UNFCCC

Background paper

on

Analysis of existing and planned investment and financial flows relevant to the development of effective and appropriate international response to climate change

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Acronyms and abbreviations

AAU	assigned amount unit (equal to one metric tonne of carbon dioxide equivalent)
ABI	Association of British Insurers
ACT	Australian Capital Territory
AFF	agriculture, forestry and fisheries
AI Parties	Parties included in Annex I to the Convention
AR4	Fourth Assessment Report of the IPCC
AUD	Australian dollar
BAPS	Beyond the Alternative Policy Scenario
BAU	business as usual
BIS	Bank for International Settlement
CAIT	Climate analysis indicators tool
CCLA	Climate Change Levy Agreements
CCRIF	Caribbean Catastrophe Risk Insurance Facility
CCS	carbon dioxide capture and storage
CCX	Chicago Climate Exchange
CDIAC	carbon dioxide information on analysis center
CDM	clean development mechanism
CER	certified emission reduction (equal to one metric tonne of carbon dioxide equivalent)
CGIAR	Consultative Group on International Agricultural Research
CH_4	methane
CHP	combined heat and power
CO_2	carbon dioxide
CO_2 eq	carbon dioxide equivalent
CMP	Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol
COP	Conference of the Parties
CRS	creditor reporting system
CT	combustion turbine
DAC	OECD Development Assistance Committee
DALY	disability adjusted life year
DAYCENT	daily service of century model
DIVA	Dynamic Interactive Vulnerability Assessment tool
DNDC	denitrification decomposition model
DOE	designated operational entity
DSM	demand side management
EAs	enabling activities
EBRD	European Bank for Reconstruction and Development
EC	European Commission
EE	energy efficiency
EEA	European Environment Agency
EIB	European Investment Bank
EMF	Energy Modeling Forum
EPPA	emissions prediction and policy analysis
ERPA	emission reduction purchase agreement
ERU	emission reduction unit (equal to one metric tonne of carbon dioxide equivalent)
ETS	emissions trading scheme
EU	European Union
EUA	European Union allowances
EUR	euro
FAO	Food and Agriculture Organisation of the United Nations
FAOSTAT	Food and Agriculture Organisation Statistical Database
FDI	foreign direct investment
FRA 2005	Global Forest Resources Assessment 2005
FRCs	forest retention certificates
FRIS	forest retention incentive scheme

G8	Group of Eight
GBD	global burden of disease
GBI	global environmental benefit index
GBP	pound sterling
GDP	gross domestic product
GEF	Global Environment Facility
GEF 1	first replenishment of the GEF
GEF 2	second replenishment of the GEF
GEF 3	third replenishment of the GEF
GEF 4	fourth replenishment of the GEF
GEF 5	fifth replenishment of the GEF
GFCF	gross fixed capital formation
GHG	greenhouse gas
GTCC	gas turbine combined cycle
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
HCFC	hydrochlorofluorocarbon
HFC	hydrofluorocarbon
HVAC	heating, ventilation and air conditioning
IATAL	international air travel adaptation levy
ICAO	International Civil Aviation Organisation
IEA	International Energy Agency
IETA	International Emissions Trading Association
IFC	International Finance Corporation
IFI	International Financial Institution
IMF	International Monetary Fund
IGO	Intergovernmental organization
IMO	International Maritime Organisation
INC	initial national communication
IPCC	Intergovernmental Panel on Climate Change
IRR	internal rate of return
ITTO	International Tropical Timber Organisation
IUCN	International Union for the Conservation of Nature and Natural Resources
JI	joint implementation
JISC	Joint Implementation Supervisory Committee
LAC	Latin America and the Caribbean
lCER	long term certified emission reduction
LDCF	Least Developed Countries Fund
LDCs	least developed countries
LNG	liquified natural gas
LPG	liquified petroleum gas
LULUCF	land use, land-use change, and forestry
M&A	mergers and acquisitions
MDB	multilateral development bank
MDGs	Millennium Development Goals
MOU	memorandum of understanding
N_2O	nitrous oxide
NAI Parties	Parties not included in Annex I to the Convention
NAPA	national adaptation programmes of action
NC	national communication
NEF	New Energy Finance
NFP	national forest programme
NGO	non-governmental organization
NSW	New South Wales
NTFP	non-timber forest products
ODA	official development assistance
OECD	Organisation for Economic Co-operation and Development

OP	operational programme
PCF	Prototype Carbon Fund
PDD	project design document
PDF	project development facility
PE	private equity
PFC	perfluorocarbon
PIF	project identification form
PRODEEM	Programme for Energy Development of States and Municipalities
PROFOR	Program on forests
RAF	resource allocation framework
R&D	research & development
RE	renewable energy
REDD	reducing emissions from deforestation in developing countries
RET	renewable energy technology
RGGI	regional greenhouse gas initiative
RMS	Risk Management Solutions
RMU	removal unit (equal to one metric tonne of carbon dioxide equivalent)
SBI	Subsidiary Body for Implementation
SBSTA	Subsidiary Body for Scientific and Technological Advice
SCCF	Special Climate Change Fund
SD-PAM	Sustainable development policies and measure
SDR	special drawing right
SFM	sustainable forest management
SIDS	small island developing States
SPA	strategic priority on adaptation
SRES	Special Report on Emissions Scenario
STRM	short-term response measures
tCER	temporary certified emission reduction
T&D	transmission and distribution
TNA	technology needs assessment
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP FI	United Nations Environment Programme Finance Initiative
UNEP SEFI	United Nations Environment Programme Sustainable Energy Finance Initiative
UNFCCC	United Nations Framework Convention on Climate Change
UNSTAT	United Nations Statistics Division
US EPA	United States Environmental Protection Agency
USD	United States dollar
VAT	value added tax
VC	venture capital
WB	World Bank
WBCSD	World Business Council on Sustainable Development
WEC	World Energy Council
WEO	World Energy Outlook
WG	Working Group
WHO	World Health Organisation
WRI	World Resources Institute
WSSD	World Summit on Sustainable Development

Units of measure

b	billion
cm	centimeter (10^{-2} meter)
EJ	10^{18} Joule
G	giga (1×10^{9})
GJ	10^{9} Joule
ha	hectare
m	million (1×10^{6})
m^3	cubic meter
MJ	10^{6} Joule
ppmv	part per million by volume
t	tonne
toe	tonne oil equivalent
°C	degree Celsius

1. INTRODUCTION

1. This technical background paper reviews and analyses existing and projected investment flows and financing relevant to the development of an effective and appropriate international response to climate change, with particular focus on the needs of developing countries. It provides an assessment of the investment and financial flows that will be necessary in 2030 to meet worldwide requirements for mitigating and adapting to climate change under different scenarios of social and economic development, especially as they impact the well-being of developing countries. In particular it provides:

- Information on current investment and financial flows in as much detail as is available;
- Projection of investment and financial flows by major sources to address adaptation and mitigation needs in 2030, including;
  - Projections of future investment flows and financing under a reference scenario;
  - Projections of future investment flows and financing under a greenhouse gas (GHG) emissions mitigation scenario;
- A summary of priorities identified by Parties not included in Annex I to the Convention (Non-Annex I Parties) as part of the UNFCCC process;
- An analysis of the potential role of different sources of investment and financing and their future potential.

2. This paper has been prepared as background information for three papers requested by the Conference of the Parties at its twelfth session (COP 12):

- A paper with providing an analysis of existing and planned investment flows and finance schemes relevant to the development of an effective and appropriate international response to climate change for the consideration of the fourth workshop on the dialogue on long-term cooperative action to address climate change by enhancing implementation of the Convention (the Dialogue)[1];
- Two papers for the consideration of the Subsidiary Body for Implementation (SBI) in its fourth review of the financial mechanism of the Convention at its twenty-seventh session,[2] namely:
  - A technical paper reviewing the experience of international funds, multilateral financial institutions and other sources of funding that may be used to meet current and future investment and financial needs of developing countries for the purposes of meeting their commitments under the Convention;
  - A report prepared in collaboration with the Global Environment Facility (GEF) secretariat, on the assessment of the funding necessary to assist developing countries.

3. To ensure that this analysis is beneficial to the UNFCCC process, the secretariat has collaborated with a number of international financial institutions (IFIs), United Nations agencies, intergovernmental organizations (IGOs) and non-governmental organizations (NGOs), other relevant agencies, and representatives of the private sector and civil society. These organizations and representatives were invited to share their experiences and views on existing and planned investment flows and finance schemes in the context of consultations.

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[1] FCCC/CP/2006/5, paragraph 61.

[2] These papers should be made available in the last quarter of 2007 as documentation for consideration at SBI 27. Please refer to decision 2/CP.12 for details of the mandates.

4. Four consultative meetings with such stakeholders have been held. Two consultative meetings were held in Bonn, Germany, with experts and representatives of IFIs, United Nations agencies, IGOs and NGOs to discuss the role of international public financing activities in addressing climate change (5-6 February and 26-28 March 2007). Another two consultative meetings were held in London, United Kingdom (20 and 21 June 2007), in collaboration with representatives of the private financial sector (including investment banks, venture capital firms, private funds, insurers and reinsurers) and the insurance sector.[3]

5. The paper draws on existing work and analysis wherever possible. Existing work used for the analysis includes the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC), the World Energy Outlook (WEO) of the International Energy Agency (IEA), the Stern Review and other published literature.[4]

6. This paper is divided into nine main parts:

- An introduction to the overall methodology and scenarios used in the paper and a summary of overall current investment and financial flows (chapters 2 and 3);
- An analysis of needs and corresponding investment and financial flows for climate change mitigation, including needs and flows related to technology research and development (R&D) (chapter 4);
- An analysis of needs and corresponding investment and financial flows for climate change adaptation (chapter 5);
- A summary of priorities related to mitigation and adaptation identified by non-Annex I Parties under the UNFCCC process (chapter 6);
- An analysis of the potential of carbon markets (chapter 7);
- An overview of financial assistance under the Convention (chapter 8);
- An analysis of the potential for enhanced investment and financial flows (chapter 9).

[3] In collaboration with the World Business Council on Sustainable Development (WBCSD), the United Nations Environment Programme Finance Initiative (UNEP FI), the United Nations Environment Programme Sustainable Energy Finance Initiative (UNEP SEFI), the European Carbon Investors and Services, the International Emissions Trading Association (IETA) and the World Energy Council (WEC).

[4] For detailed information, please refer to the list of database and references in annex 1.

2. METHODOLOGY

7. This paper presents a snapshot of current investment and financial flows based on available data. Future investment and financial flows are based on specific reference and mitigation scenarios.

8. It is important to note that the analysis in this paper do not provide for an estimate of total cost of climate change mitigation or of the total cost of adaptation to impacts of climate change.

2.1. Interpretation of investment and financial flows

9. The analysis presented in this paper uses the following definitions for investment and financial flows:

- **An investment flow** is the initial (capital) spending for a physical asset;
- **A financial flow** is an ongoing expenditure related to climate change mitigation or adaptation that does not involve investment in physical assets.

2.2. Methodology overview

10. Conceptually, the methodology employed is simple. Relevant investment and financial flows are projected for selected scenarios. These future flows are compared with the current flows and the current sources of funds because projections of the sources of future flows are not available from the scenarios.

11. Investment and financial flows are analysed for the following mitigation and adaptation sectors:

- Mitigation sectors: energy supply, industry, transportation, buildings, waste, agriculture and forestry;
- Adaptation sectors: agriculture, forestry and fisheries (AFF); water supply; human health; natural ecosystems; coastal zone; infrastructure.

12. The analysis covers the investment and financial flows needed in 2030. This is an appropriate time period for an analysis of investment flows. The level of detail available from published scenarios declines sharply as the time horizon is extended beyond 2030.

13. This analysis was disaggregated to the extent possible. Limited availability of data, especially in terms of regional detail, led to most of the results being compiled under the following regional groupings**:** Organisation for Economic Co-operation and Development (OECD) North America, OECD Pacific, OECD Europe, transition economies, developing Asia, Latin America, Africa and Middle East (see annex 1).

14. Unless otherwise specified, all monetary values have been converted to 2005 United States dollars (2005USD).

2.3. Scenarios

15. Existing scenarios had to be used because the time and resources needed to develop new scenarios were not available. There is no single scenario that covers all GHG emissions and sinks for which climate impacts have been modelled. The scenarios were selected based on their suitability for the analysis, the detail they provide on estimated investment and financial flows, and how representative they are of the literature.

2.3.1. Scenarios used for the mitigation analyses

16. Any analysis of future investment and financial flows requires a reference scenario and a mitigation scenario that reflects an international response to climate change. The mitigation analysis uses a scenario that would return emission level in 2030 to 2004 level.

17. The reference scenario used in this analysis consists of:

- The energy-related carbon dioxide (CO_2) emissions of the IEA WEO 2006 reference scenario (IEA, 2006);
- The baseline non-CO_2 emissions projections from the United States Environmental Protection Agency (US EPA) extrapolated to 2030 (US EPA, 2006);
- Current CO_2 emissions due to land use, land use change and forestry (LULUCF);
- Industrial process CO_2 emissions from the World Business Council on Sustainable Development (WBCSD) (WBCSD, 2002).

18. The mitigation scenario consists of:

- The energy-related CO_2 emissions of the IEA WEO 2006 Beyond The Alternative Policy Scenario (BAPS) scenario (IEA, 2006);
- The US EPA baseline non-CO_2 emissions projections less the reductions possible at a cost of less than USD 30 per t CO_2 eq;
- Potential CO_2 sinks increases due to agriculture and forestry practices;
- Industrial process CO_2 emissions from WBCSD (WBCSD, 2002).

19. The World Energy Outlook (WEO) provides a comprehensive reference scenario of energy supply and demand and the associated GHG emissions and investments. With the cooperation of the IEA, the cumulative investment estimates were converted to annual investment flows. In addition, the OECD provided preliminary estimates of the projected investment flows in 2030 based on the OECD ENV–Linkages model calibrated to this scenario.[5]

20. The BAPS scenario is the most aggressive mitigation scenario considered by the IEA. It returns global energy-related CO_2 levels to current levels by 2030. With the cooperation of the IEA, the BAPS scenario was disaggregated into the same regions as those of the reference scenario and the cumulative investment estimates were converted to annual investment flows.

21. The reference and BAPS case do not consider the need for increased electricity access in developing countries. From the policies and the level of investment reflected in these scenarios the IEA estimates that about 1.4 billion people will remain without access to electricity in 2030. Universal electricity access by 2030 would require an additional annual investment of USD 25 billion.

22. The US EPA projections of non-CO_2 emissions are the most comprehensive available in the literature. The US EPA provides marginal abatement curves for the cost of reducing emissions of non-CO_2 gases by sector and by region. The marginal cost increases sharply after USD30 per t CO_2 eq for most of the curves. Thus, the emissions reduction possible at a cost of less than USD30 per t CO_2 eq is approximately the maximum.[6]

[5] OECD. ENV-Linkages Model calibrated to the IEA WEO 2006 Reference scenario. Personal communication with Philip Bagnoli at OECD. For information, see chapter 3.3.

[6] At a cost of USD 60 per t CO_2 eq the reduction would be only a slightly larger.

23. No baseline scenarios with forest use, rates of change and fluxes are available in the literature. Thus, the reference scenario assumes that GHG emissions from the forestry sector in 2030 are the same as in 2004. The mitigation scenario includes the potential sinks created through reduced deforestation, forest management and afforestation/reforestation.

24. The A1 scenario in the WBCSD report *Towards a Sustainable Cement Industry (WBCSD, 2002)* is adopted as the reference scenario for the analysis on industrial process CO_2 emissions. Within the literature, a 7 per cent worldwide technical potential by 2020 was identified, of which the responding emissions were selected for as mitigation scenario of industrial process CO_2 emissions in this paper.

2.3.2. Scenarios used for the adaptation analyses

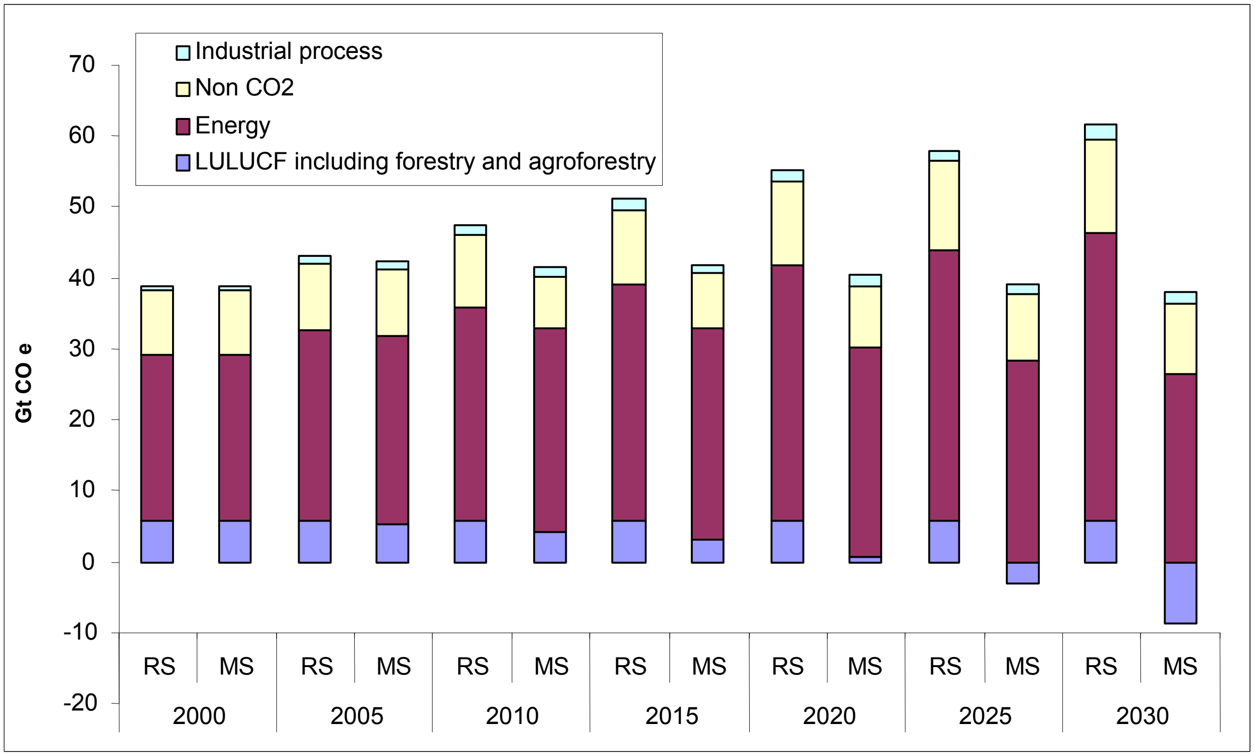
25. The analysis of investment and financial flows needed for adaptation to climate change was based on emissions scenarios for which climate change impacts could be inferred and responses to the climate impacts could be projected, so that the associated investment and financial flows could be estimated. The scenarios were selected based on their suitability for the analysis, the detail they provide on estimated investment and financial flows, and how representative they are of the literature. The following scenarios have been used for different sectors:

- IPCC SRES A1B and B1 scenarios are used for the water supply and coastal zones sectors (Nakicenovic N. and Swart R. (eds). 2000);
- For the human health sector, the scenarios used were variation from the IPCC IS92a: a scenario resulting in stabilization at 750 ppmv CO_2 equivalent by 2210 (s750), and a scenario resulting in stabilization at 550 ppmv CO_2 equivalent by 2170 (s550) (Leggett et al., 1992). These scenarios were used in the context of a WHO study on the global and regional burden of disease (GBD) (McMichael AJ et al, 2004);
- Projected investment in physical assets for 2030 from the OECD ENV–Linkage model were used as the basis for estimating additional investment and financial flows needed in the AFF and infrastructure sectors. The projected investment in physical assets for 2030 based on the OECD ENV–Linkage model corresponds to the projection of the IEA WEO reference scenario.

2.4. Projected greenhouse gas emissions

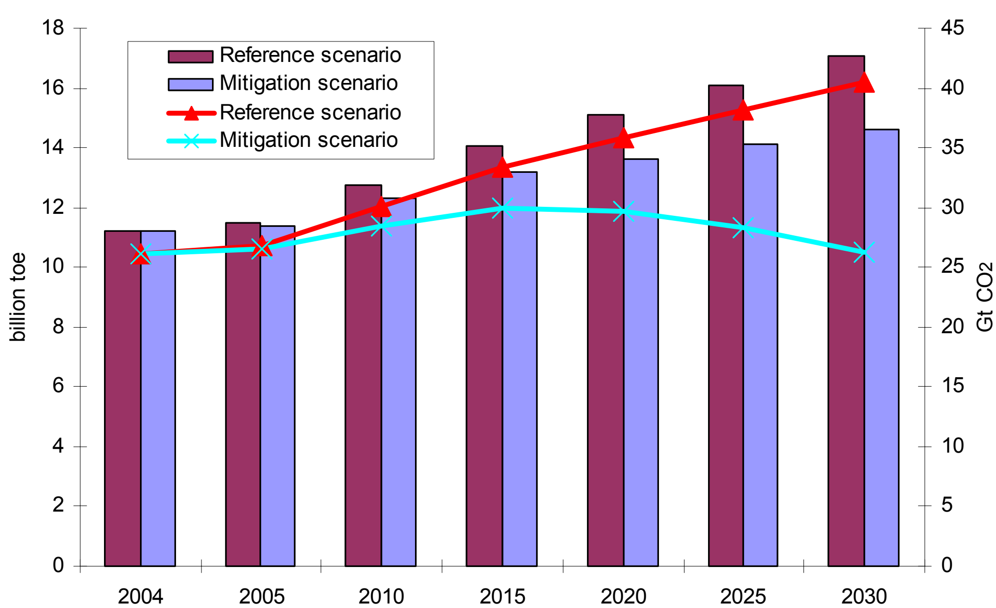
26. Figure 1 shows the GHG emissions by sources for the reference and mitigation scenarios used in the mitigation analysis. Global emissions rise from 38.91 Gt CO_2 eq in 2000 to 61.52 Gt CO_2 eq in 2030 under the reference scenario. The mitigation scenario reduces the projected emissions in 2030 to 29.11 Gt CO_2 eq. Energy-related emissions account for 65.9 per cent of the total in 2030 under the reference scenario; industrial process CO_2 (3 per cent), non-CO_2 gases (21.7 per cent) and LULUCF (9.4 per cent) make up the balance. The mitigation scenario reduces energy-related emissions projected under the reference scenario by 35 per cent, industrial process CO_2 emissions by 11 per cent, non-CO_2 gases emissions by 25 per cent and LULUCF emissions by 252 per cent (see annex 5, table 5).

Figure 1. Total greenhouse gas emissions under reference and mitigation scenarios



27. Figure 2 shows total energy supply and the related GHG emissions under the reference and mitigation scenarios used in the mitigation analysis. Energy efficiency is a major component of the mitigation scenario; energy demand in 2030 is 15 per cent lower than under the reference scenario, representing a 6 Gt CO_2 eq reduction in annual emissions. Decarbonization of energy supply, including the use of renewables, nuclear energy and CO_2 capture and storage (CCS), also plays a major role in returning emissions to the 2004 level in 2030 under the mitigation scenario, reducing annual emissions by 8 Gt CO_2 eq.

Figure 2. Energy supply and related greenhouse gas emissions under the reference and mitigation scenarios



2.5. Comparison with the scenario literature

28. Figures 3 and 4 compare the emissions and driving forces of the scenarios used for the analysis.

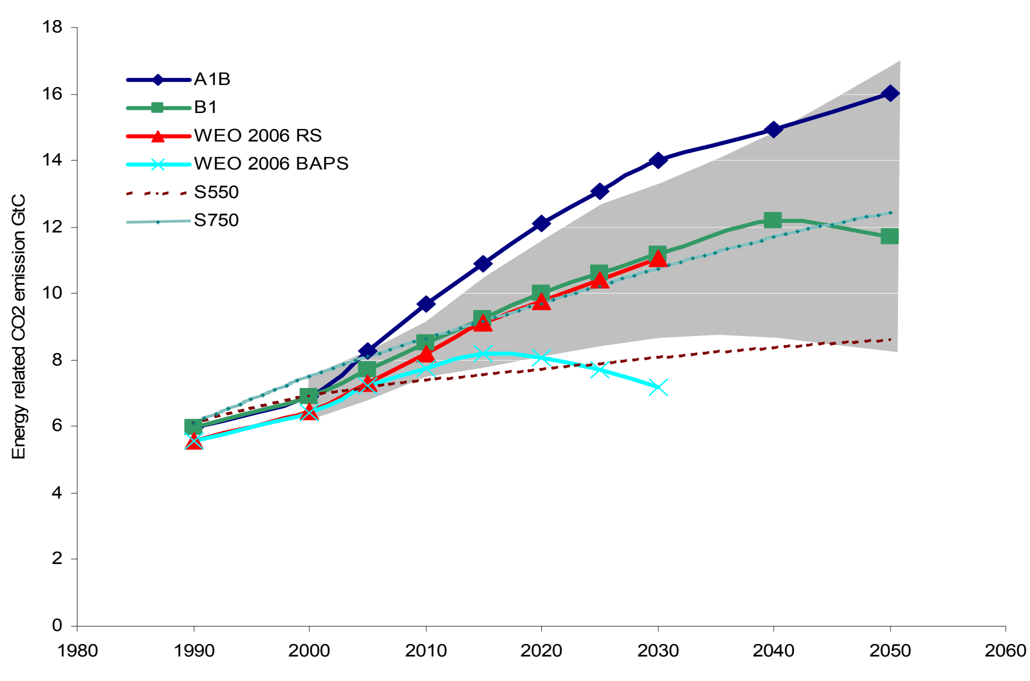
29. As shown in figure 3, emissions under IEA WEO reference scenario, the IPCC SRES B1 scenario and the 750 ppmv stabilization scenario (s750) used in the GBD study are close to each other in 2030. The shaded area in figure 3 represents the standard deviation of the scenarios available in the literature. The emission path of the three scenarios mentioned above lies in the middle of this shaded area and can thus be considered as moderate estimates.

