Conference on Trade and Development. 2005. *World Investment Report 2005*. Available at: <http://www.unctad.org/en/docs/wir2005_en.pdf>.

Figure 2
Main steps in the innovation chain



Abbreviations: S&T = science and technology; Govt. labs = government laboratories; Non-profits = Non-profit organizations.

Source: Sagar AD, Bremner C and Grubb M. 2009. Climate Innovation Centres: a partnership approach to meeting energy and climate challenges. Natural Resources Forum. 33(4): pp.274–284.

B. Collaborative research and development goals in developing countries

40. R&D collaborations with developing country partners can result in two important outcomes. Firstly, they can ensure that a suite of technological solutions is available to meet the adaptation and mitigation needs of developing countries. Secondly, they can help to build innovation capacity in developing countries, including the capacity to adopt, adapt, develop, deploy and operate technologies for adaptation and mitigation effectively within specific local contexts. The development of innovation capacity in developing countries is particularly important, especially for the long term, since it will assist and accelerate the uptake of technologies for mitigation and adaptation in developing countries, and help ensure that these technologies become more central to the underpinning development processes. In this regard, and depending on the specific technology, the goals of collaborative technology R&D in developing countries can be generally summarized as falling into three categories, namely:[12]

(a) Adaptation and modification of existing technologies and products to address climate change in the near future;

(b) Development of technologies and products, including endogenous technologies, that contribute to development goals and needs and address climate change for the poor in developing countries, but that are mostly unaddressed by global technology markets;

(c) Basic and applied R&D for the development of technologies that are important for mitigation and adaptation over the medium to long term.

[12] Sagar AD. 2009. "Technology development and transfer to meet climate and developmental challenges", background note for United Nations Department of Economic and Social Affairs background paper for the Delhi High Level Conference on Climate Change, New Delhi, India, 22–23 October 2009.

1. Adaptation or modification of existing technologies to suit local needs and conditions

41. In most cases, some adaptation, modification or even redesign of existing commercial technologies or products is needed for these to be useable in the local context or markets. If a technology does not meet the needs of the local consumers or is not optimized for local operating conditions, there will be only limited uptake, thereby limiting the contribution of this particular option to climate mitigation or adaptation. Examples include boilers that may need to be tailored to local coal characteristics and/or ambient conditions; 'green' or 'climate-proof' building designs that need to take into account local climatic conditions as well as occupants' use patterns; electrical equipment such as air-conditioners or refrigerators, where the compressor and other components may need some changes in order to perform suitably in local conditions (such as high ambient temperatures or voltage/frequency fluctuations in local power supplies), or crops and cropping practices which need to be modified for local soil and rainfall patterns.

42. Such modifications may be carried out by the original technology supplier or equipment manufacturer. For example, a diversified industrial firm that manufacturers air conditioners may change the compressor design or the working fluid to extend the range of ambient temperatures in which the device can operate without significant degradation in efficiency. But these changes may also be carried out in conjunction with the local supplier of compressors. Alternatively, the improvements may be made by third parties, although eventually they will need to be incorporated into the product design by the manufacturer.

43. Advances in this area could have immediate gains for all developing countries by enhancing the availability and uptake of technologies for mitigation and adaptation in the short term. It should be noted, though, that developing countries with a relatively weak R&D base would be helped by collaborative R&D activity on adaptation and modification of existing technologies since they often do not have capabilities to engage in these kinds of activities on their own. In many cases, technologies that would be developed through such an activity in some developing countries may be useful for other developing countries, and would lend themselves to South–South and triangular modes of cooperation.

2. Development of technologies for meeting local 'unaddressed' needs

44. A large fraction of the world's population is living in energy poverty. The IEA estimates, for example, that 2.7 billion people rely on biomass-based cooking-stoves for their household energy needs and almost 1.4 billion people do not have access to electricity.[13] The development of suitable clean and high-efficiency energy technologies for such groups can have a significant positive impact by not only advancing the sustainable development goals of developing countries but also contributing to efforts to address climate change.

45. For example, the inefficient and dirty combustion of biomass in traditional household cooking-stoves leads to indoor air pollution that can have a major deleterious effect on the health of the exposed group.[14] Furthermore, the collection of biomass is very time-consuming. Products of inefficient combustion have also been shown to have significant greenhouse effects. Therefore, the provision of a replacement technology which provides a more efficient and clean solution can lead to both climate and developmental

[13] IEA. 2010. *World Energy Outlook 2010*. Paris.

[14] The World Health Organization estimated two million excess mortalities and 41 million disability-adjusted lost-years worldwide per year, mostly suffered by women and children. WHO. 2009. *Global Health Risks: Mortality and Burden of Disease Attributable to Selected Major Risks*. Available at: <http://www.who.int/healthinfo/global_burden_disease/GlobalHealthRisks_report_full.pdf>.

gains.[15] Furthermore, a positive contribution to the human development of this group should enhance their resilience to climate impacts, thereby contributing to adaptation.

46. Similarly, clean energy technologies to deliver power to villages could have a transformative effect on rural populations by opening up avenues for economic and social development, again with concomitant adaptation and mitigation gains. Equally, there are needs within the adaptation arena that are peculiar to developing countries and can be mostly outside the realm of global technology efforts.

47. Therefore, similar to the example mentioned above, a range of technologies and products can help developing countries meet the energy needs that are relevant and peculiar to these countries. This includes endogenous technologies. Examples include cooking-stoves and other biomass-burning devices (such as industrial ovens), small-scale biomass conversion technologies (such as biomass gasifiers for power and thermal applications and biogas digesters), and advanced kerosene and solar lanterns. Other examples include water conservation technologies and agricultural technologies to improve the resilience of cropping systems to climate change. All of these examples could advance adaptation and in some cases mitigation efforts.

48. Technology R&D as well as deployment activities in this area remain small and fragmented and are generally side-stepped by global technology markets. These markets do not develop many products for poorer citizens of developing countries since their individual purchasing power is not seen as sufficient, even though cumulatively this group's needs may present a significant business opportunity.[16] Efforts are being made on these fronts, but they are not commensurate with the scale of need and opportunity.

49. These unaddressed opportunities are generally outside the mainstream global technology innovation system and, in many cases, even outside the established commercial markets in developing countries. Besides energy, there are many other unaddressed needs in developing countries, for instance in the waste management, transportation and agricultural sectors. In many such sectors, technologies for mitigation and adaptation can have significant sustainable development co-benefits.

50. Focusing on these opportunities will substantially and simultaneously advance climate and development goals (with additional gains because development can enhance climate resilience). It will help all developing countries but be especially important for smaller and poorer developing countries that do not have the resources to develop such technologies on their own.

3. Development of technologies for medium- to long-term needs

51. Looking beyond the gains possible in the short term by making available technologies to help developing countries with their climate challenges, there is also a need to work toward the development of mitigation and adaptation technologies for the medium to long term. This could include, for example, advanced renewables such as second- or third-generation biofuels or solar thermal and photovoltaic technologies, advanced nuclear generation technologies and nuclear fuel cycle technologies, and super energy efficient end-use technologies. It could also involve the development of advanced agricultural technologies (both breeding and crop production technologies) and processes that could serve both mitigation and adaptation in this sector. It could also involve the development of

[15] Venkataraman C, Sagar AD, Habib G, Lam N and Smith KR. 2010. The Indian national initiative for advance biomass cook stoves: the benefits of clean combustion. *Energy for Sustainable Development*. 14(2): pp.63–72.

[16] Prahalad, CK. 2004. *The Fortune at the Bottom of the Pyramid*. Wharton School Publishing.

technologies for adaptation such as building technologies adapted for coastal areas, technologies to protect against sea level rise and disaster management technologies.

52. The basic and applied R&D in this category could help with the development of new and improved technologies, tools and processes, all of which can make a positive contribution to mitigation and adaptation. An example of a new technology would be a new solar-photovoltaic material; a new tool might be software that could help in the design of energy-efficient buildings appropriate to local environmental and use conditions; and a new process could be a better way to grow rice so as to reduce methane emissions.

53. One characteristic of long-term R&D is that it is risky. Early on in the technology development chain, high uncertainties on outcomes prevail. Much of the funding and efforts invested in long-term R&D activities is unlikely to lead to a commercial technology. And for long-term R&D that is successful, results cannot be guaranteed within a few years.

C. Additional considerations for promoting collaborative research and development involving developing countries

1. Adaptive and incremental innovation is of central relevance, especially in many developing country contexts

54. Depending on the technology and country in question, R&D focused on adaptive innovation, which involves adaptation of existing technologies to new contexts, is likely to be of more relevance in many developing countries than an emphasis on early stage R&D or radical technological breakthroughs. Policy also needs to be open to the potential for fostering incremental technological improvements as most technological development takes place on an incremental basis.[17] Such incremental innovation, and its contribution to adaptive innovation, has been observed as central to cases where developing countries have reached or passed the international technological frontier.[18]

55. With regard to the relevance of adaptive innovation to many developing country contexts, it is important that R&D initiatives in technologies for mitigation and adaptation are demand-led. That is, there needs to be sufficient demand for resulting products to provide incentives for investing resources in R&D in the first place.[19]

2. Strategic management of collaborations can maximize their benefits to developing country partners

56. Strategic management of collaborative relationships might also be used to maximize learning opportunities for developing country firms.[20] Such firms can take a strategic approach to gain as much benefit as possible, in terms of information access and skills development, via their engagement in collaborations. Partners that are international technology leaders might also be required under funding agreements to help facilitate the sharing of knowledge and skills.

[17] Mowery DC, Nelson RR and Martin BR. 2010. Technology policy and global warming: Why new policy models are needed (or why putting new wine in old bottles won't work). *Research Policy*. 39:1011–1023.

[18] Gallagher KS. 2006. Limits to leapfrogging in energy technologies? Evidence from the Chinese automobile industry. *Energy Policy*. 34 (4):383–394.

[19] As footnote 17.

[20] Ockwell DG, Watson J, MacKerron G, Pal P and Yamin F. 2008. Key policy considerations for facilitating low carbon technology transfer to developing countries. *Energy Policy*. 36:4104–4115.

3. Innovation capacity is both an aim of and a prerequisite for participation of developing countries in collaborative research and development

57. R&D collaborations are unlikely to happen unless a certain level of innovation capacity already exists within the specific technological area and specific developing country in question. In order for R&D collaborations to accelerate the uptake of technologies for mitigation and adaptation (as opposed to simply their availability), they therefore need to include specific requirements for capacity-building, for example, personnel exchanges between developed and developing country firms and research facilities, commitments to make information relating to innovations publicly available (if possible within the context of commercial incentives for collaboration as discussed in chapter V.A), investment in new research facilities and training of research staff within developing countries.

58. R&D initiatives should only be undertaken if a careful review of existing technology and country-specific innovation capacity (including consultation with local firms) suggests that R&D is the appropriate point in the technology cycle to target collaborative efforts. Resources may be better targeted at fostering collaboration at the demonstration or deployment stages.

59. At the same time as recognizing the importance of prior technological capacity in developing countries and the potential for collaboration to contribute to building capacity, options need to be clear as to whether collaborative activities will have a strong focus on technology innovation and adoption in specific areas or whether they will have a broader development mandate.

60. Indeed, a number of empirical analyses suggest that too much emphasis has, to date, been placed on early stage R&D, particularly via centralized R&D efforts, and that this has failed to contribute to developing the capacity necessary for developing countries to undertake wide-scale technological change.[21] What is now needed is to shift the efforts towards activities at the other end of the technology development spectrum such as technology demonstration and deployment, as well as the capacity-building initiatives referred to in paragraph 38 above (for example training and international exchanges) and to orient this effort to the decentralized firm level as well as to centralized centres of excellence.

