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Item 4 of the provisional agenda
Development and transfer of technologies

SUBSIDIARY BODY FOR IMPLEMENTATION
Twenty-ninth session
Poznan, 1–10 December 2008

Item 7 of the provisional agenda
Development and transfer of technologies

Identifying, analysing and assessing existing and potential new financing resources and relevant vehicles to support the development, deployment, diffusion and transfer of environmentally sound technologies

Interim report by the Chair of the Expert Group on Technology Transfer

Summary

This document presents the results of the work on financing options for the development and transfer of technologies completed by the Expert Group on Technology Transfer by 31 October 2008. It presents the current situation on financing technology transfer by stages of technological maturity (research and development, demonstration, deployment and diffusion), by specific technologies and by sources (under and outside the Convention). It also summarizes up-to-date estimations of additional financing needs to scale up technology transfer from various sources and gives a number of insights on barriers to financing technology transfer.

The report provides information only on financing mitigation technologies; the work on financing technologies for adaptation will be presented in the final report to be completed by the thirtieth session of the subsidiary bodies.

CONTENTS

I. Introduction

A. Mandate and background

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 identification and analysis, 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 these resources.

2. The Subsidiary Body for Scientific and Technological Advice (SBSTA), at its twenty-eighth session, endorsed the terms of reference for the EGTT for identifying, analysing and assessing existing and potential new financing resources and relevant vehicles in supporting the development, deployment, diffusion and transfer of environmentally sound technologies in developing countries.[1]

3. As requested by the terms of the reference mentioned in paragraph 2 above, the work was divided into the following tasks:

(a) Task I: identify and analyse existing and potential new financing resources and relevant vehicles in supporting the development, deployment, diffusion and transfer of technologies for mitigation and adaptation in developing countries;

(b) Task II: identify and assess gaps in and barriers to the use of and access to these financing resources;

(c) Task III: prepare recommendations on future financing options and risk mitigation tools within the framework for meaningful and effective actions to enhance the implementation of Article 4, paragraph 5, of the Convention (hereafter referred to as the technology transfer framework).

4. A background paper is to be prepared on each task. Drafts of the first two background papers on tasks I and II are to be completed prior to the fourteenth session of the COP. The background paper on task III is to be completed by January 2009. The final report is to be completed by March 2009.

B. Scope of the interim report

5. This interim report presents the results of the work completed by the EGTT by 31 October 2008. The activities include:

(a) Establishing, with support from the secretariat, an international team with expertise in adaptation and mitigation technology issues as well as financing development and transfer of climate-friendly technologies, representing both developing and developed countries. This team has served as technical reviewers and authored related papers;

(b) Developing a methodological approach for tasks I and II referred to in paragraph 3 above;

[1] FCCC/SBSTA/2008/INF.2, annex II.

(c) Reviewing existing financial flows and their contribution to development and transfer of technologies and compiling existing data on technology and finance.

6. Some figures and numbers presented in this interim report may be revised in the final report because the work will be ongoing until the thirtieth sessions of the subsidiary bodies.

7. In parallel to this work, an update of the technical paper on investment and financial flows to address climate change[2] is under preparation by the secretariat for consideration at the fourth session of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention (AWG-LCA). The technical paper will include a chapter on financial support to technology cooperation, which also contains relevant information.

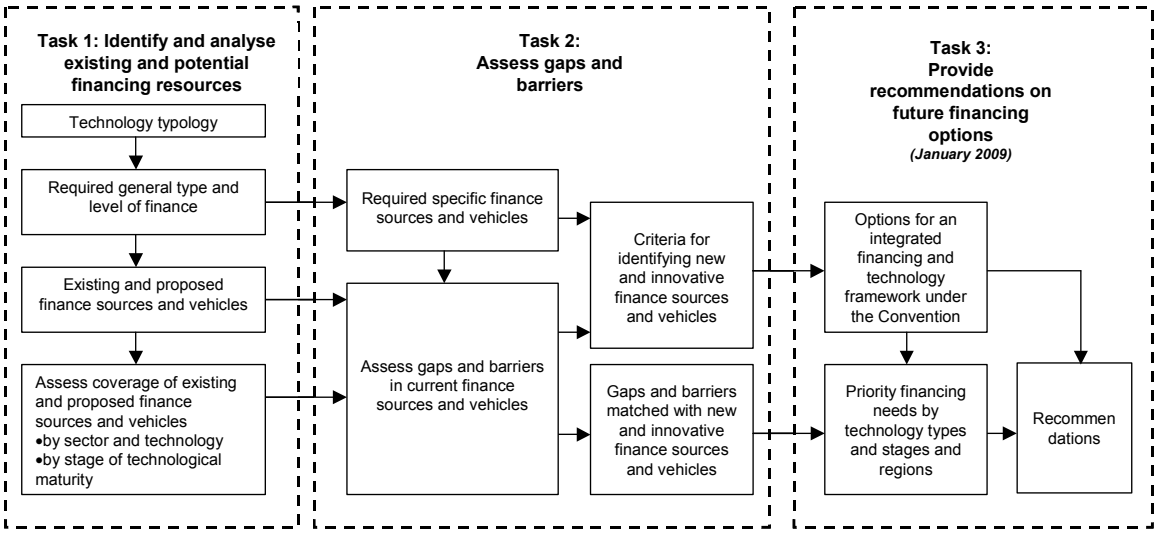
C. Possible action by the Subsidiary Body for Scientific and Technological Advice and the Subsidiary Body for Implementation

8. The subsidiary bodies may wish to review the progress of the work and, if necessary, to provide guidance to the EGTT.

II. Methodological approach

9. Figure 1 provides an overview of the methodological approach to the work referred to in chapter I above and indicates the scope of each of the three tasks.

Figure 1. Overview of the methodology



10. Work carried out under task I is intended to produce 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 in developing countries by sector, technology and stage of technological maturity.

11. First the sectors and technologies for mitigation and adaptation have been identified. The technologies are classified by their stage of technological maturity. Next, the types of financing resources and relevant vehicles, which can differ considerably depending on the stage of technological

[2] FCCC/TP/2008/5.

maturity, and the level of projected level of finance required have been collected. The projected level of financing needs is compared with the existing and proposed financing resources and vehicles that have been identified. Where possible, a distinction is made, throughout the paper, between public and private finance. Finally, the coverage of technologies by the existing and proposed financing sources and vehicles has been assessed.

12. Task II assesses gaps in and barriers to the use of and access to these financing resources and vehicles. Based on material collected for the background paper on task I, the specific type and level of finance sources and vehicles required are identified by sector and stage of technological maturity. Technology-specific gaps and barriers in finance are identified. Where possible these gaps and barriers are quantified. Finally, means to address the gaps and barriers are identified and a review of the extent to which current finance sources and vehicles address the gaps and barriers is provided.

13. Task III prepares recommendations on future financing options and risk mitigation tools necessary for enhancing the development, deployment, diffusion and transfer of technologies for mitigation and adaptation. The recommendations will be constructed based on the findings of the background paper on task 2. Using the criteria for identifying new and innovative finance sources and vehicles, the key elements of an integrated financing and technology framework under the Convention are identified. The most significant gaps and barriers will be used to identify priority financing needs. The focus will be on public financing of technologies for mitigation and adaptation under the Convention on a sufficient scale to leverage the requisite private and other public finance outside of the Convention. Based on the outcomes of all these tasks, this work will result in concrete recommendations on options for future financing.

14. The technologies referred to in this report are technologies for both mitigation of and adaptation to climate change; however, in most cases, the figures and analysis presented cover only the technologies for mitigation. The analysis of technologies for adaptation will be covered in the final report.

III. Technologies and stages of their maturity

A. Introduction

15. This report analyses financing sources and vehicles to meet projected needs for the development, deployment, diffusion and transfer of technologies for mitigation and adaptation by sector and stage of technological maturity. Therefore it is necessary:

(a) To identify technologies for mitigation and adaptation;

(b) To define the stages of technological maturity;

(c) To classify the technologies identified in paragraph 15 (a) above by stage of technological maturity;

(d) To analyse the financing required for technology transfer.

B. Identification of technologies for mitigation and adaptation

16. Technologies for mitigation and adaptation have been identified in task I by collecting the technologies listed in numerous sources, including the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), technology needs assessments (TNAs), national

adaptation programmes of action and clean development mechanism (CDM) projects.[3] A technology was included provides that it was identified by any of these sources mentioned above.

17. The technologies were classified into three orders of increasing specificity, according to sector, type and application, as illustrated in table 1. A total of 147 mitigation technologies were identified, all of which are listed in annex I. The identification of technologies for adaptation is still under preparation.

Table 1. Sample of technology classification[a]

Technology sector (first order)	Technology type (second order)	Technology application (third order)
Coastal protection	Vulnerability assessment	Light detection and ranging mapping
Energy supply	Renewable energy	Hydropower (dam)

[a] Identification and classification of the adaptation technologies is still under preparation.

C. Stages of technological maturity

18. While most commentators agree that linear progression in technological maturity is rare, a satisfying model for non-linear technology innovation has not emerged. For convenience technology innovation is usually characterized as proceeding linearly from basic research to a commercial product. The literature includes many different characterizations of this process and the associated stages of technological maturity.

19. The stages of technological maturity adopted for this analysis are shown in figure 2. The barriers associated with these stages which need to be overcome to develop a commercially competitive technology are also defined in figure 2.

[3] Other sources include: Global Environment Facility, *Operational Programs* <http://thegef.org/Operational_Policies/operational_programs/operational_programs.html>; UNFCCC, 2007. *Investment and Financial Flows to Address Climate*; Change Netherlands Environmental Assessment Agencies, 2001. *The Targets IMage Energy Regional (TIMER) Model. Technical Documentation*; IEA, 2008. *Energy Technology Perspectives 2008*; Vattenfall, 2007. *Global Mapping of Greenhouse Gas Abatement Opportunity*; Per-Anders, E., etc.. 2006. *A cost curve for greenhouse gas reduction*, McKinsey; . Energy Research Center of the Netherlands, 2007, *GHG Marginal Abatement Cost curves for the Non-Annex I region*;. S. Pacala and R. Socolow, 2004. *Stabilization Wedges: Solving the Climate Problem for the next 50 Years with Current Technologies*, Science, 13 August 2004; Ministry of Economy, Trade and Industry, Japan, 2008. *Cool Earth-Innovative Energy Technology Program*, <http://www.iae.or.jp/research/project/Cool_Earth08_e/CoolEarth_RM.pdf>; Japanese Council of Science and Technology, *Low Carbon Technology Plan*, <http://www8.cao.go.jp/cstp/english/doc/low_carbon_tec_plan/low_carbon_tech_plan.pdf>; US Climate Change Technology Programme, Technology Areas, <http://www.climatetechnology.gov/technologyareas.htm>; Asia Pacific Partnership on Clean Development and Climate, Actions plans by sectors, <http://asiapacificpartnership.org/default.aspx>; European Commission, 2007. *Towards a low carbon future – A European Strategic Energy Technology Plan*; World Business Council on Sustainable Development, 2007. *Policy Directions to 2050: A business contribution to the dialogues on cooperative action*.

