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Item 4 of the provisional agenda
Development and transfer of technologies

SUBSIDIARY BODY FOR IMPLEMENTATION
Thirtieth session
Bonn, 1–10 June 2009

Item 7 of the provisional agenda
Development and transfer of technologies

Recommendations on future financing options for enhancing the development, deployment, diffusion and transfer of technologies under the Convention

Report by the Chair of the Expert Group on Technology Transfer

Summary

This document presents the recommendations of the Expert Group on Technology Transfer on future financing options necessary for enhancing the development and transfer of technologies, for consideration by the subsidiary bodies at their thirtieth sessions. It presents three indicative financing options for enhancing the development and transfer of technologies under the Convention:
(a) the enhancement of existing and emerging technology financing arrangements;
(b) a decentralized or centralized comprehensive new international technology financing scheme; and (c) limited new technology financing and coordination arrangements with sectoral activities. The options represent the range of possible options rather than describe actual and preferred alternatives.

The executive summary of this report is contained in document FCCC/SB/2009/2/Summary.

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I. Introduction

A. Mandate

1. The Conference of the Parties (COP), by its decision 3/CP.13, annex II, requested the Expert Group on Technology Transfer (EGTT) to identify and analyse existing and potential new financing resources and relevant vehicles in supporting the development, deployment, diffusion and transfer of environmentally sound technologies (ESTs) in developing countries. The COP also requested the EGTT to assess, based on this work, gaps and barriers to the use of and access to these financing resources in order to provide information to Parties to enable them to consider the adequacy and predictability of the resources. The results of this work (identification, analysis and assessment) were requested to be made available for consideration by the subsidiary bodies at their thirtieth sessions, with a view to considering the role of new financing mechanisms and tools for scaling up development and transfer of technologies.

2. The Subsidiary Body for Scientific and Technological Advice (SBSTA), at its twenty-eighth session, endorsed the terms of reference for this work, as proposed by the EGTT in document FCCC/SBSTA/2008/INF.2.[1]

3. The SBSTA and the Subsidiary Body on Implementation (SBI), at their twenty-ninth sessions, requested the EGTT to prepare an advance report on financing options as input to the fifth session of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention (AWG-LCA).[2] This final report draws upon the views expressed by parties at the fifth session of the AWG-LCA.

B. Scope of the report

4. Three general options for future financing arrangements were described in document FCCC/SB/2009/INF.2 (hereinafter referred to as the advanced report). In this final report, the EGTT has elaborated the options to provide greater detail on the possible functions and means of implementation of possible future technology financing arrangements. The report presents recommendations which could facilitate consideration by the Parties of the role of new financing mechanisms and tools for scaling up development and transfer of technologies. The three options are presented as a continuum ranging from an enhancement of existing financing mechanisms to the establishment of a centralized international financing scheme under the Convention. The options are not mutually exclusive and it is assumed that the three options will provide the financial resources needed, although in this document the question of how resources are to be generated is not addressed.

C. Possible action by the subsidiary bodies

5. The SBI and the SBSTA may wish to consider the recommendations by the EGTT on future financing options necessary for enhancing the development, deployment, diffusion and transfer of ESTs under the Convention and determine any further actions arising from it. The SBI and the SBSTA may also wish to provide guidance to the EGTT on its possible future tasks arising from this report, as appropriate.

II. Methodological approach

A. Challenges

6. Identifying, analysing and assessing financing resources and vehicles for ESTs requires a list of the relevant technologies. The financing resources and vehicles needed depend on the stage of

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[1] FCCC/SBSTA/2008/6, paragraph 83.
[2] FCCC/SBSTA/2008/13, paragraph 27, and FCCC/SBI/2008/19, paragraph 68.

technological maturity – research, development, deployment and diffusion – of the technology and whether technology transfer is involved. Thus, the relevant technologies, financing resources and vehicles need to be assessed by stage of technological maturity. Unfortunately, available data on current financing resources and vehicles do not sufficiently match the relevant climate mitigation technologies and technologies for adaptation.

7. Estimates of the financing resources needed in the future for ESTs are wide ranging, owing to differences in assumptions relating to, inter alia, global emissions targets and projected rates of technological innovation. Available estimates of the future financing resources that are needed rarely distinguish between the stages of technological maturity, so this study has allocated portions of the total estimated resources to each stage, based on expert judgement and available literature. Analyses of the gaps and barriers in current finance sources and vehicles help to identify future financing needs.

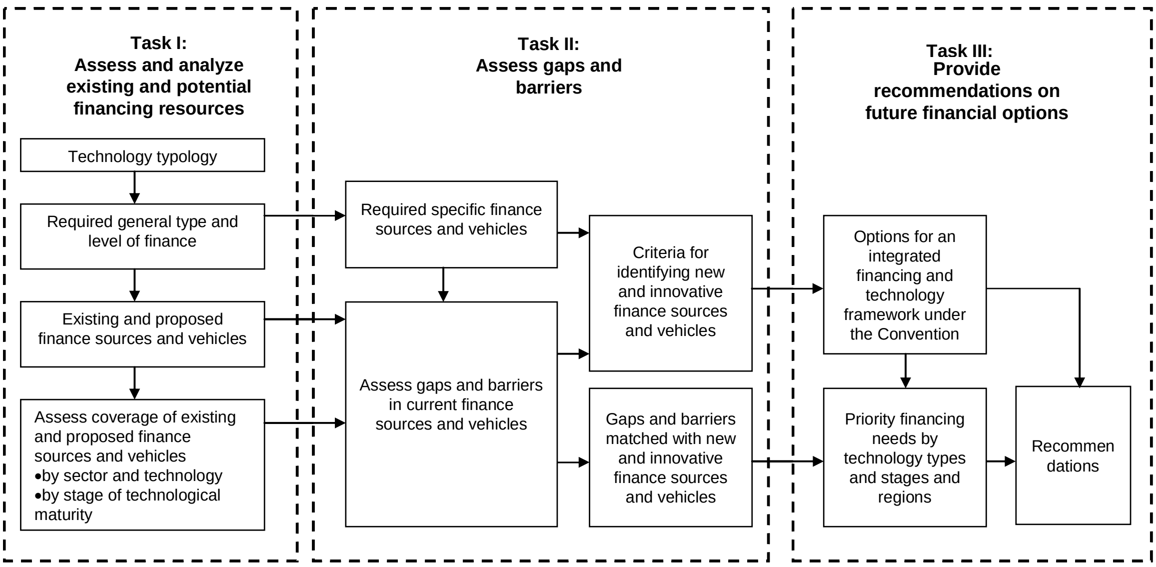
8. Research and development (R&D) in climate mitigation technologies and technologies for adaptation is dominated by a relatively small number of mostly developed countries. Since developed countries are expected to account for about half of global emissions over the next decade, there is considerable scope for deployment and diffusion in these countries. Since the cost of a technology tends to fall as its use increases, the scale of adoption by developed countries will affect the cost of its transfer to developing countries.

9. Research, development, deployment and diffusion of climate mitigation technologies and technologies for adaptation are funded mainly by the private sector; most of the remaining funding comes from national governments. International public funding covers only a very small share of the total. Funding for transfer of climate mitigation technologies and technologies for adaptation to developing countries shows a similar trend. Recommendations on future financing options and risk mitigation tools in this document therefore focus on influencing private sector decisions through policies and incentives. Where an important gap or barrier is not or cannot be adequately addressed by the private sector, new public sources or vehicles of finance are recommended.

B. Approach

10. The methodology developed to address these challenges is shown in figure 1. It also indicates the scope of the three tasks and their relationship to each other.

Figure 1. Overview of the methodology



11. Task I produces an overview of the extent to which the existing and proposed financing sources and relevant vehicles meet projected needs for the development, deployment, diffusion and transfer of technologies for mitigation and adaptation globally and in developing countries by sector, technology and stage of technological maturity.

12. First the sectors and technologies for mitigation and adaptation were identified, and the technologies were classified by their stage of technological maturity. Then, current financing resources and relevant vehicles were identified by stage of technological maturity. The share of current global financing resources available to developing countries was estimated. In addition, the sources of current financing resources – businesses, national governments and international public finance bodies – were estimated.

13. Next, estimates of the projected financing needs by stage of technological maturity were compiled and disaggregated between global and developing country needs. The projected level of financing needs was compared with the current and proposed financing resources and vehicles. Finally, the coverage of technologies by the current and proposed financing sources and vehicles was assessed.

14. Task II assesses gaps in, and barriers to the access to and use of, these financing resources and vehicles. Based on material collected for task I, the specific type and level of financing resources and vehicles required were identified by sector and stage of technological maturity. Technology-specific gaps and barriers were identified, with a particular focus on the current and proposed financing vehicles of national governments and international public finance bodies. Where possible these gaps and barriers are quantified. Finally, means to address the gaps and barriers were identified.

15. Task III prepares recommendations on future financing options and risk mitigation tools to enhance the development, deployment, diffusion and transfer of mitigation technologies and technologies for adaptation. The recommendations are based on the findings of task II. Criteria were proposed and used to identify new and innovative finance sources and vehicles. The most significant gaps and barriers were used to identify priority financing needs. The focus was on the public financing of technologies for mitigation and adaptation under the Convention on a scale sufficient to leverage the requisite business and public finance outside the Convention. This resulted in concrete recommendations for consideration by Parties on options for future financing of the development, deployment, diffusion and transfer of mitigation technologies and technologies for adaptation under the Convention.

III. Technologies and their stages of maturity

A. Introduction

16. Financing resources and vehicles differ according to the stage of maturity of the technology they are intended for. Therefore, it is necessary to:

(a) Identify relevant technologies for mitigation and adaptation;

(b) Define the stage of technological maturity;

(c) Classify the technologies identified by stage of maturity.

17. Given its particular challenges, the transfer of technology to developing countries has been distinguished in this study from technology development, deployment and diffusion, and is discussed separately in the chapter.

B. Identification of technologies for mitigation and adaptation

18. A total of 147 mitigation technologies and 165 technologies for adaptation were identified, all of which are listed in annexes I and II, respectively. They were identified from numerous studies and programmes that focus on climate change mitigation and/or adaptation, including the Fourth Assessment

Report of the Intergovernmental Panel on Climate Change (IPCC), technology needs assessments (TNAs), national adaptation programmes of action (NAPAs), clean development mechanism (CDM) projects and joint implemenatation (JI) projects.[3]

19. The technologies identified were then classified into three orders of increasing specificity, by sector, type and application, as illustrated in table 1. This was done based on the literature and expert judgement.

Table 1. Sample of technology classification

Technology sector (first order)	Technology type (second order)	Technology application (third order)
Coastal zones		Light detection and ranging mapping
Energy supply	Renewable energy	Onshore wind turbine

20. Additional orders of detail, for example, components (wind turbine blades) and sub-components (coatings for wind turbine blades), could be defined but are not necessary for an overview of financing resources and vehicles.[4]

C. Stages of technological maturity

1. The innovation cycle

21. Stages of technological maturity generally mark the progress of a technology from the research laboratory to a widely available, commercially viable product. For commercial distribution a technology may be integrated into an industrial or consumer product or a production process. This report uses the term "technology" to include the products and processes that incorporate the technology.

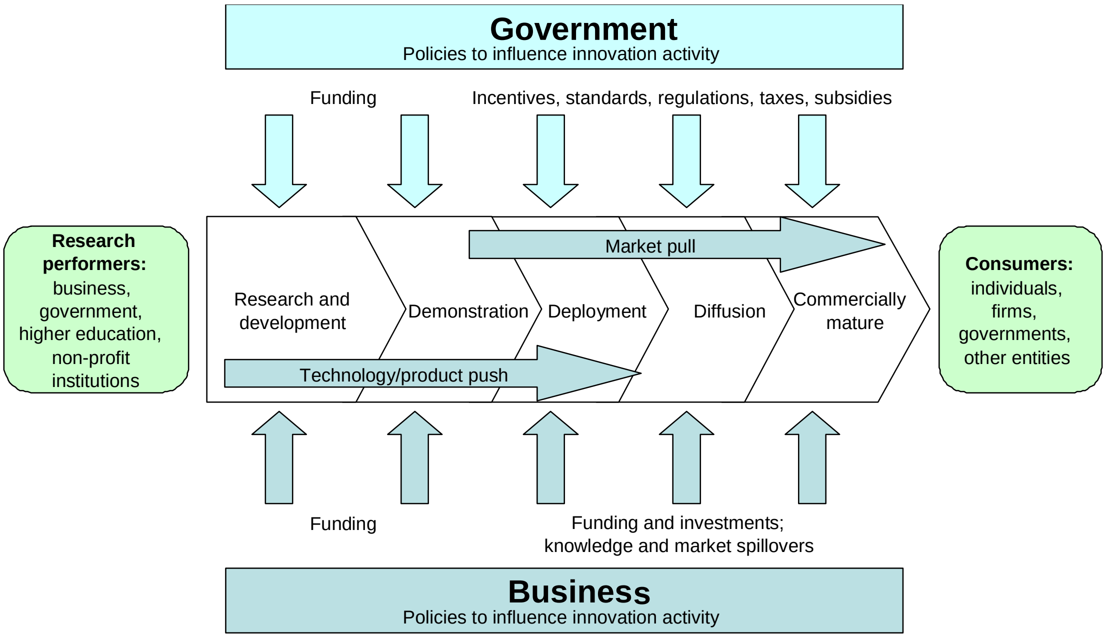
22. The innovation cycle is shown in figure 2. R&D is conducted by business, government, higher education and non-profit institutions. Funding comes mainly from business and government, but in

[3] Other sources include: (1) Asia-Pacific Partnership on Clean Development and Climate. 2008. *Action Plans by Sectors*. Available at <http://asiapacificpartnership.org/default.aspx>; (2) Council for Science and Technology Policy, Japan. 2008. *Low Carbon Technology Plan*. Available at <http://www8.cao.go.jp/cstp/english/doc/low_carbon_tec_plan/low_carbon_tech_plan.pdf>; (3) de Vries B, van Vuuren D, den Elzen M and Janssen M. 2001. *The Targets IMage Energy Regional (TIMER) Model. Technical Documentation*. Bilthoven: RIVM; (4) Enkvist P-A, Nauclér T and Rosander J. 2007. A cost curve for greenhouse gas reduction. *The McKinsey Quarterly*. February 2007; (5) European Commission. 2007. *Towards a Low Carbon Future: A European Strategic Energy Technology Plan*. Brussels: European Commission; (6) FCCC/TP/2008/7; (7) Global Environment Facility. 2003. *Operational Programs*. Available at <http://thegef.org/Operational_Policies/operational_programs/operational_programs.html>; (8) International Energy Agency. 2008. *Energy Technology Perspectives 2008*. Paris: IEA; (9) Ministry of Economy, Trade and Industry, Japan. 2008. *Cool Earth-Innovative Energy Technology Program*. Available at <http://www.iae.or.jp/research/project/Cool_Earth08_e/CoolEarth_RM.pdf>; (10) Pacala S and Socolow R. 2004. Stabilization wedges: solving the climate problem for the next 50 years with current technologies. *Science*. **305** (5686): pp.968–972; (11) UNFCCC. 2007. *Investment and Financial Flows to Address Climate Change*. Bonn: UNFCCC; (12) United States Climate Change Technology Program. 2005. "Technology areas". Available at <http://www.climatetechnology.gov/technologyareas.htm>; (13) Vattenfall. 2007. *Global Mapping of Greenhouse Gas Abatement Potential*. Available at <http://www.vattenfall.com/www/ccc/ccc/569512nextx/index.jsp>; (14) Wetzelaer BJHW, van der Linden NH, Groenenberg H and de Coninck HC. 2007. *GHG Marginal Abatement Cost Curves for the Non-Annex I Region*. Petten: Energy Research Center of the Netherlands; and (15) World Business Council on Sustainable Development. 2007. *Policy Directions to 2050: A Business Contribution to the Dialogues on Cooperative Action*. Geneva: WBCSD.

[4] The additional orders of detail would include thousands of technologies.

differing proportions throughout the process. Governments also implement policies that influence innovation activity in general[5] and affect the adoption of specific technologies. Consumers – individuals, firms, governments and other entities – determine which technologies are successful.

Figure 2. The innovation cycle



Source: Based on Metz B, Davidson O, Bosch P, Dave R and Meyer L (eds). *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge and New York: Cambridge University Press. p.157, figure 2.3.

23. Important overlaps and feedback exist between the phases of the innovation cycle, so figure 2 should not be understood to mean that the process proceeds sequentially from one stage to the next. Moreover, extensive literature suggests that the interconnections between markets, research institutions and governments, united in a "national innovation system", are essential for the success of technological development.[6] Based on its experience with new technologies in the United Kingdom of Great Britain and Northern Ireland, for example, the Carbon Trust indicates that innovation requires simultaneous progress with corporate evolution, market strategy and regulatory development because they interact with and provide feedback on each other.[7]

24. Nevertheless, a practical non-linear model of technology innovation has not emerged. Although an oversimplification, this paper characterizes technology innovation, for convenience, as proceeding linearly through the different stages.

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5 In the publication *Environmental Policy, Technological Innovation and Patents*, the Organisation for Economic Co-operation and Development notes that factors such as economic stability, functioning of capital markets, degree of "openness" and the quality of education systems are among the factors that drive innovation in general (2008. OECD: Paris. p.13).

6 Organisation for Economic Co-operation and Development. 1997. *National Innovation Systems*. Paris: OECD.

7 The Carbon Trust's low carbon technology innovation "four journeys" model is described in United Nations Department of Economic and Social Affairs. 2008. *Climate Change: Technology Development and Technology Transfer*. Background paper for the Beijing High-level Conference on Climate Change: Technology Development and Technology Transfer. New York: UNDESA. pp.75–76.

2. Stages of technological maturity for mitigation technologies

25. The stages of technological maturity adopted for the analysis of mitigation technologies – R&D, demonstration, deployment, diffusion and commercially mature – are shown in figure 3. Each stage is defined by barriers that need to be overcome to develop a commercially mature technology. These barriers help to identify the financing vehicles appropriate to each stage.

Figure 3. Stages of technological maturity and barriers to development

Barriers \ Stages	**Research and development**	**Demonstration**	**Deployment**	**Diffusion**	**Commercially mature**
Proof of concept					
Technological					
Scale					
Cost					
Economic					
Social					
Institutional					
Market failures and transaction costs					

26. **Research and development** means that while the basic science is understood, the technology is at the stage of conceptual design or testing at the laboratory or at the bench scale. The unique barriers it faces relate to the proof of concept and to technological challenges. R&D typically occurs in only a few institutions globally for a given technology.

27. **Demonstration** involves full-scale implementation of a limited number of installations by a small number of companies or research facilities. Demonstrations provide information on the capital and operating costs and performance of the technology at full scale. This information is used to improve the cost, performance or other characteristics to make the technology attractive to potential consumers.

28. A technology at the **deployment** stage is well understood and is available for selected commercial applications but is more costly than the established technology, even taking into account a price for GHG emissions or equivalent policy. The buyers must pay a premium price, owners must accept a loss on each sale or governments must provide financial or other incentives for the technology. The experience gained from additional sales usually enables the cost of the technology to be reduced.

29. At the **diffusion** stage the technology is competitive with the established technology if a price of greenhouse gases (GHG) emissions or equivalent policy is taken into account. However, the technology may still face barriers relating to the economic environment, social acceptance, cultural issues, or institutional arrangements, such as access to the grid for the sale of electricity generated or the adoption of appropriate safety standards.

30. **A commercially mature** technology is competitive with the established technology even if the price of GHG emissions is not considered, but may need to overcome market failures and specific transaction costs. The market failures faced by energy efficiency technologies are a typical example. Existing subsidies for fossil fuel and other GHG-emitting technologies are another example.

3. Categories of technologies for adaptation

31. Technologies for adaptation are classified differently from mitigation technologies in this document in order to remain consistent with the UNFCCC definitions.[8] Four categories are used:

(a) Traditional and indigenous technologies;

(b) Modern technologies;

(c) High technologies;

(d) Future technologies.

32. **Traditional/indigenous** technologies are those that have been first developed in traditional societies to respond to specific local problems. Examples include the use of herbal medicines, building irrigation canals, use of crop-specific varieties and creation of levies. These technologies could be improved in terms of their design and function through the use of modern materials and methods, and could possibly have other applications than those for which the technologies were first developed.

33. **Modern** technologies consist of approaches that have been created since the industrial revolution. These include the use of synthetic materials, modern medicines, hybrid crops, modern forms of transportation and new chemicals. These technologies are widely available but in many cases need to be tailored to the environments in which they are deployed.

34. **High** technologies are new technologies created from recent scientific advances, including information and communication technology, computer monitoring and modelling, and genetically modified organisms.

35. **Future** technologies are those that do not yet exist in a commercially viable form; examples may include medicines or monitoring and detection systems. No future technologies were identified in the course of this study.

4. The costs of technology development

36. During the demonstration, deployment and diffusion phases of a technology, the unit cost of the technology typically falls as the total number of installations rises. This is shown by the experience curve in figure 4; the unit cost declines as the number of installations increases.[9] The demonstration phase is considered to be successfully completed when the technical and scale challenges of the technologies are overcome. At the deployment and diffusion stages the cost of the climate-relevant technology is still higher than that of the incumbent technology, so policies and/or incentives are needed to increase the number of installations and so help reduce the cost of the new technology.[10]

37. The effectiveness of policies to stimulate adoption of a technology and the success of the innovation effort determine how quickly it moves from one stage to the next. With increased volume, cost reductions can come from the manufacturing process, the distribution system or support services as well as the technology itself. With additional R&D and increased application, technology for adaptation

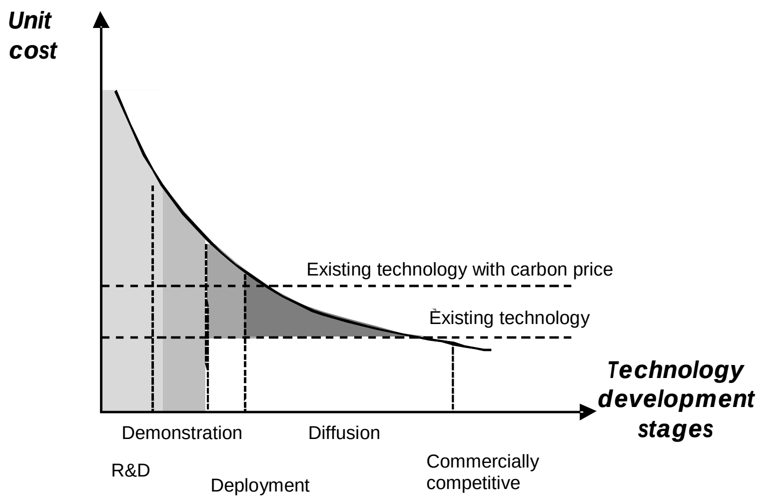
[8] FCCC/TP/2006/2, paragraphs 56–58.

[9] Papineau reviews the literature and estimates experience curves for renewable energy technologies (Papineau M. 2006. An economic perspective on experience curves and dynamic economies in renewable energy technologies, *Energy Policy*. **34**: pp.422–432).

[10] Policies can have differential effects on technological innovation. A regulation mandating the use of a technology may increase the number of installations but discourage further innovation. An emissions tax or trading scheme establishes an incentive for technological innovation, but may lead to fewer installations of a given technology.

moves from the future, to the high and modern stages and may ultimately become a traditional technology.

Figure 4. The learning curve of technology innovation



Abbreviation: R&D = research and development.

38. Discussion of financing for technology development is hampered by the lack of an agreed definition of development and transfer of technologies and a paucity of data. The definition of the financing resources needed for technology development adopted for this report is illustrated by the shaded area in figure 4. The financing resources needed for technology development are the resources needed to meet:

(a) The **full** cost of activities during the R&D and demonstration stages;

(b) Plus **the additional** cost of the new technology during the deployment and diffusion stages.

39. During the deployment and diffusion stages a new technology provides services similar to those of the conventional technology it replaces. The cost of the conventional technology reflects the value of those services, so the financing required is only the additional cost of the new technology.

40. For technologies for adaptation, the cost is defined as the full cost of future technologies plus the additional cost of high and modern technologies relative to the corresponding traditional technology.

41. The financing resources for technology development do not include costs associated with the transfer of technology to developing countries, which are discussed in chapter IV below.

42. A price for GHG emissions or, depending on the national circumstances, equivalent policy reduces the financing resources needed from business and government to the area above the line “existing technology with carbon price” in figure 4. GHG emitters subject to the emissions price or equivalent policy have an incentive to purchase the new technology rather than the existing technology. Through such purchases they provide the rest of the financing needed for technologies at the deployment stage and all of the financing needed for those at the diffusion stage. Subsidies for incumbent

technologies, such as fossil fuel subsidies, lower their cost and so increase the financing resources needed by new environmentally sound technologies.[11]

D. Classification of technologies by stage of technological maturity

43. Literature and expert judgement were used to classify each of the 312 technologies for adaptation and mitigation by its technological maturity stage or category. Some of the sources from which the list of technologies was compiled identify the stage of technology; other publications identify barriers faced by specific technologies. Where no information or conflicting information on the stage of technological maturity was available, experts at the Energy Research Centre of the Netherlands and other specialized institutes were consulted.

44. The stage or category of technological maturity assigned to each technology attempts to reflect global average conditions. Since the stages of technological maturity are defined on the basis of barriers, there can be significant regional variations in the maturity of a technology, reflecting local circumstances. For example, onshore wind power, which is classified as being at the diffusion stage, could be only at the deployment stage in a particular country owing to limited wind energy resources, institutional barriers or other factors that increase its cost in that country.

45. The classification of technologies by stage or category of technological maturity reflects the current situation, and will change over time as the technologies evolve. In some cases, technologies are advancing rapidly and their classification may be outdated. However, the classification of a specific technology is not critical to the analysis; it is the overall pattern that is of interest.

E. Technology transfer

46. The IPCC defines technology transfer as a broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change among different stakeholders such as governments, private sector entities, financial institutions, non-governmental organizations, and research or education institutions.[12] This is a comprehensive and widely used definition of technology transfer.

47. So defined, technology transfer could provide the recipient country with the capacity to:[13]

(a) Install, operate, maintain and repair imported technologies;

(b) Produce lower cost versions of imported technologies, while respecting relevant intellectual property rights;

(c) Adapt imported technologies to domestic markets and circumstances, while respecting relevant intellectual property rights;

(d) Develop new technologies.

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[11] United Nations Environment Programme. 2008. *Public Finance Instruments for Climate Mitigation: Options Document*. Paris: UNEP-SEFI.

[12] Metz B, Davidson O, Martens JW, van Rooijen S and Van Wie McGory L (eds). 2000. *Methodological and Technological Issues in Technology Transfer: A Special Report of Working Group III of the Intergovernmental Panel on Climate Change*. Cambridge and New York: Cambridge University Press. p.3.

[13] Al-Ali S. 1995. Developing countries and technology transfer. *International Journal of Technology Management*. **10**(7/8): pp.704–713.

48. Article 4, paragraph 5, of the Convention states that developed country Parties shall:

(a) Promote, facilitate and finance, as appropriate, the transfer of, or access to environmentally sound technologies and know-how;

(b) Support the development and enhancement of endogenous capacities and technologies of developing country Parties.

49. The scope for transfer of specific mitigation technologies and technologies for adaptation and support for development and enhancement of endogenous capacities varies by country.

50. Support would be needed to make a technology at the deployment or diffusion stages competitive with the incumbent technology regardless of where the sales occur, although the amount of support needed may vary by country. Such support has been included in this study's estimates of financing resources needed for technology development. To avoid double counting, the financing resources that are needed to make a technology competitive with the incumbent technology in the most cost-effective applications are excluded from the costs of technology transfer.

51. The financing resources needed for technology transfer are limited to the cost of:

(a) Enhancing participation in research, development and demonstration;

(b) Building the capacity needed to install, operate, maintain and improve the technology, while respecting relevant intellectual property rights;

(c) Creating an environment that enables the use of the technology by removing barriers to its adoption in the recipient country. These barriers range from general low levels of human capacity (because of, for example, high illiteracy rates) to the existing infrastructure and regulatory frameworks being ill suited to the new technology.

52. Some or all of the costs of technology transfer may be borne by the owners or operators of the technology in an effort to create a larger market for their technology. However, foreign firms are unlikely to invest in technology transfer in order to enter a small market.

53. An important implication of this definition of the cost of technology transfer is that any financing that supports installations of technologies for mitigation and adaptation in developing countries may also include some transfer of technologies, even if this is not an explicit objective. The participants in CDM projects, for example, report that 36 per cent of the projects, which accounts for 59 per cent of the annual emission reductions achieved under the CDM, involve technology transfer, even though this is not an explicit objective of the CDM.[14] Also, about 90 per cent of the proposed NAPA projects entail and rely on some technology transfer even though this is not explicitly mentioned in the project description.

IV. Financing resources and needs

A. Current financing resources for technology development

54. This section assembles estimates of current financing resources for the development of climate technologies. Information on financing resources for climate technologies is not systematically collected, so it must be assembled from disparate sources. The share of the global resources available to developing countries, as well as the sources of the resources – businesses, national governments and international public finance entities – are distinguished where possible.

[14] Seres S. 2008. *Analysis of Technology Transfer in CDM Projects*. Bonn: UNFCCC. p.1.

1. Global research and development spending

55. Reasonably good data are available for overall R&D spending and for government funding for energy R&D.[15] Estimates of public and private spending on R&D are available for many countries from the United Nations Educational, Scientific and Cultural Organization (UNESCO),[16] the Organisation for Economic Co-operation and Development (OECD),[17] the Ibero-American Network of Science and Technology Indicators[18] and the United States of America.[19] The countries that are covered differ and the level of detail available varies. Coverage is incomplete[20] and not fully consistent across countries, but the global data reveal patterns that probably apply to climate technologies.

56. R&D spending is an expenditure on creative work "undertaken on a systematic basis to increase the stock of knowledge – including knowledge of man, culture, and society – and the use of this stock of knowledge to devise new applications".[21] Most definitions of R&D set the cut-off at the point when a particular product or process has overcome technology and scale barriers.[22] This means that most R&D spending figures include what is defined in this report as the demonstration stage.

57. R&D activity is concentrated in a relatively small number of countries. UNESCO reports total R&D spending in over 90 countries during 2002 as almost USD 760 billion, 85 per cent of which is by OECD members. The five largest countries are the United States (36.5 per cent), Japan (14.0 per cent), Germany (7.5 per cent), China (5.2 per cent) and France (4.8 per cent).[23] The ratio of R&D spending to gross domestic product (GDP) is stable or rising in all of these countries, so R&D spending has been increasing at a faster rate than GDP.[24] In 2006, annual OECD R&D spending had grown to USD 818 billion, suggesting a global expenditure of almost USD 1,000 billion.[25]

58. Most R&D is undertaken and funded by business. Table 2 summarizes the R&D undertaken and funded worldwide by category of institution during 2002. Business conducted about 65 per cent of the R&D and funded over 55 per cent of this amount. Governments funded about 30 per cent of the R&D and spent about half this amount, with the remainder being used to support R&D activities by higher education and business. The pattern is similar in the group of OECD countries; business undertakes 69 per cent of the R&D and funds over 90 per cent of this effort.[26] Since the early 1990s, the trend in the

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[15] The International Energy Agency publishes information on government R&D funding for energy by member countries. That information is discussed in the next section.

[16] UNESCO. 2008. Statistics on Research and Development, Institute for Statistics, UNESCO, Montreal. Available at <http://stats.uis.unesco.org/unesco/ReportFolders/ReportFolders.aspx>.

[17] OECD. 2008. *Main Science and Technology Indicators*. Volume 2008/2. Paris: OECD.