30. Under the reference scenario used for the mitigation analysis, the stabilization of atmospheric concentration of CO_2 will occur at over 650 parts per million (ppmv). Figure 3 also shows that, the WEO 2006 BAPS case used for the mitigation analysis results in emission level equivalent to current level, this corresponds to a the stabilization of atmospheric concentration of between 550 and 450 ppmv.

31. The IPCC SRES A1B and the 550 ppmv stabilization scenarios (s550) from the GBD study used in the adaptation analysis for some sectors result in emission level that are respectively higher and lower than the level of the B1 scenario.

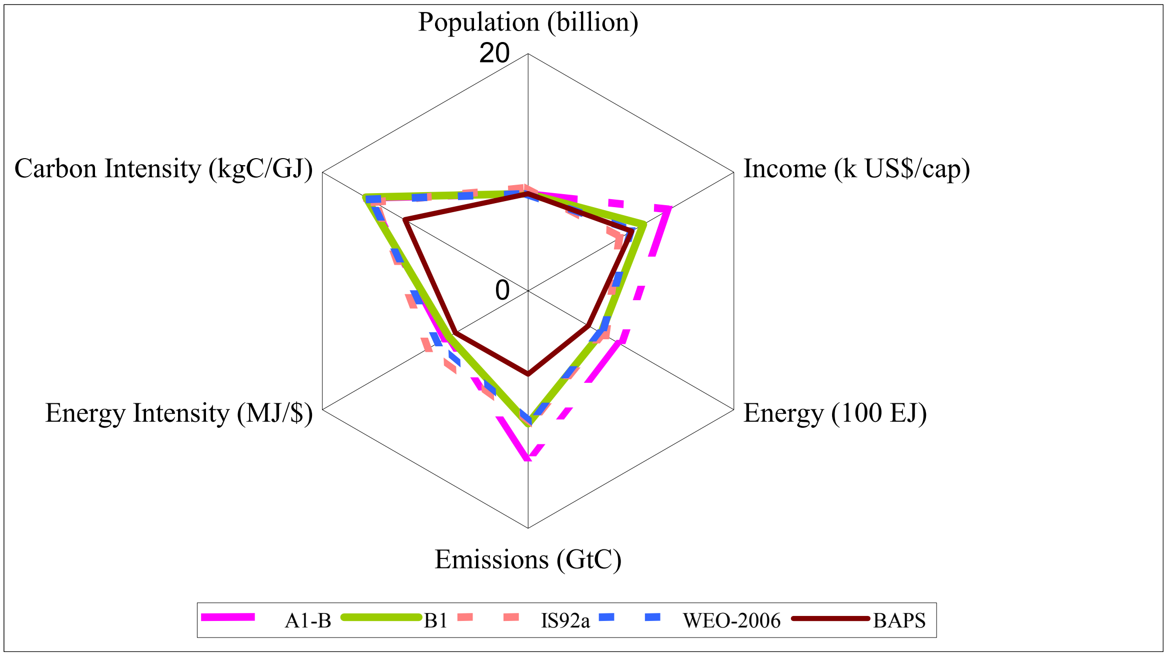
32. Figure 4 shows the variation in the driving forces of the different scenarios used in 2030. The driving forces for the WEO reference scenario are virtually identical to those for the B1 scenario, as might be expected since the emissions of those scenarios are virtually identical (see Figure 3). The A1B scenario has higher per capita income than the WEO reference scenario, which leads to more energy use and higher emissions as shown in Figure 3. The WEO 2006 BAPS case has the same population and per capita income as the reference scenario, but lower energy intensity and lower carbon intensity, leading to less energy use and lower GHG emissions.

Figure 3. Emissions projections of the scenarios used for the analyses and the scenario literature



Note: Based on IEA 2006; Nakicenovic et al., 2006; IPCC, 2007c.

Figure 4. Comparison of the main driving forces of greenhouse gas emissions under different scenarios in the literatures



3. CURRENT AND REFERENCE SCENARIO INVESTMENT AND FINANCIAL FLOWS

33. As mentioned in chapter 2, the investment flows analysed in this paper focus on capital spending for new physical assets, and financial flows relate to mitigation and adaptation activities that do not involve an investment in physical assets. This chapter discusses how data for current investment flows were compiled and adjusted for purchases and sales of financial assets where appropriate. It then provides an overview of current investment and financial flows. Next, projected investment and financial flows under the reference scenario are summarized. Finally, interpretation of the estimates is addressed.

3.1. Data on current investment flows

34. The investment in new physical assets during a given year is reported in the national accounts of countries as "gross fixed capital formation" (GFCF). The sources of the investment and the economic sectors in which the investments were made are also reported.

35. The sources reported in the national accounts are the entities – governments, corporations or households – responsible for the investments, not the sources of the funds.[7] A government, for example, could fund an investment from tax revenue or with new debt in the form of bank loans or bonds. Similarly, a corporation could fund an investment from internal savings, new debt or new equity. The debt or equity can come from within the country or from other countries.

36. Data are also available on funds obtained from other countries during the year; specifically equity foreign direct investment (FDI)), international debt, and official development assistance (ODA) in the form of grants and concessionary loans.[8] Data on how investors raise funds domestically – through internal savings, loans, or equity – are not available. The amount funded domestically is calculated by subtracting the foreign funds from the total investment (GFCF).

37. The data on GFCF, FDI, international debt, and ODA are discussed in turn. These data are all on a calendar year basis. The most recent year for which national accounts data is available for a large number of countries is 2000.

3.1.1. Gross fixed capital formation

38. GFCF is the most comprehensive and consistent measure of current investment in physical assets available. It is the spending on new physical assets in a country during a specified year.[9] Many countries report the sources and/or economic sectors of GFCF based on internationally agreed definitions; the four sources and 10 economic sectors are listed in table 1.

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[7] Determining the sources of funds is complex. For example, a household may use a mortgage from a bank to help fund its purchase of a house. The bank could be considered the source of the mortgage funds, but the bank gets those funds from deposits by households and corporations.

[8] The carbon markets, which were negligible source of investment funds in 2000, have grown rapidly since discussed in chapter 7.

[9] GFCF also includes the net change in inventories during the year. This is excluded where it is reported separately. It is usually of the order of 1 or 2 per cent of the total, so where it can not be excluded it does not greatly distort the figures.

Table 1. Sources and sectors for gross fixed capital formation

Sources	Economic sectors
Households Government Financial corporations Non-financial corporations	Agriculture, hunting, forestry and fishing Mining and quarrying Manufacturing Electricity, gas and water supply Transport, storage and communications Financial intermediation real estate, renting and business activities Construction Wholesale retail trade, repair of motor vehicles, motorcycles, etc., hotels and restaurants Public administration and defence, compulsory social security Education, health and social work, other community, social and personal services

39. Total GFCF is available for almost all countries for 2000. Values for the remaining countries were estimated based on the country's gross domestic product (GDP) and per capita GDP. GFCF by source and by sector was reported by just over 50 countries for 2000, but those countries account for 85–90 per cent of global GFCF. For countries with incomplete or missing data for GFCF by sources or sectors, the values were estimated as described in annex 2.

40. The 10 economic sectors for which GFCF (and FDI) data are available do not always match the sectors used for the mitigation and adaptation analyses. Agriculture and forestry, for example, are analysed separately in this paper but are part of the same economic sector for GFCF and FDI data calculations. Those data issues are addressed in the respective mitigation and adaptation sector analyses.

3.1.2. Households

41. Households are individuals. They invest in housing, farms, vehicles and facilities for small businesses. Households are responsible for 15–35 per cent of total global investment, all of which is assumed to come from domestic sources. However, remittances by family members working in foreign countries are substantial for some countries and could help fund household investment in the recipient countries.

3.1.3. Governments

42. Governments are the national, provincial, state and local governments of a country.[10] They invest in long-lived assets that provide local public benefits, such as transportation infrastructure, water supply, schools and hospitals, coastal infrastructure, and natural ecosystems. They channel their investments into their most pressing development priorities. High social returns are sought, such as economic growth, jobs, improved national security, improved health of citizens and a cleaner environment. Governments often use a long timeframe to evaluate the expected returns from their investments. They often try to reduce the risk of an investment not performing as expected by relying on proven technologies.

43. Governments are typically responsible for 10–15 per cent of total investment in physical assets in a country. Over 90 per cent of the funds that governments invest come from domestic sources such as the taxes and fees they collect. They may borrow funds from domestic or foreign sources. International borrowing by governments amounts to less than 10 per cent of their investment in new physical assets.

44. Operational spending by governments such as health care spending and funding for energy research may also contribute to climate change adaptation or mitigation. The Government of India estimates that adaptation expenditures related to agriculture, water supply, health and sanitation, coastal zones, forests, and

[10] Financial and non-financial corporations, such as oil companies or electric utilities, owned wholly or in part by governments are included in those source categories.

extreme weather events amounted to between 3 and 5 per cent of central government spending over the five years prior to fiscal year 2005/2006 and 8 per cent during that year.[11]

3.1.4. Financial corporations and non-financial corporations

45. Financial corporations are entities such as banks and insurance companies that provide financial services to non-financial corporations, households and governments. They also invest in physical facilities, such as buildings, using funds raised domestically or from foreign sources. They are responsible for 1-7 per cent of the investment in new physical assets.

46. Non-financial corporations produce goods, such as fossil fuels, and non-financial services, such as communications services. They need physical facilities such as commercial buildings, industrial plants, and telecommunications facilities to provide the goods and services they offer.

47. Since investment in physical assets by financial corporations is small relative to the investment from other sources, it is combined with investment by non-financial corporations for the analysis. Together these sources are responsible for 50–75 per cent of the total investment in new physical assets. All FDI is assumed to go to corporations. FDI as a share of total investment by corporations varies widely across regions. International debt as a share of total investment by corporations also varies widely across regions.

3.1.5. Foreign direct investment

48. FDI tends to be made by multinational corporations seeking to establish or expand operations overseas. As it is an equity investment, lenders of FDI seeks a higher return than most lenders, but also accepts higher risks.

49. FDI is reported by several sources, which were compared and consolidated as discussed in annex 2. The data cover both equity investment by multilateral operating companies in new physical assets and acquisition of existing physical and financial assets. Globally, purchases and sales of existing assets are approximately equal. But for an individual country, purchases and sales of existing physical and financial assets can be a large component of FDI.[12]

50. Since the analysis focuses on investment in new physical assets, two values of total FDI are compiled for each country:

- Inward FDI as reported: equity investment in new physical assets and acquisition of existing physical and financial assets in the recipient country;
- Adjusted FDI: inward FDI as reported less the value of international purchases in the recipient country, plus the value of international sales in the recipient country due to mergers and acquisitions (M&A).

51. Data on inward FDI, but not M&A, are available by sector. As a result, FDI estimates for some sectors or regions are either large or small relative to the investment in new physical facilities.

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[11] Presentation "India: Adaptation Approaches and Strategies" made by R. Ray, Deputy Secretary, Ministry of Environment and Forests, Government of India, during the third workshop of the dialogue on long-term cooperative action to address climate change by enhancing implementation of the Convention (22 May 2005), see: <http://unfccc.int/files/meetings/dialogue/application/pdf/india_-_adaptation.pdf>.

[12] For example, in a small country with a large international financial sector, FDI can be much larger than the GDP. In such cases, the FDI is obviously not all invested in new physical assets in the country.

52. Data on inward FDI are not available by source, so it is assumed that all inward FDI goes to corporations.

3.1.6. International debt

53. International debt includes loans provided by commercial banks and the sales of bonds in the capital market. Commercial bank loans generally cover periods from a few days to a few years. Bonds generally have a longer maturity, ranging up to decades. Debt provides finance to borrowers that have a demonstrated capacity to repay the loan with interest. Lenders generally want little risk and are prepared to accept lower returns than equity investors.

54. Data on international debt are published by the Bank for International Settlements (BIS). They cover only debt issued by banks in 40 large lending countries, so total international debt is understated, but there is no basis for estimating the foreign borrowing not covered by this source. Data on new international debt borrowed or issued by governments and corporations are available for each year. Data on foreign borrowing are available by sectors.

55. There is no guarantee that international debt is invested in new physical infrastructure; the corporations and governments that borrow the money could use it for operating purposes. International debt represents almost 20 per cent of total global investment and a reasonable share of the total investment made by governments and corporations. Assuming that international debt is used for operational purposes would simply increase the funds raised from domestic sources.

3.1.7. Official development assistance

56. ODA is bilateral or multilateral assistance provided on concessional terms. Bilateral assistance is provided by the government of another country, as a grant that does not need to be repaid, or as a loan with concessional terms. Multilateral assistance usually takes the form of a loan with concessional terms from an IFI. The primary objective of ODA is to alleviate poverty but some of the funding is invested in new facilities or spent in ways that contribute to climate change mitigation or adaptation.

57. The OECD collects extensive data on bilateral and multilateral ODA. Only the investment component of ODA is included in the investment flows; analyses of financial flows consider all of the relevant ODA flows. ODA data are available by sector. While some ODA funds go to non-governmental entities, all ODA is assumed to go initially to governments in the recipient countries. The investment component of ODA amounts to between 1 and 7 per cent of total investment in new physical assets in developing country regions.

58. Analyses of financial flows consider the relevant ODA flows, not just the investment component.

59. The original data are reported by the 22 members of the Development Assistance Committee (DAC) of the OECD and by the European Commission (EC) to the Creditor Reporting System (CRS) Aid Activity database. The CRS also includes data from multilateral organizations, although these are not obligated to report to the OECD.

60. Some donors do not supply data to the OECD. The major gaps in bilateral ODA reporting post 1999 come from Japan and the EC. The former does not report technical co-operation activities; the latter does not report activities financed through its budget.

3.1.8. Domestic funds

61. Most of the funds invested in new physical assets are raised domestically; 50–90 per cent in most regions. Systematic data on the sources of these funds are not available. Instead, the domestic funds invested by households, governments and corporations are estimated.

62. All investment by households is assumed to originate domestically from savings or as debt from friends or financial institutions.

63. Over 90 per cent of the funds invested by governments are raised domestically. These funds may come from tax or other revenue, be borrowed from domestic financial institutions or come from the sale of bonds in the domestic market.

64. Although corporate investment includes substantial amounts of foreign equity and international debt, over half of the funds that corporations invest globally originate domestically. These funds can come from internal cash flow, commercial loans or the sale of bonds or equity in domestic financial markets. Corporations and their domestic sources of funds are adjusted to the country risk and have first-hand knowledge of the local market. They may also find it easier to raise funds domestically since they are known to the local financial community.

3.1.9. Overview of current investment flows

65. Table 2 provides an overview of the investment flow data available, together with the sources of the data and the key assumptions. The same information, apart from the adjusted FDI and adjusted domestic sources, is available for each of the 10 economic sectors in annex 5, table 35.

Table 2. Overview of investment flow data

Source		Total/Sector	Notes
Households	Total investment	A: GFCF data	Assumed to be entirely domestic
Corporations	Total investment	B: GFCF data	
	Domestic funds	C: Calculated (B – D – G)	
	FDI	D: UNCTAD data	Assumed to be all non-financial corporations
	Adjusted domestic funds	E: Calculated (B – F – G)	
	Adjusted FDI	F: UNCTAD data	Adjusted for mergers and acquisitions; not available by sector
	Foreign debt	G: BIS data	
Government	Total investment	H: GFCF data	
	Domestic funds	I: Calculated (H – J – K)	
	Foreign debt	J: BIS data	
	ODA	K: OECD data	Assumed to be all government
Total	Total investment	A + B + H	
	Domestic funds	A + C + I	
	FDI	D	
	Adjusted domestic	A + E + I	
	Adjusted FDI	F	
	Foreign debt	F + J	
	ODA	K	

Abbreviations: BIS= Bank for International Settlement, FDI = Foreign Direct Investment, GFCF = Gross fixed capital formation, ODA = Official Development Assistance, OECD = Organisation for Economic Co-operation and Development, UNCTAD = United Nations Conference on Trade and Development.
Note: Please refer to annex 2 and annex 5 tables 1–4 for detailed information on the above definition and calculation.

66. The sources of global investment flows in 2000 are summarized in table 3. Total global investment in 2000 was USD 7,750 billions, or about 21 per cent of global GDP. Almost 60 per cent of the funds invested were raised domestically, with FDI and foreign debt accounting for just over and just under 20 per cent respectively. ODA funds invested in physical assets represent less than 1 per cent of the total investment.

Table 3. Sources of investment in 2000

Source		Amount (in billion 2000 USD)	Amount (in billion 2005 USD)	Share of total (in percentage)
Households	Total investment	1 814	2 045	26
Corporations	Total investment	4 125	4 649	60
	Domestic funds	1 429	1 611	21
	FDI[a]	1 540	1 736	22
	Foreign debt	1 156	1 303	17
Government	Total investment	937	1 056	14
	Domestic funds	850	959	12
	Foreign debt	71	80	1
	ODA	16	18	0
Total	**Total investment**	6 875	7 750	100
	Domestic funds	4 093	4 614	60
	FDI[a]	1 540	1 736	22
	Foreign debt	1 226	1 382	18
	ODA	16	18	0

Source: Estimations by UNFCCC secretariat based on data from UNSTAT, National Accounts Database; BIS, 2007; World Bank, 2006, World Development Indicator; OECD, CRS.
[a] May not include all international equity investments by financial corporations, organizations, funds, limited partnerships and other entities, for example through project finance.

67. The regional distribution of current investment is presented in annex 5, table 3. Governments provide a higher than average share of the investment in Africa, while households provide less. Investment funded through ODA accounts for over 6 per cent of the total in least developed countries (LDCs), 2 per cent in Africa and about 1 per cent in other developing country regions. Foreign debt is significant in Latin America and OECD regions. FDI is significant in OECD regions, Latin America and developing Asia. Adjustments for purchases and sales makes the most difference in OECD regions.

68. Annex 5, table 1 summarizes commercial financing by sector and region for 2000 and 2005. The data cover projects partly funded by loans from commercial banks. Such projects represent almost 30 per cent of the investment in the electricity, gas distribution and water supply sector and about 15 per cent of the transportation, storage and communications sector. The table shows the debt: equity ratio for projects in each sector. Annex 5, table 2 shows the same data by region for 2000.

3.2. Current financial flows

69. Current financial flows are specific financial flows relevant to climate change mitigation or adaptation that do not involve investment in physical assets. Information on financial flows supported by climate change funds established by the Convention and its Kyoto Protocol can be found in chapters 7 and 8. Information on current financial flows relevant to specific mitigation or adaptation measures is discussed in the analysis for the relevant sector.

3.3. Investment flows needed in 2030

70. Projections of future investment flows are available by economic sector, but not by source. Projections of future FDI, international debt and ODA are also not available. In addition, the economic sectors for which current and future investment flows are available do not always coincide with those relevant to the analysis of climate change mitigation and adaptation. This means that the future investment flow projected for a sector was assessed on the basis of the current sources of investment for the sector.

71. The reference scenario used for the mitigation analysis includes the IEA WEO 2006 reference scenario and, as shown in chapter 2, the WEO scenario is close to most of the scenarios used in the adaptation analysis. Preliminary estimates of new investment calibrated to the WEO scenario are available from the OECD's ENV–Linkages model. The projected investment in new physical assets in 2030 from that calibrated model is USD 22,270 billion. This means that total investment, adjusted for inflation, is projected to grow at a rate of 4 per cent per year, which is high by historical standards, due to economic growth over the period.

72. Global investment by sectors for 2000 and 2030 is summarized in table 4. The data for 2000 come from the sources described earlier in this chapter, while the 2030 figures come from the OECD ENV–Linkages model. The OECD ENV–Linkages model projects investment for 26 economic sectors, which do not match exactly the 10 economic sectors for which current investment flows are available.

Table 4. Global investment by sector in 2000 and 2030 (percentage)

	2000	**2030**
Agriculture, hunting, forestry; fishing	2.26	1.20
Mining and quarrying	1.80	0.83
Manufacturing	16.78	15.46
Electricity, gas and water supply	3.32	1.65
Construction	11.47	9.45
Transport, storage and communications	8.02	
Financial intermediation; real estate, renting and business activities	5.65	19.06
Wholesale retail trade, repair of motor vehicles, motorcycles, etc.; hotels and restaurants	33.69	
Public administration and defense; compulsory social security	8.03	39.94
Education; health and social work; other community, social and personal services	8.98	
Dwellings	N.A.	12.41
Total in billion USD	7 750	22 270

Source: Estimations by UNFCCC secretariat based on data from UNSTAT, National Accounts Database; BIS, 2007; World Bank, 2006, World Development Indicator; OECD, CRS; OECD, ENV-Linkages Model.

73. The proportion of investment made in primary sectors – agriculture, forestry, fishing and mining – is projected to decline although the amount invested will increase substantially: a typical pattern for economic growth. The apparent decline in the proportion of investment made in electricity supply, gas distribution and water supply will be analysed further in the energy supply chapter (chapter 4.4.1.). Significant increases in investment are projected for the transportation, storage and communications sector and the financial intermediation, real estate, renting and business activities sector.

74. The sectoral distribution indicates that the principal sources of GHG emissions and the focus of mitigation efforts – i.e. the agriculture, forestry, mining (oil and gas production), manufacturing, electricity generation, gas distribution, and transportation sectors – receive less than one-third of total investment. It is more difficult to estimate the share by sector of total investment involved in adaptation to climate change, but the agriculture, forestry, fishing, water supply and health care sectors probably receive less than 10 per cent of the total. Buildings and other infrastructure that might be damaged by the impacts of climate change may receive 20–40 per cent of total investment.

75. The relationship between investment and GDP and population by region is shown in table 5. The shares of population and GDP differ widely, leading to recognized differences in per capita GDP across regions. However, investment in new physical assets is closely related to GDP; in other words, investment as a share of GDP is approximately the same for all regions.

76. There are substantial differences across regions in the sectoral distribution of investment, as shown in table 5. Overall, developing Asia's share of global investment rises sharply between 2000 and 2030, reflecting its projected rapid growth. The slower economic growth of OECD regions causes their share of global investment to fall. Investment in primary sectors (AFF, and mining and quarrying) declines, as is typical with economic growth. The proportion of investment in primary sectors is highest in Africa (see annex 5, table 4). The fastest growing sectors in all regions are transportation and communications and the service sectors.

Table 5. Total current and projected investment by region

Regions	Current (2000)			Reference scenario (2030)		
	Percentage of world investment	Percentage of world GDP	Percentage of world population	Percentage of world investment	Percentage of world GDP	Percentage of world population
Africa	1.52	1.84	13.37	2.18	2.88	17.60
Developing Asia	10.37	8.23	52.69	27.93	19.71	46.13
Latin America	4.28	4.76	7.01	2.97	4.29	7.19
Middle East	1.80	2.04	2.44	3.57	2.80	3.66
OECD Europe	32.10	28.23	8.68	21.63	21.38	13.16
OECD North America	26.67	35.18	6.83	26.18	36.22	6.50
OECD Pacific	21.87	18.12	3.27	13.32	10.87	2.46
Other Europe	0.02	0.02	0.00	0.25	0.26	0.12
Transition Economies	1.35	1.58	5.71	1.97	1.59	3.18
World	100.00	100.00	100.00	100.00	100.00	100.00
AI Parties	77.60	79.34	20.36	56.65	64.30	20.13
NAI Parties	21.34	19.68	79.07	39.96	32.55	75.14
Least developed countries	0.51	0.56	11.08	N.A	N.A	N.A
World total (billion units)	**7750**[a]	**35440**[a]	**6.0**[b]	**22270**[a]	**79558**[a]	**8**[b]

Sources: UNSTAT, National Accounts Database; World Bank, 2006, World Development Indicator; OECD, ENV-Linkages Model.
Abbreviations: AI Parties = Parties included in Annex I to the Convention, GDP = gross domestic product, NAI Parties = Parties not included in Annex I to the Convention, OECD = Organisation for Economic Co-operation and Development.
[a] United States dollars
[b] Number of people

77. Current and projected investment flows by region for each sector are presented in annex 5, table 4. The sectoral pattern is broadly similar across all regions, except that primary sectors attract a larger share of the investment in developing country regions, such as Africa.

3.4. Financial flows needed in 2030

78. For the analysis of future financial flows needed for mitigation, the reference scenario assumes no new international agreement to address climate change. Thus, the reference scenario has no future financial flows – recurrent expenditures – to reduce emissions or enhance sinks. For the mitigation scenario, current and future financial flows are estimated by sector, specifically for reduction of non-CO_2 emissions in agriculture, reduced deforestation, forest management, extension services for agriculture, and technology research, development and deployment.