Figure 2. Stages of technological maturity and barriers

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

20. **Research and development** means that while the basic science is understood, the technology is currently 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. Research and development typically occurs in only a few institutions for a given technology.

21. **Demonstration** involves full-scale implementation of a limited number of installations. The distinguishing barrier is that the technology is not yet available on full scale. Demonstration of technology is rarely a widespread effort; it usually involves a limited number of companies or research facilities that implement full-scale demonstrations.

22. When a technology is at the **deployment** stage, the technology is well understood and demonstrated at full scale. It can also be used in selected commercial applications but is more costly than the established technology even taking into account a price for greenhouse gas (GHG) emissions or equivalent policy.

23. At the **diffusion** stage the technology is competitive with the established technology, either because a price of GHG emissions or because equivalent policy is taken into account. However, the technology may still face barriers relating to the economic environment, social acceptance or institutional arrangements.

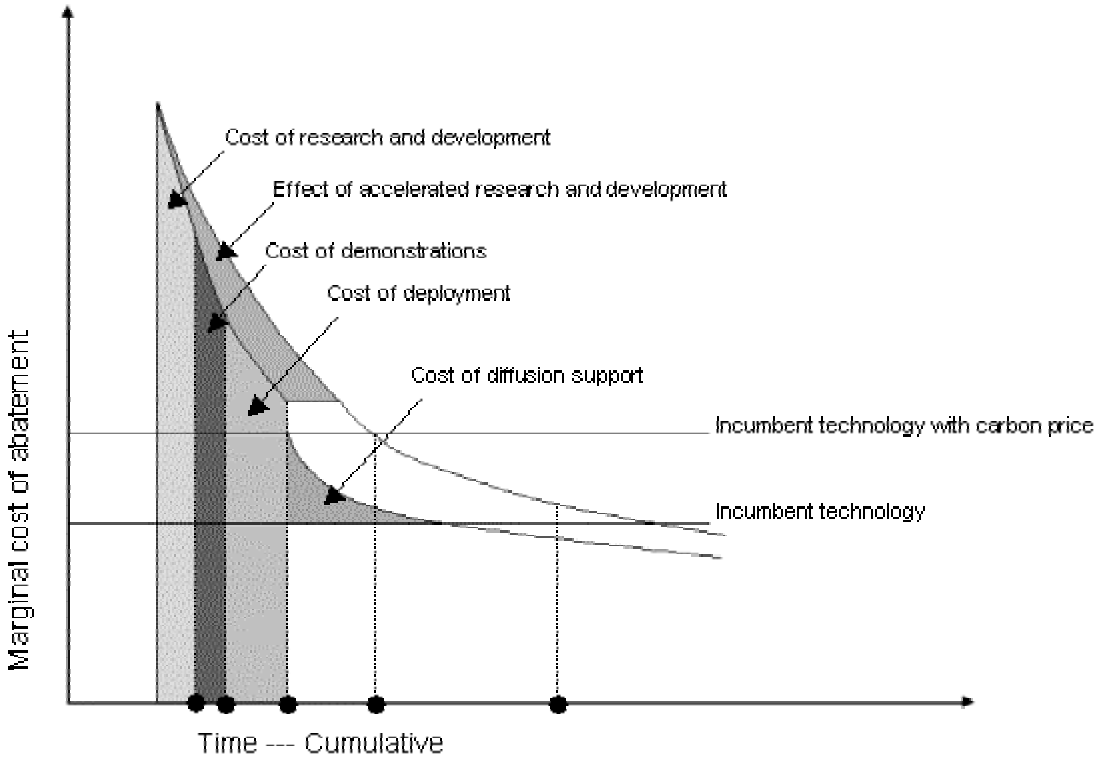
24. A **commercially mature** technology is competitive with the established technology even if the price of GHG emissions is not considered, but has to overcome market failures and specific transaction costs.

25. During the demonstration, deployment and diffusion phases of a technology, the unit cost of technology typically falls as the total number of installations rises. This is shown by the experience curve in figure 3. The unit cost declines as the number of installations increases. 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.[4]

[4] 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.

26. Discussion of financing technology development is hampered by the lack of an agreed definition and a paucity of data. The definition of the cost of technology development adopted here is illustrated by the shaded area in figure 3. The financing needed is the total cost of activities in the research and development and demonstration stages plus the additional costs for deployment and diffusion.

Figure 3. Experience curve of technology development



D. Classification of technologies by stage of technological maturity

27. Each of the 147 identified technologies shown in annex I is classified by its stage of technological maturity. The classification is based on the literature, as mentioned in paragraph 16 above, and expert judgment. Some of the sources from which the list of technologies was compiled identified 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 from the Energy Research Centre of the Netherlands were consulted.

28. The stage 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 different local circumstances. For example, onshore wind, which is classified as being at the diffusion stage could be at the deployment stage in a particular country due to a poor wind regime, institutional barriers or other factors that increase its cost in that country.

29. The classification of technologies by stage of technological maturity reflects the current situation, and will change over time as the technologies evolve. The classification of a specific technology is not critical to the analysis; it is the overall pattern that is of interest.

E. Technology transfer

30. 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 amongst different stakeholders such as governments, private sector entities, financial institutions, NGOs and research/education institutions.[5] This definition provides a comprehensive and widely used description of technology transfer. In the context of this paper, technology transfer also generally involves technologies at the deployment, diffusion or commercial stages. This is shown in figure 4.

Figure 4. Technology transfer and stages of technological maturity

<table>
<tr><td rowspan="2">Research and development</td><td rowspan="2">Demonstration</td><td>Deployment</td><td>Diffusion</td><td>Commercially mature</td></tr>
<tr><td colspan="3">Technology transfer</td></tr>
</table>

31. Consistent with the mandate of this report, technology transfer discussed in this report is limited to the transfer of technologies for mitigation and adaptation to developing countries.

32. Some or all of the costs of technology transfer relate to the creation of a larger market for the technology and may be borne by the owners of the technology. If the technology is at the deployment or diffusion stage, support may be needed to make it competitive with the incumbent technology. That cost would be incurred regardless of where the additional installations are located. Estimates of the financing needed for technology development include the support needed to encourage additional installations. To avoid double counting, the cost of support needed to make a technology competitive with the incumbent technology is considered part of technology development. The cost of technology transfer is limited to:

(a) Cost of building capacity needed to install, operate, maintain and improve the technology;

(b) Cost of creating an environment that enables the use of the technology by removing barriers to its adoption into a new jurisdiction.

33. An important implication of this definition on the cost of technology transfer is that financing that supports installations of technologies for mitigation and adaptation in developing countries may include some transfer of technologies even if this is not explicit. The participants in CDM projects, for example, report that 39 per cent of the projects accounting for 64 per cent of the annual emission reductions involve technology transfer, even though that is not an explicit objective of the CDM.

[5] IPCC. 2000. *Methodological and Technological Issues in Technology Transfer: Special Report of IPCC Working Group III*. Cambridge and New York: Cambridge University Press.

IV. Financing resources and needs

A. Current sources of financing for technology

1. Overall

34. Tables 2 and 3 show two different approaches to estimating the current level of financing for mitigation technology. Table 2 shows estimates of current financing for technology based on literature sources studying that question. Table 3 shows the financing estimated from the specific sources of finance both under and outside of the Convention. The global total in table 2 is in the order of USD 150 billion per year, which is within the range estimated in table 3. The amount of finance rises at each stage of technological maturity.

Table 2. Estimates of current financing for technology[a]

Research and development	Demonstration	Deployment		Diffusion		Total
Global	Global	Global	Developing countries	Global	Developing countries	
USD 10 billion per annum – government funding[b] or USD 20 billion per annum – total[c]	In preparation	USD 33 billion per annum[d] or USD 45 billion per annum[e]	In preparation	USD 71 billion in 2006[f]	USD 14.2 billion per annum[f]	Global: USD 124 to 136 billion Developing countries: to be completed

[a] The estimates are incomplete and subject to revision.
[b] UNFCCC, 2007. *Investment and Financial Flows to Address Climate Change.*
[c] 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*. Organisation for Economic Co-operation and Development. (Does not include investments in non-energy technologies).
[d] Stern N. 2006. *The Economics of Climate Change: The Stern Review*. Cambridge: Cambridge University Press.
[e] International Energy Agency. 2008. *Energy Technology Perspectives 2008 -- Scenarios and Strategies to 2050*. Paris. (Does not include investments in non-energy technologies).
[f] UNEP SEFI, 2007. *Global Trends in Sustainable Energy Investment 2007.* (Does not include investments in non-energy technologies and not all investments represent incremental costs).

35. Estimates of current sources of financing for the development of mitigation technologies are provided in table 3. The available estimates can only be allocated roughly to the stages of technological maturity. As illustrated in figure 3 above, the financing for the research and development and demonstration stages corresponds to the total cost of the activity, that is, financing sources need to cover the full costs the research and development and demonstration activities. For the deployment and diffusion stages the finance is the cost in excess of the incumbent technology. The total amount of finance is USD 140 to 230 billion per year.

Table 3. Estimates of current mitigation financing for technology[a]

Stage of technological maturity	Source of financing	Estimated average annual investment, USD billion
Sources outside the Convention		
Research and development and demonstration	Government funding	10[b]
	Private funding	9.8[c]
Sources under the Convention		
Deployment and diffusion	The Convention financial mechanism (GEF Trust Fund; SCCF; LDCF)	0.22–0.32[d]
	Private and public sources leveraged by the Convention financial mechanism	1.152[e]
	Kyoto flexibility mechanisms (CDM, JI)	4.5–8.5
	Private sources leveraged by the Kyoto flexibility mechanisms	45–85
Sources outside the Convention		
Deployment, diffusion and commercial	Private investment	148[f,g]
Diffusion and commercial	Export credit agencies	1–2
Deployment and diffusion and commercial	Bilateral and multilateral sources	5–10[h]
Deployment and diffusion	Philanthropic private sources (including NGOs, foundation and voluntary carbon market finance)	1
	Total	**140–230**

Abbreviations: CDM = clean development mechanism, GEF = Global Environment Facility, JI = joint implementation, LDCF = Least Developed Countries Fund, NGO = non-governmental organization, SCCF = Special Climate Change Fund.

[a] The estimates are subject to revision.

[b] International Energy Agency, 2006. *Energy Technology Perspectives 2006.* Paris (For all energy research and development in 2006).