[18] Ibero-American Network of Science and Technology Indicators. 2008. Comparative Indicators 4 through 11, RICYT - Network on Science and Technology Indicators, Buenos Aires. Available at <http://www.ricyt.edu.ar/interior/interior.asp?Nivel1=1&Nivel2=2&Idioma=ENG>.

[19] National Science Board. 2008. *Science and Engineering Indicators 2008*. Arlington: National Science Foundation. Available at <http://www.nsf.gov/statistics/seind08/>.

[20] National Science Board, *Science and Engineering Indicators 2008*, pp.4–10 and 4–37.

[21] OECD. 2002. *Proposed Standard Practice for Surveys on Research and Experimental Development (Frascati Manual)*. Paris: OECD. p.30.

[22] National Science Board, *Science and Engineering Indicators 2008*, p.4–15.

[23] The 27 European Union member States (EU 27) account for 26.1 per cent of the global R&D expenditure, and OECD members account for 85.4 per cent.

[24] OECD. 2008. *OECD Science, Technology and Industry Outlook 2008*. Paris: OECD. p.21, figure 1.3.

[25] OECD, *Science, Technology and Industry Outlook 2008*, p.20.

[26] OECD, *Science, Technology and Industry Outlook 2008*. p.22. OECD governments financed 7 per cent of business R&D (p.13). According to the National Science Board's *Science and Engineering Indicators 2008*, in the United States, the Government financed 9.7 per cent of business R&D in 2005 (p.4-18).

major R&D countries is an increasing share of business R&D spending as a percentage of GDP.[27] Incomplete data for 2003–2006 show overall global R&D spending increasing by an average 5 per cent per year.

Table 2. Global research and development expenditures in 2002

	Spending on R&D[a]		**Funding of R&D[b]**		**Net inflow**	**Net inflow as percentage of R&D conducted**
Source	**(USD billion)**	**(%)**	**(USD billion)**	**(%)**	**(USD billion)**	**(%)**
Business	496	65	420	55	76	15
Government	114	15	219	29	–105	–93
Higher education	129	17	20	3	109	85
Non-profit	18	3	13	2	5	26
Foreign			22[c]	3	–22	
Not known[c]	3		66			
Total	**760**	**100**	**760**	**92**		

Source: Calculated from United Nations Educational, Scientific and Cultural Organization. 2008. Statistics on Research and Development, Institute for Statistics, UNESCO, Montreal. Available at <http://stats.uis.unesco.org/unesco/ReportFolders/ReportFolders.aspx>.
Abbreviation: R&D = research and development.
[a] Amount of spending on R&D by business, government etc., irrespective of the source of funding.
[b] Amount of funding of R&D by business, government etc., irrespective of who undertakes the R&D activities.
[c] Some countries report research funding received from other countries, but none reports the funding provided to other countries. In principle, foreign funding received and provided on a global basis is zero.

59. Business R&D (R&D conducted by business is known as "business R&D") is dominated by a small number of "research-intensive" industries.[28] In the United States six industries – computer and electronic products, chemicals (including pharmaceuticals), computer-related services, aerospace and defence, R&D services and automotive manufacturing – account for 75 per cent of company-funded business R&D and 95 per cent of federally funded business R&D.[29]

60. Business R&D focuses on "development" rather than basic research.[30] In 2006, the United States spent an estimated USD 62 billion on basic research, USD 75 billion on applied research and USD 204 billion on development.[31] Industry devoted only 4 per cent of its R&D funding to basic research, but funded 83 per cent of the development of new and improved goods, services and processes (USD 169 billion).

61. Only a small fraction of business R&D is funded by governments; about 7 per cent for OECD countries and the United States.[32] In addition to this direct funding, many governments provide indirect

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[27] OECD, *Science, Technology and Industry Outlook 2008*, p.23, figure 1.5; and National Science Board, *Science and Engineering Indicators 2008*, p.4-9, figure 4-1.
[28] Industries with a high (usually over 5 per cent) ratio of R&D spending to sales.
[29] National Science Board, *Science and Engineering Indicators 2008*, p.4-18; p.4-19, table 4-4; and appendix, table 4-22.
[30] The term development here means bringing a technology or product to a state of "market readiness".
[31] National Science Board, *Science and Engineering Indicators 2008*, pp.4-14 and 4-15.
[32] The UNESCO data in table 2 suggest a net inflow of 15 per cent to the business sector. However, a substantial proportion of the USD 66 billion of "unknown" funding would come from business and most of the USD 21 billion of foreign funding is provided by affiliated firms. Thus the government share of business R&D spending could be less than 10 per cent.

funding in the form of tax credits for R&D expenditure by businesses.[33] Estimates of the value of R&D tax credits for 13 OECD countries total about USD 15 billion for 2005.[34] This compares with direct funding of almost USD 30 billion for the same countries in 2005 and about USD 40 billion for all OECD countries in 2006.[35] The value of the tax credits is equivalent to about 3 per cent of business R&D spending.

62. R&D activity is spreading internationally; R&D spending in some developing countries, especially China, is rising more rapidly than in developed countries. Based on the UNESCO data for 2002, China ranked fifth, the Republic of Korea seventh, India eleventh and Brazil twelfth in terms of total R&D spending. R&D spending is rising faster in these countries than in developed countries due to their faster economic growth and, in some cases, increasing R&D intensity.[36] At a corporate level, R&D activity is also spreading internationally, including to some developing countries.[37]

2. Estimates of research and development for climate technologies

63. Climate mitigation and adaptation do not fall neatly into specific industries or socio-economic objectives for which data are available. The International Energy Agency (IEA) reports government R&D budgets for energy research.[38] The R&D budgets of governments in IEA member countries account for over 75 per cent of the global total, and almost 85 per cent of global R&D occurs in IEA countries.[39] The IEA data on government R&D budgets provide a good indication of global funding for energy research by governments.

64. To relate energy R&D to climate mitigation, the energy R&D budget data were grouped for the purposes of this study into four categories that progressively include more technologies:

(a) Renewable energy: solar, wind, ocean, bio-energy, geothermal, hydropower and other renewables;

(b) Clean energy: renewable energy plus energy efficiency, hydrogen and fuel cells, and other energy storage technologies;

(c) Mitigation technologies: clean energy plus nuclear fission and carbon dioxide (CO_2) capture and storage (CCS);

(d) Energy R&D: mitigation technologies plus fossil fuels, nuclear fusion and other technologies and research.[40]

65. Table 3 shows the amounts budgeted by IEA members for the four categories of energy technologies in 2002, the last year for which reasonably complete data are available. The difference between renewables and clean energy is mainly due to R&D for energy efficiency. Almost all the differences between clean energy and mitigation technologies are due to R&D on nuclear fission. Less than half of government energy-related R&D spending goes to mitigation technologies. Energy R&D includes a large amount for "other technologies and research", which may be an unallocated total.[41]

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[33] OECD, *Science, Technology and Industry Outlook 2008*, pp.28–29 and p.83, figure 2.3.
[34] OECD, *Science, Technology and Industry Outlook 2008*, p.27 and p.28, figure 1.11.
[35] Only 21 of the 30 OECD member countries have tax credits for R&D.
[36] The term R&D intensity means R&D spending as a percentage of GDP.
[37] National Science Board, *Science and Engineering Indicators 2008*, p.4-51; and United Nations Conference on Trade and Development. 2005. *World Investment Report 2005: Transnational Corporations and the Internationalization of R&D*. Geneva: UNCTAD. Part Two.
[38] IEA. *Energy Technology RD&D, 2008 Edition*. Available at <http://wds.iea.org/WDS/ReportFolders/reportFolders.aspx>.
[39] Based on the UNESCO data for 2002.
[40] This category includes all energy-related R&D reported by the IEA.
[41] The source reporting most of this amount had no amounts allocated to other technologies.

Table 3. Amounts budgeted by International Energy Agency members for energy research and development in 2002, by category

Category of technologies	Amount (million 2006 USD)	Share of total energy R&D spending by IEA governments (%)	Share of total R&D spending by IEA governments (%)
Renewable energy	873	6	0.49
Clean energy	3 026	22	1.72
Mitigation technologies	6 354	46	3.60
Energy R&D	13 721	100	7.78

Source: Calculated from IEA and United Nations Educational, Scientific and Cultural Organization data.
Abbreviations: IEA = International Energy Agency, R&D = research and development.

66. Energy R&D is dominated by the same countries that account for most of the global R&D. The United States, the European Union[42] and Japan account for 90–95 per cent of total IEA R&D budgets for each category of technologies, but the ranking for each country/region changes by category. Japan (40.8 per cent), the 27 member States of the European Union (24.0 per cent), the United States (12.7 per cent),[43] China (5.8 per cent) and the Republic of Korea (4.6 per cent) generated most of the patents for climate mitigation technologies in the period 1998–2003.[44]

67. Business spending on energy R&D is not systematically collected in most countries and estimates of its scale and trend are therefore uncertain. For instance, some analysts suggest that private spending on energy R&D in the United States has been declining since the early 1980s.[45] More recent data indicate that private sector R&D spending in IEA member countries has stabilized.[46] The decline in private spending on energy R&D contrasts with rising business spending on R&D generally and may be due to declining oil prices[47] and deregulation of utilities.[48]

68. Nemet and Kammen indicate that private energy R&D spending in the United States has been less than public spending since the early 1990s and now only accounts for 24 per cent of the total.[49] However, a National Research Council committee estimated that the private sector was responsible for

[42] Only 17 of the 27 European Union member States belong to the IEA; only their budgets are included in the IEA data.
[43] Climate change research accounts for about 1.1 per cent of the United States federal R&D budget for fiscal year 2008 and most of that is allocated to climate science rather than mitigation or adaptation.
[44] Dechezleprêtre A, Glachant M, Hascic I, Johnstone N and Ménière Y. 2008. *Invention and Transfer of Climate Change Mitigation Technologies on a Global Scale: A Study Drawing on Patent Data*. Available at <http://www.cerna.ensmp.fr/index.php?option=com_content&task=view&id=192&Itemid=288>. p.17. Patent classes for climate mitigation technologies are identified by searching the descriptions of the classes to find those that are relevant and by searching patent titles and abstracts for relevant keywords to identify additional classes. A sample of patent titles for each patent class identified was reviewed and classes that do not consist only of patents related to climate change mitigation were excluded.
[45] Margolis R and Kammen D. 1999. Evidence of under-investment in energy R&D in the United States and the impact of Federal policy. *Energy Policy*. **27**: pp.575–584. p.578, figure 2; and Nemet G and Kammen D. 2007. U.S. energy research and development: declining investment, increasing need, and the feasibility of expansion. *Energy Policy*. **35**: pp.746–755. p.747, figure 1.
[46] IEA, *Energy Technology Perspectives 2008*.
[47] Rogner H-H, Zhou D, Bradley R, Crabbé P, Edenhofer O, Hare B, Kuijpers L and Yamaguchi M. 2007. Introduction. *In*: Metz B, Davidson O, Bosch P, Dave R and Meyer L (eds). *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge and New York: Cambridge University Press. p.112.
[48] Dooley J. 1998. Unintended consequences: energy R&D in a deregulated energy market. *Energy Policy*. **26**(7): pp.547–555.
[49] Nemet and Kammen, “U.S. energy research and development”.

about two-thirds of the energy R&D spending in the United States between 1978 and 1999, which is about the same as the business share of global R&D spending.[50] The IEA indicates that private energy R&D spending in its member countries is approximately USD 40–60 billion per year, which is four to six times higher than current government energy R&D expenditure.[51]

69. The technologies included in 13 patent families (wind, solar, geothermal, ocean energy, biomass, waste-to-energy, hydropower, methane destruction, climate-friendly cement, energy conservation in buildings, motor-vehicle fuel injection, energy-efficient lighting and CCS) represent nearly 50 per cent of all GHG abatement opportunities.[52] These families include all renewable energy technologies, some energy efficiency technologies and CCS, but exclude electric vehicles, energy efficiency in industry, and clean coal because the patented technologies do not relate primarily to the reduction of GHG emissions.[53]

70. R&D spending and patents are highly correlated.[54] Patents for the 13 classes of mitigation technologies account for 1 per cent of all patents issued.[55] As these technologies only cover about half of the total mitigation potential, all mitigation technologies might account for about 2 per cent of the total number of patents issued, which would suggest a 2 per cent share of all R&D spending. According to the OECD data, global R&D during 2006 was approximately USD 1,000 billion. A 2 per cent share for mitigation technologies would place the related R&D spending at USD 20 billion, approximately USD 6 billion (30 per cent) of which would be funded by government and approximately USD 13 billion (65 per cent) would be funded by business.

3. Estimates of current financing resources for development of mitigation technologies

71. No estimates have been found during the course of this study for current financing for the development of technologies for adaptation. This is mainly because efforts are diffuse, and many of the technologies are not developed solely for adaptation or within the framework of climate adaptation financing.

72. Table 4 shows estimates of the current financing resources for mitigation technologies by stage of technological maturity. This information is not systematically collected, so the table lists a number of estimates, based on disparate sources and using different methods and assumptions. Estimates for government and business financing are shown separately where available, as are the estimates of the financing available globally and for developing countries. The estimates should be treated as providing an order of magnitude of current financing resources for development of climate technologies.

73. The biggest gap in the estimates is in private financing for deployment of technologies. The private financing for diffusion of technologies is probably underestimated because internal funding by large firms is not included in the estimates. The data for developing countries are also incomplete, especially for deployment and diffusion. The total given is USD 70–165 billion, but the real figure could be higher or lower.

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[50] National Research Council. 2001. *Energy Research at DOE: Was It Worth It? Energy Efficiency and Fossil Energy Research 1978 to 2000*. Committee on Benefits of DOE R&D on Energy Efficiency and Fossil Energy. Washington, D.C.: National Research Council. p.1.

[51] IEA, *Energy Technology Perspectives 2008*. This implies that business accounted for 80 to 85 per cent of total R&D spending.

[52] Dechezleprêtre et al., *Invention and Transfer of Climate Change Mitigation Technologies on a Global Scale,* p.5.

[53] Dechezleprêtre et al., *Invention and Transfer of Climate Change Mitigation Technologies on a Global Scale,* p.9.

[54] In its *Science, Technology and Industry Outlook 2008* (p.42), the OECD reports a correlation of 0.98. Renewable energy patents account for approximately 0.5 per cent of all patents issued under the Patent Cooperation Treaty for 2001–2005: almost precisely the share of IEA member research budgets devoted to renewables. Margolis and Kammen show that energy patents and energy R&D in the US were closely related from 1975 through 1995 (“Evidence of under-investment in energy R&D in the United States and the impact of Federal policy”, p.578, figure 2).

[55] Dechezleprêtre et al., *Invention and Transfer of Climate Change Mitigation Technologies on a Global Scale,* p.9.

74. Despite gaps in the estimates for business financing, all of the available evidence suggests that this source dominates the total.[56] The estimates also suggest that the additional financing for deployment and diffusion exceeds the total spending on research, development and demonstration. The financing needed probably increases at each stage of technological maturity. Information on the financing resources for developing countries is sparse, but the available estimates suggest that resources represent a small share – perhaps 10 to 20 per cent – of the global total.[57]

Table 4. Estimates of current financing for development and diffusion of climate mitigation technologies, by stage of technological maturity and source
(billions of United States dollars per year)

	R&D (total spending)	Demonstration (total spending)	Deployment (additional cost of climate technologies)		Diffusion (additional cost of climate technologies)		Total
	Global	Global	Global	Developing countries	Global	Developing countries	Global
Public	6[a] 10[b]	Included with R&D	33[c] 45[d] 30[e]	NA	19.5–27.0[f]	8.0–15.5[g]	55.5–82.0
Private	At least 9.8[h] 13[a] 40–60[i]	Included with R&D	NA	NA	12–22[h]	3.3[h]	21.8–82.0
Total	15.8–70		30–45	NA	31.5–49	11.3–18.8	77.3–164.0[j]

Abbreviations: NA = not available, R&D = research and development.
[a] Based on 2 per cent share of global R&D of USD 1,000 billion in 2006.
[b] International Energy Agency. 2008. *RD&D Budgets*. Available at <http://wds.iea.org/WDS/ReportFolders/reportFolders.aspx>.
[c] Stern N. 2007. *The Economics of Climate Change: The Stern Review*. Cambridge: Cambridge University Press. p.347.
[d] Doornbosch R, Gielen D and Koutstaal P. 2008. *Mobilising Investments in Low-emission Energy Technologies on the Scale Needed to Reduce the Risks of Climate Change*. SG.SD/RT(2008)1. Paris: OECD. p.5.
[e] UNFCCC. 2007. *Investment and Financial Flows to Address Climate Change*. Bonn: UNFCCC. p.7.
[f] This estimate is the sum of financing for mitigation technologies provided by the clean development mechanism (CDM), joint implementation, bilateral official development assistance (ODA), multilateral development banks (MDBs), export credit agencies (ECAs) and by the Global Environment Facility (GEF), plus the New Energy Finance estimate of investment in carbon funds for the purchase of emissions permits in compliance and voluntary markets in 2007. It is assumed that most GEF, bilateral ODA, MDB and ECA financing is additional; however, this is not always the case.
[g] Signifies all items included in the global amount except the investment in carbon funds for the purchase of emissions permits.
[h] United Nations Environment Programme. 2008. *Public Finance Instruments for Climate Mitigation: Options Document*. Paris: UNEP-SEFI. Based on New Energy Finance data. Estimates of the additional portion of the private investment for energy efficiency and low carbon investments in the energy sector. The additional investment is the premium in excess of the investment required for conventional technologies that provide comparable services. Based on data for the GEF and the CDM the additional portion of the investment is 15 per cent of the total investment. Clearly the additional investment will vary considerably depending on the technology, the specific application and local circumstances. Total private investment in energy efficiency and low carbon investments in the energy sector is at least 6.7 times higher.
[i] International Energy Agency. 2008. *Energy Technology Perspectives 2008*. Paris: IEA. p.169. This figure includes some unspecified investments at the demonstration stage.
[j] The discrepancy with figures provided in table 5 of this document is due to data uncertainties and rounding errors.

75. Estimates of the sources of current financing for climate mitigation technologies are provided in table 5. Documentation of the estimates is presented in annex III to this document. The estimates can only be allocated roughly to the stages of technological maturity. The sources are classified as being

[56] National Research Council, *Was It Worth It?*; Nemet and Kammen, “U.S. energy research and development”; IEA, *Energy Technology Perspectives 2008*; and UNESCO, Statistics on Research and Development.
[57] IEA members account for about 85 per cent of global R&D.

under the Convention or outside the Convention. The dominant source of financing under the Convention is the sale of certified emission reductions (CERs). Convention sources account for USD 5–10 billion, or about 7 per cent of the total. However, this amount is probably an overestimation owing to gaps in estimates for the private financing for deployment and diffusion.

Table 5. Estimates of current sources of financing for development and diffusion of climate technologies, by source

(billions of United States dollars per year)

Stage of technological maturity	Source of financing	Estimated annual investment[a]
GLOBAL		
Sources outside the Convention		
Research and development and demonstration	Government funding	6 to 10
	Private funding	13 to 60
DEVELOPING COUNTRIES		
Sources under the Convention		
Deployment and diffusion	The GEF	0.19
	The CDM	4 to 8
Sources outside the Convention		
Diffusion and commercial	Export credit agencies	<1
Deployment and diffusion and commercial	Bilateral ODA Multilateral ODA	2 1 to 3
Deployment and diffusion	Philanthropic private sources	1
Deployment, diffusion and commercially mature	Private investment including FDI of USD 1 billion	1.5 to 4
DEVELOPED COUNTRIES		
Sources under the Convention		
Deployment and diffusion	Joint implementation	<0.5
Sources outside the Convention		
Deployment and diffusion	FDI Domestic private investment	1.5 to 2.2 9 to 16.5
Deployment and diffusion	Government funding	30 to 45
	Total	**69 to 153**

Abbreviations: CDM = clean development mechanism, FDI = foreign direct investment, GEF = Global Environment Facility, ODA = official development assistance.
Note: Estimates are discussed in annex III to this document.
[a] The discrepancy with figures provided in table 4 of this document is due to data uncertainties and rounding errors.

76. In summary, although estimates of private financing for the deployment and diffusion of mitigation technologies are very uncertain, the following trends can be observed: most of the funds for technology development come from private sources; the financing that is needed probably increases at each stage of technological maturity; the financing provided for developing countries is perhaps 10 to 20 per cent of the global total; and less than 5 per cent of the resources are under the Convention.

4. Estimates of current financing resources for technologies for adaptation

77. Information on current R&D spending for technologies for adaptation is unavailable. However, given that all of the technologies for adaptation that have been identified are deployable and transferable, and that the use of technologies for adaptation is highly site-dependent, the principal focus of R&D in this domain is to tailor the specific technology to the conditions and location in which it will be deployed. Thus the R&D for the implementation of a technology for adaptation will be included in the project implementation cost. Nevertheless, as projects are implemented, additional costs may be required for the demonstration of technologies in surrounding sites and communities.

78. Information on the financing available for implementation of adaptation projects in developing countries is summarized in table 6. The known financing for adaptation projects in developing countries is about USD 1 billion per year. The resources devoted to R&D for implementation of technologies for adaptation are likely to be a small share of the project implementation costs.

Table 6. Existing multilateral and bilateral adaptation instruments and funds
(billions of United States dollars per year)

Fund	Creation/closing date	Origin	Average funding per year[a]
Under the Convention			
LDCF	2001	UNFCCC	0.0244
Strategic Priority on Adaptation	2004	UNFCCC	0.0147
SCCF	2004	UNFCCC	0.0294
Adaptation Fund	2008–2012	Kyoto Protocol	0.08–0.3
Outside the Convention			
MDG Achievement Fund	2008–2011	Spain, UNDP	0.528
Supporting Integrated and Comprehensive Approaches to Climate Change Adaptation in Africa	2008–2010	Japan	0.031
Australian International Adaptation Fund	2008–2011	Australia	0.032
Climate Change Initiative	2007	Rockefeller Foundation	0.014[b]
Global Climate Change Alliance	2008–2010	European Commission	0.028[b]
German International Climate Initiative	2008–2012	Germany	0.05[b]
Pilot Program for Climate Resilience	2009–2012	World Bank	0.06[b]
Total			**0.89–1.1**

Sources: Van Drunen M et al. 2009. *Financing Adaptation in Developing Countries: Assessing New Mechanisms*. IVM report; Le Goulven K. 2008. *Financing Mechanisms for Adaptation*. Stockholm: Secretariat to the Commission on Climate Change and Development. p.19; Müller B. 2008. *International Adaptation Finance: The Need for an Innovative and Strategic Approach*. Available at <http://www.oxfordenergy.org/pdfs/EV42.pdf>; and United Nations Development Programme. 2007. *Human Development Report 2007/2008. Fighting Climate Change: Human Solidarity in a Divided World*. Available at <http://hdr.undp.org/en/reports/global/hdr2007-2008/>.
Abbreviations: LDCF = Least Developed Countries Fund, MDG = Millennium Development Goal, SCCF = Special Climate Change Fund, UNDP = United Nations Development Programme.
[a] Where possible, a 2007 actual figure is provided, otherwise the figure is the annual average over the life of the programme.
[b] Estimate only.

79. In 2007, USD 14.7 million was allocated from the Strategic Priority on Adaptation and USD 28.6 million from other Global Environment Facility (GEF) programmes to adaptation projects; these projects will leverage a total of USD 244.5 million in co-financing. In addition, USD 24.4 million was allocated from the Least Developed Country Fund for adaptation projects, which will result in

USD 65.2 million in co-financing. The Special Climate Change Fund allocated USD 29.4 million to adaptation, with co-financing of USD 139.1 million.

80. The Adaptation Fund under the Kyoto Protocol has recently become operational and is expected to deliver between USD 80 and 300 million per year, depending upon the demand for, and price of, CERs and therefore the share of proceeds flowing into the fund.[58] The Adaptation Fund could become the largest source of financing for adaptation projects.

B. Estimates of financing resources needed for technology development

1. Benefits of increased research and development

81. Technology innovation is "a (if not the) critical factor determining the long-term costs and benefits of mitigation".[59] Estimates of the cost saving due to technology innovation for a given emissions target vary widely. The technological change assumptions reflected in the baseline scenario have a major impact on future emissions and hence on the scale and cost of the reductions needed to achieve the emissions target. They also influence the technological change assumptions for the mitigation scenario. Several studies estimate the economic benefits of improved technology at trillions of dollars over the twenty-first century due to energy savings and reduced mitigation costs.[60]

82. Models incorporate technological change in different ways.[61] Some models simply make assumptions about the rate of technology improvement and the availability and cost of new technologies such as CCS; some models relate unit cost reductions to (cumulative) use of the technology, experience curves or learning by doing, while others relate technology innovation to cumulative R&D spending. Incorporating technological change into the model through R&D spending or through learning by doing lowers the cost of achieving a target, sometimes substantially, but the cost savings depend on various assumptions relating to the innovation cycle.

83. Mitigation policies induce technological innovation, but they tend to be short-term, incremental improvements.[62] Technology policies can also stimulate innovation, but they are less effective at reducing emissions than mitigation policies.[63] A combination of mitigation and technology policies is more effective than either policy in isolation. International diffusion of technology has a significant impact on the scale of the economic benefits of technological change.[64]

84. R&D for technologies for adaptation largely consists of improving the design of particular technologies or adjusting existing technologies to local circumstances. The importance and primary benefit of R&D prior to implementation is to avoid maladaptation. If the technology is not successfully

[58] FCCC/TP/2008/7, p.37, table 11.

[59] Barker T, Bashmakov I, Alharthi A, Amann M, Cifuentes L, Drexhage J, Duan M, Edenhofer O, Flannery B, Grubb M, Hoogwijk M, Ibitoye F, Jepma C, Pizer W and Yamaji K. 2007. Mitigation from a cross-sectoral perspective. *In*: Metz et al. (eds), *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, p.653.

[60] Halsnaes K, Shukla P, Ahuja D, Akumu G, Beale R, Edmonds J, Gollier C, Grübler A, Ha Dong M, Markandya A, McFarland M, Nikitina E, Sugiyama T, Villavicencio A and Zou J. 2007. Framing issues. *In*: Metz et al. (eds), *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, pp.150–151; and Clarke L, Calvin K, Edmonds JA, Kyle P and Wise M. 2008. *Technology and International Climate Policy*. Discussion paper 08-21. Cambridge, MA: Harvard Project on International Climate Agreements, Belfer Center for Science and International Affairs, Harvard Kennedy School.

[61] Barker et al., "Mitigation from a cross-sectoral perspective", pp.651–652.

[62] Blanford G. 2008. R&D investment strategy for climate change. *Energy Economics* (in press).

[63] Barker et al., "Mitigation from a cross-sectoral perspective", p.658.

[64] Clarke et al., *Technology and International Climate Policy*, figure 5.1.

calibrated to local conditions, the cost of the technology can easily outweigh the benefits and could increase the risks that it was designed to mitigate.

2. Estimates of additional financing needed for mitigation technologies by stage of technological maturity

85. Various models estimate future additional finance needs in different ways. Most models provide projections based on abatement costs, in which case the total additional costs equal the incremental costs of the required mitigation potential compared to the baseline. Other models also provide information on the investment needed; such models estimate the additional capital that will need to be invested and provided by the financial sector, private equity or public finance.

86. Following the methodology in this paper, the additional costs for the R&D and demonstration stages of technological maturity are the same, and are not significantly affected by additional carbon costs or additional capital costs. For the deployment and diffusion stages, however, the figures can diverge.

87. Available estimates of the additional costs that need to be incurred for mitigation technologies by stage of technological maturity are presented in table 7. All of the estimates relate to mitigation technologies; none covers technologies for adaptation. The spectrum of the mitigation technologies covered varies by source, which partly explains why the estimates differ widely. Some of the estimates are sensitive to the baseline and mitigation scenarios used. Virtually none of the sources splits the estimates between private and public financing, so only totals are shown.

88. Several sources recommend increased public and private R&D for energy or mitigation technologies, as shown in table 7. Estimates of the additional financing needed for the projected deployment and diffusion of mitigation technologies can be derived from models and marginal abatement cost curves. Those sources provide estimates of both the global and developing country financing needs. To distinguish the deployment and diffusion stages, a carbon price of USD 20/t CO_2 eq is used (see figure 4). For technologies with a negative marginal abatement cost, the cost of overcoming non-price barriers is assumed to be USD 2/t CO_2 eq.

89. These estimates are sensitive to the assumptions about the performance of the available technologies that are inherent in the model or marginal abatement cost curve, the baseline scenario and the mitigation scenario. The IEA *World Energy Outlook 2008* modelling, for example, assumes that a global emissions trading scheme is introduced by 2020 and that the largest emitting developing countries participate in this scheme. The IEA also projects that a large share of the abatement is achieved through energy efficiency, which has a negative cost. These assumptions have important consequences for the estimated costs for deployment and diffusion of mitigation technologies. The abatement costs would increase if:

(a) A global emissions trading scheme is not introduced, as more reductions would need to be achieved using less cost-effective policies;

(b) The energy efficiency gains are not achieved and more expensive abatement options need to be implemented;

(c) The mitigation policies fail;

(d) The costs of key technologies are not reduced as projected by the learning curve model.

90. Table 7 shows large ranges in the estimates of financing needs; these estimates cannot be compared directly as they are based on different assumptions and coverage, and are inherently uncertain. They should be treated as an indication of the amount of annual financing required to cover the

incremental costs of mitigation technology. Sources of uncertainty include projections for economic growth, use of technology, learning and technology unit costs, social developments and co-benefits.

Table 7. Estimates of overall additional costs for development, deployment and diffusion of mitigation technologies
(billions of United States dollars per year)

	R&D (total spending)	Demonstration (total spending)	Deployment (additional cost of climate technologies)		Diffusion (additional cost of climate technologies)		Total
	Global	**Global**	**Global**	**Developing countries**	**Global**	**Developing countries**	**Global**
Current total	15.8–70	NA	30–45	NA	31.5–49	11.3–18.8	77.3–164
Additional financing needed	50[a] 20–100[b] 10[c]	27–36[d]	57–94[e] 25–35[f]	10–38.5[g]	250–440[h] 200–210[i]	150–264[h] 82–180[g]	262–670

Abbreviations: NA = not available, R&D = research and development.
Note: The “Current Total” row is taken from table 4 of this document.
[a] Stern N. 2007. *The Economics of Climate Change: The Stern Review*. Cambridge: Cambridge University Press. p.371. Public finance only.
[b] Doornbosch R, Gielen D and Koutstaal P. 2008. *Mobilising Investments in Low-emission Energy Technologies on the Scale Needed to Reduce the Risks of Climate Change*. SG.SD/RT(2008)1. Paris: OECD. p.5.
[c] UNFCCC. 2007. *Investment and Financial Flows to Address Climate Change*. Bonn: UNFCCC. p.7. Public finance only.
[d] Calculated from demonstration costs estimated in: International Energy Agency. 2008. *Energy Technology Perspectives 2008*. Paris: IEA. Chapter 3.
[e] UNFCCC, *Investment and Financial Flows to Address Climate Change*, p.90.
[f] UNFCCC, *Investment and Financial Flows to Address Climate Change*, p.6.
[g] The level of investment required in developing countries is calculated using the same investment share as estimated by the secretariat, which is 40.9 per cent in developing countries and 59.1 per cent in developed countries (UNFCCC, *Investment and Financial Flows to Address Climate Change*, p.214, annex V, table 4).
[h] McKinsey. 2009. *Pathways to a Low-carbon Economy: Version 2 of the Global Greenhouse Gas Abatement Cost Curve*. Available at <http://www.mckinsey.com/clientservice/ccsi/pathways_low_carbon_economy.asp>. p.8 and p.17.
[i] UNFCCC, *Investment and Financial Flows to Address Climate Change*, p.92.