79. Climate change would occur under any of the scenarios selected for the analysis of investment and financial flows needed for adaptation. In order to respond to the impact of climate change, additional financial flows would be needed for each sector analyzed but in particular for human health and for R&D in the AFF sector.

3.5. Interpretation of the estimates of investment and financial flows

80. Estimates of investment and financial flows are for a given calendar year. The investments flows estimated correspond to the capital cost of new physical assets. The investments do not include the operating and maintenance costs of the new assets over their lifetime, because the focus is on investment flows and the timing of the operating and maintenance expenditures differs from that of investment.

81. The investment in a new asset is not the same as the annual cost of financing a given asset. For instance, if a water supply system with a capital cost of USD 100 million is needed in 2030, the investment during 2030 is estimated as USD 100 million. However, if that system is financed with a loan repayable over 20 years with a 5 per cent interest rate, the total cost would be USD 160 million and the payments during 2030 would be approximately USD 8 million. The figure used in this analysis is USD 100 million.

82. The analyses in this paper do not provide an estimate of the total cost of climate change mitigation. A comparison of the reference and mitigation scenarios indicates differences in the total investment needed for various types of physical infrastructure and the financial flows needed for various mitigation measures. The sum of those differences is not an estimate of the cost of mitigating climate change nor the cost of adapting to climate change. The analysis does not provide an estimate of the total cost of the adaptation neither. It assesses the order of the magnitude of the additional investment and financial flows that could be needed in 2030 to adapt to the adverse impact of climate change in selected sectors.

83. The change in the total investment and financial flows in measures that affect GHG emissions between the reference and mitigation scenarios should be taken as an estimate of mitigation cost. The scenarios cover only the capital costs and specified financial flows. Operating and maintenance costs of the physical assets are not included. Offsetting savings, such as reduced energy costs, are also not considered. Thus, the mitigation cost could be higher or lower than the investment and financial flows.

84. To estimate the cost of adapting to climate change it is necessary to define a ‘base’ current or pre-industrial climate from which change is measured. Neither is a meaningful option, since further changes to the current climate are already committed. In that case an operational definition of adaptation would be needed, and this is not available in the literature.

4. AN OVERVIEW OF INVESTMENT AND FINANCIAL FLOWS NEEDED FOR MITIGATION

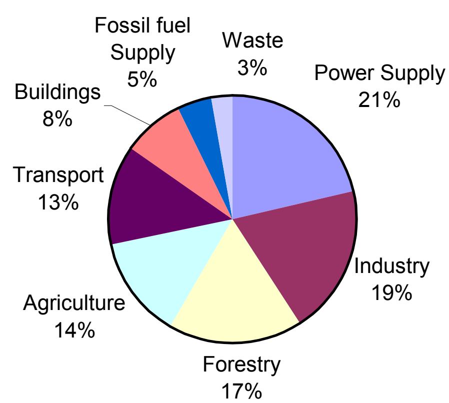
4.1. Introduction

85. Investment and finance are critical components of successful economic development. Generating the appropriate levels of capital is already a difficult undertaking when aiming to meet specific social and economic needs, but generating and allocating the investment and financial flows needed to meet the Millennium Development Goals (MDGs) and at the same time to finance significant climate change mitigation will make this task all that much harder.

86. This chapter presents an overview of estimates of investment and financial flows needed to return CO_2 eq emissions to current levels by 2030. The analysis is based on currently available scenarios, as explained below. The results should be considered indicative only.

87. The investment and financial flows for mitigation have been estimated for eight major emission sectors identified in the Working Group III contribution to the IPCC AR4 (IPCC, 2007c). The share of anthropogenic GHG emissions in each sector in 2004 is shown in figure 5 below.

Figure 5. Share of global greenhouse gas emissions by major sectors in 2004



Source: IPCC, 2007c.

88. For all the sectors (except agriculture and forestry), the estimates presented correspond to the investment and financial flows needed to make possible a shift from the reference scenario to the mitigation scenario. For fossil fuel supply and power supply, total investment needed are estimated for each scenario. For the industry, transportation, buildings and waste sectors, only the additional investment needed for the mitigation scenario is estimated.

89. For the agriculture and forestry sectors both investment flows for agroforestry and afforestation/reforestation and financial flows for reduction of non-CO_2 emissions, reduced deforestation and forest management are estimated. Financial flows are also estimated for mitigation related technology R&D and deployment.

90. The analysis of investment and financial flows for each of the emitting sectors begins with a summary of the projected emissions in 2030 and a review of the current sources of investment. Then the investment

flows needed in 2030 are estimated under the reference and mitigation scenarios. Finally, the actions needed to shift investment from the reference scenario to the mitigation scenario are discussed.

4.2. Scenarios

91. The reference and mitigation scenarios chosen for the analysis of different sectors are explained in detail in chapter 2.3.

92. For most sectors analysed (energy supply, industry, transportation and buildings), the reference scenario, unless otherwise specified, is the IEA WEO 2006 (IEA, 2006). Two assumptions underline this scenario: that the global population will increase by approximately two billion people to approximately eight billion by 2030; and that the global average per capita income will rise from USD 9,253 in 2004 to USD 17,196 in 2030. Population and per capita income will both rise more rapidly in developing countries. The IEA estimates of cumulative investment have been converted to annual investment flows. Preliminary estimates of GDP and investment by sector corresponding to this scenario were provided by the OECD from its OECD ENV–Linkages model[13].

93. The mitigation scenario corresponds to the BAPS presented in the WEO 2006. The BAPS assumes the same increase in population and per capita income as the reference scenario, but projects a significantly different pattern of energy demand and supply to return global energy-related CO_2 emissions to current levels (2004) by 2030: energy efficiency is improved significantly to provide the same services with less energy, and the mix of energy sources is changed to reduce emissions further. The IEA provides only global data for the BAPS. These data were disaggregated into the same regions as the reference scenario and the IEA estimates of cumulative investment were converted into annual investment flows.

94. The IEA has estimated in its reference scenario that without new polices and financing, about 1.4 billion people will remain without access to electricity in 2030. The BAPS does not consider this need for increased electricity access in developing countries, but focuses more on the national polices and measures related to energy security and energy-related CO_2 emissions. The additional investment needed to achieve full access to electricity by 2030 is estimated by the IEA as USD 750 billion; that is, an average of about USD 25 billion per year.

95. **For non-CO_2 emissions in the agriculture, waste and industry sectors** the reference scenario is based on projections by the US EPA. The mitigation scenario includes cost-effective emission reductions estimated using marginal abatement cost curves developed by the US EPA.

96. **For industrial process** CO_2 emissions the reference and mitigation scenarios are based on a WBCSD report on the cement industry (WBCSD, 2002).

97. **Other emissions and removals by sinks in the agriculture and forestry sectors and emissions by the forestry sector** are assumed to remain constant under the reference scenario. The mitigation scenario reflects emission reductions and removals by sinks potential estimated by the IPCC Working Group III (IPCC, 2007c).

4.3. Limitations in estimating mitigation costs

98. Given the short time frame in which the analysis had to be undertaken, this study uses existing models and available data. The analysis of specific regions, sectors and technologies are limited by the models and data used.

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[13] For more information on OECD ENV-Linkages model, please refer to chapter 2.3.

99. For instance, with regard to **regional analysis**, the models available provide little detail at the country level for some regions, in particular for Africa. It is not possible to separate South Africa share of activity and emissions from those of other African countries. However, it is acknowledged that, as for other regions, e.g. Latin America and Asia, if the largest emitters are singled out, the investment and financial flows needed for the rest of the region could differ from those of the region as a whole.

100. **With regard to sectors**, the IEA scenarios provide internally consistent projections of energy demand for industry, buildings and transportation and energy supply by fuel type. The scenarios also provide the associated CO_2 emissions and investment by sector in some detail in 2030. As discussed in chapter 4.4.1. on energy supply, estimates of current investment from the IEA scenarios and other sources vary substantially and could not be reconciled.

101. The analysis on investment in transmission and distribution (T&D) is mostly based on the total amount of electricity demand. Projection in the BAPS does not consider the need for increased electricity access in developing countries.

102. Energy efficiency improvement involves actions implemented at millions of specific facilities. The regional figures presented here are derived from global analysis by IEA based on a top down approach, so they should be considered as indicative only.

103. The agriculture and forestry sectors offer both emission reductions and sink enhancement options, of which some require investment and others require ongoing financial flows. It is necessary to draw on multiple, perhaps not fully consistent, sources to estimate the scale of the emission reductions or sink enhancement and the associated investment or financial flows.

104. For agroforestry only global estimates are available.

105. Because models for estimating the mitigation scenario are not available for the forestry sector the analysis is limited to estimating the costs of the different mitigation measures. The cost data varies widely because of different assumptions and the limited information across regions.

106. **For some technologies** still under development little information is available on current practices and/or planning. For instance, knowledge of large-scale deployment of CCS is still limited, though it is assumed to play a key role in the mitigation scenario. The geographic distribution adopted is based on limited storage potential information and growth of fossil fuels fired power plants, which may not reflect the future reality.

4.4. Investment and financial flows needed for mitigation

4.4.1. Energy supply

4.4.1.1. Introduction

107. Combustion of fossil fuels is the largest single source of GHG emissions from human activities, accounting for about 80 per cent of anthropogenic CO_2 emissions (IPCC, 2007c). Extracting, processing, transporting, and distributing fossil fuels also releases GHGs.

108. Energy supply covers the production and transformation of fossil fuels. This includes fossil fuels such as coal, oil, gas, lignite and peat, and transformation of those fuels through petroleum refining, natural gas processing and electricity generation. It also includes nuclear energy, hydropower, wind power and solar

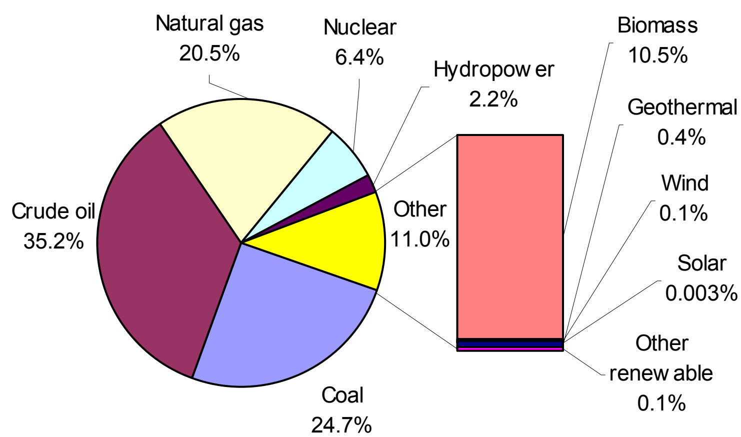
power, biomass, including waste, tidal energy, waves and ocean thermal gradients used for electrical power generation, and geothermal energy used for electrical power and heating.

4.4.1.2. Energy consumption and greenhouse gas emissions

Recent trends in energy consumption and greenhouse gas emissions

109. The world's total primary energy supply reached 11,223 Mtoe in 2004 (IEA, 2006), having grown at an average annual rate of 2.2 per cent between 1994 and 2004. In 2004, oil continued to be the world's most important primary energy source, followed by coal, natural gas, nuclear energy, hydropower and advanced renewables (see figure 6). The efficiency of conversion of primary energy to electricity varies greatly among these sources; for example, the total electricity generated from nuclear energy and hydropower is about the same, but thermal conversion processes are inherently less efficient.

Figure 6. Global primary energy mix in 2004



Source: IEA, 2006.

110. Energy supply and consumption are not distributed evenly worldwide. OECD countries, accounting for one sixth of the world's population, consumed around one half of the world's primary energy supply in 2004. Three countries - the United States of America, China and the Russian Federation - were the leading producers and consumers of world energy. These three countries produced 40 per cent and consumed 43 per cent of the world's energy.

111. Electric power production in 2004 was 17,450 TWh. Approximately 58 per cent was produced in OECD countries, 33 per cent in developing countries and the remainder by transition economies. Power sector growth was 4 per cent per year between 1994 and 2004 but the distribution of growth is highly uneven, with particularly rapid growth recorded in China and some other developing countries. Coal produced 6,944 TWh of electricity in 2004, or 38 per cent of the world's electricity output. It is the dominant fuel for electric power production in China, India, the United States, the Russian Federation, Australia and Indonesia.

112. Global CO_2 emissions from use of petroleum, natural gas and coal and the flaring of natural gas increased from 20 Gt CO_2 in 1990 to 26 Gt CO_2 in 2004. Emissions from OECD countries account for 49 per cent of the total. The United States, China, Russia, Japan, and India were the world's five largest sources of energy-related CO_2 emissions in 2004, accounting for 54 per cent of the total, followed by Germany, Canada, the United Kingdom, the Republic of Korea and Italy, which together produced an additional 11 per cent of the global total.

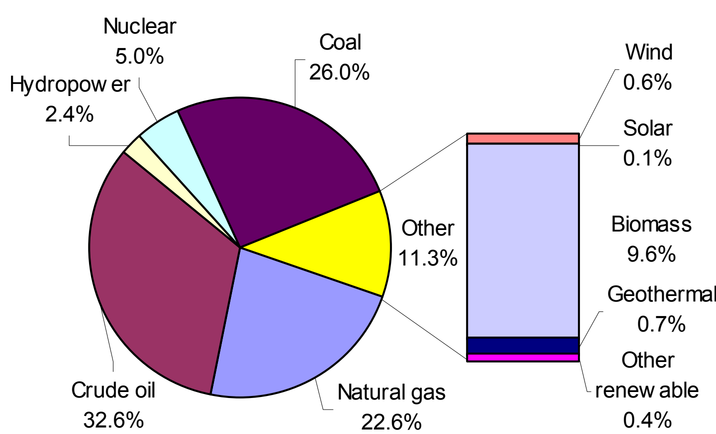
113. In 2004, oil and coal made nearly identical contributions to total CO_2 emissions, around 40 per cent each. CO_2 emissions from use and flaring of natural gas accounted for the remaining 20 per cent of energy-related CO_2 emissions. Power sector emissions increased from 7 Gt CO_2 in 1990 to 10.6 Gt CO_2 in 2004, faster than the rate of total emissions growth. Coal is the major source of CO_2 emissions in the power sector, accounting for 71.6 per cent of the total in 2004. Most of the increase (2.9 Gt CO_2) occurred in developing countries.

Energy consumption and greenhouse gas emissions in 2030 under the reference scenario

114. Fossil fuels are projected to remain the dominant sources of primary energy globally (see figure 7). Their share of global primary energy mix is projected to rise slightly under the reference scenario from 80 per cent in 2004 to 81 per cent in 2030. Global primary energy demand under the reference scenario is projected to increase by 1.6 per cent per year between 2004 and 2030, reaching 17.1 billion tonne of oil equivalent (Btoe), 53 per cent (6 Btoe) more than in 2004. Over 70 per cent of the increase in global primary energy demand between 2004 and 2030 comes from the developing countries. The increase in the demand of developing countries results from their rapid economic and population growth. Industrialization and urbanization boost demand for commercial fuels.

115. Global electricity demand is projected to increase from 17,408 TWh in 2004 to 33,750 TWh in 2030 under the reference scenario, growing at 2.6 per cent per year on average. This is slower than the GDP growth rate of 3.4 per cent and faster than the total primary energy supply of 1.6 per cent. Developing Asia is the main engine of electricity demand growth. Though world electricity generation almost doubles by 2030, the generation mix remains relatively stable.

Figure 7. Global primary energy mix in 2030 under the reference scenario



Source: IEA, 2006.

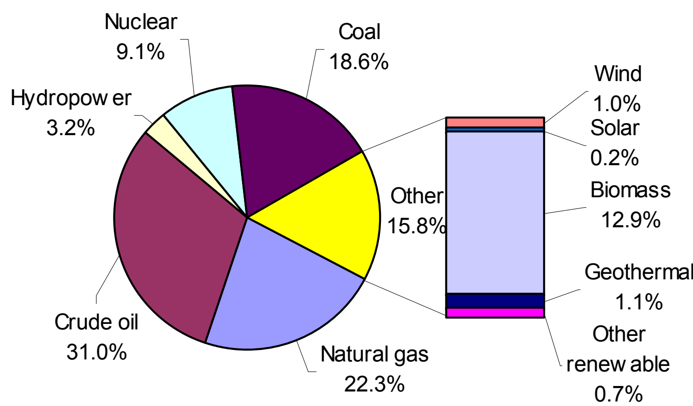
116. Global energy-related CO_2 emissions increase by 1.7 per cent per year between 2004 and 2030 under the reference scenario. They reach 40.4 Gt CO_2 in 2030, an increase of 14.3 Gt CO_2 or 55 per cent from 2004 levels. Developing countries account for over three quarters of the increase in global CO_2 emissions. This increase is greater than the growth in their energy demand, because they use more coal and less natural gas than developed countries.

117. Power generation is projected to contribute just under half the increase in global emissions between 2004 and 2030. By 2030, the power sector accounts for 44 per cent of total emissions, up from 40 per cent in 2004. Continuing improvements in the thermal efficiency of power stations are outweighed by the significant growth in demand for electricity.

Energy consumption and greenhouse gas emissions in 2030 under the mitigation scenario

118. Under the mitigation scenario strong policies increase energy efficiency significantly to provide the same services with 15 per cent less energy and shift the energy supply to more climate friendly technologies. Global primary energy demand rises from 11.1 Btoe in 2004 to 14.6 Btoe in 2030, 2.5 Btoe lower than in reference scenario. Energy demand still grows fastest in developing countries, but increased energy efficiency moderates the growth in their demand to 2.7 Btoe. Fossil fuels still play the dominant roles in primary energy supply (see figure 8). Their share decreases to 72 per cent in 2030 from 81 per cent under the reference scenario in 2030 and 80 per cent in 2004.

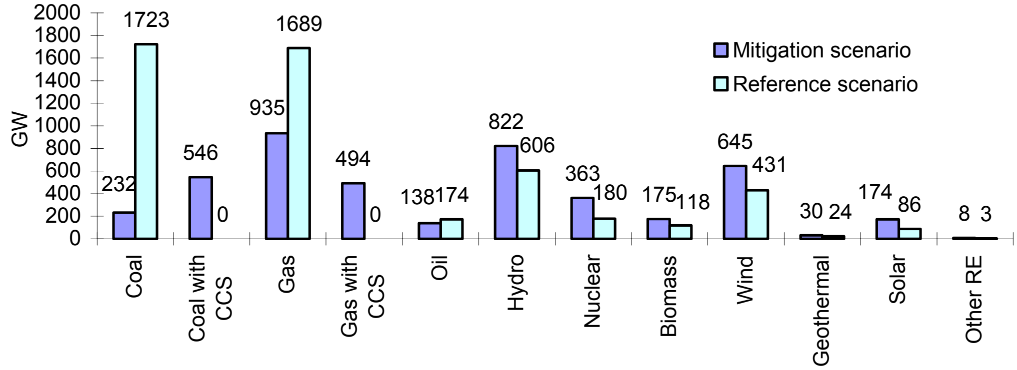
Figure 8. Global primary energy mix in 2030 under the mitigation scenario



119. Increased energy efficiency also limits the rate of growth of global electricity demand under the mitigation scenario to 27,983 TWh in 2030. The mitigation scenario also assumes a substantial shift in the global electricity generation mix in 2030. As shown in figure 9, coal remains the largest source of electricity (and generation capacity increases by 95 GW) but its share shrinks from 40 per cent in 2004 to 26 per cent in 2030. Gas-fired generation grows rapidly and becomes the second largest source at 21 per cent in 2030. The generation capacity of nuclear energy, hydropower and renewables expands significantly, each representing about 17 per cent of the total in 2030. The mitigation scenario assumes a significant amount of CCS for power plants and industry. By 2030 CCS is added to 70 per cent of the new coal capacity (545 GW) and 35 per cent of new gas capacity (494 GW).

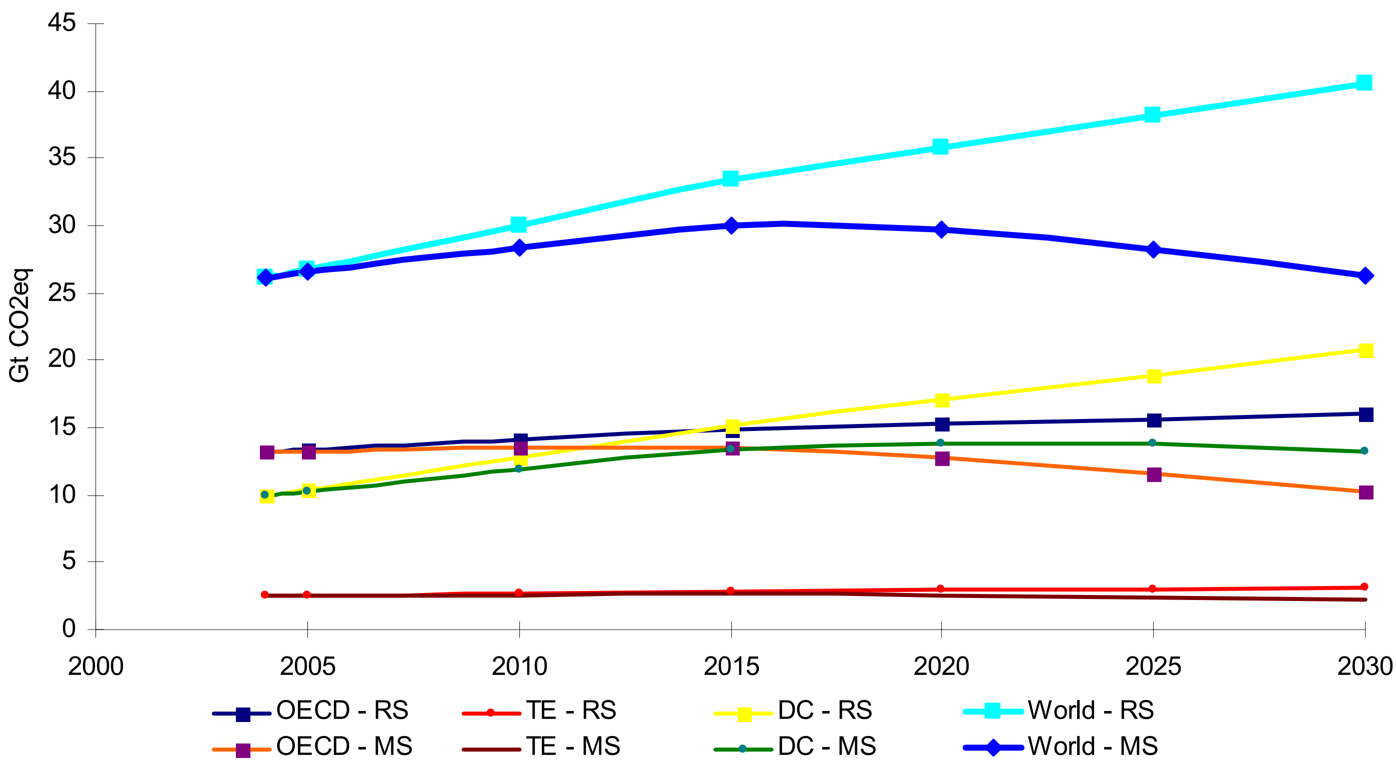
120. Global energy-related CO_2 emissions peak at 30 Gt CO_2 between 2015 and 2020 and decrease to the current level by 2030 (see figure 10). Emissions of OECD countries remain stable from 2004 to 2015 and then decrease to 10 Gt CO_2 by 2030, 7 per cent below their 1990 emissions. Developing country emissions increase by 3.3 Gt CO_2 then start to decline by 2030. The trend for emissions in transition economies is to decrease slightly under the mitigation scenario, rather than increasing slightly under the reference scenario.

Figure 9. Cumulative capacity additions in the reference and mitigation scenarios, 2004–2030



Abbreviation: CCS: carbon dioxide capture and storage; RE = renewable energy.

Figure 10. Energy-related carbon dioxide emissions under reference and mitigation scenarios, 2004–2030



Abbreviations: DC = developing countries; MS = mitigation scenario; OECD = Organisation for Economic Co-operation and Development; RS = reference scenario; TE = transition economies.

4.4.1.3. Overview of current investment and financial flows by source of financing

121. This chapter summarizes data on current investment flows related to energy supply. The information on current investment flows relates to economic sectors.

122. Components of energy supply are divided between two economic sectors. Specifically:

- Oil, gas and coal production and petroleum refining are part of the mining and quarrying sector, together with other mining activities;
- Electricity generation, T&D and gas distribution are part of electricity, gas distribution and water supply sector.

123. The electricity, gas distribution and water supply sector accounts for the largest share of energy supply investment. The sources of investment are shown in table 6.