V. Potential benefits of and challenges to collaborative research and development activities

A. Potential benefits of collaborative research and development

61. Collaborative R&D is not new; a wealth of such collaborative activities have already occurred or are ongoing for different purposes in both the public and the private sectors, which are motivated by some common benefits pursued by individual participants. An insight into these benefits could help the elaboration of options to further facilitate collaborative R&D on technology for mitigation and adaptation. These benefits include:

(a) Spreading the costs of R&D: this helps participants to stay at the technological frontier at a lower cost. In some cases participants may also qualify for

[21] Ockwell DG et al. Enhancing Developing Country Access to Eco-Innovation. The Case of Technology Transfer and Climate Change in a Post-2012 Policy Framework. OECD Environment Working Papers, No. 12: OECD Publishing and Bell M. 2009. Innovation Capabilities and Directions of Development, STEPS Working Paper 33. Brighton: STEPS Centre.

funding from governments. For instance, within EUREKA,[22] member governments can supply up to 50 per cent of the participants' research budget;

(b) Spreading the risks of R&D: considerable uncertainty is always associated with R&D activities, including uncertainty of expected breakthroughs, uncertainty of final market demand and the risk that competitors will develop their technology faster;

(c) Access to technologies, technology know-how and proprietary knowledge: collaboration will provide opportunities to the participants to access the complementary knowledge and resources that their counter-partners possess;

(d) Accessing new markets, including local knowledge and brand positioning in these markets: this is of particular importance to collaborative R&D activities that engage developing country partners;

(e) Maintain a competitive position: typical collaborative activities involve creating alliances and developing common standards.

62. Therefore, North–South, South–South and triangular approaches to collaborative R&D, as opposed to more traditional R&D efforts, may:

(a) Ensure enable a suite of technological solutions to be made available more quickly and more cost-effectively to meet the adaptation and mitigation needs of developing countries;

(b) Effectively engage the private sector;

(c) Reduce overlaps, increase complementarity and fill gaps that would otherwise remain unaddressed;

(d) Help to build the capacity to adopt, adapt, develop, deploy and operate technologies for adaptation and mitigation effectively within specific local contexts, which has long-term benefits in terms of addressing both climate and development challenges.

B. Potential barriers to successful collaborative research and development

63. Collaboration requires overcoming communication, work culture and agreeing on a common goal. It is likely that many collaborations form in the first place because of barriers, but this is difficult to evaluate as there are no empirical data on such cases. Challenges are greatest when partners come from different countries, and when collaborations occur around new product development which forms the basis of partners' competitive advantage. These challenges are likely to be due to:

(a) Knowledge externalities and the risk of collaboration: one traditional way of viewing the risks and benefits related to collaborative R&D is the idea of knowledge as a positive externality. This is where the knowledge producer incurs the cost of producing the knowledge, but cannot accrue all the benefits as that knowledge is then freely available to others. This idea of freely accessible knowledge is no longer widely accepted[23] as there are often costs involved in accessing knowledge, such as reverse engineering, or costs of partnering with knowledge leading firms. Nevertheless, access to or protection of knowledge, whether explicit (codified in patents or designs) or implicit (know-how shared among employees), can still be viewed as an important influencing factor in the risks and

[22] EUREKA is an intergovernmental network launched in 1985 to support market-oriented R&D and innovation projects by industry, research centres and universities across all technological sectors. It is composed of 39 members, including the European Community. See <http://www.eurekanetwork.org/about/history>.

[23] Cohen WM and Levinthal DA. 1989. Innovation and learning: the two faces of R&D. *Economic Journal*. 99:569–596.

benefits of collaborative R&D. This market failure has also been seen as a disincentive for investing in knowledge production and, by extension, R&D;

(b) Risks of sharing proprietary know-how: this is often viewed as the most critical risk of collaboration, particularly if the collaboration involves firms based in countries where intellectual property regimes are perceived to be weak. Participants are often hesitant to share knowledge with others not completely under their control. They fear proprietary knowledge leaking to other associates of their collaborator.[24] And if collaborations dissolve then the participant with the greater technical expertise may have been training a competitor;

(c) Desire for control: each participant usually has its strategic goal and desire for control of the collaboration might hinder the formalization of the collaboration;

(d) Differences in government policies and regulations: collaborations can be influenced by policy and regulations, such as anti-trust laws, intellectual property regulations and different legal structures in different countries, which might also influence the structure of collaborations and hence their cost and profitability.[25]

C. Key factors that influence the likelihood of collaboration research and development

64. The failure of a collaboration might be due to just one single factor, while successful collaborations usually rely on multiple factors. These factors could include:

(a) Similarity of partners: empirical and anecdotal evidence[26] suggests that entities with similarities in size, financial resources and technical endowments are more likely to pursue collaborative R&D than when the balance of expertise in a collaboration is more one-sided. Brokering developed–developing country partnerships clearly needs to overcome this bias;

(b) Previous working relationships: the existence of previous relationships, or gradual "flirtations"[27] such as technical seminars and training visits has been widely observed to have preceded the emergence of R&D collaborations. Previous relationships as customers or suppliers, through licensing or royalty agreements or through training initiatives can influence the willingness of an individual entity to enter into collaboration with another. This raises the possibility for international policy to focus on encouraging such ties between developed and developing country firms as a means to broker potential future collaborations in R&D. Such encounters provide potential partners with information on one another's skills and deficiencies. Critically, such working environments can build trust and reduce uncertainty regarding future partnerships, especially if proprietary knowledge sharing might be involved in a future partnership;

(c) Clear delineation of technology contributed to the collaboration: a more direct approach to reducing potential risks of sharing proprietary knowledge is to limit collaboration to a single stage of the R&D process, thereby reducing exchange of proprietary know-how. Such arrangements might, however, be unattractive to developing

[24] Hladik KJ and Linden LH. 1989. Is an international joint venture R&D for you? *Research-Technology Management*. 32 (4): 11–13.

[25] Hemp P. 1986. Pan-European Ventures Face Difficulties. *Wall Street Journal*. April 1: 36, April 1.

[26] Hladik KJ. 1988. R&D and International Joint Ventures *In:* FJ Contractor and P Lorange (eds). *Cooperative strategies in international business: joint ventures and technology partnerships between firms.* Lexington MA: Lexington Books.

[27] As footnote 26.

countries as they limit opportunities for knowledge flows and capacity-building. Two types of limited R&D arrangements could be:

(i) Interface cooperation where independent efforts are pursued by individual partners and knowledge is shared only when linking components in the final stages, thus limiting proprietary data exchange;

(ii) Precompetitive cooperation where partners collaborate to produce basic technologies and know-how but work independently to design and market products based on this knowledge.

D. Implications for designing options to facilitate collaborative research and development

65. The analysis of potential benefits, possible challenges and influential factors of collaborative R&D above could reveal several considerations that should guide the elaboration of options aimed at facilitating collaborative R&D on technologies for mitigation and adaptation that involve partners from both developed and developing countries. The key factors that need to be taken into account in the design of options are outlined below.

1. Knowledge, experience and access to local markets is a key asset that developing country partners can bring to collaborations

66. Local market knowledge and marketing experience, as well as access to local distribution channels, could be a useful selling point for developing country partners attempting to attract collaboration with their developed country counterparts. A range of policy interventions could be considered at the national level to provide incentives for international partners to collaborate with developing country partners. Careful thinking with regard to where such opportunities might exist and how these policy interventions could be articulated is essential for the design of effective policy incentives.

2. Access to public funding will attract participation from international technology leaders

67. Access to public funding is likely to be a critical factor influencing the decisions of partners that are international leaders in technology regarding whether to engage in collaborations with developing country partners.

3. Heavy costs associated with accessing funding often exclude developing country participation

68. Heavy costs, in terms of both time and expertise, required to bid for and manage public funding for R&D can exclude developing country partners or smaller actors with less capacity, from bidding for public R&D funds. The delay between bidding and securing funding is often also cited as problematic for actors with fewer resources and less capacity. Any successful funding mechanism related to technologies for mitigation and adaptation should therefore ensure that administrative burdens associated with accessing funding and reporting funded activities are minimized.

4. Private sector involvement in collaborations can be critical

69. While much of the early-stage basic research is likely to be undertaken within the public sector (universities and national research laboratories), engagement with the private sector is critical beyond this stage in the process of innovation. Private-sector engagement can ensure that collaborations are demanded, based on a sound knowledge of the available market, and have the potential to move beyond R&D to later stages of the innovation chain

towards commercial product development. However, it is important to ensure that private-sector partners do not establish a monopoly position as a result of their collaboration in publically funded initiatives. It should also be noted that where market opportunities are of low value or do not exist, collaborative R&D efforts may need to be pursued purely within the public sector.

5. Mechanisms may need flexible criteria to attract international partners

70. Criteria governing collaborations may need to allow partners some flexibility to ensure that the collaboration fits with their other strategic global initiatives, for example, ensuring product compatibility with other ranges to tie in sales, or avoiding markets where partners sell their own competing products. International partners may prefer R&D activities to be centralized in their existing facilities, particularly if they have key assets in the form of skills and personnel. This clearly limits the transfer of knowledge to developing countries. Policy therefore needs to consider how to provide incentives for decentralized R&D collaborations with an emphasis on maximizing developing country participation.

6. Information sharing and patenting must be explicitly addressed

71. Policy incentives may be necessary in order to ensure that collaborations result in the socially optimal level of information sharing. This may involve structuring publically funded R&D programmes to ensure broad information sharing and restrictions on patenting.[28, 29] Collaborations are likely to require upfront negotiation of intellectual property related issues. This includes agreement on ownership of the intellectual property resulting from R&D and any incentives or requirements for making knowledge available in the public realm. Reassurance regarding legal protection of intellectual property may also be necessary to attract some partners to collaborate.

7. Partners' contributions must be clearly articulated prior to collaboration

72. Potential collaborative R&D partners that are technology leaders are more likely to cooperate if technological contributions and ownership of outputs are clearly delineated prior to commencement of any collaborative agreement. However, this may be limiting in terms of facilitating knowledge flows. It also requires that a minimum level of existing technological capacity is present within developing country partners.

8. Facilitating developed–developing country contacts may lead to future research and development collaboration

73. Prior relationships are known to be important in reassuring partners that collaborations are worthwhile and low risk. Options such as developed/developing country technical seminars and training visits in targeted technology areas could be considered in order to encourage ties ahead of attempting to broker any collaborative R&D initiatives.

9. Countries should ensure domestic policy does not inhibit collaboration

74. Participating countries may need to ensure that their anti-trust laws are not prohibitive to collaborative R&D on technologies for mitigation and adaptation, which could require countries to sign specific waiver agreements recognizing the public good nature of technologies for mitigation and adaptation.

[28] As footnote 11.

[29] Successful examples of such approaches exist, including United States Department of Defense anti-trust policies, which supported the development of the semi-conductor industry, the open approach to knowledge sharing under the Human Genome Project, and the United States Department of Agriculture's support for research into consistently breeding seed varieties, which was made freely available to companies within the hybrid seed industry.

10. Policy initiatives aimed at pricing carbon emissions are important to incentivizing research and development

75. Failure to internalize the social cost of carbon within market transactions undervalues technologies for mitigation and provides a disincentive to direct R&D efforts towards them. Policies that address this issue such as carbon taxes, carbon trading schemes and national emissions limits can therefore have an important role to play in stimulating collaborative R&D.

VI. Existing international collaborative research and development activities

A. Key features of existing collaborative research and development activities

76. There is huge diversity of existing collaborative R&D activities. In order to inform the elaboration of options to further facilitate such collaborative R&D activities, a range of existing international collaborative R&D activities on technologies for mitigation and adaptation as well as some key activities that are not in the climate change domain were reviewed. These activities are listed in annex III. This list is not exhaustive. For example, many bilateral collaborative R&D activities have not been included. However, the activities are representative of the major trends in collaborative R&D related to climate change.

77. In order to capture the key features of these activities and therefore facilitate the elaboration of the options in chapter VII, a taxonomic scheme by which these collaborative R&D approaches can be classified was developed. The taxonomy is designed around three main aspects, namely:

(a) Temporal scope of collaborations;

(b) Focus of collaborations;

(c) Organizational set-up of collaborations.

78. Each of these aspects is described in more detail in the subsections below. It is important to note that any example of R&D collaboration can be classified according to the multiple categories within these variables. So an example of collaboration with a long-term temporal scope may also be an example of collaboration with a sectoral focus and a network-based organizational structure. The case of the Consultative Group on International Agricultural Research (CGIAR) as presented in annex IV is such an example.