91. Estimates of the additional costs for technology development do not take into account the benefits that result from these measures, such as the growth in markets, energy security, job creation, health benefits of reduced pollution and lower costs of adaptation to climate change.

92. In terms of additional capital costs, the IEA in its *Energy Technology Perspectives* reports investment needs in the diffusion phase of up to USD 1,100 billion annually, as an average over the years 2010–2050. For diffusion in developing countries, USD 660 per year would be required based on an investment share of 60 per cent for developing countries and 40 per cent for developed countries, as estimated by the IEA.[65] Furthermore, the IEA estimates that USD 100–200 billion per year is required globally in early deployment costs, 60 per cent of which would be required in developing countries.

[65] IEA, *Energy Technology Perspectives 2008*, p.240.

93. More recently, McKinsey estimated that global capital investment costs of EUR 530 billion per year until 2020 and EUR 810 billion per year for 2020–2030 will be required in order to halve global emissions.[66]

94. In summary, the additional financing needs for climate change mitigation technologies span a range of USD 262–670 billion per year. This suggests future financing three to four times greater than the current level. Of this increase, 40–60 per cent, or an additional USD 105–402 billion per year, is projected to be needed in developing countries. This reflects the scale of the emissions reduction potential that is estimated to be available in developing countries.

95. Many analysts have concluded that the current scale of energy R&D is inadequate for the climate challenge and propose more or less arbitrary increases to level of effort. In the United States, both the President's Committee of Advisors on Science and Technology[67] and the National Commission on Energy Policy[68] recommended doubling current government energy R&D funding. Schock et al. recommend a fourfold increase in the American energy R&D budget.[69] Nemet and Kammen claim that a five- to tenfold increase in American energy R&D spending is both warranted and feasible.[70] More broadly, Stern recommends doubling all government energy R&D budgets,[71] while the European Commission proposes that governments commit to doubling global energy research, development and demonstration spending by 2012 and increasing it to four times the current level by 2020, with a significant shift toward renewables as part of a post-2012 agreement.[72]

96. While these estimates apply only to R&D rather than all stages of technological maturity, and are more or less arbitrary, it is interesting that many of them are of similar magnitude to the three- to fourfold increase implied by the estimates in table 7.

3. Estimates of additional financing resources needed for adaptation

97. In 2008, the secretariat produced an update of its assessment of the financing resources needed for adaptation, and suggested amounts of the order of tens of billions, possibly hundreds of billions, of USD per year.[73] The World Bank estimated that adaptation will cost USD 10–40 billion in 2030,[74] and

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[66] McKinsey. 2009. *Pathways to a Low-carbon Economy: Version 2 of the Global Greenhouse Gas Abatement Cost Curve*. Available at <http://www.mckinsey.com/clientservice/ccsi/pathways_low_carbon_economy.asp>. p.8 and p.17.

[67] President's Committee of Advisors on Science and Technology. 1997. *Federal Energy Research and Development for Challenges of the Twenty-First Century*. Washington, D.C.: Office of Science and Technology Policy.

[68] National Commission on Energy Policy. 2004. *Ending the Energy Stalemate: A Bipartisan Strategy to Meet America's Energy Challenges*. Washington, D.C.: National Commission on Energy Policy. Available at <http://www.energycommission.org/ht/a/GetDocumentAction/i/1088>.

[69] Schock R, Fulkerson W, Brown ML, San Martin RL, Greene DL and Edmonds J. 1999. How much is energy research & development worth as insurance? *Annual Review of Energy and Environment*. **24**: pp.487–512.

[70] Nemet and Kammen, "U.S. energy research and development".

[71] Stern N. 2007. *The Economics of Climate Change: The Stern Review*. Cambridge: Cambridge University Press.

[72] European Commission. 2009. *Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions: Towards a Comprehensive Climate Change Agreement in Copenhagen*. Brussels: European Commission. p.9, section 3.3.

[73] FCCC/TP/2008/7, p.4; and Flåm K and Skjærseth J. 2009. Does adequate financing exist for adaptation in developing countries? *Climate Policy*. **9**(1): pp.109–114.

[74] World Bank. 2006. *Clean Energy and Development: Towards an Investment Framework*. Available at <http://siteresources.worldbank.org/DEVCOMMINT/Documentation/20890696/DC2006-0002(E)-CleanEnergy.pdf>.

Oxfam International estimated it will be more than USD 50 billion annually.[75] The United Nations Development Programme (UNDP) projected annual adaptation investment needs at USD 86 billion by 2015.[76] Christian Aid estimates adaptation costs at USD 100 billion per year in developing countries.[77] The UNFCCC estimates the additional investment and financial flows in 2030 at USD 49–171 billion globally, USD 28–67 billion of which is for developing countries.[78] More detailed sectoral estimates for developed and developing countries, based on the UNFCCC estimates, are shown in table 8. They amount to USD 33–163 billion per year in 2030.

Table 8. Global additional investment and financial flows needed for adaptation to the adverse effects of climate change
(billions of United States dollars in 2030)

Sector	Type of action	Developing countries	Developed countries	Total
Agriculture	Research	1.2	1.8	3.0
	Extension	0.05	0	0.05
	Capital formation	5.2	4.5	9.8
	Total	6.5	6.3	**12.9**
Health	Treatment of diarrhoeal diseases	2.1–7.3	-	-
	Treatment of malnutrition	0.08–0.16	-	-
	Treatment of malaria	2.6–5.4	-	-
	Total	4.8–12.8	-	**4.8–12.8**
Water supply	Additional reservoir storage; additional wells; reclaimed wastewater; desalinization; improved irrigation; unmet irrigation	-	-	**0.18–0.22**
Coastal areas	Beach nourishment	0.77	0.93	1.7
	Sea dikes	2.6	2.8	5.4
	Total	3.4	3.7	**7.1**
Infrastructure	Additional investments	2.3–39.7	5.3–90.4	**7.6–130.1**
Ecosystems	*No estimate for climate change possible*			
Total (excluding ecosystems)				**32.6–163.1**

Sources: Ebi KL. 2007. *Health Impacts of Climate Change.* Report to the UNFCCC Secretariat, Bonn, Germany; Kirshen P. 2007. *Adaptation Options and Cost in Water Supply*. Report to the UNFCCC Secretariat, Bonn, Germany; McCarl BA. 2007. *Adaptation Options for Agriculture, Forestry and Fisheries*. Report to the UNFCCC Secretariat, Bonn, Germany; Nicholls RJ. 2007. *Adaptation Options For Coastal Areas and Infrastructure: An Analysis For 2030*. Report to the UNFCCC Secretariat, Bonn, Germany; and UNFCCC. 2007. *Investment and Financial Flows to Address Climate Change*. Bonn: UNFCCC.

98. The estimates from these top-down studies are highly uncertain, owing to assumptions about the extent of future climate change, its current and future impacts, the dynamics of those impacts and vulnerability to them. The estimates are also incomplete and probably underestimate the actual needs, as they exclude costs for sectors such as ecosystem services and certain elements of costs in the health sector, and also exclude some unpriced and intangible costs and benefits.

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[75] Raworth K. 2007. *Adapting to Climate Change: What's Needed in Poor Countries and Who Should Pay*. Oxford: Oxfam International.
[76] UNDP. 2007. *Human Development Report 2007/2008. Fighting Climate Change: Human Solidarity in a Divided World*. Available at <http://hdr.undp.org/en/reports/global/hdr2007-2008/>. Chapter 4.
[77] Flåm and Skjærseth, "Does adequate financing exist for adaptation in developing countries?", table 1.
[78] UNFCCC, *Investment and Financial Flows to Address Climate Change*, p.177, table IX-65.

99. Efforts are being made to gain better insights into the financing needs for adaptation. A study financed by the Governments of the United Kingdom and the Netherlands, which is being carried out by the World Bank, is expected to arrive at a better estimate of adaptation costs. It will undertake bottom-up sectoral research in six countries and scale up the estimated needs in all developing countries using top-down approaches.

100. NAPAs have so far been completed by 38 least developed countries (LDCs). The NAPAs provide project-level information on adaptation costs, identified through bottom-up assessment. In total, the 38 LDCs have identified about 430 "urgent and immediate" adaptation projects, of which 385 have been costed.[79] The total cost of these projects is over USD 800 million, with an average project cost of approximately USD 2 million.[80] However, this represents only a small proportion of the total adaptation needed, as it is restricted to "urgent and immediate" adaptation projects in a limited number of developing countries.

101. The figures in table 8, and the others cited in this chapter, are estimates of future spending on adaptation measures, not of the cost of developing technologies for adaptation. The annual spending for technology R&D is likely to be a small fraction of these amounts.

4. National research and development targets

102. Most countries with large R&D budgets, with the exception of the United States, have set targets for higher R&D spending, as shown in table 9. Where priorities have been identified, they include climate change mitigation technologies and technologies for adaptation – renewable energies for the European Union, climate change mitigation technologies for Japan, and energy and environmental technologies for China and the Republic of Korea.[81] Although the United States does not have a target, a five- to tenfold increase in its energy R&D spending is claimed to be both warranted and feasible.[82]

Table 9. Targets for research and development spending

	2002 R&D spending (USD billion)	Recent R&D spending (% of GDP)	Target R&D spending (% of GDP)	Target date
United States of America	277	2.62	-	-
European Union (27)	198	1.76[a]	3.0[a]	2010
Japan	107	3.39[b]	1.0[b]	2010
China	39	1.42	2.0	2010
Republic of Korea	21	3.23	5.0	2012

Sources: Figures for 2002 R&D spending from United Nations Educational, Scientific and Cultural Organization; all other information from: Organisation for Economic Co-operation and Development. 2008. *OECD Science, Technology and Industry Outlook 2008.* Paris: OECD. p.22, figure 1.4; and p.72, table 2.2.
Abbreviations: GDP = gross domestic product, R&D = research and development.
[a] Includes 2.0 per cent from the private sector; compared with 1.11 per cent of GDP in 2006.
[b] Public sector spending; compared with 0.55 per cent of GDP in 2006.

103. The target increases are large relative to current R&D spending on climate technologies. Total R&D spending was 2.26 per cent of GDP in 2006 for OECD countries as a whole.[83] R&D spending on mitigation technologies is probably less than 3.6 per cent of total R&D spending in OECD countries,[84] or

[79] FCCC/TP/2008/7, p.25.
[80] Both the total and the average exclude a single large project with an estimated budget of USD 700 million.
[81] OECD, *Science, Technology and Industry Outlook 2008*, pp.70, 71, 76, 79 and 132.
[82] Nemet and Kammen, "U.S. energy research and development".
[83] OECD, *Science, Technology and Industry Outlook 2008*, p.21, figure 1.3.
[84] See table 3.

0.08 per cent of GDP.[85] The targets set for increasing R&D (see table 9) are far larger: 1.77 per cent of GDP for the Republic of Korea, 1.24 per cent for the European Union, 0.58 per cent for China and 0.45 per cent of GDP for public funding of R&D in Japan.

104. Thus, R&D spending for climate change technologies could be increased several times, in accordance with existing R&D targets and priorities, while leaving ample funding for other priorities. This applies only to the R&D and demonstration stages of a technology; additional financing for the deployment and diffusion stages could come from mitigation policies, other policies, such as renewable energy or energy efficiency targets, or government budgets.

C. Financing resources for technology transfer

105. As discussed in chapter IV C above, the financing resources needed for technology transfer are limited to the cost of:

(a) Enhancing participation in research, development and demonstration;

(b) Building the capacity needed to install, operate, maintain and improve the technology;

(c) Creating an environment that enables the use of the technology by removing barriers to its adoption in the recipient country.

106. This avoids double counting the support needed by technologies at the deployment and diffusion stages, which is part of the financing for technology development.

1. Conditions for technology transfer

107. Technology transfer is mainly a commercial activity. Most foreign technology is purchased by firms or households, and most of the technology transferred is supplied by foreign firms. Thus technology transfer requires an enabling policy environment, including stable macroeconomic conditions, a competitive tax regime,[86] low tariffs on the imported technology and regulations suited to the new technology. In addition, technology transfer requires the human and institutional capacities to select and adopt the new technology and the associated knowledge.

108. A market for the new technology in the recipient country is essential for technology transfer. The limited market for mitigation technologies and technologies for adaptation in developing countries is a major barrier to the transfer of those technologies. A market is created by domestic policies or international incentives. Developing countries do not have international emission reduction commitments, although some do have domestic policies, such as energy efficiency or renewable energy targets, which create a demand for some mitigation technologies. International financial support through the CDM, the GEF, official development assistance (ODA) and other mechanisms also creates a demand for mitigation technologies.

109. The need to adapt to the impacts of climate change will create a market for some technologies for adaptation. But technologies for anticipatory adaptation, which is usually more cost-effective, need domestic policies or international financial incentives in order to create a market for them. The

[85] 3.6 per cent of 2.26 per cent.

[86] United Nations Conference on Trade and Development. 2005. *Taxation and Technology Transfer: Key Issues*. Geneva: UNCTAD; Worrell E, van Berkel R, Zhou F, Menke C, Schaeffer R and Williams R. 2001. Technology transfer of energy efficient technologies in industry: a review of trends and policy issues. *Energy Policy*. **29**: pp.29–43; and Saggi K. 2000. *Trade, Foreign Direct Investment and Technology Transfer: A Survey*. Policy Research Working Paper 2349. Washington, D.C.: World Bank.

Adaptation Fund will create a demand for the technologies used in the projects that it funds. How projects and programmes funded by the Adaptation Fund are implemented could affect the development of the technologies used and the associated technology transfer. Purchasing large quantities of a technology for use in several countries, for example, could reduce costs. Implementing a small number of technologies on a larger scale in a country may lead to more technology transfer than implementing many technologies on a limited scale.

2. Current financing resources for technology transfer

110. Several types of international financial flows support technology transfer, including ODA, foreign direct investment (FDI), foreign portfolio equity investment and venture capital, commercial loans, commercial sales, philanthropic sources and export credit agencies (ECAs).[87] None of these financial flows provides a direct measure of technology transfer. Most of these financial flows support private-sector technology transfer.

111. These financial flows usually support technology transfer only when directly financing the technology. The estimated financing resources provided for deployment and diffusion of mitigation technologies by ODA, ECAs, FDI and philanthropic sources are discussed in annex III and presented in table 5 above.

112. A mechanism for funding technology transfer under the Convention has not yet been implemented; however, at the fourteenth session of the COP in Poznan, the GEF announced a USD 50 million strategic programme to scale up funding for technology transfer.[88] By its decision 2/CP.14, the COP requested that the GEF promptly initiate and expeditiously facilitate the preparation of projects for approval and implementation under the strategic programme, collaborate with its implementing agencies in order to provide technical support to developing countries in preparing or updating their technology needs assessments, and consider the long-term implementation of the strategic programme.

113. The financing support for deployment and diffusion of mitigation technologies in developing countries is less than USD 1 billion for ECAs, USD 1 to 2 billion each for bilateral ODA and philanthropic sources, USD 1 to 3 billion for multilateral ODA, and almost USD 7 billion for FDI, giving a total of USD 12 to 15 billion per year. No information is available on the share of this amount that supports technology transfer, but it is likely to be small. Thus, current financing support for technology transfer is likely to be less than USD 2 billion per year.

114. Financing support for adaptation projects under the Convention and some dedicated bilateral and private sources currently amount to between USD 0.89 and 1.1 billion per year, as shown in table 6 above. Only a fraction of this amount would address technology transfer. Additional support for transfer of technology for adaptation may come from sources outside the Convention, such as FDI, ODA, and developing-country budgets. Those flows are difficult to identify and, so far, have not been consistently reported or studied.

3. Technology transfer through Convention mechanisms

115. Convention mechanisms – the CDM, the funds administered by the GEF and the Adaptation Fund – provide financial incentives to implement mitigation or adaptation projects and therefore create demand for such technologies in developing countries. With the exception of the GEF strategic

[87] Metz et al., *Methodological and Technological Issues in Technology Transfer*, p.71; Worrell et al., "Technology transfer of energy efficient technologies in industry".

[88] The Poznan strategic programme on technology transfer. See document FCCC/SBI/2008/16. The period over which these funds would be disbursed is not specified.

programme on technology transfer referred to in paragraph 112 above, technology transfer is not an explicit objective of any of these mechanisms or funds. Nevertheless, where new technologies are implemented through such projects, there is likely to be some technology transfer within and possibly beyond the project.

116. The CDM contributes to technology transfer by financing projects that use technologies currently not available in the host countries.[89] About 36 per cent of CDM projects, accounting for 59 per cent of the total annual emission reductions of all projects, claim to involve technology transfer.[90] The extent of technology transfer varies greatly across project types; agriculture, hydrofluorocarbon, landfill gas, nitrous oxide destruction and wind power projects are more likely to involve technology transfer, regardless of the project characteristics, while biomass, cement, hydropower and transport projects are more likely to use local technology.[91] Technology transfer usually involves both equipment and knowledge. It is more common for larger projects and projects with foreign participants; France, Germany, Japan, the United Kingdom and the United States are the source of over 70 per cent of the technology, which is not surprising given their large share of R&D spending.[92]

117. As host-country approval is required for each CDM project, host countries can influence the nature and extent of technology transfer associated with the projects.[93] Statistical analysis indicates that technology transfer is more likely for CDM projects in Bolivia, Ecuador, Guatemala, Honduras, Indonesia, Kenya, Malaysia, Mexico, Pakistan, South Africa, Sri Lanka, Thailand and Viet Nam.[94] Technology transfer is less likely for projects in Brazil, China and India.

118. Further analysis of projects in Brazil, China and India indicates that the CDM can lead to technology transfer beyond individual projects as the number of projects of a given type in a host country increases.[95] That enables later projects of those project types in the country to rely more on local knowledge and equipment.

119. Similarly, adaptation projects facilitate the transfer of technology, concepts and approaches for adaptation assessments and implementation in developing countries. Typically, the approach to the transfer of technology in these adaptation projects is similar to that in other development projects that aim at fostering resilient livelihoods, sustainable agriculture and capacity-building for climate risk reduction. Technologies and concepts transferred include concepts and tools for integrated coastal zone and water resource management, natural hazard risk reduction, and monitoring and early warning for natural hazards.

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[89] The following three studies all discuss technology transfer in the CDM: Van der Gaast W, Begg K and Flamos A. 2009. Promoting sustainable energy technology transfers to developing countries through the CDM. *Applied Energy*. **86**: pp.230–236; Schneider M, Holzer A and Hoffmann V. 2008. Understanding the CDM's contribution to technology transfer. *Energy Policy*. **36**: pp.2930–2938; and Popp D. 2008. *International Technology Transfer for Climate Policy*. Policy Brief 39/2008. Syracuse: Center for Policy Research, Syracuse University.

[90] Seres, *Analysis of Technology Transfer in CDM Projects*.

[91] Dechezleprêtre et al. find that cement, methane, hydro, ocean and geothermal are mature technologies, which should be widely available (*Invention and Transfer of Climate Change Mitigation Technologies on a Global Scale*, p.24).

[92] Dechezleprêtre et al. find that these countries are all high innovators and high exporters of climate mitigation technologies (*Invention and Transfer of Climate Change Mitigation Technologies on a Global Scale*, p.27).

[93] Malaysia, for example, requires CDM projects to use imported equipment.

[94] Seres, *Analysis of Technology Transfer in CDM Projects*.

[95] Seres, *Analysis of Technology Transfer in CDM Projects*.

4. Estimates of financing resources needed for technology transfer

120. Only one partial estimate of financing resources needed for technology transfer was identified for this study: a submission to the secretariat from the United Nations Environment Programme (UNEP) on technical assistance and capacity-building to support the transfer of climate technologies.[96] It identifies and provides indicative cost estimates for 14 initiatives aimed at fostering market development for cleaner energy technologies in developing countries. The initiatives include actions designed to help overcome the various barriers to market-oriented technology transfer. The combined implementation cost is USD 1.9 billion over five years.

121. Capacity-building is crucial for developing and implementing adaptation projects. However, given the major uncertainties involved in projected regional and local climate change, and the lack of vulnerability and impact assessments, little information is available on the capacity-building needs in most developing countries. Estimates from NAPAs indicate that capacity-building represents about 30 per cent of the cost of all projects identified, about USD 300 million to date.

V. Financing gaps and barriers

122. The previous section focused on the level of financing resources for climate mitigation technologies and technologies for adaptation. This section focuses on the gaps in, and barriers to use of, available financing. First, the technology coverage of the major R&D programmes is reviewed to identify gaps. Next, technology needs identified by developing countries are compared with the technologies covered by mechanisms to support their deployment. The gaps identified can be related to the stage of technological maturity. Financing barriers for development and deployment of technology and for technology transfer are compiled from the literature. Finally, financing vehicles to address the gaps and barriers are identified.

A. Existing technology coverage

1. Mitigation technologies by sector and stage of technological maturity

123. Global energy R&D is dominated by European Union countries, Japan and the United States. The broadest mechanisms for international coordination of research on climate change mitigation technologies are the IEA implementing agreements and the Asia-Pacific Partnership on Clean Development and Climate (see annex I).

124. All the technologies covered by these national, regional and international programmes are included in the list of technologies (see annex I) developed for this study. Technologies identified from other sources may not be covered by these programmes. Annex I shows how many of the programmes cover a particular technology and identifies any gaps. It also shows the distribution of technologies by sector and by stage of development. This information is summarized in table 10.

125. The table shows that the distribution of mitigation technologies is similar to the level of contribution to potential GHG emission reduction by 2020 for most sectors. Each technology has a different mitigation potential, so a comparison of the emission reduction potential with the share of the technologies must be interpreted cautiously. There appear to be relatively few technologies for agriculture and forestry and many for transportation and energy supply. This might be explained by the

[96] "Thoughts concerning technical assistance and capacity-building to support the transfer of climate technologies: possible activities and their potential impact". Available at <http://unfccc.int/resource/docs/2008/smsn/igo/027.pdf>.

sources used to compile the list of mitigation technologies, some of which focus on agriculture and forestry research.

126. In the industry, residential and commercial buildings, and transport sectors much of the mitigation potential is due to energy efficiency. Energy efficiency improvements are diverse, in an advanced stage of technological maturity and commercially attractive. R&D for energy efficiency takes place in international programmes and in Japan and the United States. Many non-renewable energy supply technologies (all energy supply technologies except renewables) are at the demonstration stage. These technologies are well covered by the R&D programmes. The coverage of transportation technologies is limited, especially in Japan and the United States, perhaps because research in that sector is dominated by equipment manufacturers.

Table 10. Estimated sectoral distribution of emission reduction potential and mitigation technologies

Sector	Contribution to total emission reduction potential in 2020 (%)	Number of technologies	Distribution of stages of technological maturity				
			R&D (%)	Demonstration (%)	Deployment (%)	Diffusion (%)	Commercially mature (%)
Agriculture	8–17	8 (5%)	0	0	100	0	0
Buildings	2–40	35 (24%)	3	3	51	23	20
Energy supply	14–30	32 (22%)	9	38	28	13	13
Forestry	9–39	9 (6%)	0	67	0	11	22
Industry	8–17	17 (12%)	0	6	24	71	0
Transport	7–13	37 (25%)	19	11	27	19	24
Waste	2–8	9 (6%)	11	0	22	33	33
Total		**147 (100%)**	**12 (8%)**	**24 (16%)**	**51 (35%)**	**35 (24%)**	**25 (17%)**

Abbreviation: R&D = research and development.

Note: Contribution to reduction potential by sector calculated from: Metz B, Davidson OR, Bosch PR, Dave R and Meyer LA (eds). 2007. *Climate Change 2007: Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge and New York: Cambridge University Press. p.112.

127. The data in the table indicate that most of the mitigation technologies are relatively mature – at the deployment, diffusion or commercially competitive stages. This suggests that efforts to accelerate implementation of the technologies could yield quick results in terms of reducing both emissions and the costs of the technologies through increased installations. The relatively small number of technologies at the research and development and demonstration stages could suggest that further emission reductions will be more difficult or costly in the longer term. This may simply reflect the scope of the sources used to compile the list of technologies. In any case, new commitments to mitigate GHG emissions are likely to stimulate more innovation.

2. Technologies for adaptation by sector and category

128. A similar analysis for technologies for adaptation is shown in table 11. There is no measure of abatement potential across sectors, so the estimated investment and financial flows by sector from table 8 are used as a crude indicator of the potential scale of activity by sector. Estimates are not available for all sectors.

129. A comparison of the distribution of estimated necessary investment and financial flows with the distribution of the technologies must be interpreted cautiously because of the gaps in the estimated

investment and financial flows and because spending would differ across technologies. Nevertheless, the distribution of technologies appears to be roughly similar to the distribution of estimated investment and financial flows, except for the infrastructure and water resources sectors. The share of technologies is low for infrastructure and high for water resources. In the case of water resources it may be owing to a low estimate of the investment needed. If the UNFCCC estimate of USD 11 billion for water supply[97] is used, the share of technologies for this sector is comparable to its share of the investment and financial flows.

Table 11. Estimated sectoral distribution of adaptation needs and technologies for adaptation

	Investment and financial flows needed for adaptation		Technologies for adaptation		Distribution of stages of technological maturity (%)			
Sectors	**Amount (billion USD)**	**%**	**Number**	**%**	**Future**	**High**	**Modern**	**Traditional**
Coastal zones	7.1	4.4–21.8	27	16.4		18.5	25.9	55.6
Energy			6	3.6			33.3	66.7
Health	4.8–12.8	7.8–14.7	18	10.9		38.9	38.9	22.2
Early warning and forecasting			13	7.9		84.6	15.4	
Infrastructure	7.6–130.0	23.3–79.8	23	13.9		8.7	47.8	43.5
Terrestrial ecosystems			8	4.8			25.0	75.0
Water resources	0.2	0.1–0.6	28	17.0		25.0	46.4	28.6
Agriculture, livestock and fisheries	12.8	7.9–39.3	42	25.5		21.4	31.0	47.6
				100	**0**	**24.8**	**34.5**	**40.6**
Total	**32.6–163.0**	**100**	**165**		**0**	**41**	**57**	**67**

130. The share of technologies for adaptation declines from the traditional/indigenous to modern to high technology categories. Traditional technologies represent over half of the total in the terrestrial ecosystem, energy and coastal zones sectors. Modern and high technologies dominate for the early warning and health sectors. The absence of technologies in the “future” category probably reflects the sources used to develop the list – NAPAs and TNAs – which focus on the implementation of adaptation measures.

3. Mitigation technology needs reported by developing countries

131. Developing countries identify the technologies they need in TNAs or national communications. The technologies identified by developing countries are listed in annex I.

132. The GEF has provided financial support for various mitigation technologies in developing countries. The CDM also provides a financial incentive for eligible mitigation technologies in developing countries. The technologies that have been supported by the GEF or proposed as CDM projects are identified in annex I.

[97] UNFCCC, *Investment and Financial Flows to Address Climate Change*, p.177, table IX-65.

133. Tables 12 and 13 compare the mitigation technology needs identified by developing countries with the technologies supported by the GEF and the CDM by sector and by stage of technological maturity.

Table 12. Distribution of mitigation technologies supported, by sector

Sector	**Technologies mentioned in TNAs (%)**	**Technologies supported by the GEF (%)**	**Technologies supported by the CDM (%)**
Agriculture	75	25	12
Forestry	89	11	11
Renewables	50	44	56
Non-renewable energy	43	21	21
Industry	53	29	88
Buildings	63	34	20
Transportation	57	32	2
Waste management	67	22	44
Total	**59**	**31**	**29**

Abbreviations: CDM = clean development mechanism, GEF = Global Environment Facility, TNA = technology needs assessment.

Table 13. Distribution of mitigation technologies supported, by stage of maturity

Stage of technological maturity	**Technologies mentioned in TNAs (%)**	**Technologies supported by the GEF (%)**	**Technologies supported by the CDM (%)**
Research and development	0	0	0
Demonstration	42	17	4
Deployment	61	33	20
Diffusion	77	43	63
Commercially mature	76	36	36
Total	**59**	**31**	**29**

Abbreviations: CDM = clean development mechanism, GEF = Global Environment Facility, TNA = technology needs assessment.

134. Of the 147 mitigation technologies referred to in annex I, about 60 per cent have been identified by one or more developing countries in a TNA. The technologies identified in TNAs are evenly distributed across sectors with the exception of other energy and forestry. The distribution is also relatively even for the deployment, diffusion and commercially mature stages. The GEF and the CDM have each supported about 30 per cent of the technologies. Support by the GEF for the technologies has been fairly even across sectors with the exception of forestry, and across the deployment, diffusion and commercially mature stages. CDM projects have concentrated on industry, renewable energy and waste management technologies and on technologies at the diffusion stage.[98]

135. Deployment of energy efficiency and transportation technologies is often hindered by non-price barriers, leading to a limited scope for these technologies in the CDM and many other market-based mechanisms. The difference in the technologies employed by GEF and by CDM projects reveals the different strengths of these types of mechanisms. A funding mechanism such as the GEF is able to

[98] The stage of technological maturity is based on global average conditions. CDM projects that use commercially mature technologies may face additional barriers and costs in specific countries.

support a wider range of technologies than a market mechanism like the CDM which focuses on the most profitable projects. A funding mechanism or targeted market mechanism[99] is better able to support technologies at earlier stages of technological maturity. Commercial and near-commercial technologies are most attractive for a market mechanism.

4. Technology for adaptation needs reported by developing countries

136. About 58 per cent of the 165 technologies for adaptation compiled for this study are identified in one or more NAPAs and about 51 per cent are identified in one or more TNAs.[100] NAPAs are limited to "urgent and immediate" adaptation projects. TNAs may not identify all of the technologies for adaptation needed by a country. Both are available for a limited number of countries. A more complete picture of the technologies for adaptation needed by developing countries would take some time to prepare.

B. Gaps in existing financing resources

137. The material in the previous section reveals some gaps in the existing financing resources for the development, deployment, diffusion and transfer of ESTs, specifically:

(a) Financing for R&D relies heavily on businesses and governments in a relatively small number of countries;

(b) While R&D is becoming more international, there is no international funding mechanism and limited coordination between countries;

(c) The existing mechanisms under the Convention and the Kyoto Protocol provide very limited support for technologies at the demonstration and deployment stages;

(d) The existing mechanisms under the Convention and the Kyoto Protocol support about half of the technologies that developing countries need and lack coordination in terms of the technologies they support;

(e) No explicit mechanism or financing resources are available for technology transfer.

138. In addition, the dominance of business funding for the development, deployment and diffusion of these technologies may lead to "technological lock-in" for some sectors.[101] In the transportation sector, for example, equipment manufacturers may focus their research on private vehicles rather than public transport systems, thus inhibiting the growth of public transport systems.

C. Financing barriers by stage of technological maturity

139. The barriers associated with each stage of technological maturity are presented in table 14. These barriers have implications for both public and private financing of a technology.

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[99] A targeted market mechanism, such as a renewable portfolio standard, can be limited to specific technologies at earlier stages of technological maturity.

[100] Only 15 of the 165 technologies are identified in both a NAPA and a TNA.

[101] Halsnaes et al., "Framing issues".