Table 6. Investment flows for electricity, gas distribution and water supply in 2000 (percentage), by source and region

	Total Investment	Total Investment (USD billion	Domestic investment (private & public)	FDI flows	Debt (international borrowings)	ODA Bilateral total	ODA Multilateral total	Total
Africa	1.83	5	80.04	0.00	0.00	12.37	7.59	100.0
Developing Asia	12.28	32	75.59	8.57	3.61	7.51	4.72	100.0
Latin America	7.46	19	39.42	28.80	26.71	3.64	1.43	100.0
Middle East	1.40	4	93.29	0.00	0.00	5.88	0.82	100.0
OECD Europe	29.23	75	47.35	15.42	37.18	0.00	0.05	100.0
OECD North America	18.85	48	65.46	22.46	11.54	0.48	0.05	100.0
OECD Pacific	26.71	69	96.97	0.71	2.32	0.00	0.00	100.0
Transition Economies	2.20	6	92.12	2.95	0.72	3.43	0.78	100.0
Global Total	100.00	257	68.81	12.19	16.44	1.67	0.88	100.0
AI Parties	72.49	186	81.41	0.04	18.52	0.03	0.01	100.0
NAI Parties	26.07	67	77.72	12.63	5.76	0.60	3.29	100.0
Least Developed Countries	1.10	3	63.48	6.28	0.00	12.16	18.09	100.0

Source: Estimations by UNFCCC secretariat based on data from: UNSTAT, National Accounts Database; BIS, 2007; World Bank, 2006, World Development Indicator; OECD, CRS.
Abbreviations: AI Parties = Parties included in Annex I Parites to the Convention, FDI = Foreign Direct Investment, NAI Parties = Parties not included in the Annex I to the Convention, ODA = Official Development Assistance, OECD = Organisation for Economic Co-operation and Development.

124. In all regions, the majority of the investment is domestic but foreign equity and debt is also important in developed countries and ODA is important in LDCs. The sources of financing vary, with mostly private financing in the United States and the United Kingdom, a mix of private and government financing in much of Europe, and government funding in transition economies and most developing countries. Much developing country financing, other than in developing Asia, comes through a combination of ODA and loans from the World Bank and regional development banks.

125. Different sources provide somewhat inconsistent estimates of annual investment for different components of energy supply. These are shown in table 7.

Table 7. Alternative estimates of investment in energy supply in 2000 and 2005 for various components of energy supply (billions of United States dollars)

	Sources			
Component of energy supply	**UNCTAD 2000**	**OECD 2005**	**IEA 2005**	**Estimates of investment in renewables and energy efficiency**
Fossil-fired generation			107.0	
Large hydro and nuclear generation			44.1	
Renewables including small hydro			35.5	28.2[b] 38[c] 5.7 to 24.2[d] Up to 2.0[e]
Transmission and distribution			225.7	
Total electricity	199[a]	148	412.3	
Gas distribution	17[a]	13		
Water supply	42[a]	31		
Electricity, gas distribution and water supply	257	191		
Oil supply			84.5	
Gas supply			134.0	
Coal supply			20.0	
Petroleum refining			29.5	

Abbreviations: IEA = International Energy Agency, OECD = Organisation for Economic Co-operation and Development, UNCTAD = United Nations Conference on Trade and Development

Note:

[a] Based on gross fixed capital formation data by the respective sectors estimated assuming the same shares as the OECD data.

[b] New Energy Finance estimate for 2005. This includes investment from private equity/venture capital, public market and asset financing.

[c] REN21 2006, estimate for 2006 (2006USD million). This includes only the investment observed in the capital markets. REN21"Renewables Global Status Report 2006 Update"; Paris: REN21 Secretariat and Washington DC: Worldwatch Institute.

[d] Estimates of the investment for clean development mechanism (CDM) renewable energy and energy efficiency projects registered during 2006 and that entered the pipeline during 2006 respectively.

[e] Estimates of the investment for JI renewable energy and energy efficiency projects that entered the pipeline during 2006.

126. The investment in electricity supply estimated by the IEA, USD 412 billion in 2005 (IEA, 2006) looks high relative to the estimates from the other data sources. Over half of the total IEA estimate is for investment in T&D and that component alone is larger that the total investment estimated by other sources. Thus the explanation of the discrepancy probably lies in the estimated investment in T&D, which may not be adequately addressed in other reports, and those figures should be used with caution.

Current investment flows for renewable energy and energy efficiency

127. Table 8 shows the sources of funding for investment in renewable energy and energy efficiency in 2005. Private investment is by far the largest source of investment, USD 28.2 billion of debt and equity out of a total of USD 29.3 billion. Private investment (as measured by New Energy Finance, 2007) is defined as investment made by financial institutions and corporations. It excludes public sector investment and R&D

(whether funded by companies or governments). Since most of the investment occurs in OECD countries, it is not surprising that ODA funding for renewable energy is less than 4 per cent of the total.[14]

Table 8. Overview of funding sources in 2005 (millions of United States dollars)

	Source	Renewable energy OECD	Renewable energy Developing	Energy efficiency OECD	Energy efficiency Developing	Total	Per cent total
Total investment							
Debt							
Private sector	NEF	9 089	656	41	6	9 791	33.4
Multilateral	CRS	-	386			386	1.3
Total debt		9 089	1 041.5	40.8	6	10 177	
Equity							
Total equity (private sector)	NEF	14 107	2 906	1 342	96	18 451	63.0
Grants							
Multilateral (GEF)	GEF	-	42	-	30	71	0.2
Bilateral	CRS	-	601			601	2.1
Total grants		-	642	-	30	672	
Total investment		**23 196**	**4 590**	**1 383**	**132**	**29 300**	
Private investment		23 196	3 562	1 383	102	28 242	96.4
Multilateral/ bilateral		-	1 028	-	30	1 058	3.6

Abbreviations: CRS = Creditor Reporting System, GEF= Global Environment Facility, NEF = New Energy Finance, OECD = Organisation for Economic Co-operation and Development.

Note: New Energy Finance assumptions on leverage (debt as per cent of whole): VC (venture capital) /PE (private equity) - VC all equity, PE for companies 30 per cent debt, OTC/PIPE 10 per cent debt; Public Markets - 100 per cent equity; Asset Finance - balance sheet finance and lease/vendor finance 100 per cent equity /bond finance 100 per cent debt/project finance based on New Energy Finance standard levels of leverage (wind 74 per cent, solar 77 per cent, mini-hydro 70 per cent, geothermal 70 per cent).

128. Of the USD 26.8 billion invested in renewable energy in 2005, USD 2.9 billion was provided by venture capital and private equity investors, USD 3.8 billion was raised via the public markets, and USD 20.1 billion was supplied through asset financing. As companies mature, investors can leverage their equity investment with debt. Asset financings typically involve 20–30 per cent equity and 70–80 per cent debt.

129. The range of investment activity reflects the different stages of development of renewable technologies. Wind power is the most mature technology and therefore received the highest proportion of asset finance (USD 18 billion). Solar power received a high proportion of public market investment (USD 2.2 billion) because solar companies were raising capital to expand their manufacturing capacity.

130. Private investment is – and is likely to remain – the main source of financing for renewable energy and energy efficiency. Consequently, renewable energy has flourished in countries with supportive policies such as feed-in tariffs, developed financial markets and active private investors.

131. In developing countries, financing for renewables and energy efficiency tends to come from domestic sources (public and private) and from joint ventures between local and foreign companies, reflecting the higher investment risk of these countries. Multilateral and bilateral funding is also a significant source of investment in developing countries.

[14] Energy efficiency is implicit in CRS database (CRS is the source for ODA data).

132. This situation is changing, particularly in the fast growing emerging markets of China, India and Brazil, which are attracting increasing flows from foreign investors. Their rapidly expanding electricity sectors are also attracting foreign investors. LDCs, such as sub-Saharan Africa, for example, and smaller developing countries still attract limited private sector investment and continue to rely on ODA and soft loans[15] from IFIs such as the World Bank.

133. Production of renewable energy equipment and products is also growing rapidly in China, India and Brazil; photovoltaic cells for solar power in China, wind turbines in India, and ethanol in Brazil. Much of the output of photovoltaic cells and wind turbines and some of the ethanol produced is exported.

134. Developed countries continue to receive most of the private investment (93 per cent) into renewable energy and energy efficiency worldwide. In 2005, the United States attracted the largest investment flows in renewable energy (mainly for wind power) and in energy efficiency (Greenwood C et al., 2007).

Current estimates of energy subsidies and potential revenue of non-technical losses

Energy subsidies

135. Subsidies are introduced for specific social, economic or environmental reasons, for example to provide affordable energy to low income groups, to stimulate R&D of energy technologies, or to reduce pollution by promoting renewable energy. Data on the cost of subsidies are not routinely collected and reported. Instead, specific studies estimate the value of subsidies, but the studies differ in terms of the subsidies included[16], geographic coverage and the methodology used.

136. Putting a monetary value on some types of subsidies can be extremely difficult. For the purposes of this analysis, given the data availability, the subsidy is estimated as the difference between the actual price (cost) and the baseline price (cost) with no subsidy. The baseline must differentiate the impact on price (production cost) of a particular government intervention that generates the subsidy from the effects of all other factors that influence the price (cost). Empirical studies of subsidies typically use market price (cost) in another jurisdiction as the baseline.

137. Globally, energy subsidies total approximately USD 250–300 billion per year excluding taxes (Morgan, 2007). Non-OECD countries receive the bulk of these subsidies and use most of them to lower prices for consumers. In OECD countries, most subsidies are used for production, usually in the form of direct payments to producers or support for R&D. Worldwide, fossil fuels are the most heavily subsidized energy sources; these subsidies total an estimated USD 180–200 billion per year. Support to the deployment of low-carbon energy sources currently amounts to an estimated USD 33 billion each year: USD 10 billion for renewables, USD 16 billion for existing nuclear power plants and USD 6 billion for biofuels.

138. The most recent global quantitative analysis of energy subsidies, carried out by the IEA in 2006, measures consumption subsidies – government measures that result in an end-user price that is below the price that would prevail in a truly competitive market – in the twenty non-OECD countries with the largest primary energy consumption. Price controls, often through state-owned companies, are the most common form of energy subsidy. As shown in annex 5, table 7, the Russian Federation has the largest subsidies, USD 40 billion per year, most of which go to natural gas. Iran's energy subsidies, mostly for petroleum products, are about USD 37 billion per year. China, Saudi Arabia, India, Indonesia, Ukraine and Egypt have subsidies in excess of USD 10 billion per year.

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[15] Loans at preferential (below market) rates which meet particular economic, social or environmental objectives.

[16] The International Energy Agency has defined energy subsidies as *any government action that concerns primarily the energy sector that lowers the cost of energy production, raises the price received by energy producers or lowers the price paid by energy consumers* (IEA, 1999).

139. Forty per cent of the subsidies (USD 91 billion) go to oil products with Iran (27 per cent), Indonesia (16 per cent) and Egypt (10 per cent) having the largest shares of the total. Natural gas gets 31 per cent of the subsidies (USD 70 billion) with Russia (36 per cent), Ukraine (18 per cent) and Iran (14 per cent) accounting for most of the total. Electricity gets 24 per cent of the subsidies (USD 55 billion) with Russia (15 per cent), India (10 per cent) and China (7 per cent) having the largest shares. China accounts for most of the coal subsidies; 76 per cent of the total coal subsidies of USD 10 billion.

140. Subsidies resulting from price regulation of road transport fuels are among the easiest to observe and estimate. A recent survey of 171 countries by GTZ (2007) shows that a number of countries subsidize gasoline and diesel net of taxes (see annex 5, figures 1 and 2). In 14 countries, gasoline prices (15 countries for diesel) are lower per litre than the international price of crude oil, implying a large subsidy. Prices are below United States retail levels – the benchmark that GTZ used for determining whether fuel is subsidized – in 24 countries for gasoline and 52 countries for diesel.

141. The value of transport fuel subsidies, based on the GTZ data and 2004 consumption data from the IEA, amounts to USD 90 billion using the international fuel price plus a distribution margin as the baseline reported by GTZ (2007). Gasoline subsidies total USD 28 billion and diesel subsidies USD 61 billion. The aggregate amount is exactly the same as the 2006 estimate of the IEA, using a similar methodology, of total oil subsidies in the world's 20 largest consuming countries in 2005.

142. The effects of energy subsidies on GHG emissions are complex. Generally lower fossil fuel prices encourage greater consumption and higher GHG emissions. But subsidizing oil products in developing countries can reduce emissions by curbing deforestation when rural households switch from firewood (von Moltke et al, 2004). Nonetheless, a OECD study (OECD, 2000) estimates that trade liberalisation and elimination of global fossil-fuel subsidies in industry and the power sector would reduce energy-related CO_2 emissions by more than 6 per cent by 2010, while increasing income by 0.1 per cent (OECD 2000). Similarly, a 1999 IEA study shows that removing consumption subsidies in eight of the largest non-OECD countries would reduce their primary energy use by 13 per cent and reduce their CO_2 emissions by 16 per cent (see annex 5, table 8), while GDP rises by 1 per cent. This reduction corresponds to 5 per cent of global emissions.

143. A study by the Australian research body ABARE reports a smaller reduction of world emissions; 1.1 per cent by 2010 relative to a reference case if removing fossil fuel consumption subsidies (Sanders and Schneider, 2000) . These emission reductions would be largest in transition economies (8 per cent) while emissions would rise slightly in developed countries due to lower international coal prices.

144. The impacts of subsidy removal in OECD countries depend on country-specific circumstances, but an analysis shows that it would not lead to direct increases in prices and thus may not lower consumption or emissions. In Germany, subsidy removal might encourage coal imports because subsidies are paid to producers and coal consumers can choose suppliers. This could drive up international coal prices and thus push down coal demand and related CO_2 emissions.

Non-technical losses

145. The metered use of electricity by consumers is less than the electricity supplied by the generators due to T&D losses. T&D losses consist of both technical losses, such as transmission line loss, and non-technical losses, such as theft. Utilities generally try to minimize non-technical losses but some government owned utilities may tolerate non-technical losses as a socio-economic policy; that is, a means of providing electricity to low-income groups.

146. Non-technical loss by region is estimated for the analysis. Using T&D losses during 2000, the 71 countries for which data are available are divided into three categories according to their total T&D loss based on a comparative analyse by Smith (Smith, 2004). A pure technical loss is assumed for the countries in each category. The difference between the total T&D loss and the pure technical loss is the estimated non-technical loss. The amount of the non-technical loss is calculated and valued using the average of the industrial and residential electricity price.[17] Annex 5, figure 3 shows the estimated non-technical losses as a percentage of the total electricity supplied.

147. The estimated total revenue lost due to non-technical losses is USD 20 billion. The regional distribution of those losses as shown in annex 5, figure 4. Revenue losses are highest in developed countries because their total electricity consumption is high. Countries with estimated non-technical losses in excess of USD 1 billion per year are India, Brazil, the Russian Federation and Mexico. Developing countries account for 57 per cent of the total losses.

4.4.1.4. Estimated investment and financial flows needed

Investment and financial flows needed under the reference scenario

148. Investment in energy supply infrastructure under the reference scenario is projected to be USD 762 billion in 2030 (see table 9). The power (including generation, T&D) sector requires USD 439 billion, or 58 per cent of the total. Capital expenditure in the oil industry – oil production, pipelines and other forms of transportation, and refineries amounts to USD 154 billion, just over one-fifth of the total. Gas investment – gas production, pipelines, liquified natural gas (LNG) and other transportation investment is USD 148 billion, or 19 per cent of the total. Investment in coal supply is about USD 20 billion, or 3 per cent of total energy investment.

149. As shown in table 9, more than half of all the energy investment needed worldwide in 2030 is in developing countries, where demand and production increase most quickly. China alone needs to invest about USD 132 billion, 17 per cent of the global total. About USD 283 billion (37 per cent) is needed by OECD countries to replace and expand their facilities.

150. Upstream (production) investment accounts for 73 per cent of the total investment in the oil industry in 2030, 56 per cent of the total in the gas industry, and 100 per cent in the case of coal. Most of the oil industry investment occurs in the Russian Federation and the Middle East. Natural gas investment is concentrated in OECD North America, where demand increases strongly under reference scenario and where construction costs are high. Almost half of the coal investment occurs in China and one quarter each in North America and Australia.

[17] Since the non-technical losses are valued at subsidized prices, they are understated.

Table 9. Investment in energy supply needed under the reference scenario in 2030 (billions of United States dollars)

	Transmission and distribution	Power generation	Coal supply	Oil supply	Gas supply	Total
World	**231.0**	**208.3**	**19.9**	**154.2**	**148.1**	**761.6**
OECD	71.4	93.9	6.0	44.2	67.1	282.5
OECD North America	38.7	40.3	3.1	32.9	45.7	160.7
United States	29.5	34.0				63.5
Canada	3.2	3.7				6.8
Mexico	6.1	2.6				8.7
OECD Pacific	7.9	9.9	1.6	1.8	5.3	26.5
Japan	2.3	5.1				7.4
Korea	3.5	2.7				6.3
Australia and New Zealand	2.0	2.1				4.1
OECD Europe	24.8	43.7	1.3	9.5	16.0	95.3
Transition economies	10.9	11.9	1.3	24.6	22.7	71.3
Russia	4.2	6.2	0.6	18.4	16.9	46.3
Other EIT	6.7	5.6	0.7	6.2	5.7	24.9
Developing Countries	148.7	102.6	12.7	85.5	58.3	407.8
Developing Asia	108.7	72.9	11.5	25.5	17.6	236.1
China	64.5	39.6	9.2	13.5	4.8	131.5
India	26.3	18.3	1.5	1.9	2.1	50.1
Indonesia	4.7	3.7	0.5	1.9	3.3	14.1
Other Developing Asia	13.3	11.3	0.4	8.2	7.4	40.5
Latin America	17.3	13.0	0.4	14.5	10.2	55.5
Brazil	4.6	4.4	0.0	5.3	1.8	16.2
Other Latin America	12.7	8.6	0.4	9.2	8.4	39.3
Africa	13.4	9.5	0.8	18.7	15.9	58.2
Middle East	9.3	7.2	0.0	26.8	14.7	58.0

Abbreviations: EIT = Economies in transition, OECD = Organisation for Economic Co-operation and Development.

151. A total of 5,087 GW of generating capacity is projected to be built worldwide under the reference scenario. More than half of this capacity is located in developing countries. Total power sector investment in 2030, including generation, T&D, reaches USD 439 billion. The largest investment requirements, some USD 104 billion, arise in China. Investment needs are also very large in OECD North America and Europe. Investment to replace currently operating capacity accounts for over 40 per cent of total investment in the OECD and over 50 per cent in transition economies, but it is a very small share of total investment in developing countries.

152. Over half of the total investment in 2030, USD 231 billion, is for T&D networks, of which more than two-thirds goes into distribution systems. Despite the significant investment in T&D, the IEA reference scenario projects that 1.4 billion people will not have access to electricity in 2030. The IEA estimates that universal electricity access by 2030 would require an additional annual investment of USD 25 billion. Almost all of this added investment would be needed in sub-Saharan Africa and South Asia.

Investment and financial flows needed under the mitigation scenario

153. Under the mitigation scenario, the large increase in energy efficiency reduces energy demand and hence projected investment in energy-supply infrastructure. Implementation of the energy efficiency measures requires investments by energy consumers in the industry, buildings and transportation sectors as discussed in chapters 4.4.2. 4.4.3. 4.4.4. below.

154. Investment in energy supply infrastructure under the mitigation scenario is projected to be USD 695 billion in 2030, USD 67 billion (9 per cent) less than under the reference scenario (see table 10). The power sector requires about USD 432 billion of investment, 62 per cent of the total. Much of the increased investment in the power sector is for large-scale deployment of CCS from 2020 onwards. Capital expenditure in the oil industry – oil production, pipelines and other forms of transportation, and refineries, amounts to USD 113 billion. Investment in the gas sector– gas production, pipelines, LNG and other transportation is USD 116 billion, about the same as for oil. Investment in coal supply is about USD 12 billion, or 1.7 per cent of total energy investment.

Table 10. Investment in energy supply needed under the mitigation scenario in 2030 (billions of United States dollars)

	Transmission and distribution	Change in per cent	Power generation	Change in per cent	Coal, oil and gas supply	Change in per cent	Total	Change in per cent
World	**129.8**	**-44**	**302.4**	**45.1**	**263.2**	**-18**	**695.3**	**-9**
OECD	**23.1**	**-68**	**140.5**	**49.6**	**100.4**	**-14**	**263.9**	**-7**
OECD North America	**14.0**	**-64**	**76.8**	**90.7**	**71.6**	**-12**	**162.3**	**1**
United States	9.1	-69	69.4	104.2	0.0		78.5	24
Canada	0.4	-89	3.9	5.5	0.0		4.2	-38
Mexico	4.5	-26	3.5	33.4	0.0		8.0	-8
OECD Pacific	**2.8**	**-64t**	**16.3**	**63.4**	**6.8**	**-22**	**25.9**	**-2**
Japan	0.0	-100	7.9	53.6	0.0		7.9	6
Korea	2.0	-42	3.5	29.1	0.0		5.6	-11
Australia and New Zealand	0.8	-62	4.8	132.6	0.0		5.6	37
OECD Europe	**6.3**	**-75**	**47.4**	**8.6**	**22.0**	**-18**	**75.7**	**-21**
Transition economies	**5.6**	**-48**	**17.7**	**49.6**	**38.8**	**-20**	**62.2**	**-13**
Russia	3.2	-23	10.1	61.9	29.1	-19	42.4	-8
Other EIT	2.4	-64	7.7	35.9	9.7	-23	19.8	-21
Developing Countries	**101.1**	**-32**	**144.2**	**40.6**	**124.0**	**-21**	**369.3**	**-9**
Developing Asia	74.9	-31	106.6	46.3	45.6	-16	227.1	-4
China	46.4	-28	64.8	63.8	24.1	-12	135.3	3
India	19.6	-26	24.9	36.4	4.8	-12	49.4	-1
Indonesia	3.4	-26	5.0	35.9	5.0	-13	13.4	-5
Other Developing Asia	5.4	-59	11.8	4.4	11.8	-26	29.0	-28
Latin America	**10.3**	**-40**	**12.7**	**-2.4**	**17.3**	**-31**	**40.3**	**-27**
Brazil	1.9	-59	3.4	-22.5	4.5	-37	9.8	-39
Other Latin America	8.4	-34	9.3	8.0	12.8	-29	30.5	-22
Africa	**9.9**	**-27**	**14.1**	**49.2**	**27.5**	**-22**	**51.5**	**-12**

Abbreviations: EIT = Economies in transition, OECD = Organisation for Economic Co-operation and Development.

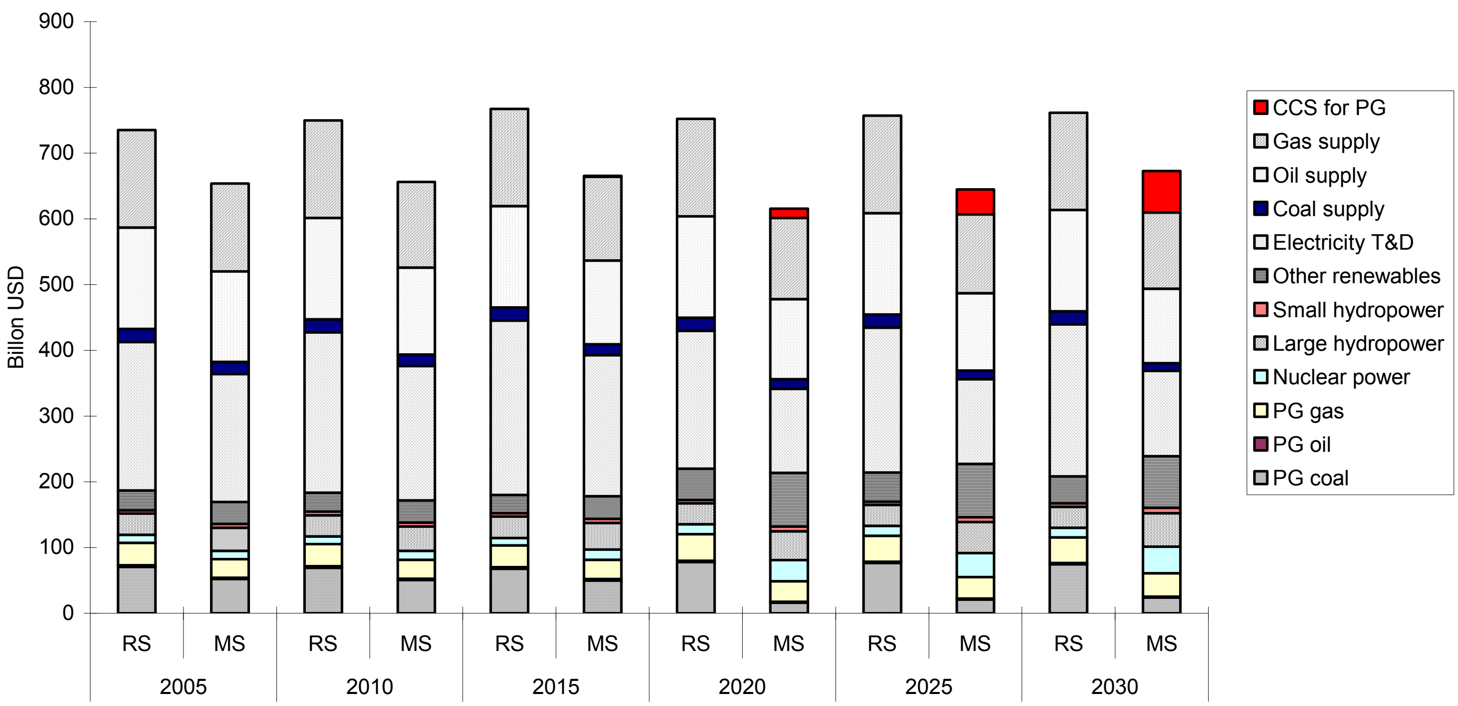
155. The projected decline in T&D investment under the mitigation scenario relative to the reference scenario warrants further analysis. The IEA estimates T&D investment based on generation capacity with one third of the investment for transmission and two thirds for distribution. Increased energy efficiency and wider use of distributed generation[18] should reduce the need for additional T&D capacity under the mitigation scenario, but further analysis is needed to ensure that the lower investment projected is consistent with the level of energy access under the reference scenario.