[c] UNEP SEFI, 2008. *Global Trends in Sustainable Energy Investment 2007* (Renewable energy and energy efficiency only for 2007).

[d] Includes capacity-building and funding for initiatives that are not technology specific.

[e] Based on GEF information. Leveraging investments includes some implementation costs other than incremental investment costs.

[f] UNEP SEFI, 2008. *Global Trends in Sustainable Energy Investment 2007.* This figure is the total private technology financing for 2007. It does not include all energy efficiency investments, and does not include some low carbon technology investments and only include investments in the energy sector. It may include some public financing, and is the full investment cost, rather than the incremental cost. Asset financing was USD 84.5 billion of the USD 148 billion total in 2007.

[g] Seres S. 2008. *Analysis of Investment and Financial Flows of CDM and JI Projects*. (Report to the UNFCCC secretariat). Of this number, USD 45–85 billion can be considered as leveraged by Convention sources.

[h] Includes some finance leveraged from the Convention financial mechanism which is factored into the total to prevent double counting.

36. Most of the finance (at least 90 per cent) is from sources outside the Convention, with at least 80 per cent coming from private sources.

37. The estimates in table 2 currently exceed the estimates in table 3. In part this is due to the need to compile estimates from numerous disparate sources. While care has been taken to prevent double counting, there may also be some residual double counting in the figures in table 3. It is also likely that some of the sources of finance in table 2 cover more than the additional cost (or incremental cost) of technology development. For example, some of the leveraged funds and the private investment may

cover the total cost of installing the technology rather than the cost in excess of the incumbent technology.

2. Current coverage by sector

38. Each technology sector faces different financing gaps and barriers and is treated differentially by the various financial sources and vehicles under and outside the Convention. Annex III shows coverage of various finance sources under the Convention for all assessed mitigation technologies in nine sectors. It also shows whether the technologies are addressed in TNAs, and whether the international technology programmes of the Asia-Pacific Partnership on Clean Development and Climate and the International Energy Agency (IEA) implementing agreements.

39. The renewable energy supply sector receives much attention and is a growing commercial market, as is reflected by its large numbers of renewable energy supply projects carried out under CDM. However, renewable energy supply faces large gaps in coverage, preventing greater penetration of all but a few of the more common, developed technologies, such as onshore wind, hydropower and biomass co-firing. As is the case for non-renewable energy supply technologies, the current levels of finance for renewable energy technology deployment are considerably lower than what is required. There are also unique and technology-specific gaps and barriers that need to be resolved, particularly in developing countries.

40. Many non-renewable energy supply technologies (all energy supply technologies except for renewable energy supply) are in the demonstration phase, which means they still need to be scaled up and face cost and economic barriers. Many international technology programmes address energy supply technologies and the coverage is fairly comprehensive. In many cases, however, financing remains modest in scale and needs to increase by an order of magnitude to bring the technology towards deployment. The IEA estimates the number of demonstration projects would be necessary for various technologies to ensure structural deployment in the medium to long term. For example, to make the projected contribution to emission reduction of carbon dioxide capture and storage (CCS) technology, 55 coal- and gas-fired plants may need to be equipped with CCS facilities annually by 2030.

41. The coverage of financing sources under the Convention is largely absent for the demonstration stage. The sources under the Convention have been designed to bring near-commercial technologies, particularly in developing countries, into commercial applications. Outside the Convention, there are few identifiable sources of finance that support demonstration projects, although interest in public-private partnerships and public financing of demonstrations for key technologies is rising. It is well known that technologies in the demonstration stage experience the ‘valley of death’ where public finance diminishes and private finance is difficult to access because of the risks involved and the fact that private investors will find it difficult to capture the benefits from the investments made (the so-called spillover effect). Technology transfer is associated only with the deployment, diffusion and commercial phases, and not with the demonstration phase (see figure 4).

42. The tables in annex III indicate information by sector. In many sectors, energy efficiency represents much of the mitigation potential. In industry, the potential for energy efficiency is considerable but coverage by sources both under the Convention and outside the Convention is rather low. This potential, however, could be realized at low cost. In the transport and residential and commercial buildings sectors, energy efficiency improvements are diverse, in an advanced stage of technological maturity and commercially attractive. Barriers are often related to social adoption, economic structures and institutional arrangements rather than cost. The IPCC highlights the great potential for emission reduction in the building sector, and the IEA stresses the crucial role that transportation will need to play in meeting mid- to long-term global emission reduction goals. The number of gaps in the building and transport sectors, both in coverage by technology programmes and in

funding under the Convention, is therefore particularly striking. Transport and building projects, for which energy efficiency technologies are important, are largely absent in the CDM and JI. In general, for energy efficiency, the main financial barrier is often related to the return on the investment, which is considerable but for various reasons cannot compete with other investments.

43. Much Attentions is given to agricultural technologies and practices in TNAs, but the Global Environment Facility (GEF) has funded only limited technology applications and has a greater focus on technologies for adaptation within this sector. With some exceptions, the CDM and JI have not been effective in driving investment within the agriculture sector. There remain significant measurement and accounting barriers to abatement in the agriculture sector, and mobilizing private sector finance is challenging because of the very large numbers of agricultural enterprises which are often exposed to international commodity prices and competition and may find it difficult to pass on abatement costs to consumers.

3. Government-funded research and development

44. International technology coordination mechanisms and programmes have been established to mobilize investments in international research and development on many technologies for mitigation and adaptation.

45. 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 according to an established set of rules.

46. Other important international technology coordination mechanisms include, among many others:

(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;

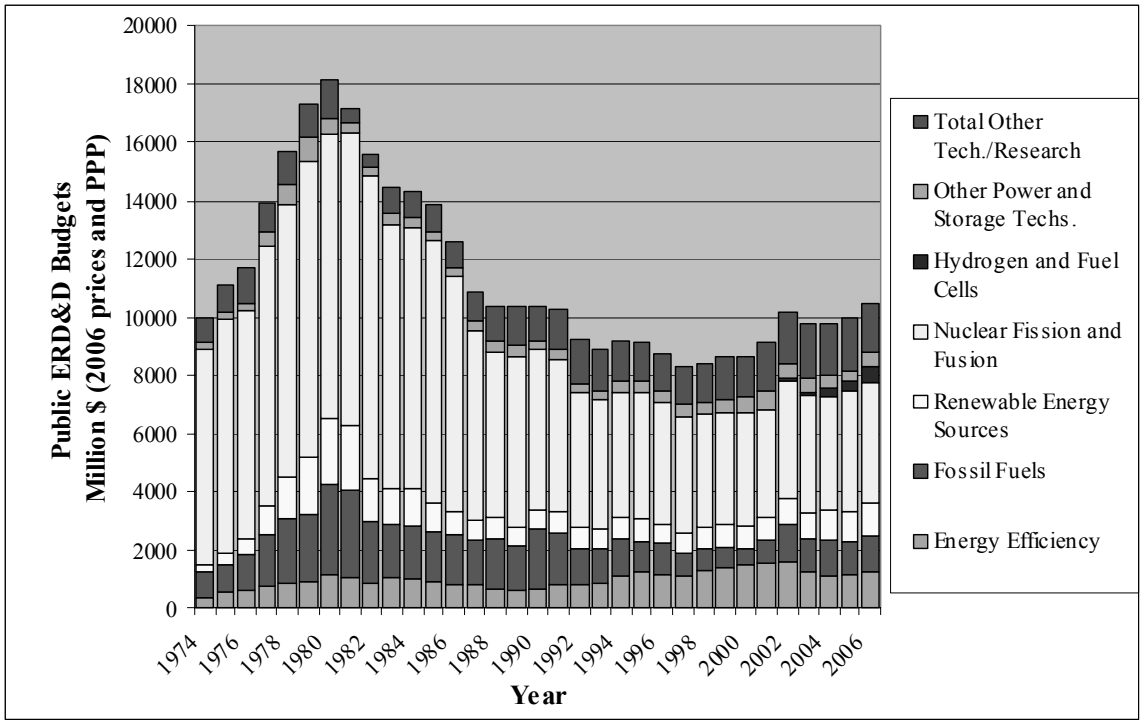
(h) The Centre for International Forestry Research;

(i) The Livestock Emissions & Abatement Research Network;

(j) The Methane to Markets partnership.

47. As illustrated in figure 5, total public investment in research and development expenditure on energy was just over USD 10 billion in 2006. An estimate of public research and development funding for technologies for adaptation is currently unavailable.

Figure 5. Government expenditure on research and development, OECD countries, 1974–2006



Source: OECD, 2006. *Do we have the right R&D priorities and programmes to support energy technologies in the future? 18th Round Table on Sustainable Development Background Paper*.
Abbreviations: ERD&D=energy research, development and demonstration; PPP=purchasing power parity; Tech.=technology.

48. Detailed information on public research and development investments by technology are currently being compiled and will be included in the final report in 2009.

4. Private sector research and development

49. In 2007, private funding for research and development on renewable energy and energy efficiency was USD 9.8 billion (see table 3). More detailed information on private research and development funding will be included in the final report at a later stage.

5. Global Environment Facility

50. The allocation of GEF Trust Fund resources to climate change activities is shown in table 4. 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. Total funding for those projects since the establishment of the GEF amounts to over USD 2 billion, or about USD 0.22 billion per year. The GEF covers only part of the cost of each project. The additional public and private sector financing leveraged by GEF for mitigation projects averages USD 1.15 billion per year.

Table 4. 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**

Abbreviation: GEF = Global Environment Facility, GEF 1 = GEF first replenishment, 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.

Source: UNFCCC. 2007. *Investment and Financial Flows to Address Climate Change*, and GEF secretariat.

51. The GEF Trust Fund is replenished on a four-year cycle. Donors agree on the amount of the replenishment and the contribution of each country is then calculated using a pre-defined 'basic' burden share. In anticipation of a replenishment, the COP makes an assessment of the funds needed to assist developing countries to fulfil their commitments under the Convention over the next cycle. The fourth review of the financial mechanism started at COP 13 and will be completed at COP 15. It will provide an input to the fifth replenishment of the GEF.

52. The GEF is currently considering establishing a USD 50 million strategic programme on technology transfer, which will include the Special Climate Change Fund of USD 15 million, to address identified gaps and to enhance technology transfer activities across the GEF Climate Change Programme. The focus will be on implementing TNAs.

53. Adaptation activities are funded by the GEF Trust Fund strategic pilot approach to adaptation, the SCCF programme for adaptation, and the Least Developed Countries Fund. 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 and forestry, water supply and coastal zones sectors in Africa, Asia and Latin America and the Caribbean. GEF funding of USD 15 million has been allocated to the Pacific Islands Adaptation to Climate Change Project. 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.

6. Adaptation Fund

54. The Adaptation Fund, financed by a levy of 2 per cent of the certified emission reductions (CERs) issued for most 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 and the level of demand in the carbon market.