Table 14. Specific financing barriers at each stage of technological maturity

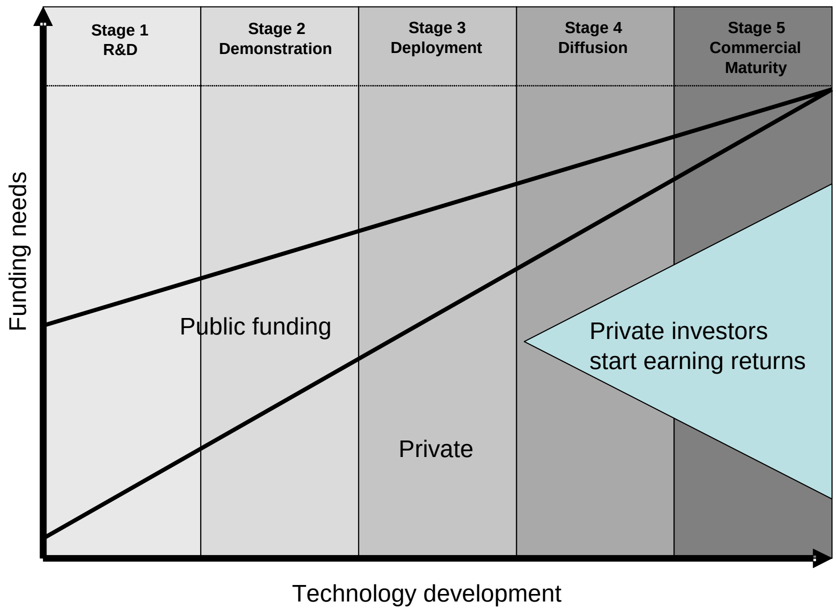
Stage of technological maturity	Category of barriers	Financing barriers	
		Public finance	**Private finance**
Research and development	Proof of concept	• Other political priorities for public finance • Unclear results of fundamental research (difficult to monitor, report and verify) • Unclear results of education and training (difficult to monitor, report and verify)	• Insufficient rate of return • Spillover effects prevent private financiers from capturing benefits of investment
Research and development	Technical	Other political priorities for government budgets and public finance	• Lack of good technical information, resulting in high-risk profiles • Spillover effects prevent private financiers from capturing benefits of investment
Research and development, demonstration	Scale	Relatively high costs to scale up from prototype	Lack of technological track record, resulting in high-risk profiles
Research and development, demonstration, deployment	Costs	High costs to reach significant deployment	Lack of policy to overcome costs, leading to low IRR
Research and development, demonstration, deployment, diffusion	Economic	• Unwillingness to interfere in the market, especially when drastic changes harm vested interests • Inflexibility of tax policy	• Energy pricing and subsidies; lack of, or insufficient, carbon price • High upfront capital costs • Lack of valuation of co-benefits, leading to low IRR • Requirement of large parallel infrastructure, leading to high upfront costs
Research and development, demonstration, deployment, diffusion	Social	• Vested interests in social/consumer preferences • Underinvestment in education and training	• Lack of a consumer or user market • Split incentives (principal-agent problem) • Lack of labour skills
Research and development, demonstration, deployment, diffusion	Institutional	• Vested interests in institutional settings • Public finance policy failures	• Lack of regulatory framework • Absence of international standards • Technology lock-in • Lack of match between ECA conditions and local finance conditions on ESTs
Commercially mature	Market failures and transaction costs	• Lack of recognition of public role in resolving market failures and transaction costs • Vested interests in bureaucracies	• Inefficient regulatory environment and bureaucracy • Lack of risk assessment and management tools specific to ESTs • Lack of appropriate financial packages • Lack of awareness and information • Imperfect markets • Technology market failure

Sources: International Energy Agency (IEA). 2006. *World Energy Outlook 2006*. Paris: IEA; United Nations Environment Programme (UNEP). 2008. *Global Trends in Sustainable Energy Investment 2008.* London: UNEP-SEFI and New Energy Finance; UNEP. 2002. *Barriers to Sustainable Energy Finance.* Paris: UNEP-SEFI; UNEP. 2005. *Public Finance Mechanisms to Catalyze Sustainable Energy Sector Growth*. Paris: UNEP-SEFI; and UNEP. 2007. *Executive Briefing. Making it Happen: Renewable Energy Finance and the Role of Export Credit Agencies*. Paris: UNEP-SEFI.

Abbreviations: ECA = export credit agency, EST = environmentally sound technology, IRR = internal rate of return.

140. Figure 5 shows how the involvement of public and private finance changes with the stage of technological maturity. Private financing is attracted by the potential profit from sales of the technology. There will be minimal returns, if any, until the technology can be deployed. Therefore, the public share of the financing is typically highest at the early stages of development. Private financing becomes easier to attract as the technology matures; the commercial potential is easier to assess and the length of time until sales begin is shorter.

Figure 5. The role of the public and private sectors in financing technology development



Abbreviation: R&D = research and development.

141. In addition to providing financing, governments play a critical role in fostering technology development through policies that encourage private spending for this purpose. Policies that reduce the cost or risk associated with technology development include direct support such as grants, and indirect support such as tax credits for R&D spending. In the case of most environmental technologies the market demand depends on government policies.

1. The importance of mitigation and adaptation policies for technology development

142. Mitigation and adaptation policies are critical to the development of technologies for mitigation and adaptation.[102] Policies create a market for the technologies. The nature of the policies determines the size of the market and influences which technologies are successful.[103] Stable policies create a more attractive environment for private financing of technology development and so encourage more R&D.

143. The available evidence indicates that R&D for environmental technologies responds quickly to environmental policies. The number of patents for mitigation technologies increased sharply after the Kyoto Protocol was adopted in 1997, but only in Parties included in Annex I to the Convention that

[102] Jaffe A, Newell R and Stavins R. 2002. Environmental policy and technological change. *Environmental and Resource Economics.* **22**: pp.41–69; and Vollebergh H. 2007. *Impacts of Environmental Policy Instruments on Technological Change*. Paris: OECD.

[103] Jaffe et al., “Environmental policy and technological change”; Vollebergh, *Impacts of Environmental Policy Instruments on Technological Change*; and OECD, *Environmental Policy, Technological Innovation and Patents*, chapter 4.

ratified the Protocol.[104] Patents for nitrogen oxide and sulphur dioxide (SO_2) control technologies increased quickly following regulations covering emissions of those pollutants by electricity generators in Germany and Japan and the United States.[105] These results suggest that domestic regulation, rather than the international market, stimulates R&D.[106] The R&D response to domestic regulation may reflect the fact that the nature of the regulations adopted affects technology development.[107] Analysis of patents for control of SO_2 emissions in 14 countries suggests that stricter policies lead to more innovation.[108]

144. On the other hand, there is some evidence of a "first mover" advantage.[109] Early adoption of abatement technologies for pulp and paper wastewater effluent by Finland and Sweden gave them a strong competitive advantage in these technologies globally. Many technologies for the control of automobile emissions were developed in Japan where the standards were initially the most stringent. As United States standards were phased in, many of the patents came from Japanese and European inventors.

145. The available evidence strongly favours emission taxes or tradable permits rather than direct regulation (technology-based controls or performance standards) to induce innovation.[110] For renewable energy, only investment and other tax incentives influence innovation for multiple technologies.[111] Investment incentives encourage innovation in solar and waste-to-energy technologies; tariffs are important for biomass; obligations and tradable certificates support wind technology; and voluntary programmes induce waste-to-energy innovation.

2. Financing barriers for technology transfer

146. The list of barriers to the transfer of technologies for mitigation and adaptation for developing countries is long.[112] The literature converges on a number of barriers that the private sector faces in the context of financing the transfer of ESTs to developing countries:[113]

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[104] Dechezleprêtre et al., *Invention and Transfer of Climate Change Mitigation Technologies on a Global Scale*, pp.12–13.

[105] Popp D. 2006. International innovation and diffusion of air pollution control technologies: the effects of NOX and SO_2 regulation in the US, Japan, and Germany. *Journal of Environmental Economics and Management*. **51**: pp. 46–71.

[106] OECD, *Environmental Policy, Technological Innovation and Patents*, p.43. Popp notes that nitrous oxide and SO_2 regulations led to innovation in the United States despite the availability of control technologies in Germany and Japan where these emissions had been regulated earlier ("International innovation and diffusion of air pollution control technologies", 2006).

[107] Jaffe et al., "Environmental policy and technological change"; Vollebergh, *Impacts of Environmental Policy Instruments on Technological Change*; and OECD, *Environmental Policy, Technological Innovation and Patents*, chapter 4.

[108] De Vries F and Withagen C. 2005. Innovation *and Environmental Stringency: The Case of Sulfur Dioxide Abatement.* CentER Discussionaer 2005-18. Groningen: Tilburg University.

[109] OECD, *Environmental Policy, Technological Innovation and Patents*, p.15 and chapters 2 and 3.

[110] Jaffe et al., "Environmental policy and technological change"; Vollebergh, *Impacts of Environmental Policy Instruments on Technological Change*; and OECD, *Environmental Policy, Technological Innovation and Patents,* chapter 1. Emission taxes and tradable permits also enable achievement of the environmental goal at lower cost.

[111] OECD, *Environmental Policy Technological Innovation and Patents*, p.161. The policy categories are: investment incentives, tax measures, tariffs, obligations, tradable certificates and voluntary programmes.

[112] Metz et al. (eds). *Methodological and Technological Issues in Technology Transfer*. p.19; FCCC/SBSTA/2006/INF.1, pp.24–26; and UNDESA, *Climate Change: Technology Development and Technology Transfer*, pp.24–28.

[113] UNEP. 2008. *Global Trends in Sustainable Energy Investment 2008*. London: UNEP-SEFI and New Energy Finance; Energy Research Center of the Netherlands (ECN). 2008. *How To Add Value to Sustainable Energy Finance?* Petten: ECN; and UNFCCC. 2004. *Innovative Options for Financing the Development and Transfer of Technologies in the Context of the UNFCCC: Background Information Paper*. Bonn: UNFCCC.

(a) Lack of general knowledge and awareness of ESTs on the part of the investors;

(b) High transaction costs of risk assessments: unfamiliarity with the technology makes it costly to carry out a detailed risk assessment if the appropriate methodologies are not readily available and need to be developed;

(c) Lack of hard facts on risks and returns: risk assessments require detailed factual, empirical data which might not be available. There is a lack of stories about successful commercially financed technology transfer;

(d) Limited financial infrastructure: underdeveloped finance institutions, especially for more complex structuring;

(e) Volatile market conditions, in particular volatility of prices of, for example, biofuels;

(f) Ethical considerations: reputation risk because of negative public reaction to, for example, nuclear energy, biofuels or CCS;

(g) Policy and regulatory ineffectiveness: not geared towards or disadvantageous to EST;

(h) Internal financing for energy efficiency: competition with other options and awareness and information barriers.

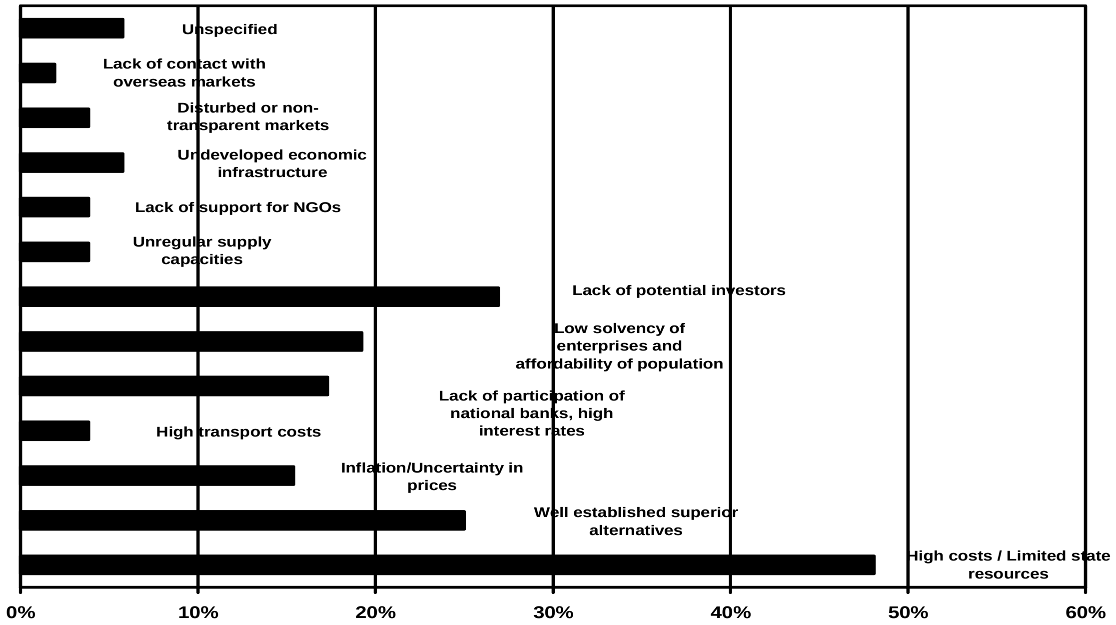
147. In addition, the limited market for mitigation technologies and technologies for adaptation in developing countries is a major barrier to the transfer of those technologies. In some cases, particularly with venture capital and private equity finance, there is also a lack of bankable projects: capital raised is consistently greater than the number of projects available for investment.

148. Information on the relative importance of barriers is available from the TNAs.[114] Each TNA identifies the barriers to technology transfer faced by the country; an average of almost 5 barriers per country.[115] The barriers are grouped into the following categories: economic and market (21 per cent of all barriers); information and awareness (14 per cent); human capacity (14 per cent); institutional (14 per cent); technical (12 per cent); regulatory (10 per cent); and policy related (10 per cent).

149. The percentage of countries that identified economic and market barriers is shown in figure 6. The three most common economic and market barriers – high cost, lack of investors and established alternatives – highlight the difficulty of implementing more costly mitigation technologies in the absence of an incentive or policy driver. The other categories of barriers – information and awareness, human capacity, institutional, technical, regulatory and policy-related – all relate to the creation of an enabling environment for the transfer and successful implementation of a technology.

[114] Document FCCC/SBSTA/2006/INF.1 provides a synthesis of the 23 TNAs available at the time.
[115] Data for an updated synthesis of 52 TNAs.

Figure 6. Economic and market barriers reported in technology needs assessments



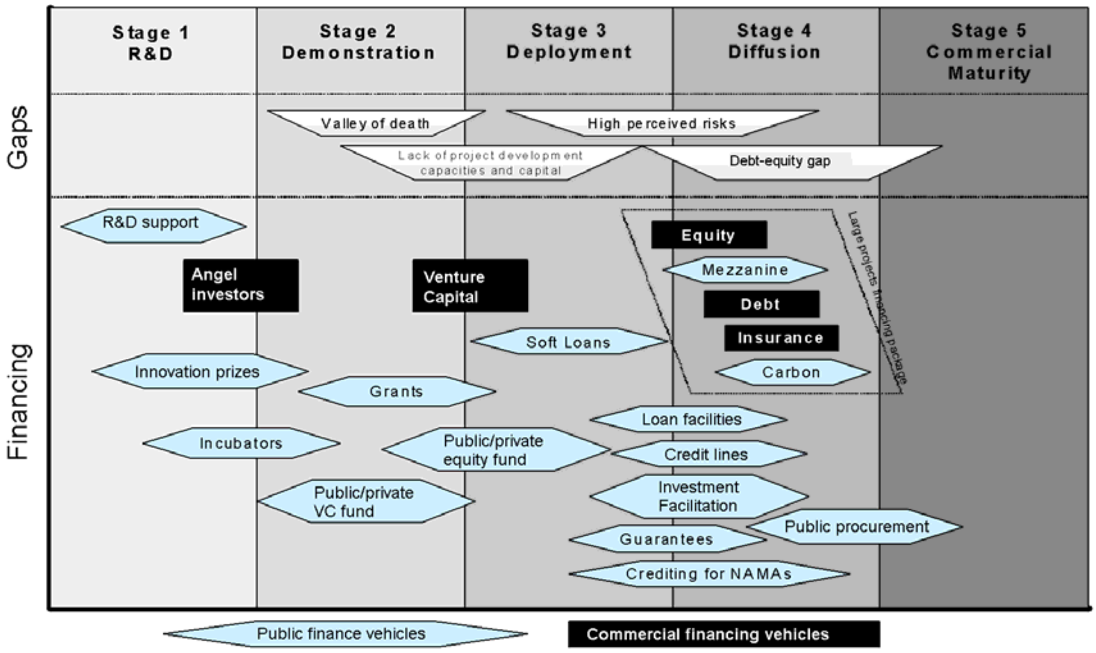
Abbreviation: NGO = non-governmental organization.

D. Financing vehicles

150. As discussed above, the financing barriers for technology development differ by stage of technological maturity for both public and private finance. Thus the appropriate financing vehicles – the means of providing financing for technology development – differ according to the stage of technological development. The financing vehicles suited to each stage of technological maturity are illustrated in figure 7.

151. Although each vehicle addresses specific financing barriers and so is suited to a specific stage of technological maturity, almost all span more than one stage of technological maturity. The public-sector financing vehicles for technology development are limited to direct support through grants and subsidies and indirect support through tax credits. Many countries have already implemented one or both of these types of vehicles. Grants and subsidies are often provided through several programmes that focus on different institutions and/or technologies. Tax credits tend to apply to most R&D activities and hence are not targeted to specific categories of technologies.

Figure 7. Financing vehicles by stage of technological maturity



Source: Adapted from United Nations Environment Programme. 2008. *Public Finance Mechanisms to Mobilise Investment in Climate Change Mitigation*. Paris: UNEP-SEFI; and Carmody J and Ritchie R. 2007. *Investing in Clean Energy and Low Carbon Alternatives in Asia*. Manila: Asian Development Bank.
Abbreviations: NAMAs = nationally appropriate mitigation actions, R&D = research and development, VC = venture capital.
Note: Functions of common financial vehicles and actors are described in annex V to this document.

152. Governments can also provide indirect financing support for technologies at the deployment and diffusion stages through policies that promote their use. Emissions fees and tradable certificates establish a price premium for mitigation technologies. Feed-in tariffs and renewables obligations provide additional revenue to the eligible technologies from electricity consumers. Regulations also establish a price premium for the adaptation or mitigation technologies that achieve compliance with the requirement. Focused subsidies and tax credits can also be used to support technologies at the deployment and diffusion stages.

153. Some of the private-sector financing vehicles are viable only in larger markets and so will not be available in all countries. In general the financing vehicles shift from equity to debt as the technology matures. And at earlier stages the equity investments involve higher levels of risk and longer periods before they earn a return, mainly in the form of capital appreciation. Individual inventors and smaller firms may have to use several of these financing vehicles while developing their technology because the capital needed tends to increase as the technology is developed. A significant percentage fail to find sufficient additional funds during the demonstration or deployment stages, so this is often called the “valley of death” for new technology. Large firms may be able to finance the development of a new technology internally without using any of these private-sector financing vehicles.

VI. Potential sources of additional financing

A. Proposals by Parties and organizations

154. Parties to the Convention have suggested a wide range of options for creating new financing sources and vehicles to enhance technology development and transfer. The processes that have been initiated under the Bali Action Plan (decision 1/CP.13) have also stimulated the development of many

proposals from international organizations and experts. The proposals can be divided into two main groups:[116]

(a) **Revenue-raising** options: proposals on how to raise revenue to support enhanced implementation of the Convention;

(b) **Options to deploy new resources**: proposals on how best to deploy new resources to reduce emissions, support adaptation to climate change and enhance technology development and transfer.

155. Parties have identified criteria by which they intend to evaluate these options when making decisions about how to raise the resources needed to finance the post-2012 agreement.[117]

156. Only the proposals relating to technology development and transfer are considered here. Options for raising revenue are summarized in annex VI and proposals of Parties for new financing options are summarized in annex VII.[118]

157. Table 15 lists the proposals and options relating to technology development submitted by Parties or organizations; elements of proposals with strong similarities are combined. The proposals and options have been classified by the stage of technological maturity that they address. They are also categorized as either actions to enhance technology development or options to finance enhanced technology development.

Table 15. Overview of proposals and detailed options by Parties and organizations for enhancing technology development

Stage of maturity	Proposal	Options	Funding or action
Research, development and demonstration	Targets for national research, development and demonstration expenditure	• Targets for the provision of financial support for R&D in developing countries • Targets for reducing or eliminating support for RD&D for environmentally harmful technologies	-
	Convention fund for research, development and demonstration	• Pooling of national research, development and demonstration expenditures • Financial assistance for developing countries for participation in international technology agreements • Investment guarantee or risk reduction tool	-
	Global network of innovation centres	• Public–private partnerships • Intellectual property sharing • Technology transfer • Various financing tools	-
	National targets for technology demonstration	• Global technology road maps • Technology agreements • Commitments to demonstration of financing in developing countries	-
	Innovation prizes		-

[116] The proposals have been summarized in documents FCCC/AWGLCA/2008/16/Rev.1 and FCCC/SB/2008/INF.7.
[117] FCCC/AWGLCA/2008/16/Rev.1, paragraph 153 (c).
[118] Proposals submitted by Parties by 30 September 2008 were included, as contained in FCCC/SB/2008/INF.7, annex II.

Table 15 (continued)

Stage of maturity	Proposal	Options	Funding or action
Deployment	UNFCCC technology fund	Could include implementation of an enhanced GEF Strategic Plan and the following sub-funds: • Renewable energy • Venture capital • Public equity • Mezzanine finance • Investment risk tools	-
	National targets for technology deployment	• 5–10-year national targets • Financial support through the financial mechanism of the Convention or the proposed technology fund	-
	Public procurement mechanism	• Tendering programme • Price guarantees • Coordinated public procurement • Advanced purchasing commitments	-
	International project-development mechanism	• Market analysis • Programme/large-scale project feasibility and scoping • Structured financial packages	-
Diffusion	Carbon financing	• Expansion of interlinked domestic emissions trading schemes • Enhanced/expanded project-based CDM • Expansion of the CDM through scaling up programmatic approaches • Sectoral approach to the CDM • Sector no-lose targets and crediting • Crediting for nationally appropriate mitigation actions	Funding
	Technology agreements and programmes	• Sectoral technology-oriented agreements (priority for steel production, coal-fired power plants, cement and road transportation) • Programme on international technology barriers to address barriers faced by specific technologies. This could include purchase of licences or patents • Global adoption of energy-efficiency standards and mandates • Technology scale-up partnerships	Action Action Funding Action Action
	International investment facilitation	• Expansion of the Private Financing Advisory Network and other similar investment facilitation programmes	Action
	Concessional financing	• Loan facility for energy efficiency measures • Credit line for senior debt; green bonds	Funding Funding
	National renewable energy and energy efficiency targets	• Support for commitments to national renewable and energy efficiency targets in developing countries	Funding
	Scale up the financial mechanism of the Convention	• Fifth replenishment of the GEF	Funding

Abbreviations: CDM = clean development mechanism, GEF = Global Environment Facility, R&D = research and development, RD&D = research, development and demonstration.

158. Parties have also identified criteria for evaluating options for deploying new financial resources.[119] From these criteria, the EGTT has synthesised criteria to evaluate financing options. Those criteria are also consistent with those used by the EGTT for the development of its strategy paper.[120] In a background paper, the proposals and options relating to technology development and transfer will be evaluated separately against these criteria to identify their main strengths and weaknesses.[121]

159. Many of the options have strengths that make them suitable for specific purposes. No single option is intended to address all of the financing gaps and barriers across all sectors and stages of technological maturity; rather, enhanced financing for technology development and transfer will consist of a package of options. In constructing such a package, the fact that the options should complement each other needs to be kept in mind.

160. The remainder of this chapter reviews the options by stage of technological maturity.

B. Research, development and demonstration

1. National targets for research, development and demonstration expenditure

161. Many Parties and organizations have identified under-investment in research, development and demonstration as a major barrier to the development of more cost-effective mitigation technologies. The IEA estimates that an additional USD 10–100 billion per year is required globally for R&D in the energy sector and that USD 27–36 billion per year is required to demonstrate 17 priority technologies. This represents a two- to tenfold increase in the current level of government funding for these technologies.

162. Developed country governments could agree to increase their R&D budgets and to implement measures to encourage businesses to carry out more R&D. A possible target might be a two- to tenfold increase in their R&D spending for mitigation technologies and technologies for adaptation. This is consistent with the scale and priorities of the R&D targets for most of these governments. The increased R&D funding could include both direct and indirect tax credits, support for research by business and other organizations, as well as contributions to international R&D activities. Commitments to increase R&D funding could also cover funding for demonstration of technologies domestically or internationally.

163. Greater government support could increase the level of business R&D, but mitigation policies to meet national emissions limitation commitments are likely to be a more important driver of business R&D spending. Such policies create the market for mitigation technologies; however, the nature and stability of the policies affects business R&D activity. Stimulating business R&D spending will have domestic economic benefits in the form of reduced mitigation costs as well as domestic and international business opportunities stemming from the technologies.

164. Parties may also wish to consider commitments to reduce or eliminate support for R&D for environmentally harmful technologies. Such support acts as subsidies which perpetuate unsustainable technologies and hamper the development and adoption of mitigation technologies. Since mitigation technologies currently receive less than half of energy R&D funding, eliminating support for other technologies would allow funding for mitigation technologies to be doubled with no changes to the current budgets.

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[119] See document FCCC/AWGLCA/2008/16/Rev.1, p.105.

[120] According to its programme of work adopted by the COP in decision 3/CP.13, the EGTT is to elaborate a strategy paper for the long-term perspective beyond 2012, including sectoral approaches, to facilitate the development, deployment, diffusion and transfer of technologies under the Convention. The advance report on this work is contained in document FCCC/SB/2009/INF.1.

[121] <http://unfccc.int/ttclear/jsp/EGTT/EGTT2.jsp>.

165. While the absolute amount of the financing of resources available for R&D is very important, effective delivery of these resources is also critical for successful technology development. The remaining proposals focus on effective support for R&D.

2. A Convention fund for research, development and demonstration

166. Increased support for R&D by developed countries may not provide sufficient support for globally significant technologies or for R&D in developing countries. A global fund for research, development and demonstration under the Convention has been proposed for these purposes.[122] A list of relevant technologies and agreements and a cost-sharing formula could be approved by an appropriate body under the Convention. For those technologies, the technology fund could provide the resources for:

(a) Development and implementation of technology road maps and coordinated research programmes;

(b) Global research, development and demonstration partnerships, including increased resources to increase the level of coordination and efficiency of existing programmes;

(c) Early-stage technology innovation and development by acting as a "fund of funds";

(d) Participation of developing countries in international technology agreements such as the IEA implementing agreements;

(e) Innovative mechanisms, such as a new global network of innovation centres (see paras. 169–172 below), or the financing of globally significant research infrastructure and the vital research infrastructure needs of developing countries.

167. Investment in demonstration of new technologies is an essential yet high-risk activity that may not deliver commercial benefits. Under-investment in demonstrating technologies creates an important gap in financing, and financial instruments that reduce the risk of demonstrating promising technologies are lacking. The global research, development and demonstration fund could develop appropriate financial instruments, such as an investment guarantee or risk-reduction tool, to support demonstration of technologies.

168. Analysis by the UNEP Sustainable Energy Finance Initiative has identified a significant gap in the seed financing for technology in all regions outside the United States.[123] The proposed Convention fund could leverage the existing financial capabilities of regional development banks and venture capital funds to meet this need. Resources could be allocated to such institutions in order to establish a series of early-stage seed capital funds, each with a focus on a particular technology or region. The likely success of such a fund depends strongly on access to adequate and predictable resources. Although it would be easily implemented, care would need to be exercised to ensure that such a fund was cost-effective.

3. A global network of innovation centres

169. The development and deployment of low-carbon technologies in developing countries depends upon effective mechanisms that build innovation capacity, particularly in those countries. India has proposed the establishment of a network of climate-technology development and diffusion centres to address the diverse range of technology, business and regulatory barriers that hinder the development and

[122] Alternatively, the fund may be constructed as a funding window within a broader fund, such as a UNFCCC technology fund.
[123] UNEP, *Public Finance Instruments for Climate Mitigation*.

diffusion of mitigation technologies and technologies for adaptation.[124] Each centre would involve technology developers, companies, regulators and policymakers in its activities.

170. The Carbon Trust has prepared a detailed proposal that reflects India's suggestion.[125] Table 16 presents the main components of the Carbon Trust proposal, including the potential leveraging effects that could be achieved, based on the experience of the Carbon Trust. Each centre would have a regional focus, and would implement an integrated set of finance and technology programmes specifically designed to address the financing and technology challenges of the region.

171. A global network could also be modelled upon the Consultative Group on International Agricultural Research (CGIAR), which has been successful in stimulating globally significant and locally appropriate research through a distributed network of agricultural research centres.

172. A global network of innovation centres is inherently flexible, able to respond to national, sectoral and technology needs, and, as illustrated in table 16, has the potential to leverage significant additional resources from other public and private sources. Working models in the Carbon Trust and existing activities in the United Nations Industrial Development Organization and CGIAR are available to help ensure the effective and efficient operation of individual centres and the proposed network as a whole. The Carbon Trust estimates that each centre would require an investment of USD 40–100 million per year, yielding a total investment of USD 1–2.5 billion over five years for five centres.

4. National targets for technology demonstration

173. Proponents of technologies at the demonstration stage have difficulty in securing financing.[126] As a result, this stage in a technology's development is known as the "valley of death", as a metaphor for the gap in financing available for technologies if they proceed beyond the R&D stage but R&D funding becomes less available – the risks are still too great for private investors and the amount of money needed is too small for funding mechanisms for more advanced stages of technological maturity (see figure 8).

[124] FCCC/AWGLCA/2008/16/Rev.1, paragraph 139.
[125] The Carbon Trust. 2008. *Low Carbon Technology Innovation and Diffusion Centres*. Available at <http://www.carbontrust.co.uk/Publications/publicationdetail.htm?productid=CTC736&metaNoCache=1)27>.
[126] Murphy L and Edwards P. 2003. *Bridging the Valley of Death: Transitioning from Public to Private Sector Financing*. Colorado: National Renewable Energy Laboratory.

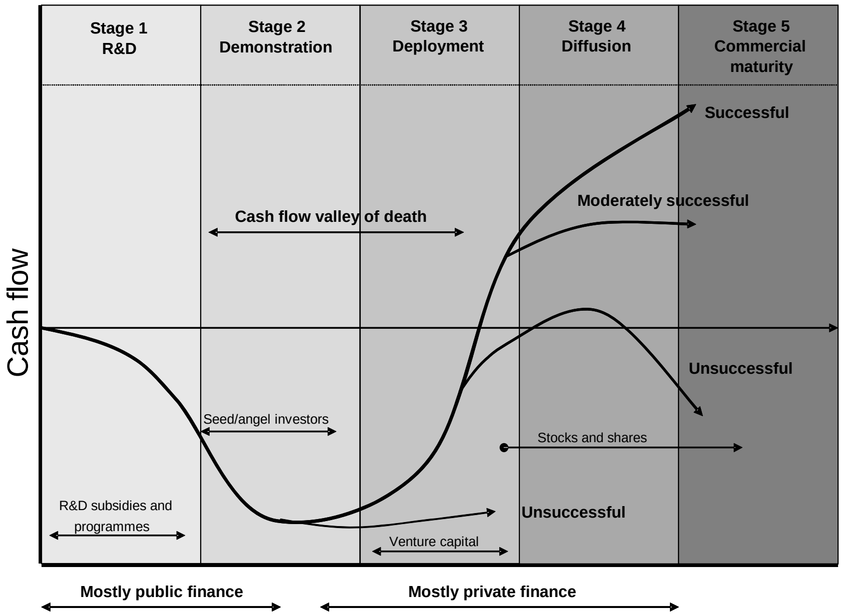
Table 16. The leveraging potential of the Carbon Trust proposal for a network of innovation centres

Activity type	Estimated required funding per project (USD million)	Type of support/funding mechanism	Typical length of project	Estimated number of projects initiated per centre per year	Indicative required funding per year (USD million)	Leverage	Resultant private investment (USD million)
Applied research and development	0.1–1	Grant (co-funding)	2–5 years	10–20	10	Direct industry co-funding (1:1 leverage potential)	10
Technology accelerators	2–10	Grant (co-funding)	2–5 years	1–5	40	Direct industry co-funding (1:2 leverage potential) Catalysed market, leading to significant commercial investment (1:10 leverage potential)	80 400
Business incubator services	0.050–0.1	Grant, advisory services and/or investment	6–12 months	5–25	2.5	Subsequent fundraising by supported companies as a result of incubation services (1:10 leverage potential)	25
Enterprise creation	10	Investment	3–7 years	1–2	10	Direct industry co-investment (1:5 leverage potential)	50
Early stage funding for low-carbon ventures	3 (for first-round funding only)	Investment or loan	3–7 years	2–10	30	Co-investment by private sector funds (1:10 leverage potential) Further catalysed market for low carbon investment through demonstrated success	300
Energy efficiency measures	0.01–0.1	Advisory services and/or loans	12–24 months, repeatable	100–1 000	50	Stimulate investment by organization receiving support (1:5)	250
Skills/capacity-building	0.05–1	Grant and/or advisory services/training	6–24 months	2–5	5	Leverage of partner company resources Catalysed markets by freeing supply chain capacity constraints (leveraging potential unknown)	Unknown
National policy and market insights	0.1–0.5	In-house and commissioned strategy work	3–12 months	2–5	2.5	Catalysed markets by enabling development of regulatory regimes which incentivize and remove risk from low-carbon private sector investment (leveraging potential unknown)	Unknown
Total					**150**		**1 115**

Source: Carbon Trust. 2008. *Low Carbon Technology Innovation and Diffusion Centres*. London: The Carbon Trust. Appendix A, p.22.