79. In addition, it is important to recognize that as well as being defined by these three key aspects, collaborations will also vary in relation to a number of other factors. These are:

(a) Geographical coverage of actors involved in collaborations: this can range from national to bilateral to multilateral. It can also include South–North, South–South or North–North collaborations;

(b) Partners involved in collaborations: collaborations can include combinations of a number of types of partners, including universities, publicly funded research laboratories, private-sector actors, non-governmental organizations (NGOs) and coordinating organizations (for example, an organization taking a lead role in coordinating a research consortium or network);

(c) Funding sources: funding for R&D collaborations can come from a number of sources, including national governments, bilateral/multilateral funding sources, private-sector investment, philanthropic sources or an NGO's own funding initiatives and public–private partnerships;

(d) Requirements as incentives for collaboration: for example, options for facilitating collaborative R&D on technologies for mitigation and adaptation could require collaborations to include developing country partners, to nurture communication and exchange of knowledge, to make patents publicly available (either immediately or after a number of years), or to be based on developing country needs as defined local stakeholder engagement.

1. Temporal scope of collaborations

80. Collaborations can vary in terms of the time over which they are intended to run. Three main categories can be identified:

(a) One-off, short-term projects: these can include opportunistic projects commissioned in response to an immediate identified need. It can also include individual short-term collaborative projects commissioned as part of a broader strategic approach; for example, individual collaborative R&D projects commissioned under the Framework Programme for Research and Technological Development of the European Union (EU) or by the Energy Technologies Institute (ETI) of the United Kingdom of Great Britain and Northern Ireland;[30]

(b) Medium- to long-term collaborations: these include collaborations formed around more long terms strategic objectives that goes beyond a simple one-off project basis. Examples include the China–United Kingdom Near Zero Emissions Coal (NZEC) initiative,[31] the United Kingdom Engineering and Physical Sciences Research Council (EPSRC), China–United Kingdom Ecoregion Research Networks[32] and strategic partnerships such as the India and EU Strategic Partnership on clean technology, the clean development mechanism (CDM) and adaptation, and the United States of America–India Bilateral Collaborative Research Partnerships on the Prevention of HIV/AIDS;[33]

(c) Long-term collaborations intended to be permanent: for example a new centre or network intended to stay open for a long time, for example, CGIAR or Fundacion Chile (a national innovation centre based in Chile – see annex IV for further details).

2. Focus of collaborations

81. Collaborations also vary according to the level at which they focus. Five categories can be defined:

(a) Sectoral: this includes collaborations with a broad sectoral focus such as agriculture, health, renewable energy, energy-efficiency, etc. Examples include CGIAR in agriculture, the United States Department of Energy's National Renewable Energy Laboratory cooperative research and development agreements in renewable energy[34] and the African Network for Drugs and Diagnostics Innovation (ANDI)[35] in health;

(b) Technology/product based: these include collaborations that focus at the level of individual technologies. Examples include the Indian National Hybrid Propulsion Platform on hybrid vehicles and the NZEC initiative on carbon dioxide capture and storage;

[30] <http://www.energytechnologies.co.uk/Home.aspx>.
[31] <http://www.nzec.info/en/>.
[32] <http://www.dongtanepsrc.org/> or <http://www.energy.soton.ac.uk/buildings/Ecoregion-Leaflet.pdf>.
[33] <http://www.cdcnpin.org/scripts/display/FundDisplay.asp?FundNbr=4086>.
[34] <http://www.nrel.gov/technologytransfer/>.
[35] <http://apps.who.int/tdr/news-events/news/pdf/ANDI-rd-landscape-abstracts.pdf>.

(c) Subject based: these include collaborations with a subject-based focus that is more specific than a sectoral focus but less specific than a single technology focus. Examples include EPSRC, Ecoregion Research Networks and the United States–India Bilateral Collaborative Research Partnerships on the Prevention of HIV/AIDS;

(d) Programmatic: these include collaborations focused around broad programmes of research, often around predefined strategic priorities, such as the EU Framework Programme;

(e) Open issue: these include collaborations that are not predefined in terms of their required focus. These often consist of national innovation funds which aim to broker collaborations between national firms and research organizations and those overseas, such as MATIMOP of Israel,[36] the International Science and Technology Partnerships Program of Canada[37] and the India– Israel Initiative for Industrial R&D.[38]

3. Organizational set-up of collaborations

82. The third, and perhaps most complex, taxonomic variable relates to the organization of collaborations. Seven categories can be identified:

(a) Induced self-assembly: these relate to collaborations formed in response to a particular incentive. This could be a request for a proposal such as through a mechanism like the EU Framework Programme or ETI. Another incentive could be an innovation prize. Innovation prizes involve making prize money available for innovations in certain specified technological areas. Examples include the United States Defense Advanced Research Projects Agency's competition in robot-controlled land vehicles and the Ansari X-Prize in the suborbital space plane (now the basis of Virgin Galactic). Advanced market commitments, which guarantee procurement of a product that meet certain performance criteria, cannot also induce R&D;

(b) Strategic self-assembly: these consist of consortia or alliances where actors broker relationships with one another on a voluntary basis to respond to certain strategic objectives, for example, technological objectives, promoting national or regional competitive advantages or delivering global public goods. Examples include the Asia–Pacific Partnership on Clean Development and Climate, EPSRC, Ecoregion Research Networks, the United States–India Bilateral Collaborative Research Partnerships on the Prevention of HIV/AIDS, Brazil's international collaborations around biofuels development, ANDI and the India and EU Strategic Partnership on clean technology, CDM and adaptation;

(c) Internally competitive consortium: members of such a consortium bid competitively inwards amongst themselves (i.e. within the consortium) for individual projects within the larger framework of the overall consortium. This is different from a consortium where all members are participating in activities jointly. An example of this is the Metals Affordability Initiative Consortium;

(d) Product development partnerships (PDPs): this is a relatively new organizational way of structuring collaborative R&D, which has developed in the health sector. A PDP is a non-profit organization that builds partnerships between the private, public, academic and philanthropic sectors to drive the development of new products for underserved markets. PDPs are created for the public good and the resulting products are made affordable to all who need them. Examples to date focus on the development of medicines, vaccines or products for use in the treatment or prevention of neglected diseases,

[36] <http://www.matimop.org.il/Content.aspx?code=18>.
[37] <http://www.tradecommissioner.gc.ca/eng/science/istpp.jsp>.
[38] <http://gita.org.in/pdf/i4rd-callforproposal.pdf>.

and include the Medicines for Malaria Venture, the International AIDS Vaccine Initiative and the Global Alliance for Vaccines and Immunization;

(e) Network models: these consist of networks of research centres across different countries focusing on R&D around a range of priority issues within a certain sector. They can be used to target funding on priority areas of research while facilitating partnerships, information sharing and capacity-building and ensuring that initiatives respond to the context-specific needs of different regions and localities. The network-based model has considerable value in that it can be used to target R&D activities across a range of levels of research, from early stage research through to adaptive R&D and the targeting of previously neglected areas, according to the nature of the technologies in question and geographically specific needs. The classic example of an international sector-based network would be the work of the CGIAR on agricultural research. ANDI provides another example from the health sector. It should, however, be noted that networks can range from lighter, relatively loose networks in which institutes participate alongside other activities (for example, IEA cost-sharing Implementing Agreements), or they can be much tighter networks where, as in the case of the CGIAR, existing institutes are built upon to develop into centres that are exclusive to that network. Tighter networks have several advantages over looser networks. Their long-term nature enables them to build and sustain capacity, to develop institutional memory (for example, building and maintaining learning of successful approaches, available knowledge sources and relationships with partners) and to develop more efficient and effective approaches to interacting across the network over time, thus significantly reducing transaction costs;

(f) Nationally based innovation centres: these consist of nationally based, often not-for-profit centres which aim to identify relevant opportunities for collaboration with international partners geared towards specific national innovation interests or needs. An excellent example of this approach is Fundacion Chile,[39] which works to identify relevant areas of innovation that might be beneficial nationally. It then brokers relationships with international technology leaders in this area and works to collaborate on R&D (either in its in-house R&D facilities or other Chilean R&D facilitates) to make these applicable within Chile;

(g) Open source: open-source R&D is a novel approach to research that lets scientists collaborate freely across organizations, disciplines and borders to solve problems in which they share an interest. It stems mainly from the software industry[40] and attention has now turned to where open source might be applicable to drug research.[41] The term "open source" denotes the type of license under which a product is made available. The distribution terms of open source must comply with specific criteria, including free redistribution, providing access to the source code and the right to modify it and to distribute it further under the same terms as the license of the original software. There are a number of licenses conveying such rights, such as the GNU[42] General Public License, the MIT License[43] and Apache.[44] Almost all success stories of open source are from the software sector, which lends itself easily to collaborative work of this kind (especially given the standardization of products and platforms in this sector). It is not clear to what extent this model can be applied successfully to technologies for mitigation and adaptation.

[39] <http://ww2.fundacionchile.cl/portal/web/guest/home>.

[40] The key example being the Linux computer operating system started in the early 1990s by Linus Torvalds, who used the nascent Internet to circulate it to fellow computer enthusiasts.

[41] Munos B. 2006. "Can open-source R&D reinvigorate drug research?," *Nature Reviews Drug Discovery* 5, 723–729.

[42] GNU is a Unix-like computer operating system developed by the GNU project.

[43] The MIT License is a free software license originating at the Massachusetts Institute of Technology.

[44] See <http://www.opensource.org/>.

B. Possible gaps in coverage of existing collaborative research and development initiatives

83. The review of existing activities as referred to in paragraph 76 above and contained in annex III not only provides information on the key features of collaborative R&D, it also reveals possible gaps in current activities where the Convention may have a specific role to play when considering options to facilitate collaborative R&D on technologies for mitigation and adaptation.

84. The review confirms the conclusions of another EGTT report on recommendations on future financing options for enhancing the development, deployment, diffusion and transfer of technologies under the Convention[45] that the portfolio of existing R&D programmes are strongly focused on energy technologies, in particular on renewable energy. There are far fewer collaborative R&D activities in industry, transport and energy efficiency in buildings, and forestry, agriculture and waste are covered only within more general programmes. It should be noted, however, that the existing focus on energy technologies does not mean that there is no gap in R&D funding for energy technologies. Various studies indicate that R&D spending on energy needs to increase multi-fold to suffice for long-term climate targets,[46] and this seems to hold true in particular for non-energy mitigation technologies .

85. Another key observation is the weak coverage on technologies for adaptation. The health and agriculture sectors are covered to some extent and are characterized by innovative new collaborative R&D approaches. There are a number of research programmes that cover technologies for adaptation as part of their portfolio. Many non climate specific programmes may also support many R&D activities that are also beneficial for climate change adaptation; annex III and the box reveal six categories, which is a limited coverage compared with the categories identified by in the report on recommendations on future financing options as referred in paragraph 84 above.[47]

86. Furthermore, the initiatives encountered with regard to adaptation mostly relate to capacity development, catalysing partnerships and enhancing enabling environments, and to a lesser extent the modification and adaptation of technology. International collaborations that focus on R&D or the demonstration of new technologies for adaptation are not easily identified.

87. One particular observation relating to technologies for both mitigation and adaptation is that, while there are many international collaborative initiatives around technologies to address climate change, many of these involve processes for identifying needs and facilitating the sharing of knowledge and experiences rather than actually undertaking collaborative R&D.

88. Collaborative R&D initiatives that involve the sharing of costs between partners is also largely absent. In addition, while some programmes aimed at the deployment of technologies do allow a component that involves the modification and adaptation of technologies to the local environment, this form of collaborative R&D is not common.

[45] FCCC/SB/2009/2.
[46] International Energy Agency (IEA). 2010. World Energy Outlook 2010. Paris.
[47] As footnote 46.