[18] Production of electricity close to where it is used.

Changes in investment and financial flows between the reference and mitigation scenarios

156. Figure 11 shows the total investment in energy supply needed under the reference and mitigation scenarios.

Figure 11. Investment in energy supply needed under the reference and mitigation scenarios, 2005–2030



Abbreviations: CCS = carbon dioxide capture and storage; PG = power generation; MS = mitigation scenario; RS = reference scenario; T&D = transmission and distribution.

157. The estimated investment flows for energy supply under the reference and mitigation scenarios in 2030 are shown in table 11. The mitigation scenario requires less investment in the production of fossil fuels and associated facilities, and substantial shifts of investments within the power sector.

Table 11. Investment flows needed for energy supply under the reference and mitigation scenarios in 2030 (billions of United States dollars)

Sectors	Global 2030			Non Annex-I Parties 2030		
	Reference scenario	Mitigation scenario	Additional investment	Reference scenario	Mitigation scenario	Additional investment
Fossil fuel supply total	**322**	**263**	**-59**	**156**	**124**	**-32**
Coal	20	12	-8	13	8	-5
Oil	154	125	-29	85	69	-16
Natural Gas	148	126	-22	58	47	-11
Power supply total	**439**	**432**	**-7**	**251**	**245**	**-6**
Coal-fired generation	75	24	-51	40	13	-27
Oil-fired plants	2	1.5	-1	1	1	0
Gas-fired plants	39	36	-3	17	13	-4
Nuclear	15	40	25	3	14	11
Hydro	37	59	22	28	46	18
Renewable	41	79	38	12	30	18
CCS Facility coal fired plants	-	40	40	0	21	21
CCS Facility gas fired plants	-	23	23	0	6	6
Transmission and distribution	231	130	-101	149	101	-48

Abbreviation: CCS = carbon dioxide capture and storage

Change in investment and financial flows needed in fossil fuel supply

158. The investment in fossil fuel supply projected under the reference scenario is USD 322 billion in 2030, of which 6 per cent is for the production of coal, 48 per cent is for oil and 46 per cent for natural gas. Upstream (production) investment accounts for 73 per cent of the total in the oil industry, 56 per cent of the total in the gas industry, and 100 per cent in the case of coal.

159. Under the mitigation scenario the total investment needed is reduced by USD 59 billion in 2030, 40 per cent reduction in coal, 19 per cent in oil and 15 per cent in natural gas. Under this scenario, the consumption of oil and natural gas would be higher than present level and consumption of coal would be about the same; thus, the lower investment reflects slower growth rather than declining output. Just over half (USD 32 billion) of the reduction in investment flows would occur in non-Annex I Parties.

160. Most of the investment is made by large corporations, either government-owned or private. The mitigation scenario means they need to invest less.

Change in investment and financial flows needed in power supply

161. Under the reference scenario, investment in power supply is projected to be USD 439 billion in 2030, of which 53 per cent is T&D, 17 per cent is for coal-fired generation, 9 per cent is for renewables, 9 per cent is for gas-fired generation, 8 per cent is for hydropower and 3 per cent is for nuclear energy.

162. Under the mitigation scenario, the total investment in 2030 would be about the same as in the reference scenario (USD 432 billion), but the investment mix would be significantly different. Less investment will be needed for T&D (USD 101 billion) and fossil-fired generation (USD 55 billion, mainly coal). Additional investment will be needed for CCS in power plants (USD 63 billion), renewables (excluding hydropower) (USD 38 billion), nuclear energy (USD 25 billion) and hydropower

(USD 22 billion). As noted in paragraph 155, the projected decline in T&D investment warrants further analysis.

163. Due to rapid economic growth, about 57 per cent of the power sector investment is projected to occur in non-Annex I Parties under both scenarios (USD 251 billion for the reference scenario and USD 245 billion for the mitigation scenario). The shift in mix of global investments described above occurs in non-Annex I Parties as well.

164. Most of the investment in electricity generation and T&D is made by government-owned or private, usually regulated, electric utilities. In all regions, the majority of the investment is made domestically, but foreign equity and debt are important additional sources of financing in developed countries and ODA is important in LDCs. Investment in renewables is currently concentrated in a few developed countries and a significant proportion is not financed by electric utilities, although both of these patterns are changing.

165. Changing the mix of technologies in the power sector as projected under the mitigation scenario poses some challenges. Specifically:

- Electric utilities will continue to add fossil-fired plants rather than switch to renewables, nuclear energy and large hydropower unless these options are less costly and their environmental, social and safety concerns are addressed;
- Electric utilities may resist adoption of CCS for fossil-fired plants because of the cost, newness of the technology, legal uncertainties and for other reasons;
- Rapid growth of renewables may be constrained by their relatively high cost, supply bottlenecks, locational constraints and grid management considerations;
- Private investors financing renewable energy projects seek supportive government policies, financial incentives, such as feed-in tariffs and renewable energy credits, and secure markets for the power generated.

166. These are challenges for Parties included in Annex I to the Convention (Annex I Parties) and non-Annex I Parties, since over a half of the projected investment is expected to occur in non-Annex I Parties. Non-Annex I Parties may need financial incentives or assistance with national policies to address these challenges.

Box 1. Summary of investment and financial flows in energy supply and infrastructure

Investment and financial flows needed in 2030
Global investment in energy supply infrastructure under the mitigation scenario is projected to be USD 695 billion in 2030, USD 67 billion (9 per cent) less than under the reference scenario. Power supply requires more than USD 432 billion of investment under the mitigation scenario, USD 7 billion (1.6 per cent) less than the reference scenario. Universal electricity access by 2030 would require an additional annual investment of USD 25 billion. Capital expenditure in fossil fuel supply would require USD 263 billion under the mitigation scenario, 59 billion (18 per cent) less than the reference scenario. More than half of all the energy investment needed worldwide is in developing countries due to their rapid economic growth.

Current investment and financial flows
In all regions, the majority of the investment is domestic, but foreign equity and debt are important in developed countries and ODA is important in LDCs. The sources of financing vary, with mostly private financing in the United States and the United Kingdom, and government funding in much of Europe, transition economies and most developing countries. Much developing country financing, other than in developing Asia, comes through a combination of ODA and loans from the World Bank and regional development banks.
Most of the investment in renewable energy and energy efficiency occurs in OECD countries; ODA funding for renewable energy is less than 4 per cent of the total ODA flows. LDCs, such as in sub-Saharan Africa, and smaller developing countries, still attract limited private sector investment and continue to rely on ODA and soft loans from IFIs such as the World Bank.

Change in investment and financial flows needed in carbon dioxide capture and storage

167. CCS for power plants, and to a lesser extent for industry, is a significant contributor to the emission reductions achieved under the mitigation scenario. The investment in CCS in 2030 is over USD 75 billion, of which over 80 per cent is for power plants. There is no CCS under the reference scenario.

168. Before large-scale implementation of CCS can occur, technology development is still required, mainly related to CO_2 capture. Though no real technical barriers have yet been identified, it is envisaged that at least two generations of pilot and demonstration plants are required, which could take up to two decades. As demonstration plants often need to operate for a considerable time before large-scale deployment, this will affect the timing of full-scale commercial implementation. A detailed analysis was undertaken by Hendriks (2007).

169. Only a few quantitative estimates of CO_2 storage potential in different regions have been made. These estimates should be treated with care as methodologies for estimating storage capacity are still under development and reliable geological data are lacking, especially for aquifers and coal seams. Storage capacity is also affected by the safety considerations. As safety requirements are still under discussion, capacity estimates are uncertain.

170. Legal implications and public attitudes are important with respect to CCS as well. Work on resolving the associated legal and regulatory issues may not be proceeding quickly enough for large-scale implementation by 2030, and for implementation of larger-scale demonstration facilities in particular. The public is still quite unaware of CCS as an option.

171. Long-term liability issues of CCS also require resolution. The legal responsibility of entities operating CCS reservoirs must be clearly defined if they are to be able to attract the required investment. The expectation is that the CO_2 will remain in the CCS reservoir for thousands of years but the entity operating a CCS reservoir cannot be held responsible for such long periods of time, and its responsibility must be transferred to the government at some reasonable time after the reservoir is sealed.

Box 2. Summary of investment and financial flows in carbon dioxide capture and storage

CCS for power plants, and to a lesser extent for industry, is a significant contributor to the emission reductions achieved under the mitigation scenario. The investment in CCS in 2030 under the mitigation scenario is over USD 75 billion, of which over 80 per cent is for power plants. Technology development, legal implications, public attitudes and long-term liability of CCS are the critical factors for large-scale implementation of CCS.

4.4.1.5. Assessment of the changes needed in investment, financial and policy arrangements to fill the gap under the mitigation scenario

172. The major reductions in emission achieved under the mitigation scenario rely on increased energy efficiency, shifts being made in the energy supply from fossil fuels to renewables, nuclear energy and hydropower and large-scale deployment of CCS (even though there are only a few CCS demonstration projects at the present time). Much of the shift will need to occur in developing countries where energy demand is projected to grow most rapidly.

173. Most of the investment in fossil fuel production, processing and transportation is made by large corporations, either government-owned or private. The mitigation scenario means they need to invest less.

174. Historically, nuclear power and large hydropower plants have been financed by the utilities that also build fossil-fired generation and transmission systems. These utilities would probably be expected to finance the cost of CCS at coal and gas plants under the mitigation scenario. The value of the added investment needed for nuclear energy, large hydropower and CCS is lower than the value of reduced investment in fossil-fired generation. Thus the financing challenge faced by electric utilities is less severe under the mitigation scenario than under the reference scenario, although some private utilities may be reluctant to invest in nuclear plants.

175. Renewable energy projects are presently financed largely by private investors. If this trend continues to, the scale of investment projected will require supportive government policies, financial incentives, such as feed-in tariffs and renewable energy credits, and secure markets for the power generated. It also will be necessary to ensure that the investment flows to the countries and regions that need it most. Africa probably faces the greatest challenge, needing to attract capacity investment of nearly USD 3 billion a year from a base of almost nothing.

4.4.2. Industry

4.4.2.1. Introduction

176. Globally, the industry sector[19] is responsible for nearly 27 per cent of world energy consumption, 19 per cent of energy-related CO_2 emissions and 7 per cent of non-CO_2 emissions (US EPA, 2006a). Energy and GHG intensity[20] varies greatly among the different industrial sectors and too therefore does the potential absolute emission reductions. This chapter focuses on the more intense sectors because even a small change in their energy or GHG intensity can significantly alter emissions levels (Nyboer, 2007). That is not to say other manufacturing sectors are not important; growth may be rapid and contributions to emissions significant. The following industrial sectors are covered in this chapter:

- Pulp and paper;
- Cement, lime, and other non-metallic minerals;
- Nonferrous metal smelting and iron and steel smelting;

[19] Petroleum refining is covered in energy supply.
[20] Emissions per unit of output.

- Metal and non-metal mining;
- Chemical products;
- Other manufacturing.

177. For energy-related CO_2 emissions, this chapter adopts the same reference and mitigation scenario as the energy supply sector – the IEA's WEO 2006 reference and the BAPS respectively. Non-CO_2 emissions are based on reference projections by the US EPA. The mitigation scenario includes cost-effective emission reductions estimated using marginal abatement cost curves developed by the US EPA. Industrial process CO_2 emissions are assumed to continue to increase under the reference scenario and to diminish under the mitigation scenario based on the WBCSD cement industry report (WBCSD, 2002).

4.4.2.2. Energy consumption and greenhouse gas emissions

Recent trends in energy consumption and greenhouse gas emissions

178. In 2000, the industry sector consumed 1,758 Mtoe energy, of which 50 per cent was consumed by OECD countries and 41 per cent by developing countries (see table 12).

Table 12. Industrial sector fuel consumption and CO_2 eq emissions in 2000

Country/region	Fuel consumption (Mtoe) Fossil fuels	Electricity	Non-fossil fuels	Total	Emissions (Mt CO_2) Combustion	Non-CO_2	Industrial process CO_2 emission	Total
World	**1 139**	**457**	**161**	**1 757**	**4 366**	**2 446**	**826**	**7 638**
OECD	538	277	67	883	1 951	1 080	266	3 296
OECD North America	242	124	45	411	822	628	66	516
OECD Pacific	100	54	5	159	413	127	70	610
OECD Europe	196	100	17	313	715	325	130	1 169.8
Transition Economies	106	41	2	149	414	497	40	951
Developing Countries	494	139	92	725	2 002	870	520	3 391
Developing Asia	332	94	36	462	1 426	527	403	2 355
Latin America	61	24	34	119	219	107	45	372
Africa	31	15	22	68	136	129	36	301
Middle East	70	6	0.2	77	221	106	36	363

Abbreviation: OECD = Organisation for Economic Co-operation and Development.

179. The OECD is responsible for 44 per cent of combustion and non-CO_2 emissions, and developing countries for 29 per cent, with the United States and China both responsible for approximately 17 per cent of global industrial emissions. Fossil fuels account for the majority of energy consumption (65 per cent) and electricity consumption makes up 26 per cent.[21] OECD countries consume 50 per cent of total fuel, slightly more than its share of emissions, while developing countries consume 26 per cent, slightly less than their share of emissions. The United States is responsible for 19 per cent of global fuel consumption, and China is the second largest consumer (15 per cent).

[21] Emissions associated with electricity generation are included in the energy supply sector.

180. Table 13 provides an overview of industrial energy consumption and GHGs under the reference scenario. Fuel consumption rises steadily in every region, but particularly in developing countries, where fuel consumption doubles between 2005 and 2030. This growth is driven by rising population levels and continued economic growth in China and other non-industrialized countries (WBCSD, 2006).

Table 13. Fuel consumption and GHG emissions in 2030 under the reference scenario in the industrial sector

	Fuel Consumption (Mtoe)				Emissions (Mt CO_2 eq)			
Country/Region	**Fossil Fuels**	**Electricity**	**Non-Fossil Fuels**	**Total**	**Combustion**	**Non-CO_2**	**Industrial Process CO_2 emission**	**Total**
World	**2597**	**940**	**395**	**3932**	**8075**	**4691**	**1871**	**14637**
OECD	903	351	139	1393	2593	1935	248	4777
OECD North America	410	140	70	620	1145	1212	62	2419
United States	319	97	57	472	899	799	56	1754
Canada	56	23	12	91	152	92	6	250
Mexico	35	21	1	56	94	321		415
OECD Pacific	189	75	20	283	588	298	49	936
Japan	100	37	8	145	320	97	32	449
Korea	67	26	6	100	208	122	14	345
Australia and New Zealand	22	12	6	39	60	79	3	142
OECD Europe	305	136	50	490	859	426	137	1422
Transition Economies	212	72	53	337	594	695	80	1369
Russia	104	43	41	189	280	307		587
Other EIT	107	29	12	148	314	388		702
Developing Countries	1483	517	203	2202	4888	2060	1542	8491
Developing Asia	1042	393	116	1551	3685	1150	1034	5868
China	657	282	63	1002	2471	710	587	3768
India	155	46	30	231	516	226	211	953
Indonesia	53	9	3	64	155	62	0	217
Other Developing Asia	177	57	21	254	544	151	236	930
Latin America	133	67	53	253	375	279	170	825
Brazil	56	26	43	125	169	71		240
Other Latin America	77	41	11	128	206	208		415
Africa	63	33	34	130	188	294	239	721
Middle East	244	23	0	268	640	338	98	1076

Abbreviations: EIT = Economies in transition, OECD = Organisation for Economic Co-operation and Development.

181. The reference scenario includes significant energy efficiency improvements and emission reduction technologies. Energy efficiency increases at 1.5 per cent annually (Vattenfall, 2007c) reducing energy intensity in developing and transition economies to close to current OECD levels by 2030 (IEA, 2006). The major emission reduction measures expected to be adopted under the reference scenario include:

- A shift of Chinese cement production to the pre-heater/precalciner technology;
- Complete switching from the basic oxygen furnace to the electric arc furnace in the steel industry by 2030;
- Commitments by the global aluminium, semiconductor, and magnesium industries to substantially reduce emissions of high GWP gases.

182. As fuel consumption increases, so do combustion-related emissions. Overall emissions grow moderately in the OECD and transition economies, but grow rapidly in developing countries. Although emissions of some non-CO_2 gases decline, emissions of others grow significantly, leading to an overall increase.

Energy consumption and greenhouse gas emissions under the mitigation scenario

183. Table 14 provides an overview of industrial energy consumption and GHG emissions under the mitigation scenario. Fuel consumption rises slowly in the OECD and transition economies, but by over 60 per cent from 2005 to 2030 in developing countries. Total emissions rise continuously in each region, but global combustion emissions fall after 2020. Reductions in emissions of some non-CO_2 gases are more than offset by increases in the emissions of others. CCS facilities are used to reduce emissions by 0.5 Gt CO_2.

Table 14. Fuel consumption and GHG emissions in 2030 under the mitigation scenario for the industrial sector

	Fuel Consumption (Mtoe)				Emissions (Mt CO_2 eq)			
Country/Region	Fossil Fuels	Electricity	Non-Fossil Fuels	Total	Combustion	Non-CO_2	Industrial Process CO_2 emission	Total
World	**2167**	**795**	**415**	**3377**	**6076**	**2931**	**1656**	**10663**
OECD	788	299	138	1225	2095	1334	221	3651
OECD North America	354	121	66	541	940	870	49	1858
United States	276	83	54	413	734	590	44	1368
Canada	47	20	12	79	125	72	5	202
Mexico	31	18	1	50	81	208		289
OECD Pacific	167	67	23	257	458	189	47	693
Japan	89	32	9	130	242	74	31	348
Korea	60	24	6	90	171	75	12	259
Australia and New Zealand	19	11	7	36	45	39	3	87
OECD Europe	266	111	50	427	697	276	126	1099
Transition Economies	173	62	49	284	445	438	77	961
Russia	87	39	38	164	222	197		419
Other EIT	86	24	10	120	224	241		465
Developing Countries	1206	433	228	1868	3536	1158	1358	6052
Developing Asia	836	328	140	1304	2544	537	886	3966
China	524	234	73	831	1646	292	509	2447
India	122	40	33	195	366	115	177	659
Indonesia	45	8	4	57	121	36		157
Other Developing Asia	145	47	30	222	410	93	200	704
Latin America	110	55	50	216	300	191	162	653
Brazil	47	21	40	107	133	48		181
Other Latin America	63	34	11	108	167	143		310
Africa	54	29	38	120	149	190	220	559
Middle East	207	21	0	228	543	241	90	874

Abbreviations: EIT = Economies in transition, OECD = Organisation for Economic Co-operation and Development.

184. Compared with the reference scenario, fossil fuel and electricity demand under the mitigation scenario decline by 17 and 15 per cent respectively, while non-fossil fuel energy consumption rises by 5 per cent. Almost all of the growth in non-fossil fuel use comes from biomass and waste consumption, particularly in Asia, where combined heat and power projects using biomass displace some gas and coal (IEA, 2006). Significant contributors to the reduction in fossil fuel demand are a substitution of natural gas for coal in China and a decline in oil demand in developing countries due to fuel switching and improvements in process heat and boiler efficiencies.

185. Electricity consumption in OECD countries falls by 25 per cent, with motor system efficiency improvements being a prime contributor to the reduction. More than half of global industrial energy savings

result from increased efficiency in the iron and steel, chemicals, and non-metallic minerals industries (IEA, 2006).

4.4.2.3. Overview of current investment and financial flows by source of financing

186. As table 15 shows, most investment in the industry sector (72 per cent globally) comes from domestic sources. This is particularly so in developing and transition economies; in OECD Europe and OECD North America, only 63 per cent and 53 per cent respectively of industrial investment is domestic. FDI provides 22 per cent of the global total, but more in OECD Europe (25 per cent of total) and OECD North America (37 per cent). Debt plays a small role, and is concentrated in developed countries, while ODA barely registers as a source of industrial investment.

Table 15. Investment flows in the manufacturing sector in 2000, by source and region (percentage)

Manufacturing

Country/ region	Total Investment	Total Investment USD billion	Domestic investment (private & public)	FDI flows	Debt (international borrowings)	ODA Bilateral total	ODA Multilateral total	Total
Africa	1.2	16	89.18	6.36	3.34	1.07	0.05	100
Developing Asia	18.66	243	81.35	18.02	0.56	0.07	0	100
Latin America	4.56	59	80.46	15.53	3.84	0.13	0.04	100
Middle East	1.07	14	75.24	24.75	0	0.01	0	100
OECD Europe	24.04	313	62.92	25.35	11.73	0	0	100
OECD North America	31.15	405	55.01	36.57	8.42	0	0	100
OECD Pacific	18	234	99.25	0.05	0.7	0	0	100
Other Europe	0.02	0	-175.61	0	275.61	0	0	100
Transition Economies	1.29	17	85.8	14.03	0.05	0.12	0	100
Global Total	**100**	**1,301**	**71.93**	**22.09**	**5.95**	**0.03**	**0**	**100**
NAI Parties	34.03	443	84.14	15.29	0.46	0.09	0.01	100
Least Developed Countries	0.33	4	75.45	11.61	12.27	0.67	0	100

Source: Estimations by UNFCCC secretariat based on data from: UNSTAT, National Accounts Database; BIS, 2007; World Bank, 2006, World Development Indicator; OECD, CRS.

Abbreviations: FDI = Foreign direct investment, NAI Parties = Parties not included in Annex I to the Convention, ODA= Official Development Assistance, OECD = Organisation for Economic Co-operation and Development.

4.4.2.4. Estimated investment and financial flows needed

Investment and financial flows needed under the reference scenario

187. As summarized in table 16, investment in the industry sector increases under the reference scenario along with the pace of economic growth. Significant investment occurs in non-Annex I Parties, accounting for 52 per cent of the global total, 6 per cent more than OECD countries. As is currently the case, a large majority of the investment is expected to come from domestic sources.

Table 16. Investment flows in the industrial sector by region and time period (billions of United States dollars)

Region	2002	2005	2010	2015	2020	2025	2030
Africa	25	20	28	36	45	56	71
Developing Asia	276	443	668	874	1 066	1 238	1 406
Latin America	88	34	44	53	61	69	79
Middle East	45	14	36	42	55	74	100
OECD Europe	313	243	291	369	417	452	431
OECD North America	323	372	426	481	543	586	628
OECD Pacific	160	251	258	342	363	387	411
Transition Economies	38	21	28	35	41	47	54
World	1 268	1 397	1 779	2 232	2 592	2 911	3 179

Source: OECD ENV–Linkage Model.

Abbreviation: OECD = Organisation for Economic Co-operation and Development.

Investment and financial flows needed under the mitigation scenario

188. The additional investment needed in 2030 for further energy efficiency improvement, CCS and destruction of non-CO_2 emissions from industrial processes to meet the mitigation scenario is shown in table 17. Of the USD 35.7 billion total, USD 19.5 billion is needed for energy efficiency improvement. Installation of CCS infrastructure accounts for around USD 14 billion; the investment for reducing of N_2O and high GWP GHGs is only USD 0.013 billion.

Table 17. Additional investment flows needed under the mitigation scenario in 2030 in the industrial sector (millions of United States dollars)

Country/region	Energy-related investment	CH_4 reduction	N_2O reduction	High GWP GHG reduction	CCS	Total
World	**19 500**	**2 028**	**9**	**4**	**14 125**	**35 665**
OECD	11 500	487	5	2	2 052	14 047
OECD North America	5 115	316	2	1	626	6 059
United States	3 899	125	2	1	561	4587
Canada	750	23	0	0	49	823
Mexico	465	168	0	0	16	649
OECD Pacific	2 340	70	0	1	798	3 209
Japan	1 194	2	0	0	550	1 747
Korea	822	8	0	0	177	1 008
Australia and New Zealand	324	59	0	0	70	453
OECD Europe	4 045	102	3	0	629	4 779
Transition economies	1 061	369	0	0	804	2 234
Russian Federation	596	157	0	0	260	1 013
Other EIT	465	212	0	0	544	1 222
Developing Countries	6 939	1 171	3	2	11 269	19 384
Developing Asia	4 887	691	2	1	10 691	16 273
China	3 157	421	2	1	8 621	12 202
India	727	154	0	0	982	1 863
Indonesia	202	41	0	0	214	457
Other Developing Asia	802	75	0	0	875	1 751
Latin America	798	125	1	0	278	1 202
Brazil	393	21	0	0	199	614
Other Latin America	405	104	0	0	80	588
Africa	410	217	0	0	275	902
Middle East	844	139	0	0	24	1 008

Abbreviations: CCS = carbon dioxide capture and storage, EIT = Economies in transition, GHG = Greenhouse gas, GWP = Global warming potential, OECD = Organisation for Economic Co-operation and Development, CH_4 = methane, N_2O = nitrous oxide.