174. Developed countries could commit to demonstrating ESTs as part of their research, development and demonstration commitments. Commitments could also be made to demonstrate technologies in developing countries. Such demonstrations could be funded internationally.

Figure 8. The investment 'valley of death': typical financing sources for each stage of technology development



Source: Adapted from Murphy L and Edwards P. 2003. *Bridging the Valley of Death: Transitioning from Public to Private Sector Financing*. Colorado: National Renewable Energy Laboratory.
Abbreviation: R&D = research and development.

175. Grubb recommends a global fund to support technology demonstrations.[127] Many Parties (Australia, China, European Union, Japan and United States) have also proposed international measures targeting the demonstration of technologies in developing countries. Japan supports global technology road maps supported by national programmes to demonstrate technologies at scale and has established a USD 10 billion 'Cool Earth' initiative to demonstrate a range of new technologies in developing countries. The European Union proposes a series of technology-orientated agreements, with a focus on technologies with large mitigation potential that are currently in the demonstration stage.

176. This option for national targets, in the form of developed country commitments and/or international funding, could benefit from international coordination to prevent duplication, ensure that data and lessons from demonstrations are shared and exploit opportunities for a more strategic and efficient multilateral approach to technology demonstration.

5. Innovation prizes

177. International prizes for R&D breakthroughs have been proposed.[128] Prizes can stimulate research and induce less risk-averse behaviour and foster more radical innovations than other motivational factors. They offer a large financial prize to motivate innovators to develop a technology that meets specified criteria. There is some evidence that prizes can be effective in mobilizing public and private R&D.

[127] Grubb M. 2005. Technology innovation and climate change policy: an overview of issues and options. *Keio Economic Studies*. **41**(2): pp.103–132.
[128] Newell R and Wilson N. 2005. *Technology Prizes for Climate Change Mitigation*. Washington, D.C.: Resources for the Future.

178. Effective prizes can be surprisingly difficult to design and administer, particularly if multiple prizes are to be established. Prizes are flexible instruments that can be targeted at intractable technological barriers and can be designed to focus on specific sector and country needs. As such, they can highly complement other policy options. An independent panel and institution would be best placed to administer a system of prizes.

C. Deployment

1. UNFCCC technology fund

179. Many Parties and organizations[129] have advocated a new technology fund under the Convention that would be the focus for financing technology development and transfer initiatives under a post-2012 agreement. The proposals often incorporate specific funds, financing windows or financing instruments into the technology fund, including:

(a) A renewable energy technology fund;

(b) An international public venture capital fund;

(c) An international public equity fund;

(d) A credit line for subordinate debt (mezzanine or bridging finance);

(e) Investment risk mitigation incentives for emerging technologies and markets.

180. There are essentially two options for the operation of a technology fund under the Convention. A technology fund could:

(a) Be a fully operational financing mechanism with all of the capabilities and resources needed to disburse funds directly to projects and programmes; or

(b) Function as a "fund of funds" that allocates financial resources to existing institutions outside the Convention on a conditional basis.

181. A technology fund could be flexible, able to respond to national, sectoral and technology needs. A predictable source of funds would be desirable. In addition, a technology fund would require careful attention to governance issues and performance monitoring to ensure its effective and efficient operation.

2. National targets for technology deployment

182. Early deployment of technology is currently dependent upon national policies, such as market-based instruments, regulations, mandatory targets, subsidies and tax incentives. While some developing countries also have policies that encourage early deployment of mitigation technologies, financial support through the GEF and incentives provided by the CDM play an important role.

183. To accelerate early deployment, Parties could commit to 5–10 year targets for the installation of specified technologies.[130] The targets would be met through policies at the discretion of national governments, such as feed-in tariffs, tradable obligations, tax credits or financial support. Targets would help countries meet their national emissions limitation commitments. Financial support could be provided (through the financial mechanism of the Convention or the proposed technology fund) for Parties without commitments.

184. The proposal is highly flexible and could be suited to an individual country's needs, but technology-specific targets may prove inefficient as the available technologies evolve. National targets for technology deployment are likely to be relatively complementary, but could be difficult to coordinate

[129] For example, the Group of 77 and China, Brazil, Ghana and India.
[130] This could potentially be based upon the road maps developed as part of the IEA Energy Technology Perspectives.

at the international level. Without commitments to provide financing resources to developing countries, the deployment of indigenous technologies is unlikely to be supported in those countries.

3. Public procurement mechanism

185. Collectively, national governments are one of the largest potential purchasers of climate change technologies, and there is the possibility of achieving economies of scale and significant efficiencies and driving down technology costs through the large combined purchasing power of public procurement. Several options have been proposed.

186. The technology fund or the financial mechanism of the Convention could purchase specified technologies for deployment in developing countries. Interested countries could bid for financial support for technology deployment. Payments could be structured to include an initial payment with future payments on the condition of continued operation. Alternatively, a maximum quantity of the technology could be offered at a specified price for deployment in developing countries.

187. Parties and/or international financial institutions may wish to commit to coordinated public procurement. In this case, participating governments and organizations would coordinate purchase commitments to stimulate production of the technology, as in the case of the deployment of solar panels or technologies for adaptation (e.g. LiDAR mapping of coastal areas).

188. Advance purchasing commitments can be targeted at technologies currently at the R&D or demonstration stage.[131] By creating a market, they provide an incentive to develop the technology. Advanced purchasing commitments require very clear contractual arrangements, which raises a range of potential legal and other issues that need to be addressed without knowing who the supplier will be. Such commitments have been applied in the health sector for the development of vaccines. There is some debate on the effectiveness of such commitments in stimulating additional R&D spending.

189. Public procurement options can prove complex to administer and require an effective institutional mechanism for coordination. Tendering programmes are likely to be the most cost-effective and, if well designed and competitive, may actually result in large-scale deployment at or below the marginal cost of the technology.

4. International project development mechanism

190. According to the Institutional Investors Group on Climate Change and other institutional investor groups, investment by large institutional investors in climate change technologies is hampered by a lack of high-quality propositions from fund managers and other parties.[132] There is also a lack of information about the potential for investment and the potential returns involved. Studies indicate that there may be more funds available than investment opportunities.[133] Ideally the reverse should be the case with the availability of investment opportunities driving investors to find new financing for climate change mitigation technologies.

191. The World Resources Institute proposes the establishment of an international project development facility, which could undertake market analysis, programme and large-scale project feasibility and early scoping and development work, and could help structure suitable financial packages

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[131] World Bank. 2008. *Global Development Finance 2008*. Washington D.C.: World Bank.

[132] Institutional Investors Group on Climate Change. 2006. *Conference Report: Managing Investment in a Changing Climate*. London: IIGCC.

[133] UNEP, *Global Trends in Sustainable Energy Investment 2008*.

drawing upon available (and new) public financing mechanisms to reveal the market potential for investment on commercially attractive terms.[134] The facility would address:

(a) The need to package many small projects;

(b) High pre-investment development and transaction costs relative to total capital deployed;

(c) Complicated technical and financial information requirements;

(d) The lack of financing experience within financial institutions;

(e) The lack of collateral offered by equipment manufacturers;

(f) Difficulties creating creditworthy financing structures and the sheer range of such structures needed to address the financing needs of various end-use sectors.

192. An international project development facility could aggregate and develop projects and programmes in collaboration with a wide range of potential partners and stakeholders and would support the development of high-quality business plans. It could also work closely with the GEF, multilateral development banks (MDBs), ECAs, the Private Financing Advisory Network (PFAN), institutional investors, venture capital and private equity funds, as well as the technology fund, if it is established.

193. Such a facility could be designed to support the development of indigenous technologies and would be reasonably flexible to target specific country, technology and sector needs. It could be relatively cost-effective due to its ability to aggregate projects and reduce transaction costs; it also has the potential to mobilize large flows of finance from the private and public sectors.

D. Diffusion

1. Carbon financing

194. International carbon financing currently is dominated by the CDM, and the European Union emissions trading scheme is the largest domestic finance vehicle. Both appear to be relatively effective in stimulating diffusion of low-carbon technology. Proposals to scale up the international carbon market include:

(a) Expansion of interlinked domestic emissions trading schemes;

(b) Extension of the CDM based on projects;

(c) Extension of the CDM based on programmes;

(d) Sectoral CDM;

(e) Sectoral crediting through no-lose targets;

(f) Crediting for nationally appropriate mitigation actions (NAMAs) or other domestic policies.

195. These proposals are relatively well documented and are extensively discussed in Party proposals, studies by research institutes and proposals by industrial organizations.

196. Any of these options depends on a demand for the credits. The scale of finance generated therefore depends on the national emissions limitation commitments of developed countries, their policies to achieve domestic emission reductions, and their acceptance of imported credits. Cost effectiveness and leveraging of private investment are demonstrated strengths of carbon financing.

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[134] World Resources Institute. 2008. *Five Components of a New Financial Agreement under the Convention: Paying for Mitigation Technology*. Washington D.C.: WRI.

Further work is required for implementation, the ability to measure the emission reductions and governance, although the current CDM provides an infrastructure for this. Carbon financing is not very effective for some technologies due to cost, institutional, or other barriers.

2. Technology agreements and programmes

197. Among the proposals to stimulate diffusion of technology are a rich variety of technology-oriented and sectoral agreements and programmes. The idea behind this category of options is that agreements on the implementation of technology groups facilitates financing for these technologies and that the international scope reduces concerns over competitiveness. Sectors specifically suited to these options include steel production, coal-fired power plants, cement and car manufacturing. Variants include:

(a) Programmes to address technology-specific barriers: for specific countries, programmes to address barriers faced by low-carbon technologies could be implemented. Removing those barriers could involve, inter alia, the purchase of licences or patents, improving capacity and developing markets;

(b) Energy efficiency standards: standards can be an effective means of promoting energy efficiency technologies. Adoption and implementation of energy efficiency standards could be coordinated among interested countries or at the international level;

(c) Technology scale-up partnerships: financial and technical support could be provided, globally or in a specific country, for a technology or sector, based on a technology road map. They could be prepared at a national level, where specific barriers could be better addressed. Currently, the IEA is developing global road maps for a variety of technologies;

(d) Sectoral technology implementation agreements: various countries could agree to implement a selected technology or to improve the carbon intensity of a specific sector. Developing countries could also adopt national renewable energy and energy efficiency targets with international financial support.

198. The effectiveness of specific technology agreements and programmes will depend heavily on the specific details of the agreement or programme.

3. International investment facilitation

199. This option aims to facilitate international investments in low-carbon technologies through expansion of PFAN and possibly through other investment catalysts. PFAN is an initiative of the Climate Technology Initiative in cooperation with the EGTT. It aims to broaden access to financing for climate-friendly and technology transfer projects. It provides coaching and technical assistance to project developers and other project participants in developing countries for the preparation of project financing proposals that meet the standards of the international financing community.

200. PFAN claims high levels of cost-effectiveness and private finance leveraging. However, it does not provide finance itself and its effectiveness and impact on the scale of financing is therefore not guaranteed. Its effectiveness is probably restricted to those investments that are cost-effective in themselves, but face barriers related to information, capacity and awareness. PFAN can play only a limited role since it does not address barriers beyond the scope of the investment. But since costs are low and impacts can be expected, cost-effectiveness can indeed be high.

4. Concessional financing

201. Concessional finance provides grants or low-interest loans for low-carbon technologies and could be implemented by national governments, MDBs or the GEF (see para. 203 below). Public funds could be provided as grants to an MDB that provides funds to commercial financial institutions (CFIs) on

softer terms and/or with greater risks than their normal practice.[135] The CFIs, in turn, provide financial products adapted to the local market for mitigation measures. Another example of concessional finance is an energy efficiency loan mechanism that would provide attractive conditions for energy efficiency investments to overcome competition with other investments.[136]

202. To make best use of the public funds, it is essential that the mechanism leverage commercial investment, indirectly build up the target markets and respond to market segments and national conditions. To be effective, the design would have to match the financing, institutional and credit characteristics of the target market segment and the national market conditions, including the stage of development of the country's economy, the financial system and the relevant industry.

5. Financial mechanism of the Convention

203. The GEF, an operating entity of the financial mechanism of the Convention, co-funds deployment, diffusion and transfer of various technologies. The GEF has been extensively evaluated and has been effective in some, but less effective in other, sectors. The GEF depends on contributions by developed countries. The scale and predictability of the finance it is able to provide depends on the four-year replenishment cycle. Since the fund infrastructure is in place, increased financing would be easy to implement; however, it is questionable whether financing could be scaled up by an order of magnitude from roughly USD 1 billion to USD 10 billion per year through the existing replenishment process. Nevertheless, there is a need for one or more mechanisms to support diffusion of technologies using financial support, technologies for which carbon financing is not effective due to market barriers or costs that differ significantly from the market price of carbon.

E. Technology transfer

204. Table 17 contains proposals and options relating to technology transfer submitted by Parties or organizations; elements of proposals with strong similarities are combined. The proposals and options are also categorized as actions to enhance technology transfer or options to finance enhanced technology transfer.

Table 17. Overview of proposals and options by Parties and organizations for enhancing technology transfer

Proposal	Options	Funding and actions
National technology transfer plans	• Country-driven, building upon TNAs and NAPAs	Action
Export credit agencies	• Use financial instruments to provide reduced interest rates, credit guarantees and insurances for technology transfer • Limit support for technology exports by their export credit agencies to environmentally sound technologies	Funding Action
UNEP proposed international technology transfer programme	• An integrated programme of related initiatives	Action and funding

Abbreviations: NAPA = national adaptation programme of action, TNA = technology needs assessment, UNEP = United Nations Environment Programme.

[135] Document FCCC/TP/2008/7, pp.71–72.
[136] World Resources Institute, *Five Components of a New Financial Agreement Under the Convention*.

1. National technology transfer plans

205. Financial support could be provided to assist developing countries to develop and implement national technology transfer plans. These plans would build upon TNAs and would identify measures to build capacity, the institutional structure and the general enabling environment for specified technologies and would identify the associated funding needs. Technology transfer plans could also be incorporated into broader national climate change plans, which would build upon NAPAs, deal more strategically with adaptation issues and create national strategies for the transition to a low-carbon economy.

206. Lack of suitable market conditions and investment environments are a major barrier to technology transfer but, if effectively implemented and supported with appropriate financing, it is likely that these plans could have a large impact on the flow of financing into developing countries for climate change technologies. Implementation is likely to be complex, although it would build upon existing processes such as those established to support the development of TNAs.

2. Export credit agencies

207. Collectively, ECAs could provide significant support for climate change technology transfer activities. Parties could commit to establishing dedicated programmes to increase the level of support available to climate change technology exporters from their ECAs. Alternatively, Parties could commit to make ECA support conditional upon achieving minimum technology transfer outcomes.

208. ECAs have traditionally been effective in leveraging public and private resources, and are considered to be cost-effective instruments that support export activities. The proposal is also likely to highly complement other options. However, reaching agreement on this option is likely to be complex.

3. International technology transfer programme proposed by the United Nations Environment Programme

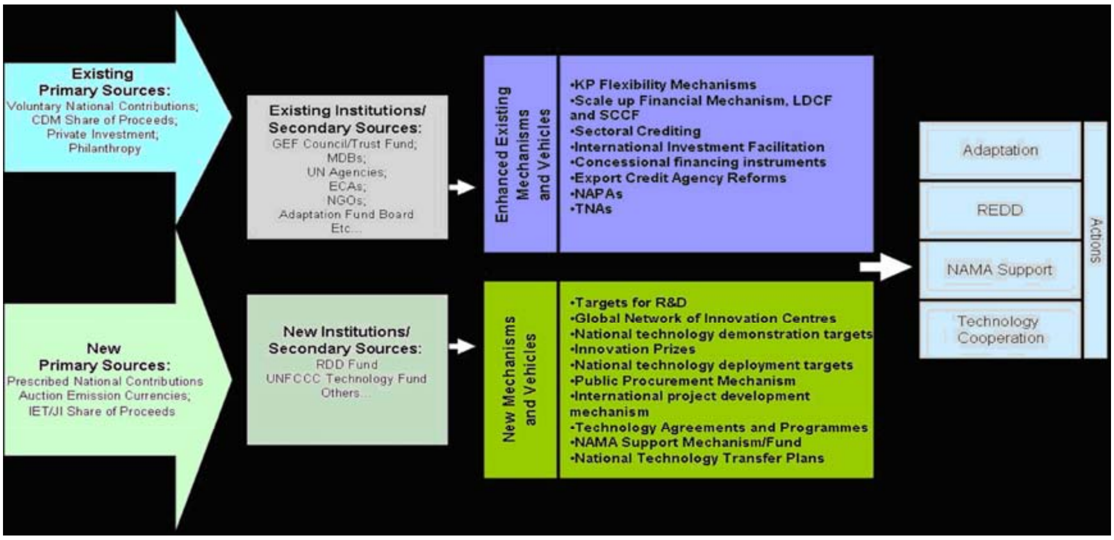
209. UNEP has proposed an international technology transfer programme with 14 integrated initiatives. The initiatives include actions designed to help overcome the various barriers to market-oriented technology transfer. The combined implementation cost is USD 1.9 billion over five years (see annex IV).

210. The initiative could potentially complement a wide range of other financing options. It would provide practical assistance and build capacity and could underpin the development of the national technology transfer plans discussed above (see para. 205 above).

F. Summary of proposals and options

211. Figure 9 attempts to put the proposals and options relating to enhanced technology development and transfer into context. The top half of the figure shows the existing sources of funds, institutions and mechanisms that deal with climate change mitigation and adaptation. The lower half shows new proposals and options. A few of the many new sources of funds are shown. Several new institutions, such as a UNFCCC technology fund, have been proposed to manage the funds allocated to enhanced technology development and transfer. And, as discussed above, numerous new mechanisms and vehicles have been proposed to enhance technology development and transfer.

Figure 9. Proposals to enhance technology development and transfer



Abbreviations: CDM = clean development mechanism, ECA = export credit agency, GEF = Global Environment Facility, IET = international emissions trading, JI = joint implementation, KP = Kyoto Protocol, LDCF = Least Developed Countries Fund, MDB = multilateral development bank, NAMA = nationally appropriate mitigation action, NAPA = national programme of action, NGO = non-governmental organization, R&D = research and development, RD&D = research, development and deployment, REDD = reduced deforestation and forest degradation in developing countries, SCCF = Special Climate Change Fund, TNA = technology needs assessment.

VII. Financing support for development and transfer of technologies

A. The current situation

212. As clarified in chapter IV above, limited information is available on the financing resources that are currently available for the development, deployment, diffusion and transfer of mitigation technologies and technologies for adaptation. This is partly because there is no agreed list of technologies for mitigation and adaptation and no agreed definition of the costs that should be financed. The available data relating to technology R&D, deployment, diffusion and transfer are also very limited; for climate technologies, sound information is really only available for renewable energy technologies. In almost all areas, more and better information is available for mitigation technologies than for technologies for adaptation.

213. Despite the nature of the information, the broad patterns are clear:

(a) The financing resources for technologies for mitigation and adaptation make up only a small share (probably less than 3.5 per cent) of the resources devoted globally to all technology development and transfer;

(b) Most of the financing resources (probably over 60 per cent) for the development and transfer of climate technologies are provided by businesses, and most of the remaining resources (about 35 per cent of the total) are provided by national governments;

(c) Most of the public sector resources (about 95 per cent) are provided directly by national governments, and the remainder is provided through multilateral sources including the Convention;

(d) Technology development is concentrated (about 90 per cent) in a few countries or regions – the United States, the European Union, Japan and China;

(e) Although R&D is becoming more international, there is no international funding and limited coordination for such activities;

(f) Only about 10–20 per cent of these resources are used for development and transfer of technologies to developing countries.

214. The existing mechanisms under the Convention and the Kyoto Protocol:

(a) Make up a small share (probably less than 5 per cent) of the total financing resources available for the development and transfer of climate technologies;

(b) Provide very limited support for technologies at the "valley of death" demonstration and deployment stages;

(c) Provide support for about half of the technologies that developing country Parties need;

(d) Lack good coordination in terms of the technologies they support;

(e) Do not explicitly provide resources for technology transfer, but do contribute to technology transfer in other ways.

B. The challenge

215. Stabilizing the atmospheric concentrations of GHGs will require current global emissions to be reduced significantly, which in turns requires mitigation action. Technology innovation is a key determinant of the long-term cost and benefits of mitigation, and the available evidence suggests that a significant increase in the financing resources available for the development and transfer of climate technologies is economically justified. But there is no agreement on the appropriate level of resources, because such calculations depend on numerous assumptions about the future.

216. The implementation challenge is to stimulate the development of a continuously changing set of technologies (currently consisting of approximately 147 mitigation technologies and 165 technologies for adaptation) that are at different stages of technological maturity and have different requirements for further development. Those technologies need to be adapted for, and transferred to, about 150 developing countries, each with its own needs for specific technologies and enabling environments to support them.

217. Developed countries will play a key role in the development of mitigation technologies and technologies for adaptation. Most R&D activity, including for technologies to address climate change, occurs in these countries. Almost all of them have emissions limitation commitments, which create markets for mitigation technologies. The scale on which the technologies are implemented in developed countries will affect the costs of the technologies and hence the cost of transferring and implementing them in developing countries.

218. The challenge for the Convention is to ensure that the technology development and transfer needs for stabilizing atmospheric concentrations of GHGs and adapting to the resulting climate impacts are met. This cannot be done without a significant increase in the financing resources devoted to development and transfer of climate technologies. However, most of the financing resources are likely to continue to come from business and national governments in a limited number of countries, and most investment in new technology is likely to continue to come from private sector sources.[137]

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[137] Table III-3 of *Investment and Financial Flows to Address Climate Change* indicates that in 2000, 60 per cent of global investment was made by corporations and a further 26 per cent was made by households (UNFCCC, p.31).

C. Potential activities for enhancing financing of technology research and development, demonstration, deployment, diffusion and transfer

1. Introduction

219. This section describes the common elements, potential activities for scaling up technology R&D, demonstration, deployment, diffusion and transfer, and combinations of activities in three distinct options. The activities and options apply both to technologies for adaptation and mitigation.

220. Current information suggests that the financing needs for technologies for adaptation differ from those for mitigation. Development and transfer of technologies for adaptation is expected to occur mainly in conjunction with the implementation of adaptation projects and programmes. In these cases, R&D largely consists of adjusting existing technologies to the local circumstances. The main vehicles for financing the development and transfer of technologies for adaptation are therefore expected to be the funds that implement adaptation projects and programmes, such as the Adaptation Fund. Adjustment of available technologies for adaptation to local circumstances, and associated technology transfer and capacity-building, should be essential features of the adaptation projects and programmes that the funds implement.

221. In contrast, mitigation technologies typically progress through the stages of technological maturity until they are able to displace the incumbent emitting technology. Thus the indicative options presented in this study are described in terms of mitigation technologies, but this would include development, deployment, diffusion and transfer of technologies for adaptation as well, where appropriate.

2. Possible common elements in options for enhancing financing of technology research and development, demonstration, deployment, diffusion and transfer

222. This section describes the elements common to all options for scaling up technology R&D, demonstration, deployment, diffusion and transfer, presented in chapter VII D below. These elements concern the following:

- The amount and source of financing;
- Interaction with market instruments;
- Barrier removal;
- Coordination between Convention mechanisms and between institutional arrangements under and outside the Convention;
- Enabling environments and capacity-building activities;
- Integrating climate change mitigation and adaptation into other national and international policy areas;
- International collaborative approaches to R&D;
- Innovative financing options and risk management tools;
- The role of governments and national policies;
- Engaging and mobilizing the private sector.

223. In all options there is a need to avoid inefficient duplication and proliferation of institutional arrangements and mechanisms, and a need to strengthen institutional coordination between existing and

possible new financing arrangements within the Convention and also between financing arrangements under and outside the Convention.

224. National policies and actions drive technology financing, leverage the private sector, build capacity, create suitable investment conditions, and support technology R&D, demonstration, deployment, diffusion and transfer.

225. All options require significant scaling up of current financing support to enhance technology R&D, demonstration, deployment, diffusion and transfer, in the order of an additional USD 262–670 billion per year for mitigation technologies and USD 33–163 billion per year to adapt to climate change (see tables 7 and 8). Enhanced action on the provision of financial resources and investment in mitigation, adaptation and technology cooperation is part of the Bali Action Plan (paragraphs 1 (b) (i), 1 (d) (i) and 1 (e)) and could be part of a Copenhagen agreement. Parties have suggested numerous options for raising additional revenue within the Convention.[138] However, in this document options for the generation of resources within the Convention are not explicitly addressed. This paper focuses on mechanisms for disbursing financial resources and for mobilizing public resources outside of the Convention and from the private sector. It is assumed that each option receives the resources needed for activities under the Convention from within the Convention and can mobilize public and private financial resources as needed for activities outside the Convention.

226. Changes to emissions trading and the project-based mechanisms under the Kyoto Protocol and possible new crediting mechanisms are under consideration as part of a future agreement. These mechanisms affect technology development, deployment, diffusion and transfer. For example, making a technology eligible under such a mechanism can stimulate its deployment, diffusion and transfer, thus making finance available and encouraging companies to invest in R&D in that technology.[139] Although the new and revised mechanisms that may be agreed are not known now, the options to scale up technology development, deployment, diffusion and transfer will take into account the effects of any new and revised mechanisms.

227. Programmes that remove barriers to finance and support the creation of suitable investment conditions and enabling environments for technology deployment, diffusion and transfer are generally considered essential elements of any future financing arrangement. As described in chapter V below, there are many barriers to financing technology, which are often particular to a country's national circumstance and require country-driven reform processes. The removal of barriers and the creation of suitable investment conditions often require financial assistance and capacity-building. Limited support is currently provided bilaterally and through agencies such as UNEP and UNDP. The experience of the GEF, which has financed barrier removal activities in developing countries, illustrates that these activities can be essential prerequisites for successful technology deployment.

228. The management of risk is a dominant factor in the financing of mitigation technologies, as investments in mitigation technologies often have a greater risk profile and may consequently have a lower return on investment in comparison to conventional technologies. The management of risk is also a dominant feature in technologies for adaptation that may not have an established market. Public financing instruments and policies for managing and reducing the risk to public- and private-sector investors and investments will be important in all options for scaling up technology R&D, demonstration, deployment, diffusion and transfer.

229. Capacity-building, including for the design of policies and programmes, for project design and implementation, and on the operation and maintenance of technological equipment, is a crucial factor in

[138] See UNFCCC, *Investment and Financial Flows to Address Climate Change*, annex IV; and FCCC/TP/2008/7, chapter V.
[139] The effect may be limited for technologies, such as energy efficiency, that face non-market barriers.

scaling up technology R&D, demonstration, deployment, diffusion and transfer. There is general support for enhancing capacity-building activities, better coordination of these activities and increasing the level of support for effective capacity-building in developing countries. Greater technical capacity would also increase the willingness of the private sector to invest in developing countries.

230. Irrespective of the financing arrangements that form part of the post-2012 agreement, it will remain essential to integrate climate change policy into a wide range of relevant international and national policy domains, such as economic, energy, water and education policies. The challenge in terms of financing technology for mitigation and adaptation fundamentally concerns shifting existing investment patterns to achieve a low emissions development path and to build resilience and adapt to the impacts of climate change.

231. As described in the advanced report, many technologies are insufficiently developed to meet in a cost-effective manner the long-term emission reductions required to stabilize GHG concentrations at levels that would meet the ultimate objective of the Convention. There is a need for a more rapid development and demonstration of new technologies which will require increased domestic climate change related R&D expenditures and greater innovative capacity, both in developing and developed countries. An important strategy which has general support from Parties is international collaborative approaches to R&D and demonstration. International cooperation in the field of R&D and demonstration of technology would increase efficiency of R&D efforts, and could enable the diffusion of innovations. They would also help developing countries to build their innovation systems. Strengthening of endogenous research and development capacity is particularly important for adaptation, long-term emission reductions and low-carbon economic growth.

232. In all options, finance must be sustained over a long enough period to enable the investments in technology that are needed to achieve low-emission economies and climate-resilient development over the long term. For mitigation technologies, financing should be provided in a way that encourages a convergence with the costs of incumbent technologies. Financing for specific mitigation technologies can be reduced as they become commercially mature and cost competitive. For technologies for adaptation, financing should be provided in a way that allows technology to be tailored to the specific site and application.

233. It would be useful to regularly review financing and technical support programmes in the light of progress made in reducing the incremental costs and GHG emissions in the short and long term. It would also be desirable to forecast the cost trajectory and if costs are not declining as expected, to review and revise the strategy for the technology, as this indicates either a technical barrier to further cost-efficiency, or that the financing arrangements are limiting further cost reductions. Financial support could be programmed to decrease over time in order to provide incentives for technology producers to increase the efficiency of production and deployment.

234. For all options there is a need to have a tool box of financing instruments that can be applied to particular technologies or national circumstances. A portfolio approach to financing and technology policies is important to maintain flexibility and to be able to tailor solutions to particular technology and financing challenges.

235. The private sector has a crucial part to play in the implementation of any future technology agreement or strategy. However, increases in private-sector investment depend largely on public policies that create the enabling environments and demand for climate change technologies. Financing the incremental costs of technologies for adaptation and mitigation is dependent upon public sources of finance and public policies. However, the majority of total investment in technology is already made by the private sector – from the balance sheets of companies or by investors or lenders. This amount will have to increase to meet the climate change challenge, and more effective leveraging of private financing through government intervention will be required. This could, for instance, be done through domestic

policies such as regulation or tax credits. Private-sector transfer of technology will be limited for some technologies and/or countries for a variety of reasons. International mechanisms are crucial to technology development, deployment, diffusion and transfer in those cases.

236. There are important relationships between the financing options and arrangements to support NAMAs and national adaptation strategies. In all options, there is a need to explore the potential interrelationships between support for technology R&D, demonstration, deployment, diffusion and transfer, NAMAs, and national adaptation strategies.

237. In all options, it is further assumed, based on the findings of this study, that:

(a) Governments operate in an international context and play a crucial role in stimulating the development, deployment, diffusion and transfer of mitigation technologies and technologies for adaptation;

(b) Governments need to encourage and support R&D, because inventors are usually unable to ensure that they receive the economic benefits generated by their inventions. This means that the level of R&D activity will be lower than optimal without financial incentives from government and protection of the intellectual property created. Governments can also play a role in promoting international joint R&D cooperation between developed and developing countries;

(c) Government policies relating to macroeconomic stability, the quality of the national education system, the functioning of capital markets and the degree of economic "openness" affect innovation rates;[140]

(d) Government policies to limit GHG emissions are essential to create markets for mitigation technologies. Unless emissions are regulated, there is no market for technologies designed to reduce them;

(e) Since GHG emissions have a global impact, cost-effective mitigation requires government action on a global scale and international collaboration to stimulate R&D, demonstration, deployment, diffusion and transfer.