7. The clean development mechanism

55. The CDM enables a project to mitigate climate change in a Party not included in Annex I to the Convention (non-Annex I Party) to generate CERs that 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 under the Kyoto Protocol. Most domestic emissions trading systems allow participating firms to use CERs toward compliance. At the end of September 2008, 3,967 projects were in the CDM pipeline, including 1,170 registered projects.[6] These projects are forecast to reduce emissions by 546 million tonnes of carbon dioxide equivalent (Mt CO_2 eq) per year.

56. Although the CDM does not have an explicit mandate for technology transfer, it contributes to it by financing projects that use technologies currently not available in the host countries. About 39 per cent of CDM projects accounting for 64 per cent of the total annual emission reductions of all projects claim to involve technology transfer. The extent of technology transfer is very heterogeneous across project types.[7] For example, projects in the sectors of cement, coal bed methane and coal mine methane, fossil fuel switching and transport involve very little technology transfer, while it is claimed for almost all energy supply and household energy efficiency and solar projects. Technology transfer is more common for larger projects and projects with foreign participants, and, where it occurs, it usually involves both knowledge and equipment, with equipment imports accounting for most of it. As host country approval is required for each CDM project as part of its modalities and procedures, host countries could have a significant impact on technology transfer outcomes of the CDM by including it as a requirement for obtaining a Letter of Approval. Some host countries include criteria on technology transfer, but they are often not implemented in a strict way.

57. The total capital that has been, or will be, invested in CDM projects that entered the pipeline by the end of June 2008 is USD 94.7 billion. This figure includes some projects that are in the validation stage and there is a chance that some projects will not proceed. However, experience shows that the rate of failure is very low for projects that reach the validation stage. The USD 46 billion estimated investment for CDM projects in 2007 is approximately 2 per cent of the total investment in new physical facilities in developing countries.

58. Most of the investment is in projects involving hydropower, wind, fossil fuel switching, biomass energy and energy efficiency in industry. Relatively small total investments occur in transport, agriculture and demand-side energy efficiency project types. The total investment in new CDM projects has grown rapidly, as shown in table 5. The investment numbers are calculated using the total investment as reported in project design documents, and extrapolated for those projects that do not report investment numbers.

59. Almost all CDM projects involve technologies in the deployment, diffusion and commercial stages of development. Only the incremental costs to the incumbent technology are financed, which corresponds to the value of the CERs. The estimated value of the CERs for the projects in each category – in the pipeline or registered – is shown in table 5. It is 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. The market value of the emission reductions by CDM projects during 2007 was about USD 8.4 billion of which USD 1.3 billion was for issued CERs. All CERs are purchased by developed countries.

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[6] Fenhann, J. 2008. *Overview of the CDM pipeline (Excel sheet)* <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. 2007. *Analysis of Technology Transfer in CDM Projects* (Report to the UNFCCC Registration and Issuance Unit).

Table 5: 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 (USD million)				Total investment projected for projects that entered the pipeline during the year, USD million
		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
1st quarter of 2008						11 816

Abbreviation: CDM = clean development mechanism
[a] Excludes projects that have been rejected or withdrawn by 30 June 2008.
[b] World Bank, *State and Trends of the Carbon Market*, various issues.

60. Unless and until post-2012 commitments are agreed by developed countries, the market for CERs generated by post-2012 emission reductions remains uncertain.[8] Estimates of potential post-2012 demand vary widely.[9] Current estimates range from 500 to 1,700 Mt CO_2 eq per year. The low end of the range is roughly the same as the current market – 400 to 600 Mt CO_2 eq per year. The upper end of the range is a market two to three times larger.

8. Joint implementation

61. Joint implementation (JI) enables a project for mitigating 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).

62. At the end of September 2008 there were 175 JI projects in the pipeline, including 22 registered projects, with expected annual emission reductions of 67 Mt CO_2 eq.[10] The dominant project types concern fugitive emissions reduction, nitrous oxide destruction and coal bed methane capture, which together account for almost 40 per cent of the projects and over 70 per cent of the annual emission reductions of all projects. The Russian Federation and Ukraine host most of the JI projects.[11] The total capital that has been, or will be, invested in JI projects that had entered the pipeline by the end of June

[8] Capoor, K. and Ambrosi, P, 2008 *State and Trends of the Carbon Market 2008*, World Bank: Washington, DC, <http://carbonfinance.org/docs/State___Trends--formatted_06_May_10pm.pdf>.
[9] UNFCCC, 2007. *Investment and Financial flows to Address Climate Change*.
[10] Fenhann, J, 2008. *Overview of the CDM pipeline (Excel sheet)* <http://cdmpipeline.org/publications/CDMpipeline.xls>. The total includes 17 Track 1 projects (5 Mt CO_2 eq) and 158 Track 2 projects (62 Mt CO_2 eq).
[11] The Russian Federation has 49 per cent of the projects representing 62 per cent of the forecast annual reductions and Ukraine has 17 per cent of the projects representing 17 per cent of the forecast annual emission reductions.

2008 is USD 7.7 billion. The estimated revenue for projected annual emission reductions is USD 98 million for 2006 and USD 418 million for 2007.

9. Export credit agencies

63. Export credit agencies (ECAs) are organizations that have a government mandate to support and expand trade in domestic goods and services. The secretariat undertook a survey of ECAs in 2005 (FCCC/SBI/2005/INF.7) based on information collated from ECA annual reports and data provided in *Statistics on Export Credit Activities,* published in 2004 by the Organisation for Economic Co-operation and Development (OECD). According to the OECD, ECAs provided finance worth USD 649 billion in 2003. Based on the OECD data, the secretariat estimated that ECAs provided long-term credits (i.e. longer than 5 years) of USD 11.7 billion to developing countries. Total climate-related finance amounted to USD 9.9 billion, of which USD 1.8 billion was for technologies for mitigation and adaptation in developing countries**.**

64. The most recently available OECD data for ECA investments by technology and industry are for 2004–2005. Total reported long-term ECA export credit investments for 2004 and 2005 were USD 29.7 billion and USD 32.4 billion, respectively. In 2005, renewable energy was made eligible for more favourable financial terms.

65. During 2004 and 2005 long-term credits provided by ECAs amounted to USD 12.1 billion and USD 14.4 billion, respectively. 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. According to the OECD website, export credit support for hydropower, wind and photovoltaic technologies increased in 2006 and 2007.

10. Official development assistance

66. The 2008 Global Development Finance Report[12] concludes there has been an increase in the share of official development assistance (ODA) disbursements (excluding debt relief) provided by Development Assistance Committee member countries since the Monterrey Consensus of the International Conference on Financing for Development was achieved in 2002. Overall, ODA (excluding debt relief) has increased from 0.23 per cent of donors' gross national income (GNI) in 2002 to 0.25 per cent in 2007. This, however, is well below the 0.33 per cent level 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 for ODA(0.7 per cent). ODA accounts for approximately 1 per cent of total investment flows.

67. Information on ODA investments in technologies for mitigation and adaptation is limited. The information available on ODA investments is for OECD countries; however, emerging economies are also increasingly important sources of ODA investments. In 2005 ODA investments in renewable energy and energy efficiency in developing countries totalled just under USD 2 billion.

11. Multilateral development banks

68. Multilateral development banks (MDBs) aim at social and economic progress (to eliminate poverty and support sustainable development) through lending, grant and country-assistance strategies that support different infrastructure projects and policy reform activities in their developing member countries. MDBs provide loans at commercial rates to governments (and government entities) in medium-income member countries, and grants to governments and government entities in low-income countries.

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[12] World Bank, 2008. *Global Development Finance 2008.*

69. While there is much activity in MDBs relating to technologies for mitigation and adaptation, precise total investment levels are currently not available. Investments in renewable energy and energy efficiency by the World Bank totalled USD 2.25 billion in 2008 (excluding carbon finance and GEF finance which is reported elsewhere), of which approximately USD 1 billion was for large-scale hydropower projects. The Climate Investment Funds established at the Group of Eight summit in 2008 will result in USD 6.1 billion being invested in technologies for mitigation and adaptation and programmes in 2009–2012.

70. Incorporation of climate change considerations across all MDB activities remains an important priority. With the proliferation of climate change activity in MDBs, there are increasing concerns regarding the degree of overall coordination and complementarity of these activities.

12. Private sources

71. The need to accelerate transfer of ESTs as a means of promoting sustainable development was recognized and highlighted by the international community at the **United Nations Conference on Environment and Development** in 1992, and particularly in its Agenda 21 Chapter 34. Private investments in clean energy has been increasing 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.[13]

13. Current funding for technology transfer

72. In this report, technology transfer is discussed separately from funding sources for technology development, deployment and diffusion, such as the ones discussed in sections 3–12 in this chapter. Current funding for technology transfer stems from a wide disparate of sources. Funding for technology transfer includes costs of capacity-building, costs of reforming subsidies and creating enabling environments, some elements of national technology development plans, and investments for technology barrier removal. Contributors include non-government organizations, international organizations, multilateral development banks and other financial institutions, transnational corporations and public funds, including ODA; however, it is not possible to obtain exact numbers.

B. Estimates of financing needs

73. Various reports and studies provide estimates of the financing needed for individual technologies and groups of technologies. Most studies do not provide detailed information on incremental investment for the full spectrum of technologies for mitigation and adaptation. Estimates of the additional financing needed to achieve the projected implementation of specified mitigation technologies can be derived from models and mitigation cost curves. These estimates are shown grouped by stage of technological maturity in table 6. The total finance needs are estimated to be between USD 300 billion and USD 1000 billion annually, but these numbers are uncertain. Estimates for technologies for adaptation shown in table 7 will be included in the final report.

74. Given the diversity of sources and the variation in their coverage and assumptions, the wide range of the estimates of financing needed is not surprising. All of the estimates are incomplete in the sense that none covers all technologies for mitigation and adaptation.