Box 3. Summary of investment and financial flows for industry

Investment and financial flows needed in 2030
The additional global investment needed under the mitigation scenario is approximately USD 35.7 billion, of which more than half accounts for energy efficiency improvement. Installation of CCS infrastructure accounts for around USD 14 billion. Approximately 54 per cent of the additional investment will be needed in developing countries, 39 per cent in OECD countries and the rest by transition economies.

Current investment and financial flows
Most investment mostly comes from domestic sources (more than 75 per cent). This is particularly so in developing countries and transition economies; in OECD countries, only approximately 50–60 per cent of industrial investment is domestic. FDI provides 22 per cent of the global total, but again is heavily weighted towards OECD countries (25-27 per cent). Debt plays a small role and is concentrated in developed countries, while ODA hardly registers as a source of industrial investment.

4.4.2.5. Assessment of the changes needed in investment, financial and policy arrangements to fill the gap under the mitigation scenario

189. In industry, investment in energy efficiency and emission reduction measures is generally self-financed, although external financial incentives are sometimes available. The energy efficiency measures assumed have very short payback periods (less than four years).

190. Achieving the projected emission reductions in the industrial sector will require:

- Aggressive policies to increase energy efficiency and emissions reductions. Such policies could include mandatory energy efficiency standards, emissions regulations, emissions trading systems for industrial sources, and, in non-Annex I Parties, clean development mechanism (CDM) projects;
- Regulations and/or incentives to adopt CCS. The technological challenges, legal aspect, costs and other issues will also need to be addressed.

191. These are challenges for both Annex I and non-Annex I Parties, since almost half of the projected investment is expected to occur in non-Annex I Parties. Non-Annex I Parties may need to financial incentives or assistance with national policies to address these challenges.

192. The feasibility of reducing industrial emissions levels to those under the mitigation scenario is high, as emissions are easy to track, most GHG emitters are large and economically rational, abatement measures do not usually have an impact on consumers' lifestyles, and non-CO_2 gases are limited and easily identifiable (Vattenfall, 2007a). Additionally, most financing for industrial efficiency improvements is internal. However, the majority of the mitigation opportunities exist in China and other developing countries, where the initial financial investment and knowledge and availability of advanced technologies are often lacking. As a result, additional mechanisms will be needed to stimulate industrial investment to reduce emissions in these countries.

193. Internationally, the key regulatory mechanism required is to ensure that CO_2 abatement opportunities are pursued in the industrial sector is a stable financial incentive to invest in low GHG emitting technology, such as a CO_2 price. A global CO_2 price would be best, as regional differences could cause distortions. Financial incentives to reduce the capital cost of more efficient equipment and to provide incentives for small-scale CCS technologies would also be useful (Vattenfall, 2007a; IEA, 2006). To reduce non-CO_2 industrial emissions, a cap and trade system or performance standards are likely to be more efficient than technology standards, as they would spur innovation and stimulate the large number of diverse measures

needed for abatement (Vattenfall, 2007a). Clear international incentives will be needed to ensure that China and non-industrialized countries achieve their abatement potential (Vattenfall, 2007a).

194. In developing countries specifically, international collaboration and technology transfer are extremely important for driving higher energy efficiency. Small-scale local industrial operations often use outdated processes and low quality fuel and feedstock, and suffer from weaknesses in transport infrastructure (IEA, 2006). As a result, there is a significant potential for energy efficiency improvement, but specific policies tailored to the industry and location are required (IEA, 2006). All of these activities should be strongly supported by IFIs, development assistance programmes and international carbon markets through the CDM (IEA, 2006).

4.4.3. Transportation

4.4.3.1. Introduction

195. Motorization of transport and rates of automobile ownership are increasing rapidly in developing countries experiencing strong economic growth. Vehicle travel continues to grow steadily in developed and developing economies, and economic globalization is driving increases in international shipping and air transport. Investments made over the next two decades in transport equipment and infrastructure, energy efficient technologies, biofuels and R&D and demonstration will have a major influence on the level of GHG emissions from the transportation sector in 2030, and beyond.

196. Transport as defined in this paper, includes passenger and freight movements by road vehicles, railways, aircraft, and both inland and maritime vessels. For aircraft and marine transport, both domestic and international energy use and emissions are included.

4.4.3.2. Energy consumption and greenhouse gas emissions

Recent trends in energy consumption and greenhouse gas emissions

197. In 2004, transport consumed 1,969 Mtoe of energy, a quarter of the world's final energy consumption. Petroleum dominates energy use by transport, accounting for 94 per cent of total energy consumption in the transport sector and 58 per cent of the world's oil consumption. Biofuels accounted for only 15 Mtoe (0.8 per cent), and all other energy sources (mostly electricity and natural gas) accounted for 93 Mtoe (4.7 per cent) (IEA, 2006).

198. Transport emitted about 14 per cent of global GHGs, 5.8 Gt CO_2 eq in 2004 nearly all of which was CO_2 (Vattenfall, 2007b). It accounts for one fifth of energy-related CO_2 emissions (IEA, 2006).[22] Although the IPCC AR4 WG III indicates that non-CO_2 emissions account for 4–12 per cent of total GHG emissions in the transport this analysis focuses on transport's energy-related CO_2 emissions.[23]

199. Road transport, including passenger and freight, is responsible for almost three quarters (73 per cent) of the sector's energy use and CO_2 emissions, followed by air transport (12 per cent), marine transport (10 per cent), rail (4 per cent) and all other modes (1 per cent) (Vattenfall, 2007b). The volume of road transport and its mode distribution varies widely across regions. In 2000, North America and Western Europe had 50 per cent higher miles per vehicle of road travel than the rest of the world combined. This

[22] As might be expected with such estimates, there are some differences in the data characterizing the transportation sector. To maintain consistency throughout the full document, the IEA estimates have been adopted.

[23] Although various studies give some consideration to N_2O and F-gases from mobile air conditioning, non-CO_2 emissions from transport, especially those from aircraft, are relatively less well understood and could be of increasing concern (IPCC, 2007c, chapter 5, box 5.1).

situation is changing rapidly as vehicle ownership increases in developing and transitional economies. Two and three-wheel motor vehicles account for significant share of road traffic in Eastern Europe, Latin America, Japan and South and Southeast Asia. Light trucks account for a large share of road traffic in the America.

Energy consumption and greenhouse gas emissions under the reference scenario

200. Under the reference scenario total energy consumption in the transport sector is projected to be 3,111 Mtoe in 2030. Petroleum remains the dominant source of energy for transportation. Biofuel use increases from 15 to 92 Mtoe, but this still represents only 3 per cent of world transport energy use in 2030. Other energy sources, including electricity and natural gas actually decrease in relative importance. Transport CO_2 emissions increase from just over 5.5 Gt CO_2 in 2005 to 8.7 Gt CO_2 in 2030. Emissions increase in all regions but by far the greatest increases occur in the developing economies.

Energy consumption and greenhouse gas emissions under the mitigation scenario

201. The mitigation scenario relies on increased use of hybrid electric vehicles and bio-fuels, and further vehicle efficiency improvements. The market share for hybrid vehicles rises from 18 per cent under the reference scenario to 60 per cent under the mitigation scenario, along with a doubling of biofuel use and further improvement on efficiency of internal combustion engine. As a result, the energy consumption in transport sector drops by 447 Mtoe to 2,664 Mtoe in 2030.

202. Although petroleum remains the dominant source of energy for transportation, its share drops to 83 per cent under the mitigation scenario. Biofuel use in transport increases greatly in OECD countries from 9 Mtoe in 2005 to 169 Mtoe in 2030. In developing countries and transition economies, biofuel use grows from 6 to 125 Mtoe. While most of the growth occurs in Brazil, there are also significant increases in India, Indonesia, China, and other developing Asia countries.

203. Transport CO_2 emissions increase from their current level, driven by the growth of motorized transport in developing economies, but the 2030 total is 2 Gt lower than it would be under the reference scenario. Most of the reductions are achieved in developing countries, where transport is growing fastest, and in OECD North America, which has the largest stock of vehicles.

4.4.3.3. Overview of current investment and financial flows by source of financing

204. Table 18 provides an estimated total global investment in transport in 2000 to be USD 889 billion, of which 66 per cent was domestic finance, 17 per cent was FDI and 17 per cent was international debt finance. In the five largest developing countries (China, India, Mexico, South Africa and Brazil) domestic finance accounted for more than 90 per cent of transport investment, FDI for approximately 8 per cent and international debt and ODA for less than 1 per cent.

205. In 2000, most of ODA for the transport sector (USD 8.2 billion) went to developing Asia, Latin America and Africa. In Africa excluding South Africa, the ODA amounted to 10 per cent of total transport investment in 2000. Developing Asia received 65 per cent of the total transport ODA. Total transport ODA is approximately half bilateral and half multilateral. The USD 8.2 billion total represented 4 per cent of the USD 211 billion of investment made in developing economies during 2000.

Table 18. Investment flows in the transportation, storage and communications sector in 2000, by source and region (percentage)

	Total Investment, Per cent	Total Investment USD billion	Domestic investment (private & public)	FDI flows	Debt (international borrowings)	ODA Bilateral total	ODA Multilateral total	Total
Africa	1.66	15	85.87	3.89	3.71	3.26	3.27	100.0
Developing Asia	15.06	134	90.10	2.43	3.43	2.06	1.98	100.0
Latin America	6.05	54	51.24	40.71	6.13	1.63	0.29	100.0
Middle East	2.57	23	98.59	0.50	0.57	0.18	0.16	100.0
OECD Europe	25.96	231	0.00	48.25	51.73	0.02	0.00	100.0
OECD North America	29.04	258	89.64	3.49	6.77	0.00	0.10	100.0
OECD Pacific	17.84	159	97.23	0.47	2.30	0.00	0.00	100.0
Other Europe	0.03	0	-140.42*	0.00	240.42	0.00	0.00	100.0
Transition economies	1.79	16	87.16	11.25	0.00	1.30	0.28	100.0
Global Total	**100.00**	**889**	**65.53**	**16.73**	**16.83**	**0.50**	**0.41**	**100.0**
AI Parties	70.94	630	77.53	0.26	22.20	0.01	0.01	100.0
NAI Parties	27.95	248	86.43	8.85	1.54	1.74	1.44	100.0
Least Developed Countries	0.54	5	68.21	9.10	0.00	11.90	10.80	100.0

Source: Estimations by UNFCCC secretariat based on data from: UNSTAT, National Accounts Database; BIS, 2007; World Bank, 2006, World Development Indicator; OECD, CRS.

Abbreviations: AI Parties = Parties included in Annex I to the Convention, FDI= Foreign direct investment, NAI Parties = Parties not included in Annex I to the Convention, ODA= Official Development Assistance, OECD = Organisation for Economic Co-operation and Development.

206. A number of projects of the GEF have addressed energy efficiency or alternative fuels in the transport sector. In 2006, a total of 16 energy efficiency projects in the transportation sector had been funded and six more were in the pipeline, with a total funding of USD 147 million. Over the same period, six alternative fuels projects were funded or in the pipeline, with a total funding level of USD 27 million (GEF Secretariat, 2007).

4.4.3.4. Estimated investment and financial flows needed

Investment and financial flows needed under the reference scenario

207. An estimate for total transport sector investment under the reference scenario was obtained from the OECD ENV–Linkages model. The global investment estimated by the OECD for 2002 (USD 1.14 trillion) shown in table 19 is approximately 28 per cent greater than the USD 0.89 trillion for 2000 reported in table 18 above. In part this can be attributed to differences in the definitions of transport, but it must be chiefly attributed to different data sources and estimation methods. The vast majority of investment is for

“trade & transport”, a category that includes infrastructure investments as well as all other transport equipment not considered road vehicles.

208. Under the reference scenario, global investment in motor vehicles would increase from USD 91 billion in 2005 to USD 209 billion in 2030, reflecting the expected growth in world motor vehicle supply and demand. The largest increases are expected in China, Japan, and East Asia; in Europe and North America the rates increase more slowly but the investment is still substantial. Gross investment in transport and trade grows from USD 1.5 trillion to USD 4 trillion over the same period. The greatest increases come in China and India, but there are substantial requirements for increased investment throughout the world.

Table 19. Projected transport-related investments under the reference scenario, (billions of United States dollars)

	2002	2005	2010	2020	2030
Motor vehicles	69	91	113	162	209
Petroleum and coal products	23	17	19	21	24
Trade and transport services	1 138	1 509	2 005	2 955	4 034

Source: OECD ENV–Linkage Model.

Investment and financial flows needed under the mitigation scenario

209. The total additional investment in transport in 2030 under the mitigation scenario is estimated USD 88 billion, of which USD 9.2 billion is for bio-fuel production and the balance mainly for more costly hybrid electric vehicles (see table 20).

Table 20. Estimated share of additional investment in the transportation sector under the mitigation scenario in 2030, by region (billions of United States dollars)

Country/region	Energy efficiency and vehicle	Biofuel
World	**78.7**	**9.2**
OECD	**41.9**	**5.2**
OECD North America	**25.3**	**2.4**
United States	21.1	2.3
Canada	1.8	0.1
Mexico	2.4	0.0
OECD Pacific	**5.2**	**0.1**
Japan	2.5	0.0
Korea	1.5	0.0
Australia and New Zealand	1.2	0.0
OECD Europe	**11.3**	**2.7**
Transition Economies	**5.3**	**0.0**
Russian Federation	3.6	0.0
Other EIT	1.7	0.0
Developing Countries	**31.5**	**4.0**
Developing Asia	18.9	1.6
China	10.6	0.8
India	2.0	0.2
Indonesia	1.7	0.2
Other Developing Asia	4.7	0.4
Latin America	**4.6**	**2.0**
Brazil	2.2	2.0
Other Latin America	2.5	0.0
Africa	**3.6**	**0.3**
Middle East	**4.3**	**0.0**

Abbreviations: EIT = Economies in transition, OECD = Organisation for Economic Co-operation and Development.

Box 4. Summary of investment and financial flows for transport

Investment and financial flows needed in 2030

The worldwide additional investment needed under the mitigation scenario is approximately USD 88 billion, of which USD 79 billion is for hybrid vehicles and efficiency improvements in vehicles and about USD 9 billion for biofuels. Of the total additional investment needed, developing countries and OECD countries account for approximately 40 per cent and 54 per cent respectively

Current investment and financial flows

About two thirds of the investment is financed domestically, one sixth from FDI and one sixth is financed from international debt. In China, India, Mexico, South Africa and Brazil domestic investment provided more than 90 per cent of transport investment. In 2000, most of the ODA for the transport sector went to developing Asia, Latin America and Africa.

4.4.3.5. Assessment of the changes needed in investment, financial and policy arrangements to fill the gap under the mitigation scenario

210. Nearly all additional transport investment needed under the mitigation scenario is for the purchase of motor vehicles and production of transport fuels; most of this investment will be made by the private sector. There will be no significant change to large transport infrastructure investments between the reference and

mitigation scenarios, such as roads, transport systems, airports, and ports, in which governments usually invest in.

211. Increased use of bio-fuels as blends with conventional fuels will need to be driven by policies. Biofuel, production and consumption are likely to be co-located, as a general rule.

212. The shift to hybrid vehicles projected under the mitigation scenario will require government policies such as vehicle efficiency standards or other policies to raise the market share of hybrid vehicles. Vehicle buyers are unlikely to voluntarily pay the added cost, about USD 1,000 per vehicle. Given the rapid growth of vehicle ownership in non-Annex I Parties, they will need to adopt such policies as well. Many developing economies will not have domestic capacity for vehicle production but will record increased spending on vehicle purchases under such policies. These countries will also require investment in physical and human capital for repairing and maintaining advanced technology vehicles.

213. International funding sources such as the GEF, ODA and the CDM have thus far had minimal impact on GHG emissions in supporting mitigation in the transport sector. It does not appear likely that the CDM will provide adequate financing for transportation mitigation in developing economies (Dave et al., 2005). Transport CDM projects have been slow to get started and are too few in number to have the necessary impact. These international funding sources would have to be increased by an order of magnitude or more to contribute a meaningful share of the estimated future investment needs for transport mitigation.

214. Although ODA currently constitutes a significant source of fund for transport (USD 10 billion per year), it is directed to a wide range of transportation unconnected to GHG mitigation. By continuing and expanding on efforts to bring climate change strategies into transport sector ODA, the role of ODA in meeting the mitigation scenario for the transport sector might be significant.

215. Most of the investment in transport mitigation in developed and developing economies will, however come from the private sector.

216. Investment flows for transport mitigation will have to be increased greatly if the emission reductions of the mitigation scenario are to be met. This will require appropriate policies in both developed and developing countries. In the developed countries, the investment requirements for mitigation are not large in relation to investment in the transport sector and it seems very likely that funding will be forthcoming, especially given the savings in energy expenditures that can be achieved by more energy efficient transport. In contrast, securing mitigation investment in the developing world will be difficult.

4.4.4. Buildings

4.4.4.1. Introduction

217. The buildings sector includes residential floor space and all commercial or service activities of the economy. Most fuel use and emissions in the buildings sector result from the combustion of fossil fuels for space and water heating. Much of the increased energy demand in this sector has been for electricity as a result of significant increases in the number of appliances, computers and cooling (HVAC) technologies over the last few decades (the number of appliances per European household has increased tenfold over the past 30 years).

4.4.4.2. Energy consumption and greenhouse gas emissions

recent trends in energy consumption and greenhouse gas emissions

218. Globally, 2,296 Mtoe energy was consumed by the building sectors in 2004 (see table 21). Fossil fuel consumption is the source of direct emissions from building sector, of which OECD countries are responsible for 64 per cent and developing countries for 25 per cent. In terms of CO_2 emissions, OECD countries are again the largest emitters, at 62 per cent of emissions, with developing countries producing only 27 per cent.

219. The largest contributor to CO_2 emissions is space heating and ventilation (36 per cent of total), followed by lighting (16 per cent), residential appliances (15 per cent), water heating (13 per cent), commercial appliances (9 per cent), and air conditioning (8 per cent) (Vattenfall, 2007c). The commercial sector has a higher CO_2 intensity than the residential sector, due to a larger share of electricity and lower share of renewables in its fuel mix (Vattenfall, 2007c).

Table 21. Fuel consumption and GHG emissions of the building sector in 2000

	Fuel consumption (Mtoe)				**Emissions (Mt CO_2)**
Country/region	**Fossil fuels**	**Electricity**	**Non-fossil fuels**	**Total**	**(All combustion)**
World	**954**	**561**	**781**	**2 296**	**2 574**
OECD	615	415	60	1 089	1 595
OECD North America	285	230	20	534	709
United States	241	202	12	455	597
Canada	34	23	2	58	86
Mexico	10	5	6	21	26
OECD Pacific	85	63	2	150	234
Japan	58	45	0	103	162
Korea	22	9	0.1	31	60
Australia and New Zealand	5	9	2	16	12
OECD Europe	245	122	38	405	652
Transition Economies	105	32	10	147	274
Russian Federation	60	18	2	80	159
Other EIT	45	14	8	68	115
Developing Countries	234	114	712	1 060	704
Developing Asia	145	55	506	707	467
China	84	20	213	318	286
India	31	8	179	218	97
Indonesia	13	4	40	56	36
Other Developing Asia	18	23	75	116	49
Latin America	28	27	26	81	73
Brazil	8	14	7	29	21
Other Latin America	20	14	19	52	51
Africa	19	12	179	210	53
Middle East	42	20	0	62	111

Abbreviations: EIT = Economies in transition, OECD = Organisation for Economic Co-operation and Development.

Energy consumption and greenhouse gas emission under the reference scenario

220. Table 22 shows the projected fuel consumption and GHG emission of the buildings sector per region in 2030 under the reference scenario. Fuel consumption in the buildings sector is projected to rise by 43 per cent between 2005 and 2030 under the reference scenario. Electricity use rises by 86 per cent, propelled by a 226 per cent increase in developing countries. Energy end-use technologies are assumed to gradually become more efficient (IEA, 2006), but because the lifetime of buildings last several decades or longer, some more efficient technologies to penetrate the market. The residential sector is responsible for approximately three quarters of buildings sector emissions and the commercial sector is responsible for approximately one quarter of emissions, with these proportions staying constant throughout the period (Vattenfall, 2007c).

221. The main drivers of increased buildings sectors emissions: are floor space growth (64 per cent residential growth by 2030) (driven by population and GDP growth, a growing service sector, and the continued rise of the information economy (WBCSD, 2006); increasing demand for electric appliances; and a fuel shift to electricity (such as for water heating in developing countries) (Vattenfall, 2007c and IEA, 2006).

Table 22. Fuel consumption GHG of the buildings sector in 2030, under the reference scenario

Country/region	Fuel Consumption (Mtoe) Fossil fuels	Electricity	Non-fossil fuels	Total	Emissions (Mt CO_2)
World	**1 500**	**1 322**	**1 146**	**3 968**	**4 089**
OECD	751	691	159	1 601	1 932
OECD North America	337	388	37	762	847
United States	274	337	27	637	687
Canada	46	35	3	84	112
Mexico	17	15	7	40	48
OECD Pacific	109	102	17	228	297
Japan	66	59	6	132	190
Korea	33	26	3	61	82
Australia and New Zealand	10	17	8	35	25
OECD Europe	304	202	105	611	788
Transition Economies	177	57	122	355	459
Russian Federation	89	28	89	206	233
Other EIT	88	29	32	149	226
Developing Countries	573	574	865	2 012	1 697
Developing Asia	354	379	548	1 281	1 078
China	208	197	203	607	638
India	74.0	91	196	361	234
Indonesia	28	21	50	98	81
Other Developing Asia	44	70	100	215	126
Latin America	63	62	30	156	177
Brazil	15	23	13	51	45
Other Latin America	49	38	18	105	133
Africa	54	58	284	396	164
Middle East	101	75	3	179	278

Abbreviations: EIT = Economies in transition, OECD = Organisation for Economic Co-operation and Development.

Energy consumption and greenhouse gas emission under the mitigation scenario

222. Table 23 shows the projected fuel consumption and GHG emission of the buildings sector per region in 2030 under the mitigation scenario. Under the mitigation scenario, electricity use drops by 22 per cent compared with the reference scenario in 2030 and fuel use is reduced by 13 per cent, which cuts emissions during 2030 by 0.5 Gt CO_2 (19 per cent). OECD countries are responsible for 40 per cent of the total emission reductions, with China contributing 20 per cent. The largest proportional decline in emissions occurs in India, where CO_2 emissions fall by 34 per cent in 2030 compared with the reference scenario.

223. The largest contributing factor in the reduction in electricity use is the use of more efficient appliances, both in OECD and non-OECD countries, with improved air conditioning efficiency (primarily in non-OECD countries), better insulation, and improved lighting efficiency (primarily in OECD countries) also significant factors (IEA, 2006).

Table 23. Fuel consumption and greenhouse gas emissions of the buildings sector in 2030, under the mitigation scenario

Country/region	Fuel consumption (Mtoe) Fossil fuels	Electricity	Non-fossil fuels	Total	Emissions ($Mt\ CO_2$)
World	**1 302**	**1 034**	**1 045**	**3 380**	**3 535**
OECD	663	555	194	1 412	1 711
OECD North America	306	319	41	665	772
United States	247	278	30	555	624
Canada	42	29	3	74	103
Mexico	16	12	7	36	45
OECD Pacific	98	83	22	202	267
Japan	60	48	8	117	173
Korea	28	20	4	52	71
Australia and New Zealand	9	14	10	33	23
OECD Europe	259	154	132	545	672
Transition Economies	150	45	113	308	390
Russia	75	21	83	179	197
Other EIT	75	23	30	129	193
Developing Countries	489	434	738	1 660	1 434
Developing Asia	294	280	454	1 028	880
China	176	148	159	482	531
India	52	73	172	298	160
Indonesia	26	16	45	87	76
Other Developing Asia	40	42	78	160	113
Latin America	56	48	31	135	158
Brazil	14	18	12	43	41
Other Latin America	43	30	19	91	117
Africa	49	47	245	342	149
Middle East	90	59	8	157	247

Abbreviations: EIT = Economies in transition, OECD = Organisation for Economic Co-operation and Development.

224. Efficiency standards allow the efficiency of equipment in non-OECD countries to approach the level of efficiency currently attained in OECD countries (IEA, 2006). Stricter building codes reduce oil and gas demand for space heating in OECD countries and solar power use doubles, primarily for water heating (IEA, 2006).

225. For the residential and the commercial sectors, the largest emission mitigation measures address heating and ventilation, including improvements to the building envelop (façade, roof and floor insulation), efficiency improvement to water heating and air conditioning. Other significant measures are improving lighting efficiency in residential buildings and improving the efficiency of other appliances and reducing standby losses (Vattenfall, 2007c).

4.4.4.3. Overview of current investment and financial flows by source of financing

226. As table 24 shows, the vast majority of commercial and residential buildings investment (97 per cent globally) are domestic, with the exception of the Middle East, where 46 per cent GFCF comes from debt. ODA to the buildings sector is virtually zero.