Overview of technologies for mitigation and adaptation covered by existing collaborative research and development initiatives

Fossil fuels, electricity and storage
- Cleaner fossil energy
- Efficient thermal (including biomass)
- Coal mining
- Cogeneration
- Pre-combustion coal-fired power with carbon dioxide
- carbon dioxide capture and storage in the power sector
- Distributed generation
- Power generation and transmission
- Smart grids
- Energy storage
- Fuel cells
- Radioactive waste

Renewable energy
- Offshore wind
- Marine, wave and tidal
- Hydraulic
- Distributed energy
- Biofuels
- Micro-hydro
- Solar power
- Biogas
- Small-scale wind power
- Geothermal
- Thermal gradient

Energy efficiency
- Improved stoves
- Eco-cities
- Sustainable design
- Construction of the urban environment

Forestry

Transport
- Alternative oils for diesel
- Biofuels

Industry
- Aluminium
- Buildings and appliances
- Cement
- Steel

Adaptation
- Water technology and management
- Agro technology
- Agriculture
- Marine resources
- Tropical food-borne infectious diseases
- Earth sciences and disaster management

89. Another observation from the review is that very few initiatives involve collaboration with least developed countries, in particular in Africa. Developing countries participating in collaborative R&D are mostly from Asia (China and India) and Latin America.

90. Annex III also lists few R&D collaborations that are initiated by, or explicitly work with, industry and the private sector. It is unclear whether the absence of industry-led R&D collaborations indicates a gap, or such initiatives are not reported or are difficult to identify because of their commercially sensitive nature.

91. In conclusion, a multitude of gaps exist in the coverage of existing collaborative R&D initiatives. While annex III does not list every existing R&D collaboration, it does show a trend towards an emphasis on energy technologies with increasing attention on non-energy mitigation sectors such as transport and agriculture and limited attention on technologies for adaptation. In addition, collaborative R&D with least developed countries is limited.

VII. Options for facilitating collaborative research and development for climate technologies

92. The objective of facilitating collaborative R&D would, first and foremost, be to help ensure accessibility and availability of a suite of technological solutions to address climate change that are suitable for deployment under local conditions, particularly those of developing countries. A second goal is to help strengthen the technological capacity in these countries, particularly developing countries, since that ultimately will have a beneficial effect in terms of enhancing the efficiency, sustainability and effectiveness of their efforts to address climate change.

93. The role of the Convention is to facilitate the development and transfer of, and access to, environmentally sound technologies.[48]The actual R&D activities do not take place under the Convention. The following options should be seen in the context of the objectives of the Convention.

94. Mechanisms initiated under the Convention, notably TNAs, and nationally appropriate mitigation actions can help in identifying specific R&D needs in a country and for specific technologies or sectors. In addition, there is a need for more top-down indication of the general, global needs for climate technology R&D. Examples include the IEA Global Technology Roadmaps,[49] which include identification of R&D needs and earlier products of the EGTT.[50]

95. As discussed in chapter IV, there are three types of needs that should be considered in elaborating options to facilitate collaborative R&D activities with developing countries:

(a) Adaptation and modification of existing technologies and products with benefits in the near future;

(b) Development of technologies and products, including endogenous technologies, that contribute to development goals and needs and address climate change for the poor in developing countries, but that are mostly unaddressed by global technology markets;

(c) Basic and applied R&D for the development of technologies that are important for mitigation and adaptation over the medium to long term.

96. Having identified the key features of collaborative R&D options as presented in chapter IV A and a range of considerations that guide the options as presented in chapters IV.C and V.D, relevant options for collaboration, the related innovation phase, typical partners involved in the R&D option, the collaboration model, the potential funding source and location focus can be identified. An overview of these characteristics of the broad options and how they relate to the developing country goals is given in table 1.

97. The following sections discuss in more detail how the identified options could address the goals listed in paragraph 95 above.

A. Options for adaptation and modification of existing technologies and products

1. Technical focus/innovation stage

98. The technical focus to address this need would be at the middle innovation stage with the effort being devoted to modifying existing technologies (from industrialized countries or developing countries) to ensure appropriate technical performance under local use conditions. Technical efforts may also be needed to modify existing products to ensure that these are attractive to users and competitive in the market, thereby ensuring a demand for them. The starting point, therefore, would be technologies and products that have already been commercialized elsewhere and are seen as having potential in developing countries. As an example, it may be possible to develop low-cost, stripped-down variations

[48] Article 4, paragraph 1(c), and Article 9, paragraph 2, of the Convention.

[49] IEA. 2009. Global Technology Roadmap on the cement sector. Paris: IEA and IEA. 2009. Global Technology Roadmap on carbon capture and storage. Paris: IEA.

[50] As footnote 46.

of products from industrialized countries that meet the price–performance targets for local consumers.[51]

2. Key research and development partners

99. The central players here would be industry (equipment manufacturers) since the technical efforts will be highly applied in nature, and also informed by local market conditions and opportunities, although it is possible that in some sectors such as agriculture, public players could have a key role. Given that only a few developing countries (for example, Brazil, China, India, South Africa) have significant industrial capabilities, a concerted effort might be required to ensure the participation of, and partnership with, industry from smaller countries. This may require the development of a network, as in the case of ANDI in the health arena, that could serve as the collaborating organization for smaller developing countries while also building local capacity.

3. Collaborative models

100. Collaborations between industrialized and developing country partners would be mutually beneficial. It would allow the former to develop a better understanding of the markets and needs of the developing country and reduce the manufacturing cost, and it would allow the latter to enhance their capabilities and have access to new products that would enable action to address climate change while improving their competitive position in the market. These collaborations may be horizontal, that is, between players at similar positions in the value chain (for example, equipment manufacturers), or vertical, that is, between players at different positions in the value chain (for example, equipment manufacturers and parts suppliers).

101. In the case of networks like CGIAR, the collaboration may be between internationally funded laboratories and local developing country research organizations. The recently proposed concept of climate innovation centres (CICs),[52] although intended to cover the full innovation chain, may also be an appropriate institutional approach to promoting collaborative R&D.

102. PDPs may also be able to play a role with regard to specific products. The establishment or enhancement of developing country based innovation centres and networks with in-house R&D facilities could be valuable in both identifying local opportunities for adaptive innovation and brokering relevant international partnerships.

4. Funding sources/models

103. Given the market-oriented nature of the R&D, there is justification for private participation in funding these activities – this cost sharing is important not only for reducing the burden on public sources but also to ensure full participation and interest from the private sector. At the same time, public funds will be useful both to guide the activities and to catalyse private investments.

104. The kind of funding model will depend on the nature of the collaboration. For example, where there is an objective to achieve cost sharing and to leverage private-sector collaboration and investment, R&D funding pools could invite competitive proposals that would require co-financing from private-sector participants. In providing support to

[51] A typical example is Tata Nano, which is a low-cost, small and relatively fuel-efficient automobile designed/produced in India and now the success of the Tata Nano is spawning the development of other cars in this price-performance segment.

[52] As footnote 12.

collaborative networks there may be support for the overall programme, with the division of resources to be decided internally.

B. Options for development of technologies for meeting local unaddressed needs

1. Technical focus/innovation stage

105. The technical focus to address this need would again be at the middle innovation stage since the main aim is technology and product development. This will need a combination of applied R&D to develop or improve technologies (specifically designed to target the needs of the poor in a way that contributes to mitigation and adaptation and possibly also to their sustainable and human development) and user-oriented technical efforts to develop products that will meet the customers' needs.

106. This may require modification of existing local products (such as biomass gasifiers) or the development of new products. It should also be clarified that development of technologies to meet such needs need not be a low-technology effort. In fact, it may require drawing on significant scientific and technical knowledge (such as clean and efficient combustion or gasification of solid biomass) and industrial design and production to ensure the delivery of a well-designed and manufactured product.

2. Key research and development partners

107. The key actors would be industry, although public laboratories could also play a role, especially in the technology development process. Bringing in NGOs or grass-roots groups into the partnership may also be helpful in order to better understand the needs of the customer and to help with suitable technology and product design.[53]

3. Collaborative models

108. The PDP model, which is increasingly popular in the health area as a way to develop drugs for neglected areas, may be useful here to get quick results on high-benefit products.

109. Publicly funded networks (along the CGIAR or the CIC model) may be able to play an important role here.

110. Another way to organize collaborative R&D would be to utilize the innovation prize model as referred to in paragraph 82 (a) above with a condition that the entries need to be from collaborative ventures.[54]

111. Again, the establishment of developing country based innovation centres could also provide a valuable approach to identifying local needs and brokering relevant international partnerships.

[53] Chesbrough H, Ahern S, Finn M, and Guerraz S. 2006. Business Models for Technology in the Developing World: The Role of Non-Governmental Organizations, *California Management Review*. 48 (3): 48–61.

[54] Specifically, this refers to an ex-ante grand prize which is designed to catalyse the achievement of a specific result, often by stimulating R&D or technology (or prototype product) development. Innovation prizes are increasingly seen as an effective way to induce the development of technology in areas that are neglected by traditional market forces; therefore it may be particularly suitable for these unaddressed needs, given the paucity of relevant organized and well-funded innovation activities.

4. Funding sources/models

112. Given the nature of the activity, public funds will need to underwrite much of the expenses, but this could include climate financing that is supplemented with funding from development agencies (bilateral and multilateral). Some private funding should also be expected, in order to ensure seriousness of intent and to share costs since products would be a revenue source for manufacturers (although their purchase costs may need to be supported by public policies such as feed-in tariffs or purchase commitments).

C. Options for development of technologies for medium- to long-term needs

1. Technical focus/innovation stage

113. The technical focus to address this need would be on the early stages of the innovation cycle, with the objective being to engage in basic and applied research that could underpin the development of new technologies in the medium- to long-term. This could also include the development of new technologies, tools and processes that could advance future climate mitigation and adaptation activities.

2. Key research and development partners

114. Universities and national laboratories from industrialized and developing countries could play an important role in this arena. Industry also could play an important role. Given the kind of capabilities needed for participating in such activities, it is likely that only a few developing countries (with a strong R&D base) could participate.

3. Collaborative models

115. Universities could collaborate with each other; such collaborations currently happen quite frequently, but they could be further catalysed through additional and targeted funding. University–industry partnerships[55] are also becoming more frequent.[56] Another possibility would be industry consortia with a focus on pre-competitive R&D to advance basic technologies, tools or processes that will be helpful for all partners in the consortium (or for the industry as a whole). In addition, CGIAR-like networks or global collaborative R&D activities that draw upon models such as the International Thermonuclear Experimental Reactor (ITER) project as described in annex IV could play a role in collaborative early-stage R&D.

4. Funding sources/models

116. Funding for early-stage R&D is predominantly from public sources in most cases and it might be expected that this could be equally applicable to the options for development of technologies for medium- to long-term needs elaborated here. Globally, public R&D expenditure is mostly funded by national programmes but that is driven mostly by national priorities. But it may well be that a collection of nationally funded programmes may not adequately cover the R&D needs (in both scale and scope) for addressing climate change challenges. Thus it may require the utilization of climate financing to support collaborative R&D programmes – this could be done through an ‘opt-in’ programme where

[55] For example, one of the aims of the Tsinghua–BP Clean Energy Center in China is to become a research base for attracting worldwide projects and teams conducting leading edge research on clean energy development.

[56] Li J. 2010. “Global R&D Alliances in China: Collaborations With Universities and Research Institutes.”. *IEEE Trans. Eng. Mgmt*, 57(1):78–87.

countries may choose to allocate a portion of their climate finance contribution to collaborative R&D.

117. In the case of industry consortia (or even university–industry partnerships), it is expected that industry would contribute co-funding.

D. Criteria to evaluate the options that could be used to support decision-making on the allocation of funding to collaborative research and development activities

118. Given the wide range of options listed above, it is crucial to develop a set of criteria that could be used to further review, evaluate and prioritize the options. There are two general aspects need to be evaluated: benefits and effectiveness.

119. Such criteria could also be used as a basis for developing criteria that could be used to support decision-making on the allocation of funding to collaborative R&D activities.

120. Criteria to evaluate the benefits that the collaboration could yield might include:

(a) Does the proposed option fill an important gap? Does the proposed option allow developing countries to do something that they cannot do by themselves?