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

Table 6. Estimates of additional financing needs by stage of technological maturity for mitigation

Research and development	Demonstration	Deployment		Diffusion	
Global	**Global**	**Global**	**Developing countries**	**Global**	**Developing countries**
USD 50 billion per annum[a] USD 20–100 billion per annum[b] USD 10 billion per annum public investment[c] USD 30–100 billion per annum[d]	USD 27–36 billion per annum until 2030[e]	USD 100–200 billion per annum (in addition to a carbon price of USD 25/tonne)[f] USD 57–94 billion per annum (in addition to a carbon price of USD 25/tonne)[g] USD 25–35 billion per annum[h]	USD 18.25–40.75 billion per annum[i] USD 10.5–18.75 billion per annum[j] USD 22.75–40.75 billion public investment per annum[k]	USD 1000 billion per annum 2010–2050[l] USD 379.5 billion per annum to 2030[m]	USD 157–600 billion per annum to 2030[n]

[a] Stern N, 2006. *The Economics of Climate Change: The Stern Review*. Cambridge: Cambridge University Press.
[b] Doornbosch, R., Gielen, D. and P. Koutstaal, 2008. *Mobilising Investments in Low-Emission Energy Technologies on the Scale Needed to Reduce the Risks of Climate Change*, OECD SG.SD/RT(2008)1.
[c] UNFCCC, 2007. *Investment and Financial Flows to Address Climate Change*, UNFCCC, Bonn.
[d] Nemet, G.F. and Kammen D.M., 2007. *U.S. Energy Research and Development: Declining Investment, Increasing Need, and the Feasibility of Expansion* Energy Policy 35(1): 746- 755.
[e] IEA, 2008. *Energy Technology Perspectives 2008*, Paris.
[f] Doornbosch, R., Gielen, D. and P. Koutstaal, 2008. *Mobilising Investments in Low-Emission Energy Technologies on the Scale Needed to Reduce the Risks of Climate Change*, OECD SG.SD/RT(2008)1.
[g] UNFCCC, 2007. *Investment and Financial Flows to Address Climate Change*, UNFCCC, Bonn.
[h] UNFCCC, 2007. *Investment and Financial Flows to Address Climate Change*, UNFCCC, Bonn.
[i] Doornbosch, R., Gielen, D. and P. Koutstaal, 2008. *Mobilising Investments in Low-Emission Energy Technologies on the Scale Needed to Reduce the Risks of Climate Change*, OECD SG.SD/RT(2008)1.
[j] Stern N, 2006. *The Economics of Climate Change: The Stern Review*. Cambridge: Cambridge University Press.
[k] UNFCCC, 2007. *Investment and Financial Flows to Address Climate Change*, UNFCCC, Bonn.
[l] Doornbosch, R., Gielen, D. and P. Koutstaal, 2008. *Mobilising Investments in Low-Emission Energy Technologies on the Scale Needed to Reduce the Risks of Climate Change*, OECD SG.SD/RT(2008)1. This is the low end of the range. Potential incremental costs up to 5600 billion per annum are possible if technology development is slow and if relatively cheap abatement in developing countries does not occur.
[m] UNFCCC, 2007. *Investment and Financial Flows to Address Climate Change*, UNFCCC, Bonn.
[n] UNFCCC, 2007. *Investment and Financial Flows to Address Climate Change*, UNFCCC, Bonn. Based on ratio of developing and developed country investment needs.

Table 7. Estimates of financing needs by stage of technological maturity for adaptation

Research and development	**Demonstration**	**Deployment**		**Diffusion**	
Global	Global	Global	Developing countries	Global	Developing countries
In preparation					

Note: More detailed analysis of technologies for adaptation and investment costs will be reflected in the final report.

75. The estimated financing needs increase with each stage of technological maturity. The support needed per installation falls at each stage, but the increased size and number of installations for the next stage more than offsets this reduction, increasing the total financing needed.

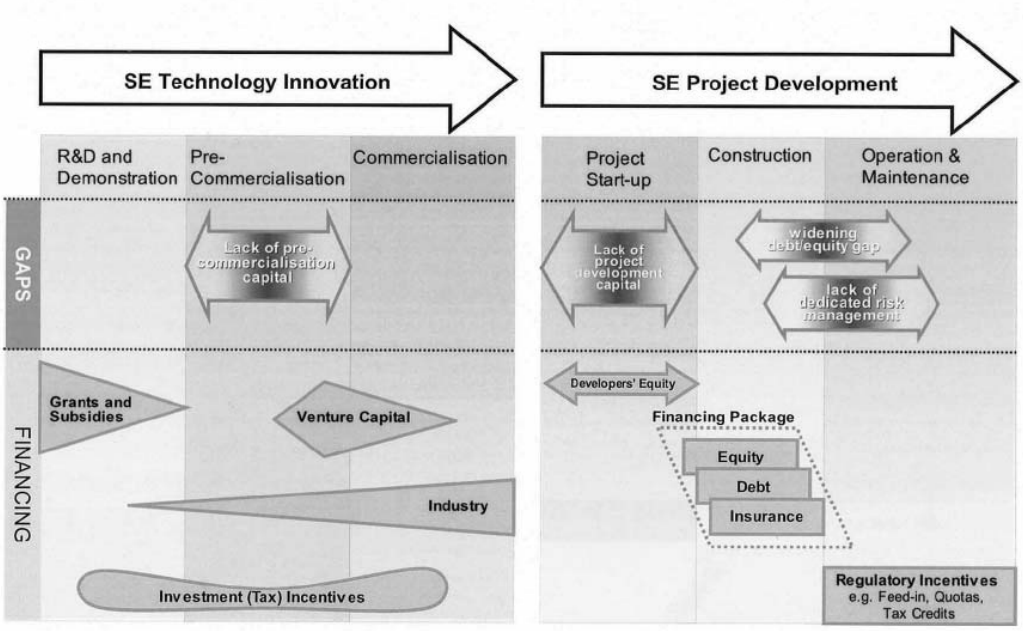
76. The estimated financing needs exceed the current level of financing at each stage of technological maturity. This reflects the cost of rapidly changing the mix of technologies to address climate change.

77. About one quarter of the extra financing for deployment and almost half of the extra financing for diffusion is estimated to be needed in developing countries. This reflects the projected development needs and increasing scale of implementation of technologies for mitigation and adaptation.

78. Since most of the extra financing for deployment and diffusion is in developed countries, measures to accelerate implementation of the technologies in these countries are required to reduce the unit cost of the technology globally.

79. From a financial perspective, the different stages of technological maturity imply different finance options, as illustrated by figure 6.

Figure 6. Financing by stage of technological maturity



Source: UNEP-SEFI 2005. *Public Finance Mechanisms to Catalyze Sustainable Energy Sector Growth.*
Abbreviation: R&D = research and development, SE = sustainable energy.

80. The majority of the financing need not come from government budgets. Many countries, for example, have policies, such as feed-in tariffs, production subsidies, tax incentives and renewable energy generation obligations, to stimulate deployment and diffusion of renewable energy and other technologies for mitigation and adaptation.

81. The CDM is stimulating adoption of technologies in the deployment and diffusion stages of technological maturity in developing countries. These projects may result in technology transfers that may have wider effects on technology adoption rates.[14]

Table 8. Summary of Party proposals to enhance international investment and financial flows to developing countries

Option/proposal	Estimated annual funds, USD billion	Specific to mitigation or adaptation	Under the Convention	Defined contribution	Go through government budget
Increasing the scale of existing mechanisms					
The GEF Trust Fund	Currently: 0.22	N	Y	Y	Y
SCCF and LDCF	Currently: 0.10	A	Y	N	Y
The CDM and other possible crediting mechanisms	Currently: 25 Future: 25–100	M	Y	N	N
The Adaptation Fund	0.50–2	A	Y	N	N
New bilateral and multilateral funds					
Cool Earth Initiative	2	N	N	N	Y
International Climate Protection Initiative	0.15	N	N	Y	Y
Clean Investment Fund	1–2	N	N	N	Y
Proposals funded by defined contributions from developed countries					
Convention adaptation fund, technology fund and insurance mechanism		N	Y	Y	Y
Adaptation fund and multilateral technology acquisition fund	170	N	Y	Y	Y
Proposals funded by contributions from developed and developing countries					
World climate change fund	10	N	Y	Y	Y
Multilateral adaptation fund	18	A	Y	Y	Y
More stringent commitments by developed countries					
Auction of assigned amount units	3.5–7	A	Y	Y	N
Nationally appropriate mitigation actions		M	Y	N	N
Other sources of funds					
Extension of the 2 per cent levy on CDM to other market mechanisms	0.03–7.0	N	Y	Y	N
International air travel adaptation levy	13	A	N	Y	N
International maritime emission reduction scheme	3	N	N	Y	N
Auction of allowances for international aviation and marine emissions	20–40	N	N	N	N

Abbreviations: A = adaptation, CDM = clean development mechanism, GEF = Global Environment Facility, LDCF = Least Developed Countries Fund, M = mitigation, N = no, SCCF = Special Climate Change Fund, Y = yes.

82. The United Nations Environment Programme Sustainable Energy Finance Initiative has analysed in detail the types of finance and the financial mechanisms and policies that can support technology development and transfer at various stages of technological maturity. Figure 6 illustrates the financing gaps that are present at various stages of technological maturity.

[14] Seres S. 2007. *Analysis of Technology Transfer in CDM Projects* (Report to the UNFCCC Registration and Issuance Unit).

83. The shift that is required towards investment in technologies for mitigation and adaptation may result in a reduction in investment needs in conventional technologies such as fossil fuel based energy generation. These reductions may also be reflected in reductions in investment in research and development in conventional technologies.

84. Table 8 summarizes options that enhance international investment and financial flows to developing countries. These options have all been suggested by Parties in submissions to the secretariat.[15] In the case of active options, the table shows the current size of the funds. For options that could be enhanced in the future and for new options and proposals, the estimated future funds are indicated. Some key features, such as whether the option aims specifically at mitigation or adaptation, whether the contribution is defined in the proposal and whether the funds would go through government budgets, are also reviewed.

85. The sums indicated in table 8 include only public finance, and on their own are insufficient to address the full technology and finance challenge outlined in the preceding sections. However, one of the key roles of public finance is to leverage much higher levels of finance from private institutions, which would finance the greater part of the investments needed.

C. Additional financing needs by sector and stage of technological maturity

86. The preceding sections have provided a quantitative estimate of financing of ESTs through existing sources and vehicles, under the Convention and outside it. They have also indicated the additional financing needs, which correspond to the gap in finance. This section reports the gap in finance based on two approaches: firstly by stage of technological maturity, and secondly by sector. Because of lack of specific data, it was not possible to identify the gap in finance for specific technologies.

87. Table 9 provides a quantitative summary of the annual financing need by stage of technological maturity by 2030. The results are obtained by merging a number of different studies[16] that have modelled the financing needs, and are generally averaged over the period from the present to 2030. The wide range of numbers reflects the uncertainties in both assumptions and in the cost of developments in the models employed.

Table 9. Quantification of the additional financing needs by stage of technological maturity

	Annual additional financing needs up to 2030 (USD billion)	
Stage of technological maturity	**Developing countries**	**Global**
Research and development	10–100	
Demonstration	27–36	
Deployment	6–41	25–163
Diffusion and commercial	176–464	380–1000[a]

[a] The International Energy Agency *Energy Technology Perspectives 2008* indicates that "the incremental investments in commercial technologies for the period 2010 to 2050 amount to an annual average of USD 1000 billion" for the 500 ppm CO_2 eq scenario.

[15] A full list of proposals is contained in annex II.