3. Activities for consideration when developing financing options to scale up the development and transfer of technologies

238. Table 18 lists possible activities for financing, to be considered as part of enhancing action to support the scale up of technology R&D, demonstration, deployment, diffusion and transfer. For each activity the relevant stage(s) of technological maturity is shown, examples of organizations and programmes that currently undertake such activities are provided, and options for new or enhanced implementation are listed. The activities listed in table 18 are further elaborated in chapter V above.

[140] OECD, *Environmental Policy, Technological Innovation and Patents*, p.13.

Table 18. Possible activities for financing, to be considered as part of the development of international mechanisms to scale up development and transfer of technologies

Possible activities	Stage of technological maturity	Examples of existing financing arrangements	Examples of new or enhanced options for financing
Increasing public funding for research and development and demonstration (RD&D)	RD&D	• National government RD&D programmes • International technology initiatives/organizations (International Energy Agency (IEA) implementing agreements, Asia-Pacific Partnership on Clean Development and Climate (APP), etc.)	• Targets for the provision of financial support for RD&D in developing countries • Targets for reducing or eliminating support for RD&D for environmentally harmful technologies • Global network of innovation centres • RD&D window of a technology fund • Pooling of national RD&D funding
Increased business funding for RD&D on climate technologies in developed countries	RD&D	• Business RD&D activities	• Mitigation and adaptation policies that create incentives for increased RD&D • Investment risk sharing tools
RD&D in developing countries	RD&D, deployment, technology transfer	• Cleaner Production Centres (United Nations Industrial Development Organization/ United Nations Environment Programme (UNEP)) • IEA implementing agreements	• Global network of innovation centres • RD&D window of a technology fund; technology agreements • Intellectual property sharing and purchasing • Public–private partnerships • Scientific and technical exchange programmes
RD&D for globally significant climate technologies	RD&D	• IEA implementing agreements	• Innovation prizes
Increased investment in demonstration of technologies in developed and developing countries	RD&D	• Cool Earth Partnership (Japan)	• National targets for technology demonstration • Technology agreements and financial support for implementation of global technology road maps

Table 18 (continued)

Possible activities	**Stage of technological maturity**	**Examples of existing financing arrangements**	**Examples of new or enhanced options for financing**
National policies to stimulate deployment of climate technologies in developed countries to help achieve their emissions limitation commitments and other objectives	Deployment	• Developed country policies such as technology targets, feed-in tariffs, tax credits, grants for specified technologies	• Further adoption of policies such as technology targets, feed-in tariffs, tax credits, grants for specified technologies
Financial support for technology deployment in developing countries	Deployment, diffusion	• World Bank Clean Investment Funds • Private venture capital	• Public venture capital or equity window of a technology fund • National policies (e.g. feed-in tariffs, tax credits, renewable energy portfolio standards) • Scaling up of the financial mechanism of the Convention • Credit line for subordinate debt within a technology fund • Investment risk mitigation incentives for emerging technologies and markets • Coordinated public procurement programmes • Expansion of the Adaptation Fund, other Convention funds and official development assistance (ODA) commitments
Measures to stimulate global deployment of selected technologies	Deployment, diffusion	• Global Environment Facility (GEF)† • ODA • Multilateral development bank financing • APP	• Financial support for deployment of selected technologies and nationally appropriate mitigation actions (NAMAs) in developing countries • Investment guarantees • Public venture capital window of a technology fund • International project development facility • Purchase of licences or patents • Global energy efficiency standards • Trade policy – elimination of tariff and non-tariff barriers • Technology standards, testing, verification and certification • Technology partnerships

Table 18 (continued)

Possible activities	Stage of technological maturity	Examples of existing financing arrangements	Examples of new or enhanced options for financing
Carbon financing	Diffusion	• Policies to meet developed country national emissions limitation commitments • Clean development mechanism (CDM)† • Joint implementation (JI)†	• More ambitious emission reduction targets • Enhanced CDM • Sectoral crediting • Crediting NAMAs • Unilateral purchase of credits by developed country governments
Investment facilitation	Diffusion	• Private Finance Advisory Network (PFAN); International Finance Corporation • National investment facilitation programmes	• Enhanced investment facilitation programmes; an international project development facility • Enhanced access to private capital markets
Concessional financing	Diffusion	• World Bank • Regional development banks • GEF†	• An energy-efficiency loan facility
Technology transfer	Deployment, diffusion, technology transfer	• GEF†	• Preparation and implementation of technology action/transfer plans or low-carbon development strategies that may include incentives for deployment of specific technologies • International technology transfer programme (proposed by UNEP) • Capacity-building – awareness and training programmes
Export credit agencies (ECA) reforms	Technology transfer	• Organisation for Economic Co-operation and Development arrangement for ECAs	• Developed countries limit support by ECAs to climate-friendly technologies • Developed countries establish active programmes for climate-friendly technologies in ECAs

239. The existing activities listed in table 18 are implemented by entities that include businesses, governments, private non-profit institutions and international organizations. Activities currently implemented under the Convention are indicated by a dagger (†) in the third column; there are only a few.

240. The financial scale of the activities listed varies widely, from tens of billions of United States dollars per year for business R&D to a few million United States dollars per year for public-sector initiatives to facilitate investment. The scope also varies widely – an activity may cover many technologies, stages of maturity and/or countries, or a single technology or country at a time.

241. Finally, the activities listed in table 18 are not ‘either/or’ options; rather, successfully scaling up technology development, deployment, diffusion and transfer is likely to involve all of the activities over

time. The challenge, then, is to ensure that the activities are implemented cost-effectively where and when needed by a specific technology and/or country.

D. Recommendations on future financing options for scaling up technology research and development, demonstration, deployment, diffusion and transfer

242. The EGTT has identified and analysed existing and potential new financing resources and relevant vehicles that support the development, deployment, diffusion and transfer of ESTs in developing countries, and has assessed, based on this work, gaps and barriers to the use of and access to these financing resources. On this basis it has prepared recommendations on future financing options for scaling up technology R&D, demonstration deployment, diffusion and transfer, which include:

- Option A: enhancement of existing and emerging financing arrangements;
- Option B: a decentralized or centralized comprehensive new international technology financing scheme;
- Option C: limited new technology financing and coordination arrangements with sectoral activities.

243. The three indicative options for international mechanisms to implement activities needed to scale up technology development, deployment, diffusion and transfer are outlined in this section. They reflect a continuum of possible options rather than a description of preferred alternatives. The options have been formulated based on several assumptions. One assumption is that most funding for technology R&D, demonstration, deployment, diffusion and transfer will continue to come from businesses and national governments. They will engage in domestic and international activities, including transfer of technology to developing countries. Another assumption is that activities undertaken by international institutions, including mechanisms under the Convention, will continue to account for only a small proportion of the total funding. A further assumption is that in all options the Convention would have an increased catalytic role in the financing of technology development, deployment, diffusion and transfer in developing countries.

244. The three future financing options are limited to national, regional and international mechanisms, because businesses, non-profit institutions and other entities will continue to operate independently, although the aim of all of these options would be to influence their activities through national policies and international activities.

245. The financing resources for technology RD&D, deployment, diffusion and transfer may be similar under all options, but the amount managed under the Convention would differ. Under all of the options, global financing for R&D, demonstration, deployment, diffusion and transfer would continue to be dominated by businesses, national governments and other institutions outside the Convention.

246. Under all of the options, more stringent emission limitation commitments by developed countries, new and revised crediting mechanisms, and NAMAs by developing countries are assumed to create larger markets for mitigation technologies, thus spurring R&D, demonstration, deployment, diffusion and transfer of technology. Increased adaptation funding will also stimulate R&D, demonstration, deployment, diffusion and transfer of technologies for adaptation under all of the options.

247. The three options are indicative and seek to represent the range of possible options rather than actual and preferred alternatives; numerous intermediate options are feasible. The options are indicative because the international mechanisms for technology development and transfer that form part of a post-2012 agreement will need to reflect other aspects of the agreement, including the mitigation commitments of developed countries, support arrangements for NAMAs by developing countries,

implications for technology R&D, demonstration, deployment, diffusion and transfer of any new or revised trading or crediting mechanisms agreed, and the financial resources available.

248. A list of possible activities is provided for each option. Parties may wish to consider various combinations and permutations of possible activities and financing arrangements to enhance action on technology development and transfer.

1. Option A: enhancement of existing and emerging technology financing arrangements

249. Under option A, technology R&D, demonstration, deployment, diffusion and transfer would be scaled up by enhancing existing and emerging financing arrangements, including the GEF, the CDM, JI, the Adaptation Fund and national, bilateral, regional and multilateral financial sources. Most of the existing and emerging financial arrangements would continue to be implemented by institutions outside the Convention. Those institutions would decide which activities and mechanisms to offer, on what scale and how best to deliver them. Further institutional arrangements could be established under the Convention to identify gaps and needs for technology financing and to work with the relevant institutions to address these gaps and needs. Parties would assist implementing institutions in raising the funds they require. Financial contributions to these institutions by developed countries to support technology research, development, deployment, diffusion and transfer would be recognized under Article 11, paragraph 5, of the Convention.

250. Enhancement of existing and emerging financing arrangements might include, inter alia:

(a) Funding for developing country participation in existing international R&D networks or partnerships (e.g. IEA implementing agreements, the Asia-Pacific Partnership and Methane to Markets);

(b) Expansion of national policies to regulate GHG emissions in developed countries, such as domestic trading schemes and emissions standards, to create markets for mitigation technologies;

(c) Mainstreaming and enhancing the consideration of climate change in existing global forums for private-sector involvement and partnerships (e.g. Johannesburg Type II partnerships, the World Economic Forum and the Global Compact);

(d) Expansion of bilateral and multilateral initiatives for the deployment and diffusion of technologies (e.g. the World Bank Clean Investment Framework, Japan’s Cool Earth Partnership, Germany’s International Climate Initiative and export credit agencies);

(e) GEF scaled up funding for deployment and diffusion of technologies;

(f) Reforming and expanding the CDM, JI and other crediting mechanisms so that they can support more technology deployment, diffusion and transfer;

(g) Expansion of national and international investment facilitation networks (e.g. PFAN);

(h) Enhancement and expansion of technology transfer programmes (e.g. UNEP/UNDP and the GEF Strategic Program);

(i) Direct participation by experts from the business and financial communities by providing advice and reviewing progress in clean energy investments in developing countries.

251. The GEF could continue to focus on deployment, diffusion and transfer of technologies, with increased attention to deployment technologies, and with a specific funding window for demonstration of new technologies. The formulae for contributions from Parties could be revised and financing could be increased by an order of magnitude. The operation of the GEF could be enhanced by providing direct

access to finance by developing countries and international and bilateral agencies, developing a more flexible resource allocation system, aligning programming with country needs and priorities, providing finance for programmes and policies, reducing transaction costs and overhead costs, and establishing a new mechanism to attract private sector financing.

252. Funding could be provided bilaterally to support developing country participation in technology R&D programmes and initiatives. Developing countries may identify as NAMAs the initiatives they wish to participate in and the role they wish to play in each R&D programme. Eligible programmes and initiatives would be decided by a governance mechanism for technology under the Convention (under current arrangements it would be the SBI under advice from the EGTT). It may be necessary to enter into some arrangement with external research and development institutions and intergovernmental institutions (such as the IEA) to ensure access is provided. Access to financing support for developing countries could also be coupled with reforms to the existing governance arrangements for these programmes and initiatives, in order to ensure that developing countries have a role in the governance and decision making processes and to help determine programme directions and priorities. International R&D programmes and initiatives could continue to be financed bilaterally through developed country contributions and existing institutions, such as the OECD and World Bank Group.

253. Under option A, national mitigation policies in developed countries would be particularly crucial in creating markets for technologies thereby helping to reduce their unit cost. Significantly increased government support for R&D would be required. Government support combined with the growing markets for low-carbon technologies driven by national policies would stimulate business spending on R&D of mitigation technologies.

254. National emissions reduction commitments in developed countries would need to create greater demand for credits for emission reductions achieved in developing countries through existing, reformed and new mechanisms, including the CDM and crediting of NAMAs. The mechanisms need to be reformed and designed to generate a greater supply of credits, including by covering sectors currently not benefiting from the CDM (e.g. transport), and countries currently not successfully attracting CDM activities. Loan facilities linked with carbon financing and enhanced barrier removal programmes could be used to facilitate greater adoption of energy efficiency measures.

255. The carbon market and the proposals for NAMAs currently do not have provisions for facilitating investment other than a carbon price or crediting for NAMAs. By integrating investment facilitation mechanisms (such as PFAN) within existing financing mechanisms (e.g. CDM, the GEF), it may be possible to increase the flow of finance.

256. Financing for technology R&D, demonstration, deployment, diffusion and transfer under the Convention would be limited to contributions to the GEF Trust Fund plus financing reported under Article 11, paragraph 5, of the Convention for bilateral, regional, and other multilateral technology research, development, deployment, diffusion and transfer activities. All enhanced financing would have to be additional to current financing, including current levels of ODA.

2. Option B: a decentralized or centralized comprehensive new international technology financing scheme

257. Under option B, a new **international technology financing scheme** would be established under the Convention with a mandate to scale up collaborative action on technology transfer and development among Parties covering all stages of the technology development cycle. The required funds would be raised through the Convention. The scheme could have a decentralized or a centralized structure.

258. The new international technology financing scheme would involve a range of substantial yet targeted financing instruments and funding windows, functioning in conjunction with the carbon market, NAMAs, NAPAs and national adaptation strategies. It would play a significant catalytic role in

supporting the technology R&D, demonstration, deployment, diffusion and transfer efforts of developing countries for mitigation and adaptation, and a lesser role in such activities in developed countries.

259. Option B might include, inter alia:

(a) A research, development and demonstration funding window to support such efforts by research institutions and public–private partnerships in developing countries. It would contract with independent research and innovation centres. The funding window could support technology partnership initiatives, global technology road maps and technology innovation prizes, help cover the costs of licensing, and provide financing support for research infrastructure in developing countries;

(b) A public venture capital and equity financing window to provide funding for promising technologies. It could invest in a few independent funds. It could also include a global ‘seed financing’ window, which would provide capital grants to assist technology innovators and support early-stage technology development, demonstration and deployment activities in developing countries. Other innovative financing instruments could be created, including risk management tools and mezzanine financing;

(c) A funding window to provide support for renewable energy and energy efficiency technologies in developing countries;

(d) Funding for institutions to deliver programmes to promote deployment and diffusion of selected technologies including financial instruments.[141] Financial instruments could include soft loans or concessional financing, or a dedicated energy-efficiency loan facility. Programmes could include the creation of a new international project development facility;

(e) Funding institutions to deliver technology transfer programmes including the creation of enabling environments for the implementation of mitigation technologies in developing countries.

260. In some cases, national capacity and institution building will be a prerequisite to enable direct access to financing from the international technology financing scheme. For example, adequate legal and institutional arrangements may need to be established, and support may need to be provided to establish the capacity to design, monitor, report and verify NAMAs or national adaptation actions. Coordination of financial and technical support for capacity-building and for technology development, deployment, diffusion and transfer will be important. Depending on the overall governance arrangements agreed as part of the post-2012 agreement, this could either occur through a technology body, such as a restructured EGTT, the SBI, or a body responsible for managing a new financial mechanism under the Convention.

261. It would be beneficial if the new international technology financing scheme were designed to complement the reform and expansion of the CDM or other crediting mechanisms so they could support more technology deployment, diffusion and transfer. In particular, financial resources could target sectors and abatement opportunities (e.g. in the transport sector) that are not adequately covered by the carbon market.

262. Consideration would also need to be given to the respective role and strategic focus of the existing financial mechanism of the Convention (the GEF) in relation to the new international technology financing scheme. One option, illustrated in figure 10, would be to focus the operations of the GEF on supporting TNAs, the removal of barriers to technology deployment and diffusion, and to support for

[141] Similar activities currently undertaken by the GEF could be phased out.

capacity-building and the establishment of suitable investment conditions and enabling environments in developing countries. The new international technology financing scheme could then focus on financing the agreed full incremental costs of technology development, deployment, diffusion and transfer actions in developing countries.

263. The new international technology financing scheme could also house an international project development facility, as described in the advanced report, to address:

(a) The need to package many small projects;

(b) High pre-investment development and transaction costs relative to total capital deployed;

(c) Complicated technical and financial information requirements;

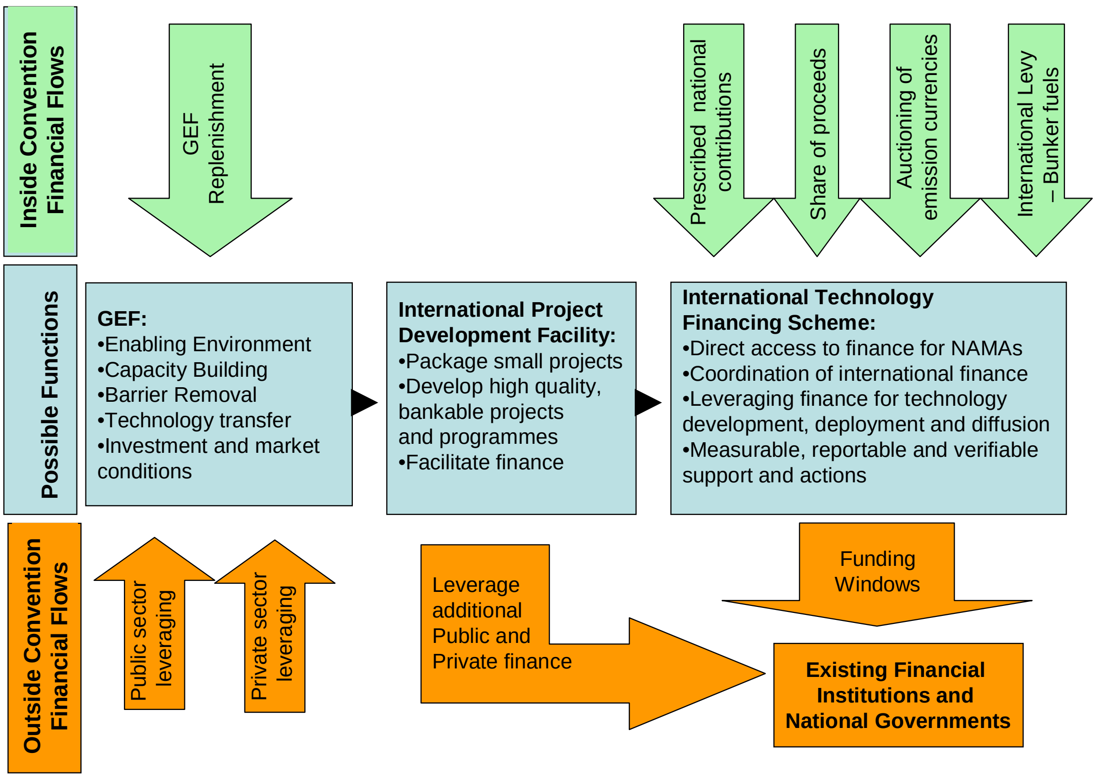
(d) The limited technological experience within financial institutions;

(e) The lack of collateral offered by equipment manufacturers;

(f) Difficulties creating credit-worthy financing structures and the sheer range of such structures needed to address the financing needs of various end-use sectors.

264. Any new mechanism would have to work in conjunction with existing mechanisms. Figure 10 illustrates how an international project development facility could aggregate and develop projects and programmes in collaboration with a wide range of potential partners and stakeholders and how it would support the development of high-quality business plans. It could also work closely with the GEF, MDBs, ECAs, PFAN, institutional investors, venture capital and private equity funds.

Figure 10. Possible functions of the Global Environment Facility, an international technology development facility and an international technology financing scheme



Abbreviations: GEF = Global Environment Facility, NAMA = nationally appropriate mitigation action.

265. The creation of a new financial arrangement within the Convention could simplify the implementation of "measurable, reportable and verifiable" requirements of paragraphs 1 (b) (i) and 1 (b) (ii) of the Bali Action Plan. An international technology financing scheme may have significant influence on existing public financial institutions, which may be necessary to align the current disparate, inadequate and inconsistent arrangements with regard to measurement, reporting and verification. It could apply and coordinate a system such as the OECD Rio markers methodology for tracking financial and technical support. Direct contractual arrangements with financial institutions and national governments could require the measuring, reporting and verification of actions and support in accordance with the guidance of the COP.

Decentralized international technology financing scheme

266. Operating as a **decentralized** structure, the **international technology financing scheme** would require the establishment of a small institution with capabilities similar to those of an equity fund manager, allocating money to various institutions or national governments for agreed activities and evaluating the results achieved.

267. The establishment of a new decentralised technology financing scheme would not:

(a) Replace activities and mechanisms implemented by institutions outside the Convention; indeed, the new body should attempt to structure its activities to coordinate with and catalyse the efforts of other institutions;

(b) Diminish the need for developed countries to implement national policies to regulate GHG emissions and to stimulate technology research, development, deployment, diffusion and transfer.

268. Adequate legal authority would be needed for the international technology financing scheme to enter into contractual arrangements with existing financial institutions. Legal authorities would also be required to facilitate direct access by national governments for the implementation of nationally appropriate mitigation actions. It will also be necessary for these institutions and for national governments to possess suitably transparent and accountable institutional mechanisms. One option would be for countries to establish national climate change funds that could ensure transparency and accountability for the disbursement of financial resources received. It may be useful to use national climate change strategies as a central vehicle for the financing of nationally appropriate mitigation actions.

Centralized international technology financing scheme

269. Implemented in a **centralized** manner, the **international technology financing scheme** would require the creation of a substantial new institution under the Convention, similar in size and capability to a Bretton Woods institution, although with different functions and features. The functions of the international technology financing scheme would be the same as for the decentralized version, but they would often be implemented 'in house' rather than be procured from other institutions.

270. The consequence would be that Parties would agree to use the centralized international financing scheme as the primary financier of climate technologies at the international level. Financial arrangements within the MDBs would largely be replaced by the international financing scheme, although they might take niche roles and would focus upon mainstreaming of climate change into development policy and practice. The purpose of doing so would be to enhance effectiveness and the chance of success, and/or to ensure that the COP retained full governance control of the international public financing of climate technologies.

271. While a centralized international financing scheme would assume a dominant role in international financing of climate technologies, international public financing would remain a small portion of total financing. The vast majority of financing would need to be provided by the private sector, supported and enabled by national policies, emission reduction and limitation commitments in developed countries, and NAMAs in developing countries. Domestic financing of climate technologies would remain a crucially important source of finance, particularly in developed countries. Similarly, ODA would continue to grow in accordance with implementation of the Millennium Development Goals and other multilateral and bilateral commitments.

272. In addition, Parties may wish to include a range of other financial and technology-based reforms, such as NAMAs and changes to the crediting mechanisms, that may contribute to the long-term strategy for technology R&D, demonstration, deployment, diffusion and transfer. These may form useful complementary strategies to enhance financing of technology in developing countries, and decrease the time and cost of achieving particular global, regional or national emissions reduction or adaptation objectives.

273. The types of functions required in a new centralized international technology financing scheme would include:

(a) A legal structure and governance system capable of making a wide range of integrated investment decisions based on a global technology development and financing strategy, which may require the establishment of a complete set of investment policies and guidelines (e.g. incremental costs, engagement with the private sector, appropriate technologies, appropriate use of financial instruments) and specific strategies for individual technologies and stages of technology maturity;

(b) An ability to coordinate at the highest levels with international, regional and national financial institutions and technology development institutions;

(c) Significant policy development, analytical, technical and planning capabilities essential for the development of long-term strategies as well as to guide short- to medium-term investment and action planning. In this regard, the structures and organizational capacity to coordinate with a wide range of existing intergovernmental and national institutions would be essential;

(d) The ability to operate a complete set of innovative financing instruments and tools, such as investment guarantees, various types of insurance, mezzanine financing, loans of various types, grants, venture capital and equity financing. The institution would be capable of designing financial packages targeted at specific technology needs. It would be necessary to possess a substantial contract development and management capacity, and would therefore need to employ teams of highly skilled employees with specialist knowledge. An important capability would be to appropriately design financing strategies that can harness the carbon market;

(e) The ability to develop projects and programmes, coordinating a wide range of project partners, including the private sector, national governments, intergovernmental organizations and non-governmental organizations;

(f) The capacity to implement a wide range of programmes to remove barriers to technology and finance, transfer technology, facilitate and coordinate public–private partnerships, coordinate public procurement and procure technologies directly, and facilitate regional and local delivery and management of projects and programmes, potentially including coordination of collaborative R&D and a global network of technology innovation centres;

(g) Internal evaluation systems to review projects and programmes, and systems to give effect to and support the “measurable, reportable and verifiable” requirements of paragraphs 1 (b) (i) and 1 (b) (ii) of the Bali Action Plan. External auditing functions could utilize existing auditing capabilities within the United Nations system.

274. Legal structures and provisions would need to be established within the governance system of the international technology financing scheme to support direct access to financing by national governments in order to support financing for NAMAs, and for direct budgetary support for national adaptation strategies. National governance, accountability and transparency for disbursed funds would also be essential. In addition, an international technology financing scheme, in particular a centralized system, may simplify the implementation of measurable, reportable and verifiable requirements for actions and support.

3. Option C: limited new technology financing and coordination arrangements with sectoral activities

275. Option C would be a combination of limited new technology and financing arrangements and enhanced sectoral coordination under the Convention for the activities discussed in table 18. With access to some funds raised through the Convention, option C would play a more active role than the coordination function under option A, as it would have a number of operational responsibilities. However, the new technology financing arrangements would have fewer operational responsibilities, and hence less Convention funding, than those proposed under option B. The new technology financing arrangements under option C would be used to facilitate technology R&D, demonstration, deployment, diffusion and transfer. It could be enhanced by a new coordination mechanism and sectoral approaches (see paras. 277–278 below).

276. Option C might include, inter alia:

(a) Developed countries committing:

(i) To scale up government funding for climate technology-related research, development and demonstration;

(ii) To implement emission reduction policies to create markets for mitigation technologies and stimulate private-sector technology development;

(iii) To create a larger market for emission credits from developing countries;

(b) Developing countries:

(i) Receiving financial support to participate in specified international research, development and demonstration initiatives (e.g. innovation centres or implementing agreements);

(ii) Receiving financial support to prepare and implement national technology transfer plans based on their TNAs and NAMAs;

(iii) Participating in credit generation mechanisms such as the CDM;

(c) Provision of financial support by the new technology financing arrangement under the Convention for:

(i) Developing country participation in international research, development and demonstration;

(ii) Developing country NAMAs, technology action/transfer plans or low-carbon development strategies;

(iii) A wide range of facilitating actions that do not require extensive financing to support the development of selected technologies, potentially based on recommendations from expert advisory panels.

277. Various existing and emerging financial arrangements outside the Convention would continue, including:

(a) International RD&D networks or partnerships (e.g. IEA implementing agreements, the Asia-Pacific Partnership and Methane to Markets);

(b) Mainstreaming and enhancing the consideration of climate change in existing global forums for private-sector involvement and partnerships (e.g. Johannesburg Type II partnerships, the World Economic Forum and the Global Compact);

(c) Expansion of bilateral and multilateral initiatives for the deployment and diffusion of technologies (e.g. the World Bank Clean Investment Framework, Japan's Cool Earth Partnership, Germany's International Climate Initiative and export credit agencies);

(d) Expansion of national and international investment facilitation networks (e.g. PFAN);

(e) Direct participation by experts from the private industrial and financial communities by providing advice and reviewing progress in clean energy investments in developing countries.

278. A new coordination mechanism for technology, possibly associated with the new international technology financing scheme, could undertake functions such as:

(a) Streamlining international research, development and demonstration cooperation by facilitating knowledge sharing and academic exchange, making essential data freely available and stimulating global cooperation on demonstration;

(b) Identifying best practices for technologies, national policy and regulation, barrier removal and stakeholder engagement processes, as well as obtaining a clearer idea of costs per sector;

(c) Facilitating cooperative public and private activities which lead to global sectoral emission reductions.

279. Cooperative sectoral approaches and sector-specific actions to enhance the implementation of Article 4, paragraph 1(c), of the Convention are also under consideration as part of a future agreement. Such sectoral approaches or actions could support development, deployment, diffusion and transfer of technologies – as well as practices and processes – that control, reduce or prevent GHG emissions. Although the sectoral approaches and actions that may be agreed are not known now, it is assumed here that implementation of activities to scale up technology development, deployment, diffusion and transfer will take into account the effects of any sectoral approaches and sector-specific actions agreed. For emissions not covered by sectoral approaches, technology development and transfer provisions from one of the other options would need to be implemented.

280. Several possible forms of sectoral approaches have been suggested, including crediting based on sectoral emissions targets, technology-oriented agreements, voluntary sharing of best practices and experiences, and international financial support for sectoral R&D and demonstration. Sectoral approaches could benefit from some form of central coordination that would be able to provide advice, monitor progress, account for credits (in the case of a crediting or tradable permitting approach) and guide a reporting and verification process.

281. Both sectoral approaches and the functions of a new central coordination mechanism (without a new technology financing arrangement) would require new institutional structure. A common suggestion by Parties is to establish a technology body, potentially a subsidiary body, executive board or a body modelled on the EGTT or the current CDM Executive Board, but with an expanded mandate and several technology- or sector-specific subcommittees. The subcommittees would consist of technology experts who would ensure that the technologies identified, facilitated and implemented through the various mechanisms were appropriate, cost-effective and environmentally sound. Another subcommittee could look into cross-cutting issues, such as issues related to measurement, reporting and verification, financing issues, barrier removal and enabling environments for technology transfer. The technology body could report to the SBI or the COP, as deemed most appropriate.

282. Financing for option C would come from the sources agreed for the provision of financial resources and investment to support action on mitigation and adaptation and technology cooperation in accordance with the Bali Action Plan. Depending on the agreement on the provision of financial resources, contributions to the GEF Trust Fund could come from the same source(s) or remain separate. Financing provided for bilateral, regional, and other multilateral technology research, development, deployment, diffusion and transfer activities might be reported under Article 11, paragraph 5, of the Convention.