Table 24. Investment flows in the construction sector by source and region in 2000 (percentage)

Construction								
Region	**Total Investment**	**Total Investment, USD billion**	**Domestic investment (private & public)**	**FDI flows**	**Debt (international borrowings)**	**ODA Bilateral total**	**ODA Multilateral total**	**Total**
Africa	1.80	8	99.72	0.28	0.00	0.00	0.00	100.0
Developing Asia	26.01	114	98.46	1.54	0.00	0.00	0.00	100.0
Latin America	4.14	18	98.76	0.97	0.28	0.00	0.00	100.0
Middle East	0.42	2	49.79	3.87	46.34	0.00	0.00	100.0
OECD Europe	14.36	63	87.43	3.25	9.32	0.00	0.00	100.0
OECD North America	36.94	162	99.09	0.17	0.74	0.00	0.00	100.0
OECD Pacific	15.16	66	97.95	0.93	1.12	0.00	0.00	100.0
Other Europe	0.02	0	100.00	0.00	0.00	0.00	0.00	100.0
Transition Economies	1.14	5	97.35	2.65	0.00	0.00	0.00	100.0
Global Total	**100.00**	**438**	**96.85**	**1.16**	**1.99**	**0.00**	**0.00**	**100.0**
AI Parties	51.31	225	95.56	1.28	3.16	0.00	0.00	100.0
NAI Parties	47.71	209	98.93	0.75	0.33	0.00	0.00	100.0
Least Developed Countries	0.88	4	98.80	1.20	0.00	0.00	0.00	100.0

Source: Estimations by UNFCCC secretariat based on data from: UNSTAT, National Accounts Database; BIS, 2007; World Bank, 2006, World Development Indicator; OECD, CRS.
Abbreviations: AI Parties = Parties included in Annex I to the Convention, FDI= Foreign direct investment, NAI Parties = Parties not included in Annex I to the Convention, ODA= Official Development Assistance, OECD = Organisation for Economic Co-operation and Development.

4.4.4.4. Estimated investment and financial flows needed

Investment and financial flows needed under the reference scenario

227. Projected investment by region during 2005–2030 in the residential and commercial buildings sector is shown in table 25. Investment grows at 5–7 per cent per year in developing country regions, reflecting the rapid population and economic growth, urbanization and rising per capita incomes. In OECD regions, the growth rate is less than 3 per cent per year.

Table 25. Investment flows in the residential and commercial sector by region and time period (billions of United States dollars)

Region	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**Annual growth rate (per cent)**
Africa	33	49	67	91	123	167	6.70
Developing Asia	432	770	1 069	1 422	1 861	2 383	7.10
Latin America	88	117	158	201	250	306	5.10
Middle East	42	88	144	200	266	343	8.80
OECD Europe	1 154	1 527	1 850	2 156	2 475	2 340	2.90
OECD North America	1 754	2 135	2 491	2 830	3 252	3 723	3.10
OECD Pacific	898	1 142	1 228	1 423	1 580	1 733	2.70
Transition Economies	38	66	91	121	156	197	6.80
World	**4 438**	**5 894**	**7 097**	**8 444**	**9 962**	**11 191**	**3.80**

Source: OECD ENV–Linkage Model.
Abbreviations, OECD = Organisation for Economic Co-operation and Development.

228. As in the current situation, almost all investment in the buildings sector is expected to come from domestic sources.

Investment and financial flows needed under the mitigation scenario

229. As shown in table 26, in 2030, USD 51 billion of additional investment will be needed worldwide in the buildings sector to meet the mitigation scenario emission levels, of which USD 14.1 billion (28 per cent) would be needed in non-Annex I Parties.

230. Most emission reductions in the buildings sector result from increased efficiency of appliances, space and water heating and cooling systems, and lighting. There is also a fuel-shift away from fossil fuels and electricity, and towards biomass and waste. Within this sector, financing for CO_2 eq abatement projects generally comes from the private sector or from consumers themselves (IEA, 2006).

Table 26. Additional investment needed in the building sector under the mitigation scenario in 2030 (billions of United States dollars)

Country/region	Energy efficiency
World	**50.8**
OECD	**34.2**
OECD North America	**16.3**
United States	13.6
Canada	1.8
Mexico	0.9
OECD Pacific	**4.9**
Japan	2.8
Korea	1.3
Australia and New Zealand	0.8
OECD Europe	**13.0**
Transition Economies	**2.5**
Russian Federation	1.4
Other EIT	1.0
Developing Countries	**14.1**
Developing Asia	9.0
China	4.3
India	2.5
Indonesia	0.7
Other Developing Asia excluding China, India and Indonesia	1.5
Latin America	**1.1**
Brazil	0.4
Other Latin America	0.7
Africa	**2.8**
Middle East	**1.3**

Box 5. Summary of investment and financial flows for buildings

Investment and financial flows needed in 2030
The additional global investment needed under the mitigation scenario for energy efficiency improvement is about USD 51 billion of which approximately 28 per cent is needed in developing countries, 67 per cent in OECD countries and rest in transition economies.

Current investment and financial flows
The vast majority of commercial and residential buildings investment (97 per cent globally) are domestic, with the exception of the Middle East, where 46 per cent of investment comes from international debt. ODA to the buildings sector is virtually zero.

4.4.4.5. Assessment of the changes needed in investment, financial and policy arrangements to fill the gap under the mitigation scenario

231. Most investment in commercial and residential energy efficiency comes from the building owner and is financed domestically. Most of the measures assumed have a very quick payback period (less than four years).

232. Aggressive policies, in particular stringent mandatory efficiency standards for appliances, equipment, and buildings, will be needed to overcome the recognized barriers to the adoption of cost-effective efficiency measures. These policies will be needed in non-Annex I Parties as well. Non-Annex I Parties may need access to financial incentives or assistance to develop and implement such policies.

4.4.5. Waste

4.4.5.1. Introduction

233. The waste sector includes both landfills and wastewater. The major GHG emissions from landfills and wastewater treatment is methane (CH_4). Produced by anaerobic degradation of organic matter, the methane is often used to power sewage treatment processes or to co-generate electricity. N_2O is also emitted during wastewater processing. Energy-related emissions of waste are not considered in this sector, since most energy consumption is covered elsewhere. For example, much of the energy used to move waste material is probably recorded in the transportation sector as freight.

4.4.5.2. Greenhouse gas emissions

Recent trends in greenhouse gas emissions

234. Global emissions of CH_4 and N_2O from waste in 2000 were 1.18 Gt CO_2 eq and 95 Mt CO_2 eq respectively. Of the total CH_4 emissions, landfills were responsible for 58 per cent while wastewater contributed the remaining 42 per cent (US EPA, 2006b).

235. The vast majority of emissions in developing countries come from untreated wastewater in latrines and open sewers; over 80 per cent of domestic wastewater is uncollected and untreated in large portions of China/centrally planned Asia, south and east Asia and Africa, with the situation worse in rural areas. Septic tanks are the largest contributor of GHG emissions from wastewater in the United States (US EPA, 2006b).

236. Developing countries contribute 53 per cent of global CH_4 emissions, with China responsible for 14 per cent and India for 10 per cent. The United States is the largest global emitter (15 per cent) of emissions. In terms of N_2O emissions, the OECD and developing countries are equal contributors, with the United States emitting 21 per cent and China 20 per cent of the global total.

Greenhouse gas emissions under the reference scenario

237. Emissions in the waste sector are projected to rise by 17 per cent between 2005 and 2030 under the reference scenario. They fall by 1 per cent in OECD countries, but rise by 15 per cent in transition economies and by 30 per cent in developing countries. CH_4 emissions from landfills gradually increase under the reference scenario, driven upwards by population growth and increases in personal incomes and expanding industrialization which lead to increased waste generation, particularly in developing countries.

238. Wastewater CH_4 emissions grow much faster than landfill emissions. By 2020, share of emissions from wastewater has grown from 42 per cent of the total to 45 per cent of the total (US EPA, 2006b). Wastewater N_2O emissions are projected to decrease in several European Union (EU) countries by 2020, but rise quickly in developing countries - particularly in Africa, where they grow by 86 per cent by 2020.

Greenhouse gas emissions under the mitigation scenario

239. The major GHG abatement opportunity undertaken in the waste sector under the mitigation scenario is capture of CH_4 from landfills and wastewater, and the use of that CH_4 for fuel or electricity production. Within the landfill sector, CH_4 emissions can also be reduced at the source by reducing the amount of degradable material that enters landfills through reduced initial waste production, and through recycling and composting. Wastewater emissions can be reduced by advanced treatment technologies that use aerobic rather than anaerobic digestion and by filtering out degradable waste.

240. The emission reductions estimated for the mitigation scenario are those that can be achieved at a marginal abatement cost of up to USD 30 per t CO_2 eq using cost curves from the US EPA (US EPA, 2006b). This value was selected because the marginal abatement cost curves rise sharply beyond this point. Thus this value captures virtually all of the potential emission reductions.

241. Waste sector emissions are reduced by almost 50 per cent from the reference scenario level and developing country emissions decline by 30 per cent from current levels rather than increasing at all. Most (approximately 65 per cent) of the abatement opportunities are in developing countries, coincident with the emissions.

Table 27. Greenhouse gas emissions under the reference and mitigation scenarios and additional investment required for the waste sector in 2030

	Reference scenario Mt CO_2 eq			Mitigation scenario Mt CO_2 eq			
	Waste			Waste			Additional Investment
Country/region	CH_4	N_2O	Total emissions	CH_4	N_2O	Total emissions	USD million
World	**1 420**	**120**	**1 540**	**707**	**90**	**797**	**936**
OECD	421	54	475	236	40	277	251
OECD North America	285	25	310	163.61	19	182	163
United States	176	21	197	102	16	118	102
Canada	44	2	46	31	1	32	17
Mexico	65	2	67	31	2	32	45
OECD Pacific	44	12	55	24	9	33	27
Japan	4	10	14	1	8	9	6
Korea	18	1	19	12	1	12	9
Australia and New Zealand	22	1	23	12	1	12	12
OECD Europe	92	17	110	48	13	61	61
Transition Economies	123	6	129	58	5	63	84
Russian Federation	40	3	44	19	2	22	28
Other EIT	83	3	86	39	2	41	56
Developing Countries	876	60	936	413	45	458	600
Developing Asia	542	40	582	256	30	286	358
China	194	22	216	91	17	108	138
India	174	3	177	82	3	84	118
Indonesia	44	3	47	21	3	23	31
Other Developing Asia	130	11	142	61	9	70	71
Latin America	125	8	133	59	6	65	88
Brazil	53	5	58	25	4	29	37
Other Latin America	72	3	75	34	3	36	51
Africa	112	7	119	53	5	58	86
Middle East	97	5	14	46	4	7	67

Abbreviations, OECD = Organisation for Economic Co-operation and Development; EIT=economies in transition. .

4.4.5.3. Estimated investment and financial flows needed

242. Data on current investment flows for the waste sector are not available. Projected investment in this sector under the reference scenario is also not available.

243. The additional investment needed under the mitigation scenario is calculated using the capital cost from the US EPA marginal abatement cost curves used to estimate the potential emission reductions. The additional investment needed globally is almost USD 1 billion in 2030 and shown in table 27 above. Most of the additional investment occurs in developing countries, coincident with the distribution of waste emissions and reduction opportunities.

Box 6. Summary of investment and financial flows for waste

The global additional investment needed to reduce CH_4 and N_2O emissions in the waste sector is approximately USD 1.0 billion in 2030. About two third of emission reductions and investment occur in developing countries, a quarter in OECD countries and the balance in transition economies.

4.4.5.4. Assessment of the changes needed in investment, financial and policy arrangements to fill the gap under the mitigation scenario

244. Many developed countries are already taking measures to reduce CH_4 emissions from landfills and wastewater treatment, generally because of environmental and public health concerns other than climate change.

245. In many developed countries, actions that reduce methane emissions from landfills and wastewater treatment are likely to be undertaken for environmental and public health concerns. However, most of the abatement opportunities in developing countries still face many barriers to access investment. These include: lack of awareness of and experience in alternative technologies; poor economics at smaller dumps and landfills; limited infrastructure for natural gas use in some regions; lack of even rudimentary disposal systems at many dumps; and difficulties bringing together the many actors involved in energy generation, fertilizer supply and waste management.

246. To overcome these barriers, a combination of several measures is necessary, including institution building and technical assistance policies, voluntary agreements, regulatory measures and financial assistance. Multilateral and bilateral ODA programmes can play an important role in institution building and technical assistance. Voluntary agreements or public-private partnerships can be set up between governments and utilities to overcome information and knowledge barriers and to identify sites with high mitigation potential. Financial assistance can come from ODA, the carbon market or other sources. The carbon markets improves the economics of these projects appreciably. Over 100 projects representing almost 10 per cent of the projected emission reductions, were in the pipeline at the end of 2006.

247. The carbon market improves the economics of landfill gas emission reduction projects appreciably. Over 100 projects representing approximately 10 per cent of the projected emission reductions were in the pipeline at the end of 2006. However, the emission reductions achieved are substantially lower than initially estimated.

4.4.6. Agriculture

4.4.6.1. Introduction

248. Agricultural lands, comprising arable land, permanent crops and pasture, cover about 40 per cent of the earth's land surface (FAOSTAT, 2007), and these lands are expanding. Most of the agricultural land is under pasture (approximately 70 per cent), and only a small per cent (less than 3 per cent) are under permanent crops.

249. There are two sources of GHG emissions from agriculture:

- Non-CO_2 GHGs from management operations;
- Energy-related CO_2 emissions.

250. In addition, the agricultural sector offers significant opportunities for increased removals by sinks mainly through agroforestry and improved grassland management.

251. Agricultural products, such as biomass energy, bio-plastics and bio-fuel, can reduce GHG emissions by replacing fossil fuel based products. Those opportunities are considered in the sectors where the products are used.

4.4.6.2. Greenhouse gas emissions and removals by sinks

Recent trends in greenhouse gas emissions and removals by sinks

252. Current global emissions from the agriculture sector are 6.8 Gt CO_2 eq, of which 6.2 Gt CO_2 eq are non-CO_2 emissions from agriculture operations and 0.6 Gt CO_2 eq come from energy use in the agriculture sector.

Greenhouse gas emissions and removals by sinks under the reference scenario

253. No widely accepted reference scenario of agriculture emissions is available, so the reference scenario is specified for each emission reduction and sink enhancement option analysed for the mitigation scenario. A detailed analysis is provided in sub-chapter 4.4.6.4. below.

Greenhouse gas emissions and removals by sinks under the mitigation scenario

254. The mitigation scenario assumes that cost-effective measures to reduce non-CO_2 emissions are implemented. The emission reductions and the associated financial flows are estimated in chapter 4.4.6.4. below. The potential for increased removals by sinks through agroforestry and the associated investment flows are also estimated in the same chapter. Options for reducing energy-related CO_2 emissions are not analysed because the level of emission reductions are low relative to the other options.

4.4.6.3. Overview of current investment and financial flows by source of financing

Financial flows

255. Global government expenditures in agriculture are increasing in real terms by 2.5 per cent annually. In developed countries, government expenditures is approximately 20 per cent of agricultural GDP; it is less than 10 per cent of agricultural GDP on average in developing countries.

Investment flows

256. The current sources of investment by region in AFF[24] are shown in table 28. The vast majority of the investment comes from domestic sources, such as the farmers themselves from their own savings, funds they borrow or government assistance. In developing countries, most of the remaining investment comes from ODA. Developed countries receive some foreign investment in the form of equity or loans.

[24] OECD ENV– Linkage model has aggregated agriculture, forest and fisheries current investment data into one category.

Table 28. Investment by source for agriculture, forestry and fisheries in 2000 (percentage)

	Total Investment	Total Investment, USD billion	Domestic investment (private & public)	FDI flows	Debt (international borrowings)	ODA Bilateral total	ODA Multilateral total	Total
Africa	5.51	10	96.16	0.97	0.00	1.79	1.07	100.0
Developing Asia	17.95	31	96.02	2.53	0.00	0.88	0.56	100.0
Latin America	9.02	16	98.53	1.04	0.00	0.39	0.04	100.0
Middle East	3.49	6	99.95	0.00	0.00	0.05	0.00	100.0
OECD Europe	35.18	62	84.79	0.13	15.08	0.00	0.00	100.0
OECD North America	13.67	24	98.52	1.43	0.05	0.00	0.00	100.0
OECD Pacific	12.10	21	98.58	0.81	0.62	0.00	0.00	100.0
Other Europe	0.05	0	100.00	0.00	0.00	0.00	0.00	100.0
Transition Economies	3.02	5	97.60	0.85	0.00	0.23	1.32	100.0
Global Total	**100.00**	**175**	**93.14**	**0.97**	**5.39**	**0.30**	**0.20**	**100.0**
NAI Parties	38.65	68	96.88	1.72	0.19	0.76	0.45	100.0
AI Parties	59.64	104	91.05	0.04	8.91	0.00	0.00	100.0
Least Developed Countries	2.42	4	92.02	2.48	0.00	2.95	2.55	100.0

Source: Estimations by UNFCCC secretariat based on data from: UNSTAT, National Accounts Database; BIS, 2007; World Bank, 2006, World Development Indicator; OECD, CRS.
Note: Only aggregated estimates for agriculture, forest and fisheries are available for current investment.

4.4.6.4. Estimated investment and financial flows needed

Investment and financial flows needed in the reference scenario

257. Table 29 shows current and projected GFCF for the agriculture sector by region. The OECD projections for cropping agriculture show rapid and accelerating growth in Africa and the Middle East, moderate growth in most developed countries, emerging economies and transition economies, and declining investments in Japan. In the livestock sub-sector, projections are for high growth in Africa, India, South and South-East Asia, the Middle East, and Turkey. Similar to the cropping sub-sector, projections are for moderate growth in most developed countries, emerging economies and economies in transition, and declining investments in Japan.

Table 29. Investment flows in the agriculture sector by region and time period (millions of United States dollars)

	2005	2010	2015	2020	2025	2030
Africa	14 275	12 601	16 204	19 668	23 605	28 074
Australia/New Zealand	3 153	3 871	3 986	4 498	5 009	5 483
Brazil	5 311	8 932	9 973	11 277	12 623	14 125
Canada	1 885	3 156	3 515	3 763	4 002	4 301
China	14 205	16 863	19 834	22 763	25 666	28 302
EU-15	7 548	11 672	13 044	14 215	15 137	15 733
India	9 320	11 800	14 299	16 881	19 640	22 457
Japan	4 513	7 673	7 186	7 471	7 606	7 723
Latin America/Caribbean	15 473	17 328	19 899	22 680	25 654	28 970
Mexico	461	2 352	2 120	2 689	3 010	3 219
Middle East	3 619	3 908	5 402	6 658	7 870	9 209
Russian Federation	1 047	1 036	1 224	1 415	1 559	1 652
South & SE Asia	13 862	17 383	20 879	24 651	28 668	32 777
Republic of Korea	192	378	382	397	435	413
Turkey	1 575	2 766	2 979	3 166	3 350	3 534
United States	12 842	15 313	16 907	17 323	18 041	19 035
Global Total	**109 281**	**137 031**	**157 833**	**179 513**	**20 1874**	**225 006**

Source: OECD ENV–Linkage Model.

Investment and financial flows needed in the mitigation scenario

Investment and financial flows needed for reduction of non-carbon dioxide greenhouse gas emissions

258. The US EPA has published two baseline (reference) scenarios for non-CO_2 emissions. The first was generated from national GHG inventories and provides disaggregated data at the country level (US EPA, 2006a). The second scenario (US EPA, 2006b) was generated from some of the same data, but used process models (daily service of century model (DAYCENT) and denitrification decomposition model (DNDC)) to improve the estimates of N_2O emissions from soils and both N_2O and CH_4 emissions from rice cultivation.

259. Both scenarios are presented in five-year increments from 1990 to 2020. The scenarios were extended to 2030 in the analysis based on a reasonable projection of the time series, usually a linear extension. The global totals for both scenarios are shown in table 30. The regional distribution of the second scenario is provided in annex 5, table 9.

260. The first scenario is useful for making comparisons among countries and regions because the methods are consistent from country to country. The second scenario is more appropriate for assessing the mitigation scenario and the costs associated with mitigation. It is substantially lower than the emissions reported in the national communications, so it may under estimate the potential reductions.

Table 30. Reference scenarios for non-carbon dioxide greenhouse gas emissions (Mt CO_2 eq) by source through 2030

	Year								
	1990	1995	2000	2005	2010	2015	2020	2025	2030
Global total, First scenario	5 343	5 528	5 928	6 291	6 713	7 158	7 648	8 071	8 493
Global total, second scenario			4 563	4 490	4 417	4 619	4 822	5 025	5 227

261. The emissions sources for non-CO_2 gases included in both baselines and their approximate share of global emissions are shown in table 31. N_2O from soils accounts for about 45 per cent of the total and CH_4 from enteric fermentation accounts for another 30 per cent of the total.

Table 31. Approximate shares of non carbon dioxide greenhouse gas from management operations

Emissions source	Share of total emissions (percentage)
N_2O from soil	45.5
N_2O from manure management	3.5
CH_4 from enteric fermentation	30.5
CH_4 from manure management	3.5
CH_4 from rice cultivation	10.5
CH_4 from other sources (Savanna burning, burning of agricultural residues, burning from forest clearing, and agricultural soils (CH_4))	6.5

Source: Calculation based on Verchot (2007).

262. A large number of mitigation options for mitigating GHG emissions from agricultural have been suggested. In many cases, production or cost trade-offs need to be understood before proper incentives for the adoption of these practices can be designed. The US EPA constructed marginal abatement curves for different regions and different sectors through 2020. Costs include capital, operation and maintenance costs. The calculation included a tax rate of 40 per cent and used a 10 per cent discount rate. Benefits include the intrinsic value of CH_4 as a natural gas or as fuel for electricity or heat generation, benefits of abatement unrelated to climate change (e.g. improved nutrient use efficiency), and the value of abating the gas given a GHG price.

263. The curves all become steep or even vertical at around USD 30 per t CO_2 eq. Thus, this analysis assumes the reduction available at USD 30 per t CO_2 eq is the maximum economic level of abatement and calculates these mitigation potentials. To construct aggregate abatement curves for agriculture, the cultivated area and number of animals can be held constant or production can be held constant. Approximately 13 per cent of total emissions could be mitigated given constant area and animal numbers. When production is held constant, approximately 16 per cent of non-CO_2 emissions could be mitigated.

264. The measures that reduce these emissions are operational measures that do not require new equipment. The annual cost of implementing the measures on the scale projected is assumed to be the marginal cost of USD 30 per t CO_2 eq. The estimated emission reductions and associated annual financial flows are presented in table 32.

Table 32. Potential total reductions in emissions (M t CO_2 eq) from agriculture for selected countries and regions with carbon prices at USD 0 and USD 30 per t CO_2 eq, with constant herd size

Regional distribution	Potential reductions (Mt CO_2 eq) from croplands		Total Cost in USD million	Potential reductions (Mt CO_2 eq) from rice cultivation		Total Cost in USD million	Potential reductions (Mt CO_2 eq) from Livestock management		Total Cost in USD million
	2030			2030			2030		
Country/Region	**USD 0**	**USD 30**		**USD 0**	**USD 30**		**USD 0**	**USD 30**	
Africa	4.2	5.4	183				2.3	11.9	403
Brazil	1.4	3.7	125				9.6	16.2	549
Mexico	4.2	9.3	315				2.1	2.1	71
Non-OECD Annex I	35.0	39.6	1 342				4.1	4.1	139
OECD	69.4	89.8	3 044	1.9	10.8	366	36.1	77.7	2 634
Russian Federation	35.0	39.6	1 342				2.5	2.5	85
S&SE Asia	2.5	3.3	112	73.2	115.6	3 919	11.2	19.2	651
Global total	**139.6**	**179.7**	**6 092**	**116.2**	**243.3**	**8 248**	**92.4**	**175.2**	**5 939**
Annex I	109.4	135.0	4 577	0.4	6.3	214	38.1	80.1	2 715
Australia/New Zealand	3.7	4.4	149				4.0	6.8	231
China	6.4	8.1	275	39.7	81.8	2 773	11.0	20.3	688
Eastern	5.8	8.9	302			0	1.7	1.7	58
EU-15	11.8	12.4	420			0	12.9	24.5	831
India	4.5	8.9	302		34.4	1 166	3.7	7.8	264
Japan	-	-	0	0.4	6.3	214	0.9	0.9	31
United States	44.9	58.6	1987				10.6	33.5	1136

Source: Table adapted from US EPA (2006b).

Estimated investment and financial flows needs for increased removals by sinks

Investment and financial flows needs for agroforestry

265. A rigorous analysis of the costs and mitigation potential for increased removals by sinks does not presently exist in the literature. The IPCC (2000) Special Report presented an illustration contribution of the potential of removals by sinks to contribute to climate change mitigation. The IPCC scenario is expanded in this analysis to illustrate the potential of increased removals by sinks through agroforestry and the associated investment.

266. Activities that increase CO_2 sinks in tropical agricultural landscapes offer a cost effective means to achieve mitigation objectives. The IPCC scenario suggests that the land area available for agroforestry is 630 million ha and that 40 per cent of this area could be in agroforestry by 2040, at a rate about 19 million ha per year after the first decade. Expanding agroforestry by 19 million ha per year would require an annual

investment of approximately USD 15 billion (USD 780 per ha) and operating costs of about USD 8 billion (USD 440 per ha).