[16] IEA, 2008. *Energy Technology Perspectives 2008*, Paris and Doornbosch, R., Gielen, D. and P. Koutstaal, 2008. *Mobilising Investments in Low-Emission Energy Technologies on the Scale Needed to Reduce the Risks of Climate Change*, OECD SG.SD/RT(2008)1.

88. In more advanced stages of development, the size of the total finance gap (both public and private) increases, as the size and amount of installations of the technology increases as it moves from the research and development stage towards the deployment or diffusion stages. Table 9 shows that there is a significant gap in public and private finance for all stages of technological maturity. This gap is present on a global scale but also in all regions and most countries, particularly in developing countries.

89. Table 10 shows estimates of the share of the emission reduction potential and the number of mitigation technologies by sector. The share of mitigation technologies is similar to the reduction potential for most sectors. Each technology has a different mitigation potential, so comparison of the reduction potential and the share of the technologies must be interpreted cautiously. However, there appear to be relatively few technologies for agriculture and forestry and numerous technologies for transportation. The agriculture and forestry results could be explained by the scope of the sources used to compile the list.

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

Sector	Estimated contribution to total reduction potential in 2020, %	Number of technologies	Stage of technological maturity				
			R&D, %	Demon-stration, %	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.

90. The table suggests that most of the mitigation technologies are relatively mature – at the deployment, diffusion or commercially competitive stages. This suggests that efforts to accelerate adoption of the technologies could yield relatively quick results, both in terms of reducing the costs of the technologies through increased installations and emission reductions.

91. The relatively small number of technologies at the research and development and demonstration stages could be interpreted to suggest that additional emissions reductions will be more difficult in the longer term. However, the numbers may just reflect the scope of the sources used to compile the list. In any case, new commitments to mitigate GHG emissions are likely to stimulate more innovation.

92. The relative global finance gap is greatest in the energy supply sector, with an emphasis on energy demand reduction. The second largest gap is in the transport sector. However, the coverage by financing sources both under and outside the Convention is very limited in transport sector. Industry is covered to some degree by financing sources under and outside the Convention, but in the agriculture and buildings sectors coverage could be increased substantially.

93. While the figure for a specific sector may indicate relatively good funding and coverage by Convention or non-Convention funding vehicles, this may not be the case for specific technologies in the

sector. This is particularly the case for JI and CDM, but this can be quite readily explained by the way those mechanisms work. Once a new technology-specific baseline methodology is approved, many projects in the same category tend to use it. In such a case, transaction costs drop immediately and implementation of the technology is enabled.

94. The technologies mentioned in TNAs can be interpreted as an indicator of demand for the availability of the technology in developing countries. To supply such a technology through the Convention, it would need to be covered by the Convention vehicles or at least be part of the technology programmes assessed. There are gaps between the technologies mentioned in TNAs and the other Convention and non-Convention vehicles. The largest discrepancies are in the transport, buildings and agriculture sectors. Resolving the gaps and barriers in these sectors is particularly urgent as, according to the IPCC, these sectors show considerable emission reduction potential in 2030.

V. Barriers to finance

A. Introduction

95. The preceding sections have identified considerable gaps in finance. To overcome these gaps, more public finance needs to be mobilized across sectors, stages of technological maturity and regions, and this public finance needs to leverage larger amounts of private finance. Public finance includes grants for research and development, subsidies for demonstration of technology, and incentives for the early deployment of technology. Private finance may include asset finance and venture capital.

B. Barriers to public and private finance

96. According to the IPCC (2000),[17] the public sector has direct responsibility for managing public and common goods, and investing in their protection and conservation. The role of public sector finance becomes particularly important in supporting the development and dissemination of ESTs in the absence of efficient pricing mechanisms or other policies to incorporate environmental costs, when the private sector finance will be unable to operate efficiently. Generally, private funding needs a higher rate of return than does public funding, and public funding often focuses on the earlier stages of technological maturity. Innovative approaches to finance often try to find the optimum between public and private funding. The different character and aims of public and private finance result in different sets of barriers.

97. Both public finance and private finance face barriers that differ according to circumstances, such as the country's policies, and relate to the gaps that each stage of technological maturity faces (see chapter III). The general gaps and barriers and financial gaps and barriers are explained in table 11.

[17] IPCC, 2000. *Methodological and Technological Issues in Technology Transfer: Special Report of IPCC Working Group III*. Cambridge and New York: Cambridge University Press.

Table 11. Specific financing barriers related to stage of technological maturity[18]

Stage of technological maturity	Categories of gaps and barriers	Financing barriers	
		Public finance	Private finance
Research and development	Proof of concept	• Other political priorities for public finance • Unclear results of fundamental research • Unclear results of education and training	• Insufficient rate of return • Spillover effects prevent private financiers from capturing benefits of investment
Research and development	Technical	• Other political priorities for 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 scale	• 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 environmentally sound technologies

[18] IEA, 2007. *World Energy Outlook 2006*. Paris, France; UNEP SEFI, 2002. *Barriers to sustainable energy finance;* UNEP SEFI, 2007. *Executive Briefing: Making it Happen: Renewable Energy Finance and the Role of Export Credit Agencies*; NEF, 2008. *Global trends in sustainable energy investment 2008*. ISBN: 978-92-807-2939-9, DTI/1066/PA.

Table 11 (continued)

Stage of technological maturity	Categories of gaps and barriers	Financing barriers	
		Public finance	Private finance
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

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

98. The variety of actors and barriers make a technology and finance framework a complex matter. The list of barriers, such as the one reported in IPCC (2000),[19] is long. The literature does converge, however, on a number of specific barriers for ESTs in developing countries that the private sector faces in the context of financing technology transfer:[20]

- Lack of general knowledge and awareness of ESTs on the part of the investors;
- 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;
- 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 commercially financed success stories;
- Limited financial infrastructure: underdeveloped finance institutions, especially for more complex structuring;
- Volatile market conditions, in particular volatility of prices of, for example, biofuels;
- Ethical considerations: reputation risk because of negative public reaction to, for example, biofuels or CO_2 capture and storage;
- Policy and regulatory ineffectiveness: not geared towards or disadvantageous to environmentally sound technology;
- Internal financing for energy efficiency: competition with other options and stronger awareness and information barriers.

[19] IPCC, 2000. *Methodological and Technological Issues in Technology Transfer: Special Report of IPCC Working Group III*. Cambridge and New York: Cambridge University Press.

[20] UNEP SEFI and NEF, 2008, *Global trends in sustainable energy investment 2008*; ECN, 2008, *How to add value to sustainable energy finance?* Internal document; UNFCCC, 2004. *Innovative options for financing the development and transfer of technologies in the context of the UNFCCC: Background Information Paper*. by Paul van Aalst.

VI. Summary

99. Estimates of the additional financing needed for mitigating climate change vary depending on the assumptions used in the estimates. The incremental cost for mitigation is potentially in the order of USD 1 trillion annually and without public investment in research and development, demonstration and deployment support, investment needs could increase significantly. There are much greater levels of uncertainty in incremental adaptation costs. There are many gaps; coverage of Convention and non-Convention sources of financing is particularly low for major sectors such as transport and building. Finding ways to leverage private finance by public finance remains a challenge which will need to be addressed by new and innovative options.

VII. Remaining work

100. The remaining work of the EGTT to be completed on this matter by the thirtieth sessions of the subsidiary bodies is as follows:

(a) To complete the data collection and analysis: include similar work on technologies for adaptation, verify and add numerical estimates, and fill other gaps that remain in this document and in draft background papers on tasks I and II referred to in paragraphs 3 and 4 above;

(b) To write a background paper on task III. This paper will describe and assess various options for future financing options and risk mitigation tools necessary for enhancing the development, deployment, diffusion and transfer of technologies for mitigation and adaptation;

(c) To complete the final report of the work on technology transfer and finance as referred to in paragraph 4 above.

101. The schedule for the remainder of the work is to finalize the background paper on task III in January 2009 for discussion at the EGTT meeting to be held in February 2009. The final report of this task will be submitted to the secretariat in March 2009.

Annex I

List of technology types and stage of technological maturity (commercial, diffusion, deployment, demonstration, research and development stages)

Sector	Technology type	Technology application	Technological maturity
Energy supply	Efficiency	Plant efficiency	Commercially mature
	Renewable	Biomass co-firing	
		Hydropower (dam)	
	Non-renewable	Fuel switch	
Residential and commercial buildings	Appliances	Evaporative cooler	
		Solar thermal water heater	
		District heating and cooling system	
		Efficient air conditioners	
		Wind water pumps	
		Standby power	
Transport	Improved train efficiency	Engine fuel efficiency	
		Nitrous oxide abatement	
	Alternative fuels	Natural gas	
	Road transport – modal shifts	Public transport – bus	
	Transport systems	Public transport – rail	
	Rail	Regenerative braking	
	Aviation	Optimal flight speed/paths/altitude	
	Shipping	Fleet optimization	
	Urban design	Urban design	
Industry	Efficiency	Furnaces	
		Boilers	
		Motors	
		Fuel switching	
		Feedstock change	
		Steam system efficiency	
	Emissions controls	HFCs	
		Avoided methane production	

Sector	Technology type	Technology application	Technological maturity
Waste management	Methane	Landfill methane recovery	Commercially mature
		Landfill methane destruction	
	Waste to energy	Combustion of MSW	
Forestry	Afforestation	Afforestation	
	Forest management	Increase forest carbon density	
Industry	Efficiency	Product change	All stages
Energy supply	Renewable	Offshore wind (floating)	Demonstration
		Geothermal – enhanced geothermal systems	
		Concentrated solar power/solar thermal (solar towers, fresnel, dish-stirling, solar chimney)	
	Non-renewable	Coal ultra-supercritical steam cycle	
		Coal integrated gasification combined cycle	
		Integrated gasification fuel cell combined cycle	
		Coal with carbon dioxide capture and storage	
		Gas with carbon dioxide capture and storage	
		Oil with CCS	
Residential and commercial buildings	Building envelope	Advanced airtight housing/building	
Transport	Reducing vehicle loads	Lightweight materials	
	Transport systems	Non-motorized transport	
	Aviation	Lightweight materials	
Industry	Renewable energy	Various	
	Emissions controls	Carbon dioxide capture and storage	
Forestry	REDD	Avoided deforestation	
		Avoided degradation	
	Forest management	Increase landscape scale carbon stocks	
		Maintain landscape scale carbon stocks (minimize disturbance)	
	Forest products	Increase carbon stock in products	
	Fire management	Reductions in wild fires	
Energy supply	Efficiency	Hydrogen production, storage and distribution	
	Renewable	Ocean power (saline gradient (osmosis), thermal gradient (OTEC), wave)	
	Non-renewable	Hydrogen production, storage and distribution	