(b) Will the proposed option, if successful, yield benefits for a number of developing countries, even if they are not all involved in the collaborative R&D?

(c) Does the proposed option include participation of developing country partners? If not, is the case for collaboration between developed countries only (for example, early stage research based in international research facilities, which, however, might include the engagement/use of scientists from developing countries where appropriate expertise exists) well justified?

(d) Does the proposed option include specific capacity-building opportunities (for example, training opportunities for developing country personnel, knowledge and information exchange, international exchanges)?

121. Criteria to evaluate the effectiveness could include:

(a) Does the proposed option minimize the administrative burden for developing country partners?

(b) Does the proposed option require an very high level of capacity (both technical as well as project management) in order to bid for funds (so that partners with less international expertise might be excluded or discouraged from bidding for funds or leading bids)?

(c) Will funds be made available soon enough to enable poorer partners to participate? This is a question that might need particular consideration in relation to the use of innovation prizes where funding does not become available until the very end of collaboration, and only if the collaboration is successful in achieving a specified goal ahead of competing collaborations;

(d) Does the proposed option engage with the private sector? If not, is this appropriate or should private-sector engagement be encouraged?

(e) Does the proposed option facilitate articulation of the benefits to technology leading partners to engage in collaboration (for example, access to new markets or access to local market knowledge and distribution channels)? Is there space for supporting initiatives that explicitly aim to articulate and promote the benefits to international collaboration, in particular climate relevant areas?

(f) Are the funding criteria flexible enough so as not to clash with partners' strategic global initiatives?

(g) Has explicit attention been given to articulating the role of each partner prior to commencement?

(h) Has information sharing been addressed? Will information and learning from the collaboration be made available publicly to assist in catalysing innovation elsewhere?[57]

(i) Does domestic policy (for example, anti-trust laws) prohibit collaboration? Is this being addressed to facilitate collaborative R&D on technologies for mitigation and adaptation?

VIII. Next steps

122. The options presented in this document highlight general features that can be used to develop operational options to promote collaborative R&D activities on technologies for mitigation and adaptation both under and outside of the Convention. Once these general options are selected, further work would be required to develop operational collaborative R&D activities that could be considered by Parties for implementation under the Convention.

123. There is also a range of issues that need further analysis, which would help to design effective operational options to facilitate collaborative technology R&D for mitigation and adaptation. These include:

(a) A more systematic and thorough mapping of existing collaborative initiatives on climate technology and any R&D components therein. This will both inform the discussion about future potential collaborative R&D activities and highlight possible synergies between existing and future initiatives;

(b) Mapping landscape of country-specific innovation activities: The implementation of effective R&D collaboration models should take into account what is already ongoing in a country. Such a mapping exercise could be conducted in combination with the existing technology needs assessment process and/or possible future processes to identify the types of mitigation and adaptation actions that a country prefers, and could provide valuable information about how to prioritize R&D collaboration options. In order to obtain a full picture, it is important that private-sector R&D activities are also included in such analyses;

(c) The impact of R&D capacity of potential partners on their participation of recommended activities: The effectiveness of collaborations will be dependent on the levels of innovation capacity that exist in the developing countries. In many cases, it may be that collaboration around demonstration or deployment activities, or around capacity-building activities, might be better suited to accelerating the uptake of climate technologies in developing countries than collaboration on R&D. This may be particularly the case for (although it will not be unique to) least developed countries where capacity for early stage

[57] This includes restricting patenting where the initiative is seen as being of broader public good. As discussed in chapter V, several successful examples exist of public funded R&D with restrictions on patenting. However, with smaller project-based collaborations where market access is a key incentive for international technology leading firms to collaborate, it might be necessary to negotiate patenting regulations that satisfy commercial interests. This does not restrict the potential for making patents publicly available at a later date. For example, schemes could require public availability of patents and related knowledge at affordable rates several years after initial development. This provides a commercial incentive for investment while still recognizing the public good nature of any resulting innovation.

R&D does not exist and innovation capacity might best be developed via collaborations at later stages of the innovation chain or via focused capacity-building activities. Considerable value could therefore be added via focused research, in close consultation with local stakeholders, that seeks to understand the complex and specific socio-technical systems of developing countries within which innovation and technology uptake occurs. This would better enable collaborations to be targeted to needs-based opportunities where such collaborations can have maximum impact within the context-specific socio-economic, environmental and technological circumstances of the country in question;[58]

(d) R&D collaboration on indigenous technologies: Both the Convention and the literature emphasizes the relevance of indigenous technologies, in particular in developing countries. Such technologies are often better adapted to local circumstances, align better with cultural habits and preferences and can therefore be more efficient in fulfilling needs than foreign technologies that need expensive adaptations. However, little is known about how to realize this potential. R&D on indigenous technologies may need different models for collaboration and to organize research. Focused empirical research on R&D for indigenous technology could be conducted with a view to producing models for R&D collaboration that work for this group of climate technologies;

(e) Private-sector R&D in challenging contexts: The private sector in developed countries is relatively well studied and can clearly articulate its needs to government . In the more challenging investment and research climate in many developing countries, a lack of clarity prevails about how local private companies operate and innovate. Engagement with relevant private-sector stakeholders within these countries may yield considerable insights as to which technologies might most usefully be targeted, which international technology companies would be appropriate partners in such collaborations and which elements of the technology innovation system or enabling environment for innovation would be most urgent to address.

124. Notwithstanding the need for further analysis, several approaches could be taken to further specify the general options that have been described in this document:

(a) A review and prioritization process could be initiated so as to identify the most important collaborative R&D gaps that relate to each of the needs identified in this document, followed by the development of collaborative approaches that would be most suited for each of these gaps;

(b) A more focused approach could entail a focus on a particular sector, in which case the priority gaps within that sector could be identified, and operational options developed to meet those gaps;

(c) Alternatively, Parties could consider an approach that would focus on developing particular collaborative models that have wide applicability (examples could include product-development partnerships, public–private co-funded industry partnerships, or enhanced networks of existing R&D centres). Specific collaborative R&D activities would subsequently emerge from the adopted models.

125. In all cases, it is imperative that a wide range of stakeholders be consulted in the process of further elaborating specific options and that the needs and concerns of developing countries drive the process.

126. It may also be useful to pay particular attention to which existing initiatives could be leveraged since that will both avoid duplication and result in the faster delivery of enhanced collaborative R&D.

[58] Ockwell D, et al. 2009. A blueprint for post-2012 technology transfer to developing countries. Sussex Energy Group Policy Briefing Note. Brighton: Sussex Energy Group.

Annex I

Questionnaire on international collaborative R&D activities on technology to address climate change

1. Has your organization been, or is it currently, involved in any major international collaborative research and development (R&D) activities, particularly R&D activities on technologies to address climate change?

2. How would you describe these collaborative activities in terms of:

(a) Substantive area (for example photovoltaic materials);

(b) Type of activity, that is basic research, product development, etc.;

(c) Nature of partners, that is other firms (large/small?), universities, government laboratories;

(d) Length of collaboration;

(e) Nature of the agreement (joint venture, one-time cooperation, consortium, collaborative project, etc.);

(f) Management/governance of activity;

(g) Funding sources (own funding, external co-financing, grant funding etc.).

3. What are the motivation and/or incentives for your organizations engagement in such collaborations? (Please provide any further details.):

(a) To benefit from the partner’s knowledge;

(b) To benefit from the partner’s experience and know-how;

(c) To gain access to intellectual property rights;

(d) Necessary to obtain funding;

(e) Working with the partner improves my own reputation;

(f) Cost sharing/reduction;

(g) Other, namely.

4. How did the collaboration originate? How is the collaboration facilitated?

5. How did you evaluate “success’? Did you have particular metrics by which you measured progress on the activity?

6. Are you aware of other collaborations in your or other industries (even if you weren’t involved)? Were they successful? Why / why not?

7. What challenges did you face when undertaking R&D collaboration?

(a) Coordination of activities;

(b) Sharing of IPR and other products;

(c) Different working culture;

(d) Communication;

(e) Time difference;

(f) Lack of funding;

(g) Language;

(h) Other.

8. Does your organization have examples of where these barriers/challenges have been successfully addressed? Please mention them.

9. What advice do you have for preventing barriers that your organization is aware of?

10. What policies or other incentives could help broadly to enhance collaborative R&D?

11. Are you familiar with any new/innovative collaborative R&D approaches that you think would be useful to explore? Why?

12. Does your organization have experience or views on how the participation of developing countries could be strengthened in international collaborative R&D?

13. Has your organization developed, or are you aware of, criteria that could be suitable for guiding decision making on promoting collaboration R&D at the international level (this include, for example, additional funding, better networking, programmatic support, etc.)?

Annex II

Summary of responses to the questionnaire on international collaborative research and development activities on technology to address climate change

1. A questionnaire (see annex I) was sent out on 25 August 2010 to around 70 research organizations, private companies, governments and international organizations. Seven valid responses were received by 30 September 2010, giving a response rate of 10 per cent. The response and questionnaire format did not allow for statistical analysis, but the responses did contain insights that are collated in this annex.

2. Two of the responses were from international organizations,[1] three from private sector led technological research and development (R&D) consortia,[2] and two from developing country research institutes.[3] These involved in a number of public- and private-sector R&D activities. Most of the respondents reported various activities. The fields of R&D and demonstration were carbon dioxide capture and storage, wood-derived biofuels, wind energy, electric vehicles and solar energy. There were no respondents in the field of technologies for adaptation. Answers relating to policy or specific deployment activities are not included in the summary of the results below.

3. In addition to responses from the questionnaire, relevant results (concerning R&D collaboration) from interviews conducted in the context of an earlier report have been included.[4]

1. Why do partners collaborate?

4. The reasons for collaboration most mentioned are cost-related: collaboration (with public or foreign institutions) helps to obtain funding or reduce costs. In addition, benefiting from partners' knowledge, experience or know-how is mentioned in industry collaborations. Research organizations indicated that involving industry in R&D activities increased the likelihood that the technology would be commercialized later on and research–industry collaborations were therefore important.

5. One of the developing country public research institutes mentioned building capacity in-country and greenhouse gas reduction as specific reasons to collaborate, but also indicated that a lack of human resources and skills was inhibiting this aim. The other reported that benefiting from a partner's knowledge, experience and know-how was important. One developed country research institute indicated that collaboration with industry in fast-growing developing countries benefited the speed of market penetration of the technology it developed.

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[1] United Nations Industrial Development Organization and International Renewable Energy Agency.

[2] Agenda 2020, TNT Corporation and BASF Corporation.

[3] China Science and Technology Association and South African National Energy Research Institute.

[4] United Nations Environment Programme, Energy Research Centre of the Netherlands and National Renewable Energy Laboratory. 2010. *An Exploration of Options for Operational Modalities of Climate Technology Centres and Networks*. To be published. (Draft of May 2010 consulted. Data were derived from cases of the Energy Research Centre of the Netherlands, the Consultative Group on International Agricultural Research, the European Energy Research Alliance and the National Renewable Energy Laboratory.)

2. What challenges arise?

6. All private-sector and research organization respondents indicated that it was often a challenge to balance the interests of all partners involved in the collaboration, including the funding partner. In the one solely private-sector collaboration that responded, this was not flagged as an issue. In far-reaching collaborations between research institutes working in similar fields, trust between the institutes needed to be built.

7. Further observations relating to collaborations included:

(a) All responding collaborations involved public funding, even when all partners were private companies;

(b) All collaborations were one-off collaborations. Timelines, however, varied from one to several years;

(c) Most collaborations involving private partners indicated that intellectual property rights were an issue.

8. Barriers mentioned included:

(a) Aligning the interests of many diverse actors, especially in a large consortium;

(b) Communication and differences in working culture (communication being the barrier mentioned most often);

(c) The aim of the collaboration was not always clear upfront to all involved; the collaboration needed to have a clear focus;

(d) Funding was limited and an impediment to progress.

9. One consortium highlighted project management capabilities as a specific barrier. One developing country respondent indicated the following problems: lack of human resources and skills; donor preferences that were not in the greatest interest of the project participants; and too much dependence on a single person to lead the programme.