Annex I

Mitigation technologies covered by various programmes and mechanisms

Table 19. Mitigation technologies covered by various programmes and mechanisms

(a) Agriculture

Stage of maturity	Technology type	Technology application	* TNAs	Convention financial sources GEF	CDM	JI	Technology programmes and IEA implementing agreements Japan	USA	EU	APP	IEA-IA
Deployment	Cropping	Cropland management	Yes	No	0	0	–	Yes	–	–	–
		Alternative fertilizers	Yes	No	0	0	–	Yes	–	–	–
		Management of organic soils	Yes	No	0	0	–	Yes	–	–	–
	Grazing	Grazing land management	No	No	0	0	–	Yes	–	–	–
		Livestock management	Yes	No	0	0	–	Yes	–	–	–
		Manure/bio-solid management	Yes	Yes	429	2	–	Yes	–	–	–
	Restoration of degraded lands	Restoration of degraded lands	No	No	27	0	–	Yes	–	–	–
	Renewable energy	Bioenergy	Yes	Yes	0	0	–	Yes	–	–	–

(b) Forestry

Stage of maturity	Technology type	Technology application	* TNAs	Convention financial sources GEF	CDM	JI	Technology programmes and IEA implementing agreements Japan	USA	EU	APP	IEA-IA
Demonstration	REDD	Avoided deforestation	Yes	No	–	–	No	No	No	No	No
		Avoided degradation	Yes	No	–	–	No	No	No	No	No
	Forest management	Increase landscape-scale carbon stocks	Yes	No	0	0	No	No	No	No	No
		Maintain landscape-scale carbon stocks (minimize disturbance)	Yes	No	0	0	No	No	No	No	No
	Forest products	Increase carbon stock in products	No	No	0	0	No	Yes	No	No	No
	Fire management	Reductions in wildfires	Yes	No	0	0	No	No	No	No	No
Diffusion	Renewable energy	Increase bioenergy and substitution	Yes	Yes	0	0	No	No	No	No	No
Commercial	Afforestation	Afforestation	Yes	No	27	0	Yes	Yes	No	No	No
	Forest management	Increase forest carbon density	Yes	No	0	0	No	Yes	No	No	No

(c) Renewable energy

Stage of maturity	Technology application	* TNAs	Convention financial sources GEF	CDM	JI	Technology programmes and IEA implementing agreements Japan	USA	EU	APP	IEA-IA
R&D	Biomass fuel cell and CCS power generation	No	No	0	0	No	No	No	No	No
	Power storage	No	No	0	0	Yes	Yes	No	Yes	Yes
	Solar nanotechnology photovoltaic	No	No	0	0	Yes	No	No	No	Yes

Table 19 (c) (continued)

Stage of maturity	Technology application	* TNAs	Convention financial sources GEF	CDM	JI	Technology programmes and IEA implementing agreements Japan	USA	EU	APP	IEA-IA
Demonstration	Ocean power (saline gradient (osmosis), thermal gradient (OTEC), wave)	No	No	0	0	No	No	Yes	No	Yes
	Offshore wind (floating)	No	No	0	0	Yes	Yes	Yes	No	Yes
	Geothermal – enhanced geothermal systems	No	No	0	0	No	Yes	No	Yes	Yes
	Concentrated solar power/solar thermal	No	Yes	0	0	No	Yes	Yes	Yes	Yes
Deployment	Offshore wind (fixed)	No	No	0	0	Yes	Yes	Yes	No	Yes
	Biomass integrated gasification combined cycle, gasification and pyrolysis	Yes	Yes	578	16	No	Yes	No	Yes	Yes
	Biogas	Yes	No	429	2	No	Yes	No	Yes	Yes
	Solar photovoltaic	Yes	Yes	13	0	Yes	Yes	Yes	Yes	Yes
	Concentrated solar power/solar thermal (parabolic trough)	Yes	Yes	1	0	No	Yes	Yes	Yes	Yes
	Tidal (barrier, stream)	No	No	1	0	No	Yes	No	No	Yes
Diffusion	Onshore wind	Yes	Yes	504	16	Yes	Yes	Yes	Yes	Yes
	Run of river hydropower	Yes	Yes	676	2	No	Yes	Yes	Yes	Yes
	Geothermal – conventional	Yes	Yes	13	0	No	Yes	Yes	Yes	Yes
Commercial	Hydropower (dam)	Yes	No	334	3	No	Yes	Yes	Yes	Yes
	Biomass co-firing	Yes	Yes	578	16	No	Yes	No	Yes	Yes

(d) Other energy supply

Stage of maturity	Technology type	Technology application	* TNAs	Convention financial sources GEF	CDM	JI	Technology programmes and IEA implementing agreements Japan	USA	EU	APP	IEA-IA
Demonstration	Efficiency	Hydrogen production, storage and distribution	No	No	0	0	Yes	Yes	No	No	Yes
	Non-renewable	Hydrogen production, storage and distribution	No	No	0	0	Yes	Yes	Yes	Yes	Yes
		Coal – ultra supercritical steam cycle	No	No	0	0	Yes	Yes	Yes	Yes	Yes
		Coal – integrated gasification combined cycle	No	No	0	0	Yes	Yes	Yes	Yes	Yes
		Integrated gasification fuel-cell combined cycle	No	No	0	0	Yes	No	Yes	Yes	Yes
		Coal with CCS	Yes	No	–	–	Yes	Yes	Yes	Yes	Yes
		Gas with CCS	Yes	No	–	–	Yes	Yes	Yes	No	Yes
		Oil with CCS	No	No	–	–	No	No	No	No	No
Deployment	Efficiency	Energy distribution	Yes	Yes	16	7	Yes	Yes	No	Yes	Yes
	Non-renewable	High-efficiency natural gas-fired power generation	Yes	No	0	0	Yes	Yes	No	No	No
		Stationary fuel cells	No	Yes	0	0	Yes	Yes	Yes	Yes	No
Diffusion	Non-renewable	Nuclear	No	No	–	–	Yes	Yes	No	No	Yes
Commercial	Efficiency	Plant efficiency	Yes	No	40	14	Yes	Yes	Yes	Yes	No
	Non-renewable	Fuel switch	Yes	Yes	130[a]	8	Yes	Yes	No	Yes	No

[a] This number includes fuel switching in industrial applications.

Table 19 (continued)

(e) Industry

Stage of maturity	Technology type	Technology application	* TNAs	Convention financial sources GEF	CDM	JI	Technology programmes and IEA implementing agreements Japan	USA	EU	APP	IEA-IA
Demonstration	Emissions controls	CCS	No	No	1	1	Yes	Yes	No	Yes	No
Deployment	Emissions controls	PFCs	No	No	8	1	No	Yes	No	Yes	No
		N_2O	No	No	65	17	No	Yes	No	No	No
		SF_6	No	No	2	0	No	Yes	No	Yes	No
		Fugitive emissions	Yes	No	28	8	No	Yes	No	Yes	No
Diffusion	Efficiency	Energy efficiency	Yes	Yes	168	11	Yes	Yes	No	No	Yes
		Power, heat and fuel recovery	Yes	Yes	363	1	No	Yes	Yes	Yes	Yes
		Material efficiency	Yes	No	0	0	Yes	Yes	No	No	Yes
		Industrial process efficiency	No	No	0	0	Yes	Yes	No	No	Yes
		Furnaces	Yes	Yes	168	11	No	Yes	No	No	Yes
		Boilers	Yes	Yes	168	11	No	Yes	No	No	Yes
		Motors	Yes	Yes	168	11	No	Yes	No	No	Yes
		Fuel switching	Yes	No	130[b]	8	No	No	No	No	Yes
		Feedstock change	No	No	–[c]	0	No	No	No	No	Yes
		Steam system efficiency	Yes	No	168	0	No	No	No	No	Yes
	Emissions controls	HFCs	No	No	22	2	No	Yes	No	Yes	No
		Avoided methane production	No	No	2	12	No	Yes	No	No	No
All stages	Efficiency	Product change	No	No	0	0	No	No	No	No	No

[b] This number includes fossil fuel switch in the energy sector.

[c] No separate category in the CDM database, but two approved consolidated methodologies (ACM0005 and ACM0015).

(f) Residential and commercial buildings

Stage of maturity	Technology type	Technology application	* TNAs	Convention financial sources GEF	CDM	JI	Technology programmes and IEA implementing agreements Japan	USA	EU	APP	IEA-IA
R&D	Building envelope	Ultra-long-term housing	No	No	0	0	Yes	No	No	Yes	No
Demonstration	Building envelope	Advanced air-tight housing/building	–	Yes	0	0	Yes	No	No	No	Yes
Deployment	Building envelope	Structural insulation panels	Yes	Yes	8	0	Yes	Yes	No	No	Yes
		Ceiling insulation	Yes	Yes	8	0	Yes	Yes	No	No	Yes
		Advanced glazing	Yes	Yes	0	0	Yes	Yes	No	No	Yes
		High reflective building materials	No	Yes	0	0	Yes	Yes	No	No	Yes
		Thermal mass	No	Yes	0	0	Yes	Yes	No	Yes	Yes
	Appliances	Biomass-derived liquid fuel stove	Yes	No	0	0	No	No	No	No	No
		Cogeneration/CHP	Yes	No	8	0	No	Yes	Yes	No	Yes
		Efficient space heating	Yes	No	8	0	Yes	Yes	No	No	Yes
		Solar space heating and cooling	No	No	0	0	No	Yes	No	No	No
		In-situ/distributed photovoltaic	Yes	Yes	0	0	Yes	Yes	Yes	No	Yes

Table 19 (f) (continued)

Stage of maturity	Technology type	Technology application	* TNAs	Convention financial sources GEF	CDM	JI	Technology programmes and IEA implementing agreements Japan	USA	EU	APP	IEA-IA
		Air to air heat exchanger	No	No	0	0	No	No	No	No	Yes
		High efficiency lighting	Yes	Yes	9	0	Yes	Yes	No	No	Yes
		Advanced supermarket and office technologies	No	No	0	0	No	Yes	No	No	Yes
		Variable speed drives	No	No	0	0	No	No	No	No	No
		Advanced control systems	No	No	0	0	Yes	Yes	No	No	Yes
		Solar water pumps	Yes	No	0	0	No	No	No	No	No
		High efficiency water pumping	Yes	No	0	0	No	No	No	No	No
		Water-efficient devices	No	No	0	0	No	No	No	No	No
Diffusion	Building envelope	Passive solar heating and cooling	Yes	Yes	0	0	Yes	Yes	No	No	Yes
	Appliances	Heat pumps	Yes	No	0	0	Yes	Yes	No	No	Yes
		Solar cookers	Yes	No	6	0	No	No	No	No	No
		Efficient stoves/ovens	Yes	No	0	0	No	No	No	No	No
		Solar dryers	Yes	No	0	0	No	No	No	No	No
		High efficiency domestic refrigerators	Yes	Yes	0	0	No	No	No	No	No
		Building management systems	No	No	0	0	No	Yes	No	No	Yes
		Social systems	No	No	0	0	Yes	No	No	No	Yes
Commercial	Appliances	Evaporative cooler	Yes	No	0	0	No	No	No	No	Yes
		Solar thermal water heater	Yes	Yes	0	0	No	Yes	Yes	No	Yes
		District heating and cooling system	Yes	Yes	0	0	No	Yes	No	No	Yes
		Efficient air conditioners	Yes	No	0	0	Yes	No	No	No	No
		HC or CO_2 air conditioners	No	No	0	0	No	No	No	No	No
		Wind water pumps	Yes	No	0	0	No	No	No	No	No
		Standby power	No	No	0	0	No	No	No	Yes	Yes

(g) Transportation

Stage of maturity	Technology type	Technology application	* TNAs	Convention financial sources GEF	CDM	JI	Technology programmes and IEA implementing agreements Japan	USA	EU	APP	IEA-IA
R&D	Alternative fuels	Synfuels CCS biomass	No	No	0	0	No	Yes	No	Yes	Yes
	Aviation	Alternative fuels	No	No	0	0	No	No	No	No	No
		Hydrogen	No	No	0	0	Yes	No	Yes	No	Yes
		Biofuels	No	No	0	0	No	No	No	No	No
	Shipping	Alternative fuels	No	No	0	0	No	No	No	No	No
		Renewable energy	No	No	0	0	No	No	No	No	No
		Hydrogen fuel cells	No	No	0	0	Yes	Yes	Yes	No	Yes

Table 19 (g) (continued)

Stage of maturity	Technology type	Technology application	* TNAs	Convention financial sources GEF	CDM	JI	Technology programmes and IEA implementing agreements Japan	USA	EU	APP	IEA-IA
Demonstration	Alternative fuels	Hydrogen fuel cells	Yes	Yes	0	0	Yes	Yes	Yes	Yes	Yes
	Reducing vehicle loads	Lightweight materials	Yes	No	0	0	No	Yes	No	No	No
	Transport systems	Non-motorized transport	Yes	Yes	0	0	No	No	No	No	No
	Aviation	Lightweight materials	No	No	0	0	Yes	Yes	No	No	No
Deployment	Reducing vehicle loads	Aerodynamics	Yes	No	0	0	No	Yes	No	No	No
		Mobile air conditioning	Yes	No	0	0	No	No	No	No	No
	Improved drive train efficiency	Advanced direct injection	Yes	No	0	0	No	No	No	No	No
		Hybrid drive trains	Yes	Yes	0	0	Yes	Yes	No	No	Yes
	Alternative fuels	Biofuels	Yes	No	0	0	Yes	Yes	Yes	Yes	Yes
		Electric vehicles	Yes	Yes	0	0	Yes	Yes	No	No	Yes
	Transport systems	Eco-driving	No	Yes	0	0	No	No	No	No	No
	Rail	Lightweight materials	Yes	No	0	0	Yes	No	No	No	No
	Aviation	Aerodynamics	No	No	0	0	Yes	Yes	No	No	No
		Engine fuel efficiency	No	No	0	0	Yes	Yes	No	No	No
Diffusion	Transport systems	Transport management systems	Yes	Yes	0	0	Yes	Yes	No	No	No
	Intramodal shifts	Freight shifts	Yes	Yes	0	0	Yes	No	No	No	No
		Freight efficiency	Yes	Yes	0	0	Yes	No	No	No	No
	Rail	Aerodynamics	Yes	No	0	0	Yes	No	No	No	No
	Aviation	Air traffic management	No	No	0	0	No	No	No	No	No
	Shipping	Hydrodynamics	No	No	0	0	Yes	No	No	No	No
		Optimal routes/speeds	No	No	0	0	No	No	No	No	No
Commercial	Improved drive-train efficiency	Engine fuel efficiency	Yes	No	0	0	No	No	No	No	No
		Nitrous oxide abatement	No	No	0	0	No	Yes	No	No	No
	Alternative fuels	Natural gas	Yes	Yes	0	0	No	Yes	No	Yes	No
	Road transport – modal shifts	Public transport – bus	Yes	Yes	2	0	No	Yes	No	No	No
	Transport systems	Public transport – rail	Yes	Yes	0	0	Yes	No	No	No	No
	Rail	Aerodynamics	Yes	No	0	0	Yes	No	No	No	No
		Regenerative braking	Yes	No	0	0	Yes	No	No	No	No
	Aviation	Optimal flight speed/paths/altitude	No	No	0	0	No	No	No	No	No
	Shipping	Fleet optimization	No	No	0	0	No	No	No	No	No
	Urban design	Urban design	Yes	Yes	0	0	No	Yes	No	No	No

Table 19 (continued)

(h) Waste management

Stage of maturity	Technology type	Technology application	*	Convention financial sources			Technology programmes and IEA implementing agreements				
			TNAs	GEF	CDM	JI	Japan	USA	EU	APP	IEA-IA
Deployment	Waste to energy	Gasification of municipal solid waste	Yes	No	1	0	No	Yes	–	No	No
	F-gas management	F-gas management	No	No	0	0	No	Yes	–	No	Yes
Diffusion	Methane	Wastewater and sludge treatment	Yes	Yes	429	0	Yes	No	–	No	Yes
	Waste to energy	Composting	Yes	No	0	0	No	No	–	No	No
	Material efficiency	Material efficiency	Yes	No	0	0	Yes	No	–	Yes	No
Commercial	Methane	Landfill methane recovery	Yes	Yes	290	5	Yes	Yes	–	No	Yes
		Landfill methane destruction[d]	No	No	0	0	Yes	No	–	No	Yes
	Waste to energy	Combustion of municipal solid waste	Yes	No	11	0	No	No	–	No	No

[d] Going by its appearance in the TNAs and the number of projects in the CDM, landfill methane recovery, as opposed to destruction, is often the superior technology. However, in locations or for types of waste where recovery is difficult, destruction might be the only solution.

(i) Other

Stage of maturity	Technology application	*	Convention financial sources			Technology programmes and IEA implementing agreements				
		TNAs	GEF	CDM	JI	Japan	USA	EU	APP	IEA-IA
R&D	Ocean storage	No	No	–	–	No	Yes	No	No	No
All stages	Other (earth observation projects, specific monitoring, geo-engineering)	No	No	0	0	Yes	Yes	No	Yes	No

* Technology needs assessments (TNAs) are national assessments enabled and supported through the Convention that identify technology needs in a developing country. They can be used to assist a country in accessing finance; however, they are not sources of finance in themselves.

Abbreviations: APP = Asia-Pacific Partnership on Clean Development and Climate, CCS = carbon dioxide capture and storage, CDM = clean development mechanism, CHP = combined heat and power, EU = European Union, F-gas = fluorinated gas, GEF = Global Environment Facility, HC = hydrocarbons, IEA = International Energy Agency, IEA-IA = International Energy Agency implementing agreements, JI = joint implementation, OTEC = ocean thermal energy conversion, R&D = research and development, REDD = reduced emissions from deforestation and forest degradation in developing countries, TNA = technology needs assessment.

Note: This table indicates whether a technology is included or mentioned in relevant initiatives (TNAs, the GEF and the various programmes and agreements) or, in the case of the CDM and JI, how many projects use the technology.

Annex II

Technologies for adaptation covered by various programmes and mechanisms

Table 20. Technologies for adaptation

(a) Coastal zones

Technology	Technology type	NAPAs	TNA
Restoration of coastal forests and coral reefs	**Traditional/indigenous**	Yes	No
Monitoring coastal and coral erosion		Yes	No
Sand dune restoration and construction		Yes	No
Dykes, dams, levees, nets and dredging		Yes	No
Community-based conservation programmes and aquaculture		Yes	No
Sea walls, revetments and bulkheads		No	Yes
Dykes and gryones		No	Yes
Saltwater intrusion barriers		No	Yes
Tidal barriers		No	Yes
Reef protection		No	Yes
Beach nourishment and dune restoration		No	Yes
Protection and restoration of wetlands		No	Yes
Littoral drift replenishment		No	Yes
Afforestation		No	Yes
Creation of drainage areas		No	Yes
Monitoring coastal and coral erosion	**Modern technology**	Yes	No
Dykes, dams, levees, nets and dredging		Yes	No
Detached breakwaters		No	Yes
Dykes and gryones		No	Yes
Saltwater intrusion barriers		No	Yes
Tidal barriers		No	Yes
Reef protection		No	Yes
Monitoring coastal and coral erosion	**High technology**	Yes	No
Sea level and tide monitoring		No	Yes
Coastal zone monitoring		No	Yes
Impact assessment studies		No	Yes
LiDAR (Light Detection and Ranging)		No	Yes

(b) Energy

Technology	Technology type	NAPAs	TNA
Use of biomass for small-scale energy production	**Traditional/indigenous**	Yes	No
Use of solar energy for small-scale indigenous industrial processes		Yes	No
Unspecified use of renewables		Yes	No
Use of jatropha oil		Yes	No
Use of hydropower	**Modern technology**	Yes	No
Unspecified use of renewables		Yes	No

Table 20 (continued)

(c) Health

Technology	Technology type	NAPAs	TNA
Malaria protection and prevention	**Traditional/indigenous**	Yes	No
Promoting a communications system to inform people of disease		Yes	No
Improved water storage and transportation		No	Yes
Health education		No	Yes
Malaria protection and prevention	**Modern technology**	Yes	No
Monitoring and improving sanitation and water control		Yes	Yes
Improving heath treatment infrastructure		Yes	No
Promoting a communications system to inform people of disease		Yes	No
Database and information centre for climate-related diseases epidemics		Yes	No
Unspecified vector disease control		Yes	Yes
Improved water storage and transportation		No	Yes
Production of biopesticides	**High technology**	Yes	No
Spatial information system for disease monitoring		Yes	No
Improve health treatment infrastructure		Yes	No
Unspecified vector disease control		Yes	Yes
Early warning systems		No	Yes
Medical research		No	Yes
Improvement of collector and drain array and prophylactics		No	Yes

(d) Early warning and forecasting

Technology	Technology type	NAPAs	TNA
Agriculture and food security management system	**Modern technology**	Yes	No
Natural disaster response systems		Yes	No
Improved weather forecasting	**High technology**	Yes	Yes
Early warning system for floods and droughts		Yes	No
Unspecified early warning systems		Yes	No
Unspecified monitoring systems		Yes	No
Improved data gathering		No	Yes
Improved hydrometeorological networks		No	Yes
Improved communications systems		No	Yes
Improved weather prediction tailored to the needs of health systems with regard to heat waves		No	Yes
Early warning system for desertification		No	Yes
Early warning system for famine		No	Yes
Unspecified remote sensing and geographic information system (GIS) use		No	Yes

Table 20 (continued)

(e) Infrastructure

Technology	**Technology type**	**NAPAs**	**TNA**
Improved technical design and construction	**Traditional/indigenous**	No	Yes
Changes in roofing material		No	Yes
Improved levee construction		Yes	Yes
Establishment of building codes		No	Yes
Windmills		No	Yes
Burying electric cables		No	Yes
Improved planning		No	Yes
Use of local non-metallic construction material		Yes	No
Unspecified coastal infrastructure improvement		Yes	No
Unspecified urban infrastructure improvement		Yes	No
Improved technical design and construction	**Modern technology**	No	Yes
Changes in roofing materiel		No	Yes
Improved levee construction		Yes	Yes
Establishment of building codes		No	Yes
Windmills		No	Yes
Rehabilitation and construction of dams and dykes		Yes	No
Rehabilitation of waterways		Yes	No
Construction of water gates		Yes	No
Unspecified coastal infrastructure improvement		Yes	No
Unspecified urban infrastructure improvement		Yes	No
Rehabilitation of multiple use reservoirs		Yes	No
Implementation of communications infrastructure	**High technology**	Yes	No
Rehabilitation and reconstruction of meteorological/climate stations		Yes	No

(f) Terrestrial ecosystems

Technology	**Technology type**	**NAPAs**	**TNA**
Afforestation, replanting and improved silviculture	**Traditional/indigenous**	Yes	No
Watershed restoration and management (unspecified)		Yes	No
Flood zone restoration and creation		Yes	No
Protection and rehabilitation of degraded soil and lands (unspecified)		Yes	No
Forest and brush fire prevention methods		Yes	No
Promotion of agro-farming and forestry in semi-arid landscapes		Yes	No
Lake training	**Modern technology**	Yes	No
Eradication of invasive flora species		Yes	No

(g) Water resources

Technology	**Technology type**	**NAPAs**	**TNA**
Water harvesting	**Traditional/indigenous**	Yes	Yes
Spate irrigation		Yes	No
Control of sand encroachment		Yes	No
Unspecified small-scale irrigation and harvesting for arid areas		Yes	No
Gravity irrigation systems		Yes	No

Table 20 (g) (continued)

Technology	**Technology type**	**NAPAs**	**TNA**
Maintenance and construction of reservoirs and wells		Yes	No
Creation of safety zones and backup devices to control pollution		Yes	No
Capture of water run-off		Yes	Yes
Drip irrigation	**Modern technology**	Yes	No
Installation and maintenance of water pumps		Yes	Yes
Groundwater recharge of wells		Yes	No
Maintenance and construction of reservoirs and wells		Yes	No
Wastewater treatment		Yes	Yes
Establishment, maintenance and improvement of water supply infrastructure		Yes	No
Solar power drilling systems		Yes	No
River training		Yes	No
Registry containing information on protected areas		No	Yes
Additional pumps		Yes	Yes
Sustainable urban drainage systems		No	Yes
Water transfer		No	Yes
Water quality monitoring		Yes	No
Desalinization	**High technology**	No	Yes
Early warning flood systems		No	Yes
Reverse osmosis		No	Yes
Leakage detection systems		No	Yes
Computer simulation of floods		No	Yes
Online, searchable flood risk maps		No	Yes
Diversify and improve aquaculture		Yes	No

(h) Agriculture, livestock and fisheries

Technology	**Technology type**	**NAPAs**	**TNA**
Investigation of new techniques for live bait management	**Traditional/indigenous**	Yes	No
Erosion control		Yes	Yes
Development, use and treatment of fodder crops		Yes	No
Implementation of irrigated crops and cropping techniques		Yes	No
Zero-grazing techniques		Yes	No
Improving grazing and pasturing of livestock		Yes	No
Development of swamps for rice production		Yes	No
Integrated farming practices		Yes	No
Improvement of pluvial zone agriculture (unspecified)		Yes	No
Soil conservation and land improvement		Yes	
Coastal zone protection		Yes	No
Changing cultivars and crop varieties		No	Yes
Improved water distribution networks		No	Yes
Improving cultivation practices		No	Yes
Crop rotation		No	Yes
Bench terracing and contour cropping		No	Yes
Construction of windbreaks		No	Yes
Integrated pest management		No	Yes

Table 20 (h) (continued)

Technology	**Technology type**	**NAPAs**	**TNA**
Dry farming		No	Yes
Diversify and improve aquaculture		Yes	No
Investigation of new techniques for live bait management	**Modern technology**	Yes	No
Food processing and preservation		Yes	No
Development, use and promotion of drought- and heat-resistant crops		Yes	Yes
Implementation of irrigated crops and cropping techniques		Yes	No
Genetic improvement of local bovine species		Yes	No
Unspecified livestock improvement to deal with climate stress		Yes	Yes
Unspecified modernization and diversification of agricultural production		Yes	No
Changing cultivars and crop varieties		No	Yes
Drip irrigation systems		No	Yes
Improved water distribution networks		No	Yes
Pest-resistant crops		No	Yes
Sub-surface dams to use underground water		No	Yes
Research and promotion of saline resistant crops		Yes	No
Improve quality of fishery-related data	**High technology**	Yes	No
Installation of Device for Fish Concentration (DFC) on coastal zones		Yes	No
New navigation technologies for fishing		Yes	No
Development, use and promotion of drought- and heat-resistant crops		Yes	Yes
Changing cultivars and crop varieties		No	Yes
Pest-resistant crops		No	Yes
Networks of early warning systems		No	Yes
Promotion of new rice varieties		No	Yes
Agricultural forecast modelling		No	Yes

Note: This table indicates whether a technology is mentioned or included in national adaptation plans of action (NAPAs) or technology needs assessments (TNAs).

Annex III

Current sources of financing for development of climate technologies

1. This annex develops estimates of financing resources for climate technologies according to source, both under the Convention and outside the Convention. It is not possible to develop estimates for each stage of technological maturity; the stages are grouped into research, development and demonstration, for which the full cost is estimated, and deployment and diffusion, for which the additional costs of the climate technologies are estimated. The estimates are summarized in table 5. The estimates relate to mitigation technologies. Incomplete estimates for current investments in technologies for adaptation can be found in table 6.

A. Research, development and demonstration

2. Currently no funding resources for research, development and demonstration are provided under the Convention.

Sources outside the Convention

Government-funded research and development

3. The amounts budgeted for research and development (R&D) by International Energy Agency (IEA) member countries for four categories of energy technologies during 2002 (the last year with reasonably complete data) are shown in table 21. The data cover energy technologies (including energy efficiency and carbon dioxide capture and storage (CCS)), but not all of the energy technologies reduce greenhouse gas (GHG) emissions. On the other hand, the data do not cover many non-energy mitigation technologies. If the USD 6,354 million for "mitigation technologies" is scaled up to a global total, the amount is USD 7.5 billion in 2002.[1]

Table 21. Amounts budgeted by International Energy Agency members for energy-related research and development in 2002, by category

Category of technologies	Amount (million 2006 USD)	Share of total R&D spending by IEA governments (per cent)
Renewable energy	873	0.49
Clean energy	3 026	1.72
Mitigation technologies	6 354	3.60
Energy R&D	13 721	7.78

Source: Calculated from IEA and United Nations Educational, Scientific and Cultural Organization data.
Abbreviations: IEA = International Energy Agency, R&D = research and development.

4. The amount budgeted by IEA governments for energy-related R&D during recent years – about USD 10 billion – is sometimes used as a proxy for R&D on climate technologies.[2] In chapter IV A 2, government R&D funding for mitigation technologies in 2006 is estimated at USD 6–10 billion, a range that spans the other estimates.

[1] IEA governments account for almost 85 per cent of all government research and development funding.
[2] IEA. 2006. *Energy Policies of IEA Countries: 2006 Review*. Paris: OECD/IEA. This covers all energy R&D in 2006.

International research and development mechanisms

5. International technology coordination mechanisms and programmes have been established to mobilize investments for R&D in many climate technologies.

6. The IEA hosts many international technology coordination programmes, known as Implementation Agreements. These allow member and non-member governments and organizations to collaborate on energy technology research according to an established set of rules. Most of the participants are research institutions and universities; participation by the business sector is limited. The number of participating countries differs depending on the agreement.

7. Other important international coordination mechanisms for climate mitigation technologies include, inter alia:

(a) The Asia-Pacific Partnership on Clean Development and Climate;

(b) The Carbon Sequestration Leadership Forum;

(c) SIMBA, a European Commission project;

(d) The International Railway Research Board;

(e) The Consultative Group on International Agricultural Research;

(f) The International Partnership for the Hydrogen Economy;

(g) The Global Carbon Project;

(h) The Centre for International Forestry Research;

(i) The Livestock Emissions & Abatement Research Network;

(j) The Methane to Markets partnership.

8. These mechanisms coordinate, rather than fund, R&D. They do not have separate funding sources and therefore, even if the figures were available, to tabulate spending under these mechanisms would double count a proportion of government or business financing figures.

Private sector research and development

9. Private funding for research and development on renewable energy and energy efficiency in 2007 was estimated at USD 9.8 billion.[3] The IEA estimates current private sector R&D in energy technologies at USD 40–60 billion.[4] Although this covers energy technologies that reduce GHG emissions – renewables, energy efficiency, nuclear fission and CCS – it also includes R&D for fossil fuel technologies.

10. In chapter IV A 2, R&D for mitigation technologies is estimated at 2 per cent of global R&D. This estimate corresponds to business R&D spending for mitigation technologies of USD 13 billion in 2006. The estimate is also consistent with government R&D spending of USD 6 billion.

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[3] United Nations Environment Programme. 2008. *Global Trends in Sustainable Energy Investment 2007*. Paris: UNEP-SEFI. This covers renewable energy and energy efficiency for 2007 only.

[4] IEA. 2008. *Energy Technology Perspectives 2008*. Paris: IEA. p.169. This figure includes some unspecified demonstration investments.

11. The IEA data in table 21 suggest that mitigation technologies could represent up to 3.6 per cent of total R&D spending, or almost USD 36 billion. About USD 23 billion of that amount would be spent by business and about USD 10 billion by governments.

B. Deployment and diffusion

12. Estimates for the deployment and diffusion stages should be for the additional costs of climate mitigation technologies relative to the existing technologies.

1. Sources under the Convention

Global Environment Facility

13. The Global Environment Facility (GEF) is a financial mechanism under the Convention that has been funding climate change activities since 1991. The allocation of GEF Trust Fund resources to climate change activities is shown in table 22. Most of the resources have been allocated to long-term mitigation projects, including renewable energy, energy efficiency, low-greenhouse gas emitting technologies and sustainable transport. Since the GEF was established, total funding for those projects has amounted to over USD 2.5 billion,[5] or about USD 0.19 billion (in 2007) when the figure is adjusted to remove expenditures for capacity-building and project planning.

Table 22. Allocation of GEF Trust Fund resources to climate change activities
(millions of United States dollars)

	Pilot phase	**GEF 1**	**GEF 2**	**GEF 3**	**GEF 4**	**Total**
OP 5: Energy efficiency	70.6	128.6	200.1	286.7	158.53	844.53
OP 6: Renewable energy	108.8	191.3	251.8	299.2	38.83	889.93
OP 7: Low-GHG-emitting energy technologies	10.1	98.4	98.6	111.1	7	325.2
OP 11: Sustainable transport	0	0	46.4	82.2	60.83	189.43
Enabling activities	20.2	46.5	45.3	73.9	5	190.9
Short-term response measures	70.8	42.2	25.1	3.7	270.19	411.99
SP 5: LULUCF	0	0	0	0	19.6	19.6
Strategic pilot approach to adaptation	0	0	0	25	14.7[a]	39.7
Total	**280.5**	**507**	**667.3**	**881.8**	**304.49**	**2641.09**

Sources: UNFCCC. 2007. *Investment and Financial Flows to Address Climate Change,* Bonn: UNFCCC; and the GEF secretariat.
Abbreviations: GEF = Global Environment Facility, GEF 1 = GEF first replenishment, GHG = greenhouse gas, LULUCF = land use, land-use change and forestry, OP = operational programme, SP = strategic programme.
[a] This sum does not include co-contributions of USD 43.3 million from other GEF programmes.