Sector	Technology type	Technology application	Technological maturity
Transport	Alternative fuels	Hydrogen/fuel cells	Demonstration
Energy supply	Efficiency	Energy distribution	Deployment
	Renewable	Offshore wind (fixed)	
		Biomass IGCC, gasification and pyrolysis	
		Biogas	
		Solar photovoltaic	
		Concentrated solar power/solar thermal (parabolic trough)	
		Tidal (barrier, stream)	
	Non-renewable	High-efficiency natural gas-fired power generation	
		Stationary fuel cells	
Residential and commercial buildings	Building envelope	Structural insulation panels	
		Ceiling insulation	
		Advanced glazing	
		High reflective building materials	
		Thermal mass	
	Appliances	Biomass derived liquid fuel stove	
		Cogeneration/CHP	
		Efficient space heating	
		Solar space heating and cooling	
		In situ/distributed photovoltaics	
		Air to air heat exchanger	
		High efficiency lighting	
		Advanced supermarket and office technologies	
		Variable speed drives	
		Advanced control systems	
		Solar water pumps	
		High-efficiency water pumping	
		Water efficient devices	
Transport	Reducing vehicle loads	Aerodynamics	
		Mobile air conditioning	
	Improved drive train efficiency	Advanced direct injection	
		Hybrid drive trains	

Sector	Technology type	Technology application	Technological maturity
	Alternative fuels	Biofuels	
		Electric vehicles	
	Transport systems	Eco-driving	
	Rail	Lightweight materials	
	Aviation	Aerodynamics	
		Engine fuel efficiency	
Industry	Emissions controls	PFCs	
		N_2O	
		SF_6	
		Fugitive emissions	
Waste management	Waste to energy	Gasification of MSW	
	Fluorinated gas (F-gas) management	F-gas management	
Agriculture	Cropping	Cropland management	
		Alternative fertilizers	
		Management of organic soils	
	Grazing	Grazing land management	
		Livestock management	
		Manure/biosolid management	
	Restoration of degraded lands	Restoration of degraded lands	
	Renewable energy	Bioenergy	
Residential and commercial buildings	Appliances	Heat pumps	
		Hydrocarbons or CO_2 air conditioners	
Energy supply	Renewable	Onshore wind	Diffusion
		Run-of-river hydropower	
		Geothermal – conventional	
	Non-renewable	Nuclear	
Residential and commercial buildings	Building envelope	Passive solar heating and cooling	
	Appliances	Solar cookers	
		Efficient stoves/ovens	
		Solar dryers	
		High efficiency domestic refrigerators	
		Building management systems	
		Social systems	

Sector	Technology type	Technology application	Technological maturity
Transport	Transport systems	Transport management systems	
	Intramodal shifts	Freight shifts	
		Freight efficiency	
	Rail	Aerodynamics	
	Aviation	Air traffic management	
	Shipping	Hydrodynamics	
		Optimal routes/speeds	
Industry	Efficiency	Energy efficiency	
		Power, heat and fuel recovery	
		Material efficiency	
		Industrial process efficiency	
Waste management	Methane	Wastewater and sludge treatment	
	Waste to energy	Composting	
	Material efficiency	Material efficiency	
Forestry	Renewable energy	Increase bioenergy and substitution	
Energy supply	Renewable	Biomass fuel cell and CCS generation	Research and development
		Solar nano-technology photovoltaic	
Transport	Aviation	Alternative fuels	
		Hydrogen	
		Biofuels	
	Shipping	Alternative fuels	
		Renewable energy	
		Hydrogen fuel cells	
Energy supply	Renewable	Power storage	
Residential and commercial buildings	Building envelope	Ultra-long-term housing	
Transport	Alternative fuels	Synfuels – CCS – Biomass	
Other	Sequestration	Ocean sequestration	

Abbreviations: CCS = carbon dioxide capture and storage, CHP = combined heat and power, IGCC = integrated gasification combined cycle, MSW = municipal solid waste, OTEC = Ocean Thermal Energy Conversion, REDD = reducing emissions from deforestation and forest degradation in developing countries, USCSC = ultra super critical steam cycle.

Annex II

Summary of proposals by Parties for financing mechanisms (as at 30 September 2008)

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/CPR.2
	Scale up support for existing mechanisms	Voluntary contributions from Annex II Parties	EC[a]	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 formulae (emissions, population, gross domestic product)	Mexico	See 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	See <http://unfccc.meta-fusion.com/kongresse/SB28/downl/080603_SB28_China.pdf>

Table (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 and 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 and 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 Adaptation Technology	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 (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 decision1/CP.13. The mechanism comprises an Executive Body and a Multilateral Climate Technology Fund operating under the Conference of Parties.	Contributions from Annex II Parties	G77 & China	See submissions from G77 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 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 technology workshop <http://unfccc.int/files/meetings/ad_hoc_working_groups/lca/application/pdf/eu_pres-08-06-02-awglca2_technology.pdf>

Table (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	See 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	See FCCC/AWGLCA/2008/MISC.2
	Adaptation finance	Adaptation financed through auctioning a share of AAUs of all Annex 1 Parties	Norway	See FCCC/AWGLCA/2008/MISC.2
	Credits for implementing nationally appropriate mitigation actions	Market mechanism driven by stronger commitments from Annex 1 Parties	Republic of Korea	See 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
	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 Institute for Energy Studies, EV 36, Oxford, UK, October 2006.

Table (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 publication *Investment and Financial Flows to Address Climate Change*
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 riskand 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, IPR = intellectual property rights, ODA = official development assistance, RMU = removal unit.

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

Annex III

Coverage of technologies financing sources under and outside the Convention, by sector

The tables in this annex provide an overview of which mitigation technologies identified in the background papers on task I are covered by technology needs assessments (TNAs), financing sources under the Convention and international technology programmes. The financing sources under the Convention are the Global Environment Facility (GEF), the clean development mechanism (CDM) and joint implementation (JI). The international technology programmes are the Asia-Pacific Partnership on Clean Development and Climate (APP) and the International Energy Agency (IEA) Implementing Agreements. For the TNAs, the GEF, the APP and the IEA Implementing Agreements, it is indicated whether the source or vehicle covers the specific technology. For JI and CDM, the number of projects that utilizes the technology is indicated as a more specific indicator.

Table 1. Coverage of agriculture technologies and practices by Convention mechanisms and via selected international technology programmes

Stage of maturity	Technology type	Technology application	TNAs	Sources under the Convention		
				GEF	CDM (number of projects)	JI (number of projects)
Deployment	Cropping	Cropland management	Yes	No	0	0
		Alternative fertilizers	Yes	No	0	0
		Management of organic soils	Yes	No	0	0
	Grazing	Grazing land management	Yes	No	0	0
		Livestock management	Yes	No	0	0
		Manure/biosolid management	Yes	Yes	429	2
	Restoration of degraded lands	Restoration of degraded lands	No	Yes	27	0
	Renewable energy	Bioenergy	Yes	Yes	0	0

Abbreviations: CDM = clean development mechanism, GEF = Global Environment Facility, JI = joint implementation, TNAs = technology needs assessments.

Table 2. Coverage of various energy supply technologies by Convention mechanisms and via selected international technology programmes

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

Abbreviations: APP = Asia Pacific Partnership, CCS = carbon dioxide capture and storage, CDM = clean development mechanism, GEF = Global Environment Facility, IEA-IA = International Energy Agency-implementing agreements, JI = joint implementation, NA = non applicable, TNAs = technology needs assessments, UCCS = carbon dioxide capture and storage.

Table 3. Coverage of various renewable energy supply technologies by Convention mechanisms and via selected international technology programmes

Stage of maturity	Technology application	TNAs	Convention sources			APP	IEA-IA
			GEF	CDM (number of projects)	JI (number of projects)		
R&D	Biomass fuel-cell and CCS power generation	No	No	0	0	No	No
	Power storage	No	No	0	0	Yes	Yes
	Solar nanotechnology photovoltaic	No	No	0	0	No	Yes
Demonstration	Ocean power (saline gradient (osmosis), thermal gradient (OTEC), wave)	No	No	0	0	No	Yes
	Offshore Wind (Floating)	No	No	0	0	No	Yes
	Geothermal – enhanced geothermal systems	No	No	0	0	Yes	Yes
	Concentrated solar power/solar thermal	No	Yes	0	0	Yes	Yes
Deployment	Offshore wind (fixed)	No	No	0	0	No	Yes
	Biomass IGCC, gasification and pyrolysis	Yes	Yes	578	16	Yes	Yes
	Biogas	Yes	Yes	429	2	Yes	Yes
	Solar photovoltaic	Yes	Yes	13	0	Yes	Yes
	Concentrated solar power/solar thermal (parabolic trough)	Yes	Yes	1	0	Yes	Yes
	Tidal (barrier, stream)	No	No	1	0	No	Yes
Diffusion	Onshore wind	Yes	Yes	504	16	Yes	Yes
	Run-of-river hydropower	Yes	Yes	676	2	Yes	Yes
	Geothermal - conventional	Yes	Yes	13	0	Yes	Yes
Commercial	Hydropower (dam)	Yes	No	334	3	Yes	Yes
	Biomass co-firing	Yes	Yes	578	16	Yes	Yes

Abbreviations: APP = Asia-Pacific Partnership on Clean Development and Climate, CCS = carbon dioxide capture and storage, CDM = clean development mechanism, GEF = Global Environment Facility, IEA-IA = International Energy Agency-implementing agreements, IGCC = integrated gasification combined cycle, JI = joint implementation, R&D = research and development, TNAs = technology needs assessments, OTEC = ocean thermal energy conversion.

Table 4. Coverage of various forestry technologies and practices by Convention mechanisms and via selected international technology programmes

Stage of maturity	Technology type	Technology application	TNAs	Convention sources			APP	IEA-IA
				GEF[a]	CDM (number of projects)	JI (number of projects)		
Demonstration	REDD	Avoided deforestation	Yes	No	NA	NA	No	No
		Avoided degradation	Yes	No	NA	NA	No	No
	Forest management	Increase landscape scale carbon stocks	Yes	Yes	0	0	No	No
		Maintain landscape scale carbon stocks (minimize disturbance)	Yes	No	0	0	No	No
	Forest products	Increase carbon stock in products	No	No	0	0	No	No
	Fire management	Reductions in wild fires	Yes	No	0	0	No	No
Diffusion	Renewable energy	Increase bioenergy and substitution	Yes	Yes	0	0	No	No
Commercial	Afforestation	Afforestation	Yes	No	27	0	No	No
	Forest management	Increase forest carbon density	Yes	No	0	0	No	No

Abbreviations: APP = Asia-Pacific Partnershipon Clean Development and Climate, CDM = clean development mechanism, GEF = Global Environment Facility, IEA-IA = International Energy Agency-implementing agreements, JI = joint implementation, NA = non applicable, TNAs = technology needs assessments, REDD = reducing emissions from deforestation and forest degradation in developing countries.