3. Recommendations

10. Many respondents indicated that limited funding for R&D, either relating to specific renewable energy technologies or more generally, was a barrier, implying a need for increased funding. Various respondents as well as interviewees indicated the importance of long-term funding and programmes. One private-sector respondent also talked about “government policies that encourage companies to commit funds and other resources to industrial RD&D”. This implies that there may be a greater willingness to invest in R&D with private-sector actors, but the policies were not detailed. Grants for early-stage technologies and project-specific grants to encourage deployment of particular technologies were mentioned as being required. A more general recommendation was made relating to the creation of enabling environments for R&D in developing countries. The respondent did not specify what it meant by “enabling environments”, but it is assumed that it was referring to issues such as building capacity among developing country actors and ensuring that domestic and international policy environments are appropriate to encouraging R&D.

11. Intellectual property (IP) was mentioned both in public and private collaborations. Suggestions for addressing this included incentives around IP for participation of private-sector actors and all parties signing an agreement on non-disclosure and IP early on in the collaboration.

12. Two independent respondents indicated that the goals and aims of the collaboration needed to be clearly stated and agreed upon in advance of the start of the collaboration.

Clarity on the objectives of the programme also made the incentives for participation clearer, and could possibly lead to better aligned interests during the collaboration.

13. Other recommendations mentioned include:

(a) Venture capital investments in R&D and new technology could be incentivized by public funding;

(b) Public guarantees for private loans to technologically risky projects or companies which would not otherwise access debt;

(c) "R&D promotion" zones: an instrument usually aimed at attracting innovative firms to a region through lenient settlement conditions and low taxes, which could be tailored to climate technology R&D;

(d) Mapping and categorizing existing collaborative R&D initiatives.

Annex III

Illustrative list of existing research and development initiatives

Table 2 contains a list of research and development (R&D) collaboration initiatives that was compiled based on Internet and literature sources and personal knowledge and networks. The intention is to give an impression of the international collaborative R&D landscape. A number of caveats and explanations should be mentioned:

(a) The list is not exhaustive – many more such collaborations exist;

(b) The list includes both R&D collaborations themselves (e.g. FutureGen), organizations that have R&D activities as a part of their portfolio (such as the Inter-American Development Bank, for with R&D is a very small part of its broader work) and funding programmes for collaborations (e.g. the European Union 7th Framework Programme, which funds hundreds of international R&D collaborations);

(c) The list does not include R&D collaborations and organizations referred to in the case studies (in annex IV) and the questionnaire responses;

(d) A large number of bilateral collaborations were identified (such as a collaboration on biofuels between Brazil and the Bolivarian Republic of Venezuela), but insufficient further information could be found to justify inclusion in the table;

(e) Another common feature in the list is science and technology international programmes initiated by one country with developing countries, often countries that share a language. Such programmes often fund a large number of technologies. Many examples of environmental and energy technologies are found and included in the list, but technologies for adaptation are found less often;

(f) The list includes a large number of collaborations on technology but not on R&D. Examples include Methane2Markets, the Global Carbon Capture and Storage Institute, cost-sharing Implementing Agreements of the International Energy Agency and the International Platform for the Hydrogen Economy. Often, such international collaborations focus on knowledge sharing and coordination rather than on R&D;

(g) The list includes any international collaboration that indicated that it would, alongside technology-enabling activities, also undertake or fund technology modification and adaptation to local circumstances, even if this was only a small share of its overall activities (e.g. the Renewable Energy and Energy Efficiency Partnership, Wisions);

(h) The list is in no particular order.

Table 2
Non-exhaustive list of illustrative existing research and development initiatives, organizations that undertake research and development initiatives, partnerships, and funding programmes involving research and development activities. The list is in no particular order

International, regional or bilateral	*Name and details of organization or initiative*	*Innovation phase*	*Key player(s)*	*Climate technologies*	*Description and main activities*
Bilateral	International Science and Technology Partnerships Program (ISTPP) (Canada) <http://www.tradecommissioner.gc.ca/eng/science/istpp.jsp>	Collaborative research and development (R&D) funding programme	Government of Canada – bilateral engagement with Israel, India, China and Brazil	No clear focus, but could possibly incorporate climate technologies	• Funds 50 per cent of costs of approved joint research initiatives • Two separate delivery organizations: International Science and Technology Partnerships Canada (ISTP Canada) is the delivery organization for the India, China and Brazil components of the ISTPP • Canada–Israel Industrial Research and Development Foundation is the delivery organization for the Israel component of the ISTPP • Industry–academia links encouraged but seems mostly private–private • Projects and partnership development activities – "matchmaking events" (to generate new or expand existing research and technology-based partnerships between two countries)
International	International Renewable Energy Agency <http://www.irena.org/>	All	Governmental	Renewable energy	• See work programme for 2010 • Includes activities geared towards cataloguing R&D capacities and identifying cooperation possibilities
International	Renewable Energy and Energy Efficiency Partnership	Deployment	Multiple	Renewable energy	• International steering board and regional developing country steering boards • Funds projects • Funds policy networks • Funds dissemination
International	Practical Action, or Intermediate Technologies Development Group <www.itdg.org>	Demonstration and deployment	Non-governmental organizations	• Improved stoves • Micro-hydro • Solar power • Biogas • Small-scale wind power	• Improves efficiency and productivity of biomass use • Provides small-scale, low-cost, off-grid electricity options • Assists communities looking for energy technology options (community

International, regional or bilateral	*Name and details of organization or initiative*	*Innovation phase*	*Key player(s)*	*Climate technologies*	*Description and main activities*
					engagement)
International	Koru Foundation <www.korufoundation.org>	Demonstration and deploy	Non-governmental organizations	Renewable energy	• Link between renewable energy industry and impoverished communities • Helps develop appropriate renewable energy technologies • Funds, facilitates and initiates projects for renewable energy technologies by working with local partners
International	African Rural Energy Enterprise Development	Demonstration and deploy	Intergovernmental organizations and national counterparts	Renewable energy	Provides low-interest funds and assistance in developing business plans for renewable energy for productive applications
International	Commercialization of Renewable Energy in India	Demonstration and deploy	United Nations Environment Programme, United Nations Development Programme, Winrock India and local-level foundations and self-help groups	Various (alternative oils for diesel, solar power, etc.)	Provides low-interest funds and assistance in developing business plans for renewable energy for productive applications
International and bilateral	Commercialization and Technology Transfer Program of the United States National Renewable Energy Laboratory <http://www.nrel.gov/technologytransfer/>	Diffusion	National Renewable Energy Laboratory, industry	Renewable energy Smart grids	The National Renewable Energy Laboratory works with industry and organizations to transfer renewable energy and energy efficiency technologies into the marketplace
International	FutureGen	Demonstration	Countries (United States led) and international private sector	Pre-combustion coal-fired power with carbon dioxide capture and storage	Realization of a 250 MW pre-combustion coal-fired power plant. Initially only Government of the United States, later (when the United States Congress rejected the budget) open for private sector and international participants Current status of the project is unclear
Regional and international	Asia Pacific Partnership	R&D, demonstration,	Australia, Canada, China, India, Japan,	• Aluminium • Buildings and	Mainly focuses on enabling and diffusion, but some technology research, development

International, regional or bilateral	*Name and details of organization or initiative*	*Innovation phase*	*Key player(s)*	*Climate technologies*	*Description and main activities*
		diffusion	Republic of Korea, United States	appliances • Cement • Cleaner fossil energy • Coal mining • Power generation and transmission • Renewable energy and distributed generation • Steel	and demonstration, primarily in China. For example <http://www.asiapacificpartnership.org/pdf/Projects/Cement/PSU/CMT-06-05.pdf>
International and regional	European Union’s framework funding for R&D <http://cordis.europa.eu/fp7/>	R&D	Research institutions and universities in European Union member States; sometimes also third countries and private sector	All	Extensive R&D programme, not only for technologies to address climate change
Regional and bilateral	India and European Union Strategic Partnership			Technologies for mitigation and adaptation	Cooperation in the area of clean technology and the clean development mechanism as well as on adaptation to climate change
Regional South–South	IBSA Dialogue Forum <http://www.ibsa-trilateral.org/>	Demonstration and deployment	Brazil, India, South Africa	• Mainly biofuels • Other renewable energy technologies • Science and technology on nanotech and health (malaria, tuberculosis, acquired immunodeficiency syndrome) and biotech and oceanography	• Promotes the production and use of biofuels • Information exchange on biofuels and renewable energy
National and international	Energy Technologies Institute <http://www.energytechnologies.co.uk/>	Research, development and deployment	Government (United Kingdom) and private sector	• Offshore wind • Marine, wave and tidal • Distributed energy	

International, regional or bilateral	*Name and details of organization or initiative*	*Innovation phase*	*Key player(s)*	*Climate technologies*	*Description and main activities*
Bilateral	MATIMOP Israel <http://www.matimop.org.il/Content.aspx?code=18>	R&D	Government of Israel • Bilateral collaborations with several countries in Europe and Asia, as well as the United States, Canada, Argentina and Australia • Bilateral fund activities with the United Kingdom, Singapore, the United States and the Republic of Korea • Also a few multilateral	• Energy efficiency • Alternative energy • Energy storage	Two main programme models are followed: • Independent bilateral funds, with each nation making an equal contribution • Parallel support arrangements, whether bi-national or multilateral, whereby each nation is committed to funding R&D performed by the joint venture partner company from its own country in accordance with their respective laws and regulations Whether an actual fund, with an independent legal structure, a “virtual fund” based on parallel support, or cooperation in the context of multilateral programmes, all international industrial R&D support programmes share similar characteristics and guidelines
Bilateral	Inida–Israel Initiative for Industrial research and development (i4RD) <http://www.gita.org.in/programmes_overview1.htm>	R&D	Government of India Government of Israel	Specific emphasis on the following technology areas: • Nanoscience/nanotechnology • Water management • Non-conventional energy resources (particularly solar) • Biotechnology • Space science and technology	• A bilateral framework providing financial support for collaborative industrial R&D ventures between Indian and Israeli companies • Within the context of the i4RD bilateral framework, funding mechanisms have been created through which industry may seek support for joint bilateral R&D projects involving at least one Indian and one Israeli company • Existing partnership arrangements detailed at <http://gita.org.in/pdf/i4rd-callforproposal.pdf>
National	Global Innovation and Technology Alliance <http://gita.org.in/index.htm>	R&D	Government of India Indian industry	• Environment • Water technology/water management • Renewable energy	Main activities: • Supporting joint R&D on cutting-edge technologies of national interest • Supporting joint industrial R&D and its commercialization

International, regional or bilateral	*Name and details of organization or initiative*	*Innovation phase*	*Key player(s)*	*Climate technologies*	*Description and main activities*
				• Agro technology	• Facilitating technology transfer and creating joint ventures through a commercial entity Financial support in the form of soft loans and grants to the Indian applicant for joint R&D, depending on the rules and regulations of individual guidelines. Counterpart agencies will implement the programme in the partnering country
Bilateral	India–Taiwan (China) programme of cooperation in science and technology <http://gita.org.in/Call-for-proposals-2010.pdf>	R&D	Government of India Taiwan (China)	• Energy storage devices • Tropical food-borne infectious diseases • Structural biology, functional genomics, bamboo flowering	Financial support is available only for mobility of scientists/researchers from each side. Normally two visits per year from each side for three years would be available
Bilateral	India–Canada Scientific and Technological Cooperation Agreement	R&D leading to commercial success, social good and benefit to both countries	Government of India Government of Canada	• Alternative energy and sustainable environmental technologies • Biotechnology, health research and medical devices • Earth sciences and disaster management	• Whereas the proportion of the Indian cost may vary from the Canadian cost (and vice versa) in the total project cost, funding will be limited to 50 per cent of the eligible national cost, with a limit of 600 000 Canadian dollars on the Canadian side • Canadian companies receiving an ISTP Canada contribution will be required to repay the contribution upon successful completion of the project • Canadian academia part of the project funding will be given as a non-repayable grant in India • While retaining the financial ceiling similar to Canada per project, public funded academic and research organization applicants may receive grants up to 100 per cent • Industry may receive up to 50 per cent of the eligible national cost in the way of a