14. The GEF funds only part of the cost of a project. The rest of the cost is funded by other sources including international agencies such as the United Nations Development Programme, international financial institutions such as the World Bank, national governments, and other public and private entities in the recipient country. The GEF reports these additional funds as leveraged financing. The financing leveraged by GEF for mitigation projects has averaged USD 1.15 billion per year and amounted to USD 1.5 billion in 2007. This represents the total cost of the projects, not the additional cost of the mitigation technologies.

15. Adaptation activities are funded by the GEF Trust Fund strategic pilot approach to adaptation, the Special Climate Change Fund programme for adaptation and the Least Developed Countries Fund.

[5] This figure includes capacity-building and funding for initiatives that are not technology-specific.

Since 2005 about USD 79.1 million has been allocated to adaptation projects, including USD 12 million for the preparation of national adaptation programmes of action. Most of the funding for adaptation has been allocated to the agriculture, forestry, water supply and coastal zone sectors in Africa, Asia, Latin America and the Caribbean. Investment in technologies for adaptation in each sector and region has the effect of increasing the learning rates for these technologies and reducing the cost for subsequent applications.

Adaptation Fund

16. The Adaptation Fund, financed by a levy of 2 per cent of the certified emission reductions (CERs) issued for most clean development mechanism (CDM) projects, is just becoming operational. It will support technologies for adaptation and will increase the deployment of technologies for adaptation. It could have USD 80–300 million per year at its disposal for adaptation projects and programmes in developing countries during 2008–2012, including investments in technologies for adaptation. After 2012 the Adaptation Fund will depend on the continuation of the CDM, the possible extension of the levy to other mechanisms, and the level of demand in the carbon market.

The clean development mechanism

17. The CDM enables a project to reduce GHG emissions in a Party not included in Annex I to the Convention to earn CERs. These CERs can be used by Parties to the Convention that are also Parties to the Kyoto Protocol with commitments inscribed in Annex B to the Kyoto Protocol (Annex B Parties) to meet their national emissions limitation commitments. Most domestic emissions trading systems allow participating firms to use CERs toward compliance.

18. At the end of 2008, there were 4,364 projects in the CDM pipeline, including 1,300 registered projects.[6] These projects are forecast to reduce emissions by 596 million tonnes of carbon dioxide equivalent (Mt CO_2 eq) per year. The total amount invested in registered CDM projects in 2006 was a little over USD 4.5 billion.[7] The amount that has been, or will be, invested in projects that entered the pipeline by the end of 2006 was almost USD 37 billion and the amount for all projects in the pipeline as of June 2008 was almost USD 95 billion.[8]

19. Almost all CDM projects involve technologies in the deployment, diffusion and commercially mature stages of development. Only the costs in excess of the existing technology are considered as technology development costs. These incremental costs should be less than the value of the CERs. The estimated value of the CERs for the projects in each category – either in the pipeline or registered – is shown in table 23. It was calculated as the projected annual emission reductions for those projects multiplied by the average price during the year. For registered projects the value is split between the CERs issued and the remaining reductions.

[6] Fenhann J. 2008. Overview of the CDM Pipeline (Excel sheet). Available at <http://cdmpipeline.org/publications/CDMpipeline.xls>. As part of the validation process, the project design document of a proposed project must be posted for public comment. A project that has reached this stage is said to be in the CDM pipeline.

[7] Seres S. 2008. *Analysis of Technology Transfer in CDM Projects*. Bonn: UNFCCC. p.17, figure 6.

[8] About 30 per cent of the projects have been registered, suggesting an investment of USD 11 billion (30 per cent of USD 37 billion) compared with the estimated investment of USD 4.5 billion. This is because many early projects, such as hydrofluorocarbon destruction, had low capital costs compared with the more recent wind power and hydropower projects.

Table 23. Estimated revenue for projected emission reductions and total investment in clean development mechanism projects by year

Year ending December 31[a]	Average price USD/t CO_2 eq[b]	Estimated revenue for projected annual emission reductions (millions of USD)				Total investment projected for projects that entered the pipeline during the year (millions of USD)
		Registered projects		Other projects in the pipeline	Total revenue for projected annual emission reductions by all CDM projects in the pipeline	
		Revenue for issued CERs	Revenue for projected reductions	Revenue for projected reductions		
2003	4.55	0	0	25	25	133
2004	5.63	0	2	62	64	867
2005	7.51	0	214	788	1 002	9 854
2006	10.90	262	909	2 715	3 886	26 087
2007	13.60	1 284	1 293	5 816	8 393	45 920

Abbreviations: CDM = clean development mechanism, CER = certified emission reduction.
[a] Excludes projects that were rejected or withdrawn by 30 June 2008.
[b] World Bank, *State and Trends of the Carbon Market*, various issues.

20. The financing provided for deployment and diffusion of mitigation technologies by the CDM is taken to be the market value of the emission reductions by CDM projects during 2006 or 2007 (USD 4–8 billion). The market value of the emission reductions should be higher than the additional cost of the technologies or the projects would not proceed. These data suggest that the additional cost is 10 to 20 per cent of the total investment.

Joint implementation

21. Joint implementation (JI) enables a project to mitigate climate change in an Annex B Party to generate emission reduction units that can be used by another Annex B Party to help meet its emission limitation commitment. Projects can be implemented under rules established by the host country (Track 1) or international rules administered by the Joint Implementation Supervisory Committee (Track 2). At the end of 2008 there were 190 JI projects in the pipeline, including 30 registered projects, with expected annual emission reductions of 70 Mt CO_2 eq.[9] The estimated revenue for projected annual emission reductions is USD 98 million for 2006 and USD 418 million for 2007. Based on these estimates, the financing provided for deployment and diffusion of mitigation technologies by JI is taken to be USD 0.5 billion or less.

2. Sources outside the Convention

Export credit agencies

22. Export credit agencies (ECAs) are organizations that have a government mandate to support and expand trade in domestic goods and services. According to the Organisation for Economic Co-operation and Development (OECD), ECAs provided finance worth USD 649 billion in 2003.[10] Based on the OECD data, the secretariat estimated that ECAs provided long-term credits (i.e. longer than five years) of

[9] Fenhann J. 2008. Overview of the JI Pipeline (Excel sheet). Available at <http://cdmpipeline.org/publications/JIpipeline.xls>. The total includes 25 Track 1 projects (9 Mt CO_2 eq) and 165 Track 2 projects (62 Mt CO_2 eq).
[10] Organisation for Economic Co-operation and Development (OECD). 2004 [and subsequent years]. *Statistics on Export Credit Activities*. Paris: OECD.

USD 11.7 billion to developing countries.[11] Total climate-related finance amounted to USD 9.9 billion, USD 1.8 billion (about 15 per cent) of which was for mitigation technologies and technologies for adaptation in developing countries.[12]

23. The most recently available OECD data for ECA investments by technology and industry are for 2004–2005. Total long-term export credits for 2004 and 2005 were USD 29.7 billion and USD 32.4 billion, respectively, of which USD 12.1 billion and USD 14.4 billion, respectively, was provided to developing countries. Renewable energy accounted for 1.1 per cent of the total in 2004 and 1.4 per cent in 2005, with nuclear power plants representing another 0.5 per cent in 2005. Therefore, the total is estimated at less than USD 2 billion per year.

24. The financing provided by ECAs for deployment and diffusion of mitigation technologies in developing countries is taken to be approximately 15 per cent of the long-term credits of USD 12.1–14.4 billion provided to developing countries, or USD 1–2 billion. This represents total investment; the incremental financing for mitigation technologies is likely to be less than USD 1 billion per year.

Official development assistance

25. The 2008 Global Development Finance Report indicates that official development assistance (ODA) disbursements (excluding debt relief) increased from 0.23 per cent of donors' gross national income (GNI) in 2002 to 0.25 per cent in 2007.[13] This, however, is well below the 0.33 per cent attained in the early 1990s. Existing commitments by donors imply that ODA will increase to 0.35 per cent of their GNI by 2010, only half of the United Nations target of 0.7 per cent for ODA.

26. Information on ODA investments in mitigation technologies and technologies for adaptation is limited. In 2005, bilateral ODA investments by OECD countries in renewable energy and energy efficiency in developing countries totalled just under USD 2 billion. It is assumed that ODA covered only the incremental cost of those investments and hence this represents bilateral ODA funding for deployment and diffusion of those technologies.

Multilateral development banks

27. Multilateral development banks (MDBs) aim to alleviate poverty and support sustainable development through lending, grants, and country-assistance strategies for infrastructure projects and policy reform activities in their developing-country members. While MDBs provide grants and loans for mitigation technologies and technologies for adaptation, precise figures are currently not available.

28. Investments in renewable energy and energy efficiency by the World Bank totalled USD 2.25 billion in 2008, approximately USD 1 billion of which was for large-scale hydropower projects.[14] The World Bank accounts for about 70 per cent of total MDB concessional financing,[15] so the total investment by MDBs is of the order of USD 1–3 billion. It is assumed that grants and loans from MDBs cover only the incremental cost of mitigation investments and hence this amount is the multilateral ODA funding for deployment and diffusion of mitigation technologies.

29. The Climate Investment Funds established in 2008 will result in USD 6.1 billion being invested in technologies for mitigation and adaptation in 2009–2012.

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[11] FCCC/SBI/2005/INF.7.

[12] USD 1.8 billion for mitigation technologies and technologies for adaptation in developing countries as a percentage of USD 11.7 billion of long-term credits for developing countries.

[13] World Bank. 2008. *Global Development Finance 2008*. Washington, D.C.: World Bank.

[14] These figures exclude carbon finance (CDM and JI projects) and co-funding for GEF projects.

[15] OECD. 2007. *2006 Development Co-operation Report*. Volume 8, No. 1. Paris: OECD. p.174, Statistical Appendix table 17.

Philanthropic sources

30. Numerous charitable foundations, non-governmental organizations and other entities provide financial support for mitigation technologies and technologies for adaptation in developing countries, both directly and through implementation of projects to generate emission reduction credits for sale on the voluntary carbon market. The additional support provided by such groups is arbitrarily estimated at approximately USD 1 billion, since the support is likely to be less than that provided by bilateral or multilateral ODA.

Private sources

31. The United Nations Environment Programme reports private investment in energy efficiency and low carbon technologies during 2007 as USD 79.8–148 billion.[16] The estimates are the full investment cost rather than the additional cost. They cover only investments in the energy sector and may include some public financing, but not all energy efficiency and low-carbon technology investments are included. These estimates are 1.7–3.2 per cent of total corporate investment of USD 4,649 billion in 2005.[17]

32. Private investment in clean energy has increased rapidly from USD 33.2 billion in 2004 to USD 148 billion in 2007 and asset financing (i.e. investment in new renewable energy, energy efficiency and low-carbon energy technology assets) has increased from USD 12.4 billion in 2004 to USD 84.5 billion in 2007.[18] Private investment in clean energy in developing countries has also grown rapidly, reaching USD 22.3 billion in 2007.[19] This compares well with the estimated investment in CDM projects in 2007 of USD 10–25 billion.[20]

33. Foreign direct investment (FDI) constitutes a substantial share of private investment in developed and, to a lesser extent, developing countries. FDI inflows for new facilities during 2005 amounted to USD 1,736 billion: USD 1,541 billion for developed countries and USD 195 billion for developing countries.[21]

34. FDI relevant to climate change will typically be in the form of greenfield investments by transnational corporations (TNCs).[22] During 2003–2007, there were 383 alternative and/or renewable energy and recycling projects by TNCs in developed countries and 210 in developing countries, out of a total of 54,000 greenfield investment projects. If it is assumed that the greenfield projects account for all FDI inflows for new facilities then FDI investment in mitigation projects during 2005 was about USD 12 billion in developed countries and almost USD 7 billion in developing countries.[23]

35. These estimates of FDI for mitigation projects appear consistent with the estimates of the total investment in such projects; USD 12 billion out of USD 57.5–125.7 billion for developed countries and USD 7 billion out of USD 10–25 billion for developing countries.

36. All of these amounts represent the total investment. Information for the GEF and the CDM suggests that the additional cost is, respectively, 14 per cent and 10–20 per cent of the total; hence the additional private costs are estimated at 15 per cent of the total.

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[16] UNEP. 2008. *Public Finance Instruments for Climate Mitigation: Options Document*. Paris: UNEP-SEFI.
[17] UNFCCC. 2007. *Investment and Financial Flows to Address Climate Change*. Bonn: UNFCCC. p.31, table III-3.
[18] UNEP, *Public Finance Instruments for Climate Mitigation*.
[19] UNEP, *Public Finance Instruments for Climate Mitigation*.
[20] Haites E. 2007. *Carbon Markets*. Bonn: UNFCCC. This figure represents the total investment in the projects. The value of the CERs – USD 4–8 billion – is the additional financing; this suggests that the additional financing is 30–40 per cent of the total.
[21] UNFCCC, *Investment and Financial Flows to Address Climate Change*, pp.212–213, annex V, table 3.
[22] FCCC/TP/2008/7, p.63.
[23] 383/54000 (developed countries) and 210/54000 (developing countries) times USD 1,736 billion respectively.

National governments

37. Three estimates of financial support by national governments in developed countries for deployment of technologies range between USD 30–45 billion per year.[24]

[24] Stern N. 2007. *The Economics of Climate Change: The Stern Review*. Cambridge: Cambridge University Press. p.347; Doornbosch R, Gielen D and Koutstaal P. 2008. *Mobilising Investments in Low-Emission Energy Technologies on the Scale Needed to Reduce the Risks of Climate Change*. Paris: OECD. p.5; and UNFCCC, *Investment and Financial Flows to Address Climate Change*, p.7.

Annex IV

Summary of initiatives proposed by the United Nations Environment Programme for an international technology transfer programme

Table 24. Summary of initiatives proposed by the United Nations Environment Programme for an international technology transfer programme

Initiative		Scope	Funding required and proposed activities
Focus area 1: Policy	1. Climate policy support	Help governments resolve specific issues related to the design and implementation of climate and sustainable energy policies and programmes	USD 50 million Support 100 policies
	2. National cleaner energy technology plans	Prepare comprehensive national technology plans that provide the basis for the systematic removal of barriers needed to develop markets for prioritized technologies	USD 100 million Develop national plans for 100 countries
	3. Improving energy subsidy frameworks	Provide institutional and financial support to governments willing to test out changes in energy subsidy regimes in favour of climate-mitigation technologies	USD 200 million Remove 50 perverse subsidies
	4. Financial innovation support facility	Help first-mover financial institutions develop new financial products, move up the learning curve and reduce the high transaction costs of initial climate sector commitments	USD 50 million Launch 100 financial products
Focus area 2: Networking	5. Regional climate change networks	Operate regional networks of climate change officials that provide a means for sharing knowledge, exchanging information and experience, and accelerating technology transfer through cooperative regional efforts	USD 40 million Establish 10 networks, covering 147 countries
	6. National cleaner energy technology centres	Establish national centres of excellence in clean energy technology, building on existing energy agencies or other suitable institutions	USD 100 million Establish centres in 100 countries
Focus area 3: Finance	7. SME (small and medium-sized enterprise) finance facility	Facilitate the scale-up of seed financing and later-stage bank financing to climate entrepreneurs	USD 100 million Launch 200 SMEs
	8. Risk mitigation facility	Establish fund guarantee programmes to share market and technology risks, targeting the mobilization through local commercial banks of domestic lending for climate projects	USD 200 million USD 2 billion in domestic lending across 15 new climate technology markets

Table 24 (continued)

Initiative		Scope	Funding required and proposed activities
	9. Least-developed country credit facility for climate infrastructure	Provide affordable long-term financing on concessional terms for low-carbon infrastructure projects	USD 500 million Finance USD 2 billion in 10 countries
	10. End-user finance facility	Help the domestic banking community to begin financing the uptake of cleaner technology amongst households and small business	USD 200 million Create 50 lending sectors, benefiting 20 million people
	11. Carbon finance facility	Facilitate first-of-a-kind carbon transactions based on new methodologies and approaches	USD 50 million Serve 200 projects
	12. Incentive facility for first movers in industry	Provision of targeted support for first-movers investing in cleaner energy technologies through financial assistance and information, which can help reduce transaction costs	USD 200 million 20 different technologies in 50 countries
Focus area 4: technology	13. Regional technology market assessments	Creation of technology platforms to scale-up the uptake of cleaner energy technologies at the regional level in key areas such as energy-using devices, energy intensive industries or fossil-fuel power generation	USD 80 million Establish 4 platforms, covering 10 subregions
	14. Energy efficiency standards and labels	Development of standards and norms for selected products and strengthening of national and regional capacities to adopt, implement and enforce a range of product standard programmes	75 million 5 product standard programmes in 100 countries
		Total	**USD 1.9 billion**

Source: Submission from the United Nations Environment Programme under the Bali Action Plan – Technology <http://unfccc.int/resource/docs/2008/smsn/igo/027.pdf>.
Note: The implementation period for each initiative is five years.

Annex V

The roles of vehicles, entities and actors involved in the provision of financing

Vehicle, entity or actor	Role
Angel or seed investor	Typically, angel investors are affluent individuals who invest in early stage technologies and start-up companies in return for (convertible) ownership equity. Like venture capital investors, angel investors do invest in high risk enterprises – but they do not usually pool their assets and tend to select investments based on a combination of idealistic and financial motives.
Incubator	A business incubator is an organizational structure aimed at providing targeted services for business start-ups. Services include assistance in commerce and marketing, training in presentation skills and other areas, and providing access to expert networks.
Venture capitalist	Venture capital investors are active, high-risk investors that provide equity to high potential, high growth start-up companies in the interest of generating a return through an event such as an initial public offering or a sale of the company. Venture capital funds pool investments and assets and are actively involved in a managerial or advisory role.
Project developer	A project developer organizes the various aspects of a project, such as planning, information exchange, arranging finance, performing technology assessments and managing the project. A project developer is typically the representative to the financial sector.
Project sponsor	The lead entity or actor financing the development of, and taking overall responsibility for, the project. The extent to which a sponsor is actively involved in the operational choices made by the company varies.
Private equity investor	A private equity investor provides higher risk capital to companies that are not publicly traded on a stock exchange. Private equity investment can involve different types of asset, from high-risk seed capital to convertible bonds and mezzanine debt. Private equity investors tend to invest in starting companies with a high risk and high return potential profile.
Subordinated lender	A subordinated loan refers to a loan that is serviced after normal (senior) debt but typically before any equity asset. In the event of a result pay-out or bankruptcy, normal debt has priority over subordinated debt. Mezzanine debt is an example of a subordinated loan.
Senior lender	Senior lenders provide debt with a relatively high certainty of servicing and repayment. Senior debt is a high priority for repayment in cases of liquidation and is often covered by collateral.
Credit guarantee agency	An entity whose main objective is to assist companies that have no track record or inadequate collateral in obtaining credit from financial institutions by providing guarantees to such institutions.
Insurer	A commercial party whose business it is to insure against risk of contingent loss, for example loss of income or productive assets. The insurer requires a premium for the transfer of the risk.

Vehicle, entity or actor	**Role**
Credit line provider	A credit line is a facility from which a (start-up) company can extract loans to prevent liquidity problems. Credit lines are not normally secured by collateral, but they are bound to a certain period of time.
Grant issuer	Grants are monetary gifts or donations, usually provided by a government, trust or foundation. Grants are typically issued for individual projects or in reply to a request for proposal in which the eligibility conditions are presented.
Technology incubator	Technology incubators are public or private institutions that support the entrepreneurial process, helping to increase survival rates for innovative start-up companies and the technologies that they are developing. Entrepreneurs and technology developers with feasible projects are selected and admitted into the incubator, where they are offered resources and support services.
Soft loan	Financing that offers flexible or lenient terms for repayment, usually at lower than market interest rates. Soft loans are usually provided by government agencies and not by financial institutions. Also called concessional funding.
Mezzanine finance	Non-conventional funding that shares characteristics of both debt and equity. It comprises equity-based options (such as warrants) and lower priority (subordinate) debt, and is commonly used in financing acquisitions and buyouts. Also called mezzanine debt or bridging finance.

Annex VI

Options for raising revenue to finance technology development and transfer activities under the Convention

Table 25. Options for raising revenue to finance technology development and transfer activities under the Convention

(*billions of United States dollars*)

Proposal	Source of funding	Purpose	Notes	Nominal annual level of funding
Increasing the scale of existing mechanisms				
European Union	Continue 2 per cent levy on SoP from CDM	A	Ranging from low to high demand in 2020	0.2–0.68
Bangladesh, Pakistan	3–5 per cent levy on SoP from CDM	A	Ranging from low to high demand in 2020	0.3–1.7
Many Parties	CDM and other crediting mechanism	M	In 2020	10–34
Defined budgetary contributions from developed countries				
Group of 77 and China	0.5–1 per cent of GNP of Annex I Parties[a]	A, M	Calculated for 2007 GDP	201–402
Contributions raised through market-based mechanisms and taxation				
Mexico	Contributions based on GDP, GHG and population and possibly auctioning permits in developed countries	A, M	Initial phase	10
Norway	2 per cent auctioning of AAUs	A	Annually	15–25
Switzerland	2 USD per t CO_2 with a basic tax exemption of 1.5 t CO_2 eq per inhabitant	A	Annually	18.4
Republic of Korea	Crediting NAMAs	M		Uncertain
Colombia, LDCs	2 per cent levy on SoP from joint implementation and emissions trading	A	Annually, after 2012	0.03–2.25
LDCs	Levy on international air travel (IATAL)	A, M	Annually	4–10
LDCs	Levy on bunker fuels (IMERS)	A	Annually	4–15
Tuvalu	Auction of allowances for international aviation and marine emissions	A, M	Annually	28

Sources: FCCC/AWGLCA/2008/16/Rev.1; FCCC/TP/2008/6; Müller B. 2008. *International Adaptation Funding. The Need For An Innovative and Strategic Approach*. Oxford: Oxford Institute for Energy Studies; and UNFCCC. 2007. *Investment and Financial Flows to Address Climate Change*. Bonn: UNFCCC.

Abbreviations: A = adaptation, AAU = assigned amount unit, CDM = clean development mechanism, GDP = gross domestic product, GHG = greenhouse gas, GNP = gross national product, IATAL = International Air Travel Adaptation Levy, IMERS = International Maritime Emission Reduction Scheme, LDCs = least developed countries, M = mitigation, NAMAs = nationally appropriate mitigation actions, SoP = share of proceeds.

[a] Owing to a lack of information on GNP, potential funding was calculated using GDP.

Annex VII

Summary of proposals by Parties for enhancing technology development and transfer under the Convention

Table 26. Summary of proposals by Parties for enhancing technology development and transfer under the Convention[a]

Type of measure	Proposal	Financial means	Parties	Detailed proposal
Funds under the Convention	Streamline existing funding mechanisms	Not applicable	Several	FCCC/AWGLCA/2008/MISC.2 and FCCC/AWGLCA/2008/CRP.2
	Scale up support for existing mechanisms	Voluntary contributions from Annex II Parties	EC[b]	To be considered as part of review of the financial mechanism of the Convention
	Resource all developing countries to develop national adaptation action plans or programmes	Not specified	Bangladesh, Cook Islands, Gambia, Slovenia, United States of America	Not available
	Convention adaptation fund	Not specified	AOSIS, China	Dialogue working paper 14 (2007)
	Renewable energy technology fund	Not specified	AOSIS	Dialogue working paper 14 (2007)
	World climate change fund – mitigation, adaptation, technology cooperation	Through financial contributions from developed and developing countries based on a formula (emissions, population, GDP)	Mexico	FCCC/AWGLCA/2008/MISC.2
	Multilateral technology acquisition/ cooperation fund under the Convention: o Disseminate existing technologies; o Purchase licences of patented technologies; o Provide incentives to the private sector; o Support international cooperation on research and development; o Support venture capital based on a public–private partnership; o Remove barriers	Percentage of GDP from developed countries in addition to ODA	Brazil, China, Ghana, Mexico	<http://unfccc.meta-fusion.com/kongresse/SB28/downl/080603_SB28_China.pdf>

Table 26 (continued)

Type of measure	Proposal	Financial means	Parties	Detailed proposal
	Create new financial architecture under the Convention with funds for technology acquisition, technology transfer, venture capital for emerging technologies, and collaborative climate research fund	Not specified	India	Not available
	Establish a multilateral fund to provide positive incentives to scale up development and transfer of technology and support innovating funding and incentives to reward development and transfer of technology	Not specified	Summary from the AWG-LCA Chair	FCCC/AWGLCA/2008/CRP.2
Risk management	International insurance mechanism	Not specified	Bangladesh, China, AOSIS; also addressed in Swiss proposal below	FCCC/AWGLCA/2008/MISC.1
Governance and coordination	Network of regional adaptation centres to support regional cooperation and knowledge sharing	Not specified	Bangladesh, China, Cook Islands	Not available
	Framework for action on adaptation to delineate the responsibilities of developing and developed countries	Not applicable	EC	Submission from the EC on BAP, paragraph 1. See FCCC/AWGLCA/2008/MISC.2
	Climate change adaptation committee under the Convention	Contributions from Annex II Parties	China	Proposal outline presented: aims and functions of the Committee
	Coordinating body for technologies for adaptation	Contributions from Annex II Parties	Cook Islands	
	New financial architecture under the Convention (see also India's proposal for specific funds under this new architecture outlined above)	Contributions from Annex II Parties	India	
	Establish a new overarching international mechanism or enhanced framework	Contributions from Annex II Parties	Summary from the AWG-LCA Chair	FCCC/AWGLCA/2008/CRP.2

Table 26 (continued)

Type of measure	Proposal	Financial means	Parties	Detailed proposal
	An enhanced institutional mechanism will address all aspects of cooperation on technology research, development, diffusion and transfer in accordance with Articles 4.1(c), 4.3, 4.5 and other relevant Articles of the Convention, in order to enable mitigation and adaptation under the relevant paragraphs of decision 1/CP.13. The mechanism comprises an executive body and a multilateral climate technology fund operating under the Conference of the Parties	Contributions from Annex II Parties	Group of 77 and China	See submissions from Group of 77 and China in FCCC/AWGLCA/2008/MISC.5
	An effective institutional and organizational arrangement coordinating, supporting, enabling and managing the activities related to technology, including the recognition of activities and commitments undertaken by Parties and other actors, both within and outside the Convention	Contributions from Annex II Parties	EC	See submission from EC in FCCC/AWGLCA/2008/MISC.2
	Scale up technology cooperation by enhancing international cooperation on research and development of specific technologies, multilateral cooperation on the deployment of sector-specific technology, and establishing joint ventures to accelerate the diffusion and transfer of technology	Contributions from Annex II Parties	Barbados, Brazil, EC, Ghana, Japan	See submission from Japan in FCCC/AWGLCA/2008/MISC.2
	International mechanism could be put in place to create additional value and crediting for participation in technology development, deployment, diffusion and transfer	Contributions from Annex II Parties	Ghana	See submission from Ghana in FCCC/AWGLCA/2008/MISC.2/Add.1
	o Developing regulatory frameworks for technology agreements in different sectors; o Structures and funding for improved research, development and demonstration of key technologies		EC	Presentation at the technology workshop at the second session of the AWG-LCA <http://unfccc.int/files/meetings/ ad_hoc_working_groups/lca/application/ pdf/eu_pres-08-06-02-awglca2_technology.pdf>

Table 26 (continued)

Type of measure	Proposal	Financial means	Parties	Detailed proposal
	Accelerated research and development of technology by: o Enhancing networks between centres of excellence and strengthening research in the public domain; o Working in collaboration and jointly owning the resulting IPRs. Accelerating transfer and diffusion through a global financial arrangement	Contributions from Annex II Parties	India	Not available
Market mechanisms	Incentives to reward and credit the development and transfer of technologies	Not specified	EC, Ghana, Republic of Korea	FCCC/AWGLCA/2008/MISC.2
	Sectoral technology-oriented agreements (priority for steel production, coal-fired power plants, cement and road transportation)	Credits for reductions significantly below the baseline within a sector. Credits could be a separate currency generated through a new mechanism or an extension of the CDM	Japan, EU	FCCC/AWGLCA/2008/MISC.2
	Adaptation finance	Adaptation financed through auctioning a share of AAUs of all Annex I Parties	Norway	FCCC/AWGLCA/2008/MISC.2
	Credits for implementing nationally appropriate mitigation actions	Market mechanism driven by stronger commitments from Annex I Parties	Republic of Korea	FCCC/AWGLCA/2008/MISC.2
	Multilateral fund for adaptation and insurance and national climate change funds (the levy would be raised by national governments and divided between national funds, and contributions to the multilateral fund for adaptation)	Global carbon tax (with exemptions for countries with annual per capita emissions of less than 1.5 tonnes of carbon dioxide)	Switzerland	Schwank O and Mauch S. 2008, *Global Solidarity in Financing Adaptation: A Swiss Proposal for a Funding Scheme* (discussion draft). Bern: Federal Office for the Environment
	Levy – international air travel adaptation levy. Charge applied to international air fares based on emissions for the flight	Levy on international air travel	-	Limited information in FCCC/AWGLCA/2008/MISC.2 and Müller B and Hepburn C. 2006. *IATAL — An Outline Proposal For an International Air Travel Adaptation Levy*. Oxford: Oxford Institute for Energy Studies

Table 26 (continued)

Type of measure	Proposal	Financial means	Parties	Detailed proposal
	Levy – share of proceeds applied to other mechanisms. Can be applied to international transfers of AAUs, ERUs or RMUs, or can be applied to quantities of AAUs and RMUs issued (ERUs are exempt because they are converted AAUs which have already been levied.) The latter approach is basically the same as the Norwegian proposal to auction a share of the AAUs	Extension of the share of proceeds (from the CDM to the Adaptation Fund) to other mechanisms	Several	Submission from Mexico in FCCC/AWGLCA/2008/MISC.2
	Levy – International Maritime Emission Reduction Scheme. A fee is levied on maritime fuel use. The revenue is used to buy CERs for emissions in excess of the baseline and to contribute to an adaptation fund	Levy on bunker fuels	Supported by Norway at IMO meeting	Andre Stochinol <www.imers.org>
	Auction of allowances for international aviation and marine emissions	Auction of allowances		UNFCCC. 2007. *Investment and Financial Flows to Address Climate Change*. Bonn: UNFCCC
Monitoring, reporting and verification	Performance assessment and monitoring the speed and range of technology flow and cost-effectiveness of resulting emissions reductions	-	-	Not available
Enhancing dialogue between Parties and the private sector	Round table at COP 14 to discuss innovative policy approaches to manage and share risk and technology cooperation	-	Canada	Referred to in FCCC/AWGLCA/2008/MISC.2. Proposal not available

Abbreviations: AAU = assigned amount unit, Annex II Parties = Parties included in Annex II to the Convention, AOSIS = Alliance of Small Island States, AWG-LCA = Ad Hoc Working Group on Long-term Cooperative Action under the Convention, BAP = Bali Action Plan (decision 1/CP.13), CDM = clean development mechanism, COP 14 = the fourteenth session of the Conference of the Parties, EC = European Community, ERU = emission reduction unit, GDP = gross domestic product, IMO = International Maritime Organization, IPRs = intellectual property rights, ODA = official development assistance, RMU = removal unit.

[a] Proposals submitted by Parties by 30 September 2008 were included.

[b] The European Commission is the official title of the European Union as recorded in the Annexes to the Convention.