[a] The GEF biodiversity focal area has a more extensive coverage of the forestry sector than climate change focal area. The coverage reported here relates only to activities under the climate change focal area since 2008.

Table 5. Coverage of various industry technologies by Convention mechanisms and via selected international technology programmes

Stage of maturity	Technology type	Technology application	TNAs	Convention sources			APP	IEA-IA
				GEF[a]	CDM (number of projects)	JI (number of projects)		
Demonstration	Emissions controls	CO_2 capture and storage	No	No	1	1	Yes	No
Deployment	Emissions controls	PFCs	No	No	8	1	Yes	No
		N_2O	No	No	65	17	No	No
		SF_6	No	No	2	0	Yes	No
		Fugitive emissions	Yes	No	28	8	Yes	No
Diffusion	Efficiency	Energy efficiency	Yes	Yes	168	11	No	Yes
		Power, heat and fuel recovery	Yes	Yes	363	1	Yes	Yes
		Material efficiency	Yes	Yes	0	0	No	Yes
		Industrial process efficiency	No	Yes	0	0	No	Yes
		Furnaces	Yes	Yes	168	11	No	Yes
		Boilers	Yes	Yes	168	11	No	Yes
		Motors	Yes	Yes	168	11	No	Yes
		Fuel switching	Yes	Yes	130[b]	8	No	Yes
		Feedstock change	No	No	NA	0	No	Yes
		Steam system efficiency	Yes	Yes	168	0	No	Yes
	Emissions controls	HFCs	No	No	22	2	Yes	No
		Avoided methane production	No	No	2	12	No	No
All stages	Efficiency	Product change	No	Yes	0	0	No	No

Abbreviations: APP = Asia-Pacific Partnership on Clean Development and Climate, CDM = clean development mechanism, GEF = Global Environment Facility, HFCs = hydrofluorocarbons, IEA-IA = International Energy Agency-implementing agreements, JI = joint implementation, NA = non applicable, PFCs = perfluorocarbons, TNAs = technology needs assessments.

[a] The GEF chemicals focal area has a more extensive coverage in some industrial sectors than climate change focal area. The coverage reported here only relates to activities under the climate change focal area since 2008.

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

Table 6. Coverage of residential and commercial buildings technologies by Convention mechanisms and via selected international technology programmes

Stage of maturity	Technology type	Technology application	TNAs	Convention sources			APP	IEA-IA
				GEF	CDM (number of projects)	JI (number of projects)		
R&D	Building envelope	Ultra-long term housing	No	No	0	0	Yes	No
Demonstration	Building envelope	Advanced airtight housing/building	NA	Yes	0	0	No	Yes
Deployment	Building envelope	Structural insulation panels	Yes	Yes	8	0	No	Yes
		Ceiling insulation	Yes	Yes	8	0	No	Yes
		Advanced glazing	Yes	Yes	0	0	No	Yes
		High reflective building materials	No	Yes	0	0	No	Yes
		Thermal mass	No	Yes	0	0	Yes	Yes
	Appliances	Biomass derived liquid fuel stove	Yes	No	0	0	No	No
		Cogeneration/CHP	Yes	No	8	0	No	Yes
		Efficient space heating	Yes	Yes	8	0	No	Yes
		Solar space heating and cooling	No	No	0	0	No	No
		In-situ/distributed photovoltaic	Yes	Yes	0	0	No	Yes
		Air to air heat exchanger	No	No	0	0	No	Yes
		High efficiency lighting	Yes	Yes	9	0	No	Yes
		Advanced supermarket and office technologies	No	No	0	0	No	Yes
		Variable speed drives	No	Yes	0	0	No	No
		Advanced control systems	No	No	0	0	No	Yes
		Solar water pumps	Yes	No	0	0	No	No
		High efficiency water pumping	Yes	No	0	0	No	No
		Water efficient devices	No	No	0	0	No	No

Table (continued)

Stage of maturity	Technology type	Technology application	TNAs	Convention sources			APP	IEA-IA
				GEF	CDM (number of projects)	JI (number of projects)		
Diffusion	Building envelope	Passive solar heating and cooling	Yes	Yes	0	0	No	Yes
	Appliances	Heat pumps	Yes	No	0	0	No	Yes
		Solar cookers	Yes		6	0		
		Efficient stoves/ovens	Yes	Yes	0	0	No	No
		Solar dryers	Yes	No	0	0	No	No
		High efficiency domestic refrigerators	Yes	Yes	0	0	No	No
		Building management systems	No	Yes	0	0	No	Yes
		Social systems	No	No	0	0	No	Yes
Commercial	Appliances	Evaporative cooler	Yes	No	0	0	No	Yes
		Solar thermal water heater	Yes	Yes	0	0	No	Yes
		District heating and cooling system	Yes	Yes	0	0	No	Yes
		Efficient air conditioners	Yes	Yes	0	0	No	No
		HC or CO_2 air conditioners	No	No	0	0	No	No
		Wind water pumps	Yes	No	0	0	No	No
		Standby power	No	No	0	0	Yes	Yes

Abbreviations: APP = Asia-Pacific Partnership on Clean Development and Climate, CDM = clean development mechanism, CHP = combined heat and power, GEF = Global Environment Facility, IEA-IA = International Energy Agency-implementing agreements, JI = joint implementation, R&D = research and development, TNAs = technology needs assessments.

Table 7. Coverage of transport technologies by Convention mechanisms and via selected international technology programmes

Stage of maturity	Technology type	Technology application	TNAs	Convention sources			APP	IEA-IA
				GEF	CDM (number of projects)	JI (number of projects)		
R&D	Alternative fuels	Synfuels - CCS - biomass	No	No	0	0	Yes	Yes
	Aviation	Alternative fuels	No	No	0	0	No	No
		Hydrogen	No	No	0	0	No	Yes
		Biofuels	No	No	0	0	No	No
	Shipping	Alternative fuels	No	No	0	0	No	No
		Renewable energy	No	No	0	0	No	No
		Hydrogen fuel cells	No	No	0	0	No	Yes
Demonstration	Alternative fuels	Hydrogen fuel cells	Yes	Yes	0	0	Yes	Yes
	Reducing vehicle loads	Lightweight materials	Yes	No	0	0	No	No
	Transport systems	Non-motorized transport	Yes	Yes	0	0	No	No
	Aviation	Lightweight materials	No	No	0	0	No	No
Deployment	Reducing vehicle loads	Aerodynamics	Yes	No	0	0	No	No
		Mobile air conditioning	Yes	No	0	0	No	No
	Improved drive train efficiency	Advanced direct injection	Yes	No	0	0	No	No
		Hybrid drive trains	Yes	Yes	0	0	No	Yes
	Alternative fuels	Biofuels	Yes	No	0	0	Yes	Yes
		Electric vehicles	Yes	Yes	0	0	No	Yes
	Transport systems	Eco-driving	No	Yes	0	0	No	No
	Rail	Lightweight materials	Yes	No	0	0	No	No
	Aviation	Aerodynamics	No	No	0	0	No	No
		Engine fuel efficiency	No	No	0	0	No	No
Diffusion	Transport systems	Transport management systems	Yes	Yes	0	0	No	No
	Intramodal shifts	Freight shifts	Yes	Yes	0	0	No	No
		Freight efficiency	Yes	Yes	0	0	No	No
	Rail	Aerodynamics	Yes	No	0	0	No	No
	Aviation	Air traffic management	No	No	0	0	No	No
	Shipping	Hydrodynamics	No	No	0	0	No	No
		Optimal routes/speeds	No	No	0	0	No	No

Table (continued)

Stage of maturity	Technology type	Technology application	TNAs	Convention sources			APP	IEA-IA
				GEF	CDM (number of projects)	JI (number of projects)		
Commercial	Improved drive train efficiency	Engine fuel efficiency	Yes	No	0	0	No	No
		Nitrous oxide abatement	No	No	0	0	No	No
	Alternative fuels	Natural gas	Yes	Yes	0	0	Yes	No
	Road Transport - modal shifts	Public transport – bus	Yes	Yes	2	0	No	No
	Transport systems	Public transport – rail	Yes	Yes	0	0	No	No
	Rail	Regenerative braking	Yes	No	0	0	No	No
	Aviation	Optimal flight speed/paths/altitude	No	No	0	0	No	No
	Shipping	Fleet optimization	No	No	0	0	No	No
	Urban design	Urban design	Yes	Yes	0	0	No	No

Abbreviations: APP = Asia-Pacific Partnership on Clean Development and Climate, CCS = carbon dioxide capture and storage, CDM = clean development mechanism, GEF = Global Environment Facility, IEA-IA = International Energy Agency-implementing agreements, JI = joint implementation, R&D = research and development, TNAs = technology needs assessments.

Table 8. Coverage of waste management technologies by Convention mechanisms and via selected Annex I and international technology programmes

Stage of maturity	Technology type	Technology application		Convention sources				
			TNAs	GEF	CDM (number of projects)	JI (number of projects)	APP	IEA-IA
Deployment	Waste to energy	Gasification of MSW	Yes	No	1	0	No	No
	F-gas management	F-gas management	No	No	0	0	No	Yes
Diffusion	Methane	Wastewater and sludge treatment	Yes	Yes	429	0	No	Yes
	Waste to energy	Composting	Yes	No	0	0	No	No
	Material efficiency	Material efficiency	Yes	No	0	0	Yes	No
Commercial	Methane	Landfill methane recovery	Yes	Yes	290	5	No	Yes
		Landfill methane destruction[a]	No	No	0	0	No	Yes
	Waste to energy	Combustion of MSW	Yes	No	11	0	No	No

Abbreviations: APP = Asia-Pacific Partnership on Clean Development and Climate, CDM = clean development mechanism, F-gas = fluorinated gas, GEF = Global Environment Facility, IEA-IA = International Energy Agency-implementing agreements, JI = joint implementation, MSW = municipal solid waste, TNAs = technology needs assessments.

[a] Landfill methane recovery is often considered to be preferable to landfill methane destruction; however, in locations, or for type of waste, where recovery is difficult, destruction might be the only solution.

Table 9. Coverage of remaining technologies by Convention mechanisms and via selected Annex I and international technology programmes

Stage of maturity	Technology application	TNAs	Convention sources			APP	IEA-IA
			GEF	CDM	JI		
R&D	Ocean storage	No	No			No	No
All stages	Other (earth observation projects, specific monitoring, geo-engineering)	No	No	0	0	Yes	No

Abbreviations: APP = Asia-Pacific Partnership on Clean Development and Climate, CDM = clean development mechanism, GEF = Global Environment Facility, IEA-IA = International Energy Agency-implementing agreements, JI = joint implementation, R&D = research and development, TNAs = technology needs assessments.