International, regional or bilateral	*Name and details of organization or initiative*	*Innovation phase*	*Key player(s)*	*Climate technologies*	*Description and main activities*
					soft loan, repayable upon successful completion of the project
Bilateral	Near Zero Emission Coal <http://www.nzec.info/en/>	Demonstration by 2020, but by necessity involving adaptive R&D	Government of the United Kingdom Government of China	Carbon dioxide capture and storage in the power sector	A government-to-government programme with the aim of realizing a full-scale demonstration of carbon dioxide capture and storage in the power sector in China. It involves industry and research partners from China and the United Kingdom. It is collaborating with European Union programmes in the same field
Bilateral	Ecocit	R&D on planning, design and implementation of eco cities	Imperial College London, United Kingdom Tongji University, China	Ecological cities	Established, with support from the United Kingdom Engineering and Physical Sciences Research Council, to investigate the processes associated with the planning, design and implementation of eco cities. It has a special focus on Dongtan, on Chongming Island close to Shanghai. Arup is responsible for the master plan and design of Dongtan
Bilateral	United Kingdom Engineering and Physical Sciences Research Council, SUPERGEN fuel cells research	Research, development and demonstration		Fuel cells	
Bilateral	United Kingdom Engineering and Physical Sciences Research Council, collaborative research with China on cleaner fossil fuels			Clean fossil fuels	
Bilateral	United Kingdom–China sustainability research collaboration <http://www.ucl.ac.uk/news/news-articles/0902/09020602>	Research	The Thames Gateway Institute for Sustainability, Arup and Tongii University, China	Sustainable design Construction of the urban environment	
Bilateral	Fundacion, Chile	R&D,	Fundacion Chile, a non-	Range of industrial	Aims to identify innovations internationally

International, regional or bilateral	*Name and details of organization or initiative*	*Innovation phase*	*Key player(s)*	*Climate technologies*	*Description and main activities*
	<http://ww2.fundacionchile.cl /portal/web/guest/home>	demonstration, deployment, diffusion	profit organization based in Chile	sectors, several of which are of explicit environmental relevance: forestry, agriculture, marine resources, environment and chemical metrology	that might be of relevance to improving the performance (including environmental performance) of Chilean industry. Uses a number of methods to adapt, demonstrate and roll out these innovations, thus reducing risk and encouraging uptake among Chilean firms. The approach Fundacion uses is based on three stages. First, opportunities for innovation (often adaptive innovation) are identified based on careful assessments of international and national capabilities and in close consultation with the private sector. The next stage involves obtaining, developing or adapting the technology via three approaches. These include: • Transferring and adapting a technology obtained from an outside supplier • Developing a technology using Fundacion's own in-house R&D capabilities • Developing a technology via collaboration with an established network of indigenous R&D institutions The third stage involves scaling up and disseminating the technology via a number of approaches, which include: • Creation of innovative companies, always with strategic partners (usually private-sector). Fundacion usually sells its share in these companies once they are self-sustaining and reinvests the funds in new initiatives • Sale and licensing of technologies (when new technologies become available via its in-house R&D or its collaborations with external, indigenous R&D centres)

International, regional or bilateral	*Name and details of organization or initiative*	*Innovation phase*	*Key player(s)*	*Climate technologies*	*Description and main activities*
					• Supply of technological services across the different key areas in which it works • Certification and implementation of standards • Broad dissemination through training, seminars, publications and Internet websites
National	National Hybrid Propulsion Platform	Demonstration	Government of India Indian car manufacturers	Public–private collaboration	Aims to create an indigenous demonstration fleet of hybrid cars
Bilateral	Carbon Trust/China Energy Conservation Investment Corporation (CECIC) China Initiative <http://www.carbontrust.com/emerging-technologies/pages/cecic1.aspx>	Technology adaptation and modification	Carbon Trust/CECIC	Low greenhouse gase emissions technologies	The collaboration has two core objectives: • To incubate new and emerging low-carbon technologies and introduce selected low-carbon businesses in the United Kingdom to China • To provide financial investment for United Kingdom and Chinese low carbon businesses in China Output: • Developing and transferring low-carbon technology within China, facilitating access to Chinese market opportunities • Arranging access to space on CECIC's industrial parks at preferential rates, help with staff recruitment and provide legal and business support
Bilateral	International cooperation of the French Agency for Innovation <http://www.oseo.fr/>	R&D	French research entities, universities and the private sector, also third countries		This fund is given by the Government of France to local entities that set international projects with the aim of cooperative technology development
European	Joint Technology Initiatives for European countries	Research, development and deployment	European public and private entities set projects with a level of co-funding for proven	Energy technologies	Provides funds mainly to energy, nano-materials, information and communication technologies

International, regional or bilateral	*Name and details of organization or initiative*	*Innovation phase*	*Key player(s)*	*Climate technologies*	*Description and main activities*
			technologies		
International	Integrated support for the strengthening of scientific teams of the South (AIRES-Sud)	R&D	Algeria, Benin, Burkina Faso, Cameroon, Congo, Côte d'Ivoire, Ethiopia, Gabon, Ghana, Mali, Morocco, Niger, Senegal, South Africa, Togo, United Republic of Tanzania	Solar energy	Supports R&D in research centres and universities and promotes the exchange of new knowledge between research entities and stakeholders. Programme is broader than low greenhouse gas emission energy technologies and includes renewable energy
Bilateral	National Council on Science and Technology of Mexico	R&D	Local universities, research centres and private companies from Argentina, Belgium, Brazil, Bulgaria, Chile, China, Colombia, Cuba, Czech Republic, France, Germany, Hungary, India, Italy, Japan, Peru, Poland, Republic of Korea, Russian Federation, Spain, United Kingdom, United States, Venezuela (Bolivarian Republic of), Viet Nam	Unclear	This fund is given by the Government of Mexican to local entities that set international projects with the aim of cooperative technology development
International	Fondo Nacional de Desarrollo Científico y Tecnológico, Chile	R&D	Local universities, research centres and private companies from the Argentina, Brazil, Canada, China, Czech Republic, France, Germany, New Zealand, Poland, Russian Federation, Spain, United Kingdom	Unclear	Funds R&D activities and scientific staff exchange in order to enhance and contribute to the Chilean national projects

International, regional or bilateral	*Name and details of organization or initiative*	*Innovation phase*	*Key player(s)*	*Climate technologies*	*Description and main activities*
			and United States		
International	Innovación e Investigación en Tecnologías de Energías Renovables, Peru	Deployment	Governments, universities and non-governmental organizations in Peru, the Funding: Cooperation of Catalonia (Spain) and the Directorate General for International Cooperation (the Netherlands)	Renewable energy technologies	Funds adaptation of renewable energy technologies
International	Waterloo Foundation, United Kingdom	Deployment	Governments, non-governmental organizations and private companies	Renewable energy technologies	Part of its portfolio (and in collaboration with the Toyota Foundation) is funding the adaptation of renewable energy technologies
International	Toyota Foundation, Japan	R&D, demonstration	Governments, non-governmental organizations and private companies	Renewable energy technologies	Part of its portfolio (and in collaboration with the Waterloo Foundation) is funding the adaptation of renewable energy technologies
International	Agencia Española de Cooperación Internacional, Spain	Deployment	Research centres, universities, non-governmental organizations and private companies (mostly from Latin America)	Renewable energy technologies	Cooperation on technology adaptation with Spanish-speaking countries
International	Electric Power Development Company, Japan	Deployment	Private and state-owned companies in new markets in Latin America	Efficient thermal power generation and biomass energy	Collaborative projects to adapt power generation technologies to regional circumstances, for example around efficiency in thermal power generation
International	Sustainable energy project support	R&D, demonstration, deployment	Non-governmental organizations in developing countries	Renewable energy and energy efficiency technologies	As a part of its larger portfolio, Wisions funds a few small projects concerning the improvement of renewable energy technologies and energy efficient

International, regional or bilateral	*Name and details of organization or initiative*	*Innovation phase*	*Key player(s)*	*Climate technologies*	*Description and main activities*
					appliances
Regional	Inter-American Development Bank	Technology modification and adaptation	Governments, non-governmental organizations and private companies (mostly from Latin America)		A small part of the Inter-American Development Bank portfolio includes loans for private-sector entities for the adjustment of technology to local conditions
International	Various activities mentioned under <http://en.openei.org/wiki/Concept:CLEAN_Resource_Assessment_Programs>		Developed and developing country research institutions and technical assistance providers	Low greenhouse gas emission technologies	The website mentions collaboration on technical software tools
International	Medicines for Malaria Venture	R&D	Public–private partnerships, non-governmental organizations. Open to any project ideas from any organization – proposals reviewed by the Expert Scientific Advisory Committee	Antimalarial drugs	Non-profit entity Aims at discovering and developing affordable antimalarial drugs

Annex IV

Detailed case studies of existing collaborative technology research and development activities

1. Consultative Group on International Agricultural Research[1]

Objectives and scope

1. The aim of the Consultative Group on International Agricultural Research (CGIAR) is to reduce poverty and hunger through scientific and technological agricultural research. It therefore focuses on its links to climate change through agriculture, primarily around vulnerability, resilience and adaptation of the agriculture sector, but there are also activities related to mitigation, mostly related to land use and forestry. CGIAR's 15 research institutes are spread over the developing and the developed world. As the discussion in chapter VI above demonstrates, the networked approach to collaborative research and development (R&D) that CGIAR illustrates is flexible and could be applied across all three of the different categories of developing country technology needs, even though determining the usefulness of individual technologies, sectors and countries will need further study. In the case of CGIAR the focus has tended to be on a combination of adapting existing technologies to new circumstances and developing and adapting technologies to meet unaddressed needs.

2. CGIAR dates back to the 1960s. It started out as an initiative of the Rockefeller and Ford Foundations, and was soon joined by governments and multilateral organizations. Currently public partners dominate the membership of the Consultative Group. Current annual funding is approximately USD 550 million, of which roughly USD 100 million originates from charities and the remainder from governments and multilateral organizations, in particular the United Nations Development Programme and the Food and Agriculture Organization of the United Nations. CGIAR currently has 80 members and is technically a public–private partnership among private parties, national governments and international organizations.

3. Although in recent years CGIAR has sought more collaboration with other centres, most of its work is done in the 15 research centres shown in table 3.

4. The development of CGIAR over the years can be characterized by a number of phases. The early phase focused on seed improvement, initially sorghum, rice and wheat. These programmes were very successful; the varieties developed at CGIAR reached penetration levels of more than 50 per cent in Asia and Latin America, but stayed low in Africa, where the conditions and enabling environment for diffusion were absent. Demand-driven research also contributed to success; the initial founders in particular were interested in seed varieties that would do well on the global market.

5. Over time more institutes joined CGIAR. Subsequent phases focused on agro-technology, socio-economic research, environmental research (such as biodiversity and forestry), systems analysis and eco-regional programmes, and, under the Generational Challenges Programme, broad global challenges, such as nutrition and climate change.

[1] <http://www.cgiar.org>. Part of this discussion draws on United Nations Environment Programme, Energy Research Centre of the Netherlands and National Renewable Energy Laboratory. 2010. *An Exploration of Options for Operational Modalities of Climate Technology Centres and Networks*. To be published.

CGIAR's current focus is the integration of the different programmes both within CGIAR and with non-CGIAR institutions, such as universities in Brazil, China and Europe.

Table 3
CGIAR research centres

Name of research centre	*City*	*Country*
International Food Policy Research Institute	Washington, DC	United States of America
International Center for Agricultural Research in the Dry Areas	Aleppo	Syrian Arab Republic
International Crops Research Institute for the Semi-Arid Tropics	Patancheru	India
International Rice Research Institute	Manila	Philippines
WorldFish Center	Penang	Malaysia
Center for International Forestry Research	Bogor	Indonesia
World Agroforestry Centre	Nairobi	Kenya
International Water Management Institute	Colombo	Sri Lanka
International Institute of Tropical Agriculture	Ibadan	Nigeria
Bioversity International	Rome	Italy
International Livestock Research Centre	Nairobi	Kenya
Africa Rice Centre (WARDA)	Cotonou	Benin
International Institute of Tropical Agriculture	Cali	Colombia
International Potato Center	Lima	Peru
International Maize and Wheat Improvement Centre	Mexico City	Mexico

Governance and organization

6. Over the years, the institutes in CGIAR have developed into project implementation organizations. Another process currently under way aims to improve strategic planning at CGIAR by limiting its scope to a small number of large programmes rather than many small projects. Over the years, CGIAR had to reorganize a number of times in order to address changing circumstances and because the earlier governance structure did not suffice. In 2010 the governance structure changed into a two-pillar organization of the Consortium of CGIAR Centres and the CGIAR Fund. All members of CGIAR meet on a biennial basis. A Fund Council decides on more short-term issues and is chaired by a Vice-President of the World Bank and comprises eight representatives of donor countries, eight representatives of developing countries and regional organizations, and six representatives of multilateral and global organizations and foundations. An Independent Science and Partnership Council (ISPC) consists of a group of nine leading global scientists who are appointed by the Fund Council. This ISPC plays a key role in the programming and strategic process, as well as in quality awareness and control. It makes sure that the research programmes are aligned with the strategic research framework of CGIAR.

Incentives, knowledge sharing and intellectual property

7. The incentives of public partners to become donors in CGIAR include cost-sharing and CGIAR's proven ability to bring new technologies to the market. The early private members of CGIAR were interested in market access of different seed varieties. Given the strong market shares of those early seed varieties, this collaboration seems to have paid off. The results of CGIAR, however, have become less tangible recently, as the low-hanging fruit (technical improvement in seed quality) in addressing hunger was addressed and the complexity of the problem increased. Now partners seem to participate to obtain access to specific technical knowledge and for the potential impact on policy in the field.

8. As the research centres in the CGIAR over the past years were perceived to be working increasingly independently, leading to less consistency in the research portfolio, measures were undertaken to facilitate knowledge sharing and skills transfer, particularly in the governance structure. The directors of the research centres meet twice a year. The CGIAR research centres employ scientists from different countries, often on temporary contracts. As CGIAR research centres are highly acclaimed, researchers are eager to work there, even on a temporary basis. The mobility of these scientists is thought to contribute to knowledge sharing and skills transfer.

9. With regard to intellectual property, CGIAR has a dedicated Central Advisory Service on Intellectual Property (IP). It is an explicit aim of this service to "assist, support, facilitate, and secure access to intellectual assets as public goods" and it carries out the following actions:

(a) Contributes legal information to the CGIAR that benefits subsistence farmers in developing countries;

(b) Maintains a knowledge base of IP lessons learned within CGIAR;

(c) Provides market development, planning and implementation;

(d) Consults on IP risk management, licensing and design of distribution and supply chains;

(e) Introduces the next generation of lawyers to "agricultural public goods" practice.

2. Project PANDA: collaboration between Yingli, the Energy Research Centre of the Netherlands, and Tempress on photovoltaic manufacturing

Objectives and scope

10. In June 2009, Project PANDA was started with the Energy Research Centre of the Netherlands (ECN), Yingli Green Energy Holding Company Limited and Tempress Systems, Inc. (a subsidiary of Amtech System, Inc.). ECN is a not-for-profit research institute, Yingli is a solar panel manufacturer in China and Tempress is a Netherlands-based specialized furnace manufacturer. The PANDA project focuses on solar photovoltaic (PV) module manufacturing in China. The solar cells manufactured are a modification of PV technology (higher efficiency) and the manufacturing of n-type silicon solar cells. The project can therefore be classified as falling into the "adaptation of existing technologies" category of developing country goals to which collaborative R&D can contribute. The objectives of the project are to demonstrate the technology, investigate the feasibility of low-cost production, improve the efficiency of PV cells, manufacture and certify modules, address bottlenecks and develop specifications of fabrication equipment. As such, the project performs R&D on the demonstration phase of PV cell manufacturing.

11. Yingli Green Energy Holding is a vertically integrated PV product manufacturer. The company was interested in setting up a new pilot production in an existing pilot PV production line. Tempress had links with Yingli in China, and was familiar with the latest ECN progress on efficiency in n-type bifacial solar cells. ECN was looking for a partner with which it could deploy its latest technology, but could not find interested investors in Europe. Tempress served both as a matchmaker and a participant in the formation of the consortium.

12. New production lines will be designed to produce next-generation high-efficiency n-type silicon solar cells based on the technology developed through Project PANDA. The high-efficiency cells utilize the cell design (n-type technology) of ECN, the solar diffusion technology and dry phosphosilicate glass removal technology of Tempress and Yingli Green Energy's cell process technology. On the PANDA pilot line, cells with an average efficiency of 18 per cent or higher had already been produced. In September 2010, ECN, Yingli and Tempress reported an average efficiency of over 19 per cent on the commercial production lines, which was higher than expected.

Organization and governance

13. Project PANDA is a one-off collaborative effort consortium. Yingli supplies the 300 MW manufacturing line for n-type monocrystalline silicon cells and modules in China and operates the manufacturing. It also debugs and optimizes operation of the pilot. ECN provides the cell technology and process optimization knowledge. Tempress is responsible for the diffusion process (important for efficiency in the cell) and its optimization, and for the glass removal equipment. The resources for the project came from the industry partners.

Incentives, knowledge sharing and intellectual property

14. For Yingli, the incentive for the collaboration seems to lie in access to specific technical knowledge and experience with the technology. For Tempress, the incentives appear to be market access in China and access to knowledge. For ECN the project meant that its technology could be brought to the market much more quickly than in the slower European context. Another advantage was that Yingli already had a pilot construction line set up and ready to use. In addition, ECN received fees for the IP and its work on the line.

15. Despite this being a collaboration beween industrialized and developing countries, no specific measures were put in place to facilitate knowledge sharing and skills transfer. In fact, ECN reports very smooth cooperation between Yingli and the Dutch partners. The IP arrangements correspond to normal IP arrangements; they are not different from those normally applied in the European context. Yingli is mostly interested in fast take-up of the technology and learning from the process optimization by ECN. This is demonstrated by the extremely fast timescale: in a little over one year after the project start, the line was producing solar cells at a level of efficiency that was significantly higher than targeted.

3. International Thermonuclear Experimental Reactor[2]

16. The largest international collaborative deployment project (in terms of funding) after the International Space Station is the ITER fusion reactor. Fusion power offers the potential of essentially inexhaustible, non-CO_2 electricity without the levels of radioactive waste associated with nuclear fission. However, many physics and technology issues remain to be resolved. Fusion energy for electricity generation is expected to be commercially available by 2040, provided the scientific advances are made and funding is consistent.

[2] <http://www.iter.org/procurementsharing>. Coninck et al. 2008. International technology-oriented agreements to address climate change. *Energy Policy*, 36: pp.335–356.

Objectives and scope

17. ITER is an international fusion experiment designed to show the scientific and technological feasibility of a full-scale fusion power reactor. The ultimate aim of the project is the demonstration of fusion technology, although because of the complexity of the technology, much applied R&D is also taking place. ITER builds on prior research devices but will be considerably larger. From a climate change perspective, the focus is on mitigation. These characteristics, coupled with its more long-term R&D nature, place this collaboration within the category of initiatives that contribute to developing new climate technologies that might meet the needs of developing countries in the medium to long term.

Organization and governance

18. ITER began in 1985 as a collaboration between the European Union (EU), Japan, the United States of America and the Union of Soviet Socialist Republics. Participation has varied over time, and currently there are seven parties participating in the ITER programme: China, the EU, India, Japan, the Republic of Korea, the Russian Federation and the United States. Conceptual and engineering design phases led to a detailed design in 2001, supported by USD 650 million worth of R&D by participating countries. The programme was planned to last for 30 years – 10 years for construction and 20 years of operation – and costs were expected to be approximately USD 12 billion.

19. After many years of deliberation, and a contentious debate over locating the project in France versus Japan, the participants announced in 2005 that ITER will be built in Cadarache, France. Japan was promised that 20 per cent of the research staff on the French location of ITER as well as the head of the ITER administrative body will be from Japan. In addition, a research facility for the project will be built in Japan, for which the EU will contribute about 50 per cent of the costs. Overall, the participating ITER members have agreed on a division of funding contributions where five elevenths are contributed by the hosting member (the EU) and one eleventh by each of the six non-hosting members.

20. Reaching agreement on ITER was not easy. The rules for procurement to cover the high costs of the fusion reactor are precisely negotiated between the participating countries. Eighty-nine per cent of the items used in the reactor will be provided ‘in kind’, while the remainder will be procured through a joint fund. ITER has a detailed sharing of items between the participating countries and the joint fund.[3] This shows that even when there is collaboration, when budgets are significant countries require visible benefits.

Incentives, knowledge sharing and intellectual property

21. The high uncertainty over whether fusion research will ever deliver a full-scale energy option, its low near-term commercial value and the very high costs of the demonstration facility make a cost-sharing arrangement necessary for countries that are interested in the option of nuclear fusion. Another incentive for countries to embark on this experiment is the technological spin-offs for other technological areas, such as nuclear fission and material science.

22. ITER is located in Cadarache, France. Other facilities necessary for testing and data will be operated in Japan. In addition, the European agency Fusion for Energy is the procurement agency for ITER, vetting agreements on components and technologies for ITER with the ITER parties and other countries and organizations. The ITER organization is supported by several international networks of fusion experts, including the International Tokamak Physics Activity (ITPA), the IEA Fusion Power Co-ordinating Committee and the fusion-related IEA Implementing Agreements.

[3] See <http://www.iter.org/procurementsharing>.

23. The International Energy Agency (IEA) facilitates over 40 multilateral technology agreements: the IEA IAs. Each IA has a specific technological focus. The collaboration model of an IA is determined by the members of each IA, depending on the needs and preferences of the technology and the type of members involved. The membership of most IAs is dominated by OECD countries, including Mexico and the Republic of Korea, but some of them, notably agreements in the field of renewable energy, also involve developing countries. Brazil, for instance, plays a significant role in the IA on Bioenergy and South Africa recently joined the IA on Solar Heating and Cooling.

24. In general, IAs coordinate technology RD&D activities and share knowledge and experiences. Potentially, IAs can set up joint development programmes, which would qualify as R&D activities under this document. One is the IEA IA on Solar Heating and Cooling. Twenty countries are members of this IA, two of which are developing countries: Mexico and South Africa.

25. Since it was founded in 1977, the IEA IA on Solar Heating and Cooling has completed 36 tasks. Tasks are defined as specific projects with an aim, a number of specific activities and a workplan. Eight tasks are still ongoing:

(a) Task 44 – Solar and Heat Pump Systems;

(b) Task 43 – Solar Rating & Certification Procedure;

(c) Task 42 – Compact Thermal Energy Storage;

(d) Task 41 – Solar Energy and Architecture;

(e) Task 40 – Towards Net Zero Energy Solar Buildings;

(f) Task 39 – Polymeric Materials for Solar Thermal Applications;

(g) Task 38 – Solar Air-Conditioning and Refrigeration;

(h) Task 36 – Solar Resource Knowledge Management.

26. In the case of the Solar Heating and Cooling IA, funding for R&D activities does not come from a common budget. Partners in a task finance their activities under the task from their respective national research budgets. If relevant, participation of industrial partners is pursued. Industrial partners tend to fund their contributions in-kind.

27. Within the Solar Heating and Cooling IA tasks, several involve collaborative R&D. Typical tasks in this IA have around eight to 10 participating countries. An example is task 35 on PV/Thermal Solar Systems, which was started in 2005 and completed in 2009, had as its objective to "catalyze the development and market introduction of high quality and commercially competitive PV/Thermal solar systems, to increase general understanding of the technology, and to contribute to internationally accepted standards on performance, testing, monitoring and commercial characteristics of PV/Thermal solar systems in the building sector". The task combined a questionnaire on design, purchase, supply and installation of PV/T with development of PV/Thermal systems and testing them under different circumstances outside. For the testing, the collaborative aspects were most pronounced.