267. In most cases agroforestry systems are more profitable than subsistence agriculture. But resource poor farmers cannot shift to agroforestry because of the initial costs are not recovered for three to five years. Many farmers lack knowledge about the income potential of agroforestry systems and how to grow the trees. In addition, agroforestry systems are more labour intensive than cropping systems, so labor shortages during peak seasons may inhibit their adoption.

Investment and financial flows needs for grassland management

268. IPCC scenario suggested that the land area available for improved grassland management is 3,400 million ha and that it would be possible, with considerable international effort, to have 20 per cent of this area under improved pasture management by 2040, at a rate of about 68 million ha per year after the first decade. No estimate is available for the cost of grassland management measures to increase removals of CO_2 under the scenario.

Summary of investment and financial flows needs

Table 33. Summary of investment flows for the reference and mitigation scenarios in 2030 (billions of United States dollars)

Region	Non-CO_2 crops[a]	Non-CO_2 livestock[a]	Removal by sinks agroforestry[b]	Mitigation scenario
World	14.3	5.9	15	35.2
Annex-1	4.8	2.7	N.A.	
Non Annex-1	9.6	3.2	N.A.	

Note: [a] financial flow, [b] investment flow.

269. Table 33 above summarizes the additional investment and financial flows under the mitigation scenario in 2030 for the measures analysed for the agriculture sector. The additional investment and financial flows needed for the mitigation scenario total about USD 35 billion per year. For livestock and crops 50–70 per cent of the additional financial flow is needed in developing countries. A regional split for agroforestry is not available.

Box 7. Summary of investment and financial flows for agriculture

Investment and financial flows needed in 2030

In the agriculture sector the global additional investment and financial flows needed under the mitigation scenario total approximately USD 35 billion of which USD 20 billion (financial flow) is non-CO_2 emissions reductions (rice cultivation, cropland practices and livestock management) and USD 15 billion (investment) is for removal by sinks through agroforestry. About 65 per cent of the financial flows for reducing non-CO_2 emissions occur in developing countries.

Current investment and financial flows

In the agriculture sector most of the investment, by far, comes from domestic sources, such as the farmers themselves from their own savings, funds they borrow or government assistance. In developing countries, most of the rest of the investment comes from ODA.

4.4.6.5. Assessment of the changes needed in investment, financial and policy arrangements to fill the gap under the mitigation scenario

270. Most of the costs of farm operation are borne by the farmer but financial incentives may be needed to encourage adoption of N_2O and CH_4 emission reduction measures in developing countries.

271. Projects to reduce CH_4 emissions from livestock manure are being implemented under the CDM. Projects to collect and use agricultural waste, such as bagasse and rice husks, are also being implemented under the CDM. The CDM can contribute to reducing the non-CO_2 emissions but it cannot address the full mitigation in agriculture sector because some measures are not eligible and projects need to exceed a minimum size to be economical.

272. In principle, transition from pure agriculture to agroforestry system by planting trees is eligible as a CDM project. But that does not address the initial capital cost barrier of planting trees, or the knowledge and labour supply barriers. Since agroforestry system is more profitable than cropping system, there is a role for mechanisms that provide the initial capital and knowledge and receive a return from a share of the new crops and CDM credits.

4.4.7. Forestry

4.4.7.1. Introduction

273. This chapter focuses on the land in forests at each point in time. It does not include agroforestry, which is addressed in the agriculture sector, bio-energy, which is addressed in the transport and energy supply sectors, or management of wood products. Mitigation options for the forestry sector are reduction of deforestation, better management of productive forest (forest management) and afforestation and reforestation to increase the forest area.

4.4.7.2. Greenhouse gas emissions and removals by sinks

Recent trends in greenhouse gas removals by sinks in the forestry sector

274. Annex 5, table 10 compares the principal data sets for CO_2 fluxes and forest area losses. Due to differences in methods and scope, values from different data sets are not directly comparable, therefore, the table presents samples of reported results only. The main sources of information for fluxes are those reviewed by IPCC AR4 Working Group III (IPCC, 2007c)[25]. Flux estimates from the Climate Analysis Indicators Tool (CAIT) database[26] of the World Resources Institute (WRI) are also reported. Data on forest area and forest area lost between 2000 and 2005 are from the Food and Agriculture Organisation of the United Nations (FAO) Global Forest Resources Assessment (FRA) 2005 (FAO, 2006). Other estimates of forest area lost and degraded from different sources are also reported.

Greenhouse gas removals by sinks in the reference scenario

275. The forestry section of the IPCC WG III contribution to AR4 found there had been little new effort to develop global baseline scenarios for land-use change and the associated carbon balance against which mitigation options could be examined. Since no suitable scenario for baseline emission for the forestry sector

[25] According to FAO (2005) equalling 4000 Mt CO_2 year-1 FAO, 2005: Forest Finance: sources of funding to support sustainable forest management (SFM). Rome: FAO.

[26] The CAIT of the WRI in Washington uses data from: Carbon Dioxide Information Analysis Center (CDIAC), Dutch National Institute of Public Health and the Environment (RIVM), EarthTrends (WRI), Mr. Richard Houghton (Woods Hole Research Center), IPCC, IEA, The World Bank, World Health Organization (WHO).

are available, the reference scenario assumes that GHG emissions from the forestry sector in 2030 are the same as in 2004, as estimated at section 11 of the IPCC WG III contribution to the AR4 estimated at 5.8 G t CO_2 eq. This estimate excludes peat and other bog fires (see annex 5, table 11).

Greenhouse gas removals by sinks in the mitigation scenario

276. The potential of reducing greenhouse gas emissions or enhancing removals by sinks in the forestry sector is estimated as mitigation potential for different mitigation options. A detailed analysis is provided in section 4.4.7.4. below.

4.4.7.3. Overview of current investment and financial flows by source of financing

277. Data on the sources of current investment in forestry are aggregated with agriculture and fisheries and are shown in table 28 (see chapter 4.4.6 on agriculture). Most of the investment comes from domestic sources. In non-Annex I Parties, most of the rest of the investment comes from ODA.

278. OECD ENV–Linkages model estimates for forestry alone put the total new investment at about USD 23 billion for 2005. Other estimates indicate that FDI into the forestry sector of developing countries has been increasing, while the share of ODA going into forestry has seen a steady decline to about USD 1.75 billion per year (Noble, 2006). Estimates vary, but all agree that FDI considerably exceeds ODA.

279. Table 34 contains information on selected funding and investment flows in the forestry sector from various sources, without claiming to be comprehensive or complete.

Table 34. Information on funding and investment flows in the forestry sector

Funding source	Volume	Comments
Direct private investments	USD 63 billion per year, USD 15 billion per year to developing countries	USD 63 billion per year in total (all countries). USD 15 billion per year to developing countries and EITs. Mainly domestic direct investments (over 90 per cent)[a]
ODA	USD 328 million total in 2000, of which USD 110 million is capital investment	Source: Creditor Reporting System (CRS), 2006, OECD Statistics.
IFC	USD 65 to 75 million per year	Source: PROFOR, 2004
ITTO	USD 11.5 million in 2006	Conservation and sustainable management, use and trade of tropical forest resources[b]
GEF	USD 1.25 billion since 1997	236 projects through six operational programmes. Leveraged co-financing USD 3.45 billion[c].
NFP Facility	USD17.3 million over five years (2002 to 2007), of which 12.5 is committed	The Facility has programmes in approximately 50 countries, each of which receives 300.000 USD over 3 years. Committed: USD 1.7 million in 2005, over USD 2 million in 2006. In 2006, 44 per cent of the funding went to Africa, 7.5 per cent to Central Asia, 13 per cent to Asia and the Pacific and 35 per cent to Latin America and the Caribbean[d].

Funding source	Volume	Comments
PROFOR	USD 8.2 million between 2002 and 2006	34 different activities. Themes include: livelihoods, governance, financing, cross-sectoral cooperation, and knowledge management. USD 8.2 million over the period 2002 to 2006, 58 per cent was spent on global activities, 6 per cent in regions and 36 per cent in countries. It has leveraged USD 1.3 million in co-financing
World Bank Global Forest Alliance	USD 1.5–2 million per year	It expects to raise about USD 100 million for technical and catalytic functions, about USD 300 million for piloting avoided deforestation schemes in selected pilot countries and about USD 75 million for carbon finance reforestation projects with poverty reduction objective[f]
Other funds	USD 53.8 million	Biocarbon fund[g]
New South Wales GHG Abatement Scheme		USD 6.7 million to date based on prices of AUD 11.50 per t CO_2 eq for forestation and a traded volume 0.7 M t CO_2 eq[h]

Abbreviations: IFC=International Finance Corporation; ITTO=International Tropical Timber Organization; NFP = National forest programmes; USD = United States dollar.

[a] Tomaselli 2006 cited in Savco Indufor 2006.

[b] www.itto.or.jp.

[c] GEF/C.27/14, 12 October 2005 and information directly from the GEF secretariat.

[d] 2006 Progress Report. Courtesy of NFP Facility.

[e] Savcor Indufor 2006.

[f] World Bank, 2007.

[g] www.carbonfinance.org.

[h] Modified after Savcor Indufor 2006.

280. Reconciling the available data is a challenge:

- Total investment in AFF in 2000 was about USD 175 billion. OECD model estimates for forestry alone put the total new investment at about USD 23 billion for 2005. The Tomaselli (2006) estimate of USD 63 billion is three times this amount. The Tomaselli figure could include investments to purchase existing assets, such as forest land, and investments in wood products industries;
- Total ODA in 2000 for forestry was about USD 370 million, of which USD 124 million was capital investment. Some of the spending under the IFC and ITTO programmes could be included in the ODA total. The ITTO spending includes very little capital investment.
- The GEF figure of USD 1,250 million since 1997 (about USD 150 million per year) is the total spending, not just capital investment, under six operational programmes. Some contributions to GEF and some spending by implementing agencies funded by GEF could be included in the ODA total (see annex 5, table 12).

281. Most of the current investment and financial flows into the forestry sector are not related to climate change. The vast majority of investment and financial flows into the forestry sector, including SFM are from the private sector. According to Savcor Indufor (2006) over 90 per cent of the private sector investments are domestic and less than 25 per cent is invested in developing countries and transition economies.

282. According to PROFOR (2004), current levels of investment in the forestry sector, both domestic and foreign, fall far short of the level necessary to realize the potential of well-managed forest resources to

contribute to poverty alleviation, the protection of vital environmental services, and sustainable economic growth in developing and transition countries.

4.4.7.4. Estimated investment and financial flows needed

283. The reference scenario assumes that GHG emissions from the forestry sector remain constant from 2004 through 2030 at 5.8 G t CO_2 eq, excluding peat and other bog fires. This involves no additional investment or financial flows.

Investment and financial flows needed under the mitigation scenario

284. The mitigation options for the forestry sector are:

- Reduced deforestation[27];
- Better management of productive forest (forest management);
- Forestation to increase the forest area (afforestation and reforestation).

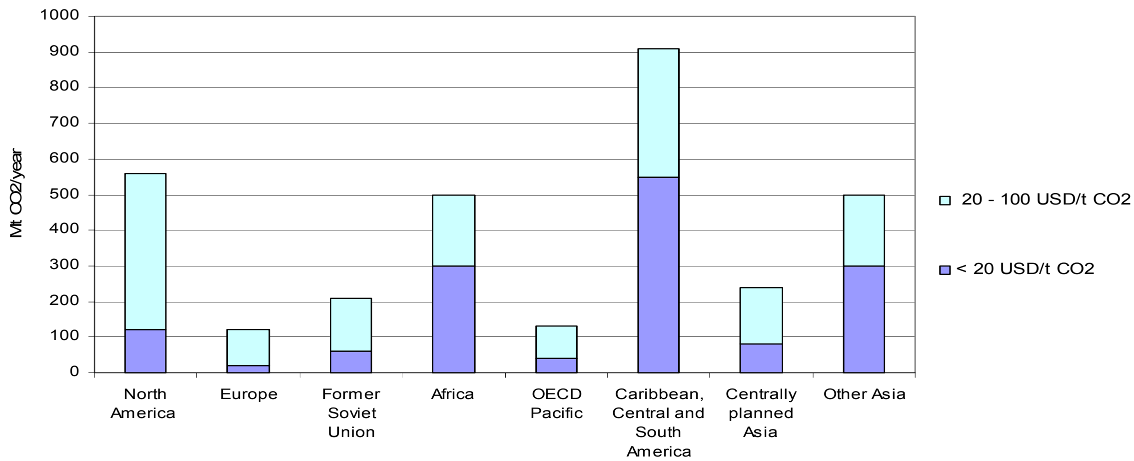
285. Forestry mitigation projections are regionally unique, but linked across time and space by changes in global physical and economic forces. Boreal primary forests could be sources or sinks, depending on the net effect of enhancement of growth due to climate change versus a loss of organic matter from soil and emissions from increased fires. The temperate forests in United States, Europe, China and Oceania, will probably continue to be net carbon sinks, partly because of enhanced forest growth due to climate change. Tropical forests are expected to continue to be sinks because of human induced land-use changes. Enhanced growth of large areas of primary forests, secondary regrowth, and increasing plantation areas will also increase the sink.

286. IPCC WGIII AR4 presents estimates of the mitigation potential for different costs per tonne for 2030, but no indication is given as to what area is required to achieve those potentials. Figure 12 shows the annual economic mitigation potential in the forestry sector by world region and cost class in 2030. The IPCC WGIII AR4 estimate that forestry mitigation options have the economic potential (at carbon prices up to USD 100 per t CO_2) to contribute between 1,270 and 4,230 M t CO_2 in 2030 (medium confidence, medium agreement). About 50 per cent of the medium estimate can be achieved at a cost under

287. USD 20 per t CO_2 (1,550 M t CO_2 per year). Over two thirds of the total mitigation potential, and over 80 per cent of the low cost potential, is located in developing countries.

[27] Reducing emission from deforestation in developing countries as defined in Subsidiary Body for Scientific and Technological Advice (SBSTA).

Figure 12. Estimated economic mitigation potential in the forestry sector by region and cost class



Source: adapted from IPCC, 2007c
Note: The regions mentioned in the figure above are as per the Fourth Assessment Report of the IPCC.

Costs of reduced deforestation

288. Estimates for costs of reduced deforestation include reducing emissions from both deforestation and degradation. The biggest mitigation potential in the forestry sector is to reduce deforestation and degradation in the tropics, where almost all of the emissions from deforestation and degradation originate. Available studies differ widely in basic assumptions regarding carbon stocks, costs, land areas, and other major parameters. A thorough comparative analysis is therefore very difficult.

289. The financial flow needed to reduce deforestation/degradation is estimated as the opportunity cost of converting forest to other land uses.

290. The three major direct drivers of deforestation/degradation as follows:

- Commercial agriculture (national and international markets)
  - Commercial crops
  - Cattle ranging (large-scale)
- Subsistence farming
  - Small-scale agriculture/shifting cultivation/slash and burn agriculture
  - Fuelwood and NTFP gathering for local use, mostly family based
- Wood extraction
  - Commercial (legal and illegal) for national and international markets
  - Traded fuelwood (commercial at sub national and national level).

291. The driver for converting forest to one of these other land uses determines the opportunity cost of maintaining the forest; preventing the deforestation/forest degradation. Estimates of the opportunity costs by driver are based on ITTO (2006); Forner et al (2006); Kaimowitz and Angelsen (2001); Moutinho and Schwartzman (2005); Chomitz and Kumari (1998); Chomitz, K. (2006) and Geist and Lambin (2002) and expert judgement.

292. The total net loss for countries with a negative change in forest area was 13.1 million ha per year for 1990–2000 and 12.9 million ha per year for the period 2000–2005 (FRA, 2005). Consequently, the forest

loss through deforestation/degradation by main direct driver has been assumed to be 12.9 million ha per year in the absence of mitigation measures.

293. The direct drivers for deforestation/degradation differ in each country where it occurs. The share of total forest area lost to each direct driver was estimated based on the area lost by country and the direct drivers for the country.

294. Applying the opportunity cost for drivers relevant to each region to the area lost to deforestation/degradation each year in the region yields an estimated annual cost of USD 12.2 billion to reduce deforestation/forest degradation of 12.9 million ha per year as shown in table 35. Reducing deforestation/forest degradation completely would reduce emissions by 5.8 G t CO_2 in 2030.

Table 35. Cost for reducing deforestation

Main direct drivers	Rate of Deforestation/Degradation (percentage)	Area of Deforestation/Degradation (million ha per year)	Opportunity cost of forest conversion (USD per ha)	Financial flow required to compensate the opportunity costs (USD million per year)
Commercial agriculture				
Commercial crops	20	2.6	2 247	5 774.18
Cattle ranching (large-scale)	12	1.6	498	801.35
Subsistence farming				
Small scale agriculture/shifting cultivation	42	5.5	392	2 148.13
Fuel-wood and NTFP gathering	6	0.75	263	196.95
Wood extraction				
Commercial (legal and illegal)	14	1.8	1 751	3 187.4
Fuel-wood/charcoal (traded)	5	0.7	123	85.96
Total	**100**	**12.9**		**12 193.97**

Note: Various studies have estimated cost for reducing deforestation ranging from 0.4 billion to as high as 200 billion per year. However these estimates vary greatly in assumption and opportunity cost for the deforestation drivers and the area of reduced deforestation Sathaye et al. (2006), IIED (2006), Stern (2006) and Trines (2007).

295. Opportunity costs vary significantly by location and over time. The underlying drivers for deforestation (e.g. structural changes in land tenure or in agricultural or forest policies) also affect the opportunity costs. The opportunity costs do not include investment or maintenance costs of alternative land-use. They also do not include administrative and transaction costs for reducing emissions from deforestation and/or forest degradation. The estimates presented above therefore must be considered as indicative only.

296. Another estimate of cost of reducing deforestation (Trines, 2007) assumes that the area of primary forest lost as reported in FRA 2005 is deforestation. The annual rate of primary forest loss between 2000 and 2005 is assumed to continue through 2030. The analysis uses primary forest loss data for 40 countries that were responsible for over 66 per cent of the CO_2 emissions in 2000 (WRI CAIT). The CO_2 emitted due to deforestation is estimated using carbon content values presented in the FRA 2005. This approach yields an estimate of approximately 148 million ha of deforestation by 2030 with total emissions of about 60,000 Mt CO_2 or annual emissions of about 2,300 Mt CO_2.

297. The highest marginal cost to completely stop deforestation – the "choke price" – is applied to the projected deforestation to estimate the cost of reduced deforestation. Choke prices estimated by Sathaye et al. (2006) vary between USD 11 to 77 per t CO_2, excluding transaction costs. Applying those prices to the projected emissions due to the loss of primary forest in each region yields a cost of USD 25 to 185 billion per year to stop deforestation.

298. However for this report, the mitigation potential and cost of reducing deforestation have been estimated using the opportunity costs of the direct drivers of deforestation and forest degradation.

Costs of forest management

299. Forest management, in particular SFM has received ample attention over the past decade, and is promoted by the private sector, and aid agencies, but in a non-climate context. Public forests in Annex I Parties are already managed to relatively high standards, which limits possibilities for increasing removals by sinks through changed management practices (for example, by changing species mix, lengthening rotations, reducing harvest damage and or accelerating replanting rates). There may be possibilities to increase carbon storage by reducing harvest rates and/or harvest damage.

300. This analysis assumes that forest management can reduce emissions from production forests in developing countries. The production forests in each country is assumed to remain constant at the 2005 area of 602 million ha (FRA, 2005).

301. The ITTO Expert panel report estimated the costs to achieve SFM at USD 6.25 per ha for all tropical production forests in ITTO member countries (about 350 million ha) (ITTO, 1995). Adjusting for inflation and the larger area of production forest, the cost is estimated at USD 12 per ha.

302. For non-Annex I Parties in tropical and subtropical areas, the cost of achieving (sustainable) forest management on 602 million ha of production forests would be about USD 7.2 billion per year leading to increased annual removals of 5.4 G t CO_2 (see table 36 below). Non-Annex I Parties with temperate and boreal forests have the potential to increase carbon stocks through SFM at a cost of USD 20 per ha (Whiteman, 2006) for an annual cost of USD 1 billion and increased annual removals of 1.1 G t CO_2. Thus the annual potential for increased removals through forest management in non-Annex I Parties is estimated at 6.5 G t CO_2 at an annual cost of USD 8.2 billion in 2030.

Table 36. Potential removal by sinks through forest management

Regions	Area of production forest (x 1000 ha)	Cost estimate for SFM (USD million)	Global estimate of carbon in biomass (t CO per ha)	Forest managed area at a 25-years rotation basis ('000 ha)	Additional annual growth potential through SFM (m^3 per ha and year)	Increased carbon removal potential per ha through SFM t CO_2	Additional carbon removals potential in the year 2030 (Mt CO_2)
Total Eastern and Southern Africa	43 948	527	233.045	1.758	2.8	5.138	227.54
Total Northern Africa	46 129		95.42	1.845	0.5	0.9175	44.04
Total Western and Central Africa	123 912	1 487	568.85	4.956	5.8	10.643	1 317.53
Total East Asia	125 369	1 505	136.891	5.015	3.5	6.422	803.73
Total South and Southeast Asia	120 046	1 440	282.6	4.802	7	12.845	1 541.4
Total Caribbean, Central America & Mexico	46 645	560	438.198	1.866	6	11.01	513.8
Total South America	96 459	1 158		3.858	5.5	10.0925	
Tropics	602 185	7 231	308.28	24.1	4.4	8.074	5 420.59

Source: FAO FRA, 2006.

Costs of forestation

303. So far, afforestation and reforestation (here is referred to as 'forestation') initiatives have been driven mainly by the private sector, for 'no regret' options, such as commercial plantation forestry, or governments. Owing to the lack of liquidity of the investment, the high capital cost of establishment and long period before realizing a financial return, many plantation estates have relied upon government support, at least in the initial stages. Incentives for plantation establishment take the form of forestation grants, investment in transportation and roads, energy subsidies, tax exemptions for forestry investments, and tariffs on competing imports.

304. The drivers that influence forestation vary by region and often even within a country, and originate predominantly from outside the forestry sector. Hence, modelling the area likely to be planted as part of a forestation initiative is complicated.

305. Sathaye et al. (2006) present the land area planted and removals by sinks benefits across a number of scenarios relative to a reference case to 2100. For 2050 the range of land area planted is 52–192 million ha whereas the carbon benefits range from 18–94 Mt CO_2.

306. Establishment costs for forests range from USD 654 per ha on good sites to USD 1580 per ha on difficult sites (ORNL, 1995). Using this range, the initial investment required to mitigation 18–94 M t CO_2 through afforestation/reforestation on 52–192 million ha land is USD 34–303 billion.

307. The IPCC WGIII AR4 estimate of the mitigation potential of afforestation by 2030, 1,618 to 4,045 Mt CO_2 year^{-1}, is substantially lower than the estimate of Sathaye et al. Using a similar ratio between carbon sequestered and hectares planted, the WGIII AR4 estimates would require 4.6–8.2 million ha. At establishment costs of USD 654–1580 per ha establishment costs that would be USD 3–12.9 billion or USD 0.1–0.5 billion per year over 25 years. Conservative estimates from IPCC have been taken for this analysis.

308. The estimated investment and financial flows for the mitigation options analysed are summarized in table 37.

Table 37. Investment and financial flows needed for mitigation options in the forestry sector

	Afforestation/Reforestation				Forest management		Reduced deforestation	
Country / Region	Emission offset potential (Mt CO_2) in 2030		Cost in USD billion in 2030		Emission avoided Mt CO_2	Cost in USD billion in 2030	Emission reduced in 2030 Mt CO_2	Cost in USD billion in 2030
	Lower	Higher	Lower	Higher				
Annex I	18.79	46.96	0.03	0.15	-	-	-	-
Non- Annex I	43.51	108.74	0.07	0.35	6522	8.2	5790	12.3
Global	64.7	161.9	0.1	0.5	6522	8.2	5790	12.3

Box 8. Summary of investment and financial flows for forestry

Investment and financial flows needed in 2030

In the Forestry sector the additional global investment and financial flows needed under the mitigation scenario total about USD 21 billion, of which financial flows for emission reductions through reduced deforestation account for USD 12 billion and for forest management account for USD 8 billion. Afforestation and reforestation accounts for USD 0.12–0.5 billion in 2030. Almost all forestry sector related investment and financial flows occur in developing countries.

Current Investment and Financial Flows

The majority of investments in forestry sector come from the private sector, mainly in plantation development and forestry concessions. Over 90 per cent of these are domestic. In non-Annex I Parties, most of the rest of investments come from ODA.

4.4.7.5. Assessment of the changes needed in investment, financial and policy arrangements to fill the gap under the mitigation scenario

309. How much funding is currently being diverted to avoided deforestation, forest management or forestation is not known as financial flows are hardly ever pertinent to single activity.

Forestation

310. Forestation projects in developing countries can earn credits under the CDM for the carbon sequestered. The project activity extension of the CDM to forestation projects is relatively recent and not many projects have been developed yet. Thus it is too early to know whether the CDM will be able to stimulate a significant amount of forestation activity.

311. The BioCarbon Fund, which buys emission reductions, now has total capital of USD 80 million, mostly for reforestation, but also some for avoided deforestation and carbon management of the soil. More than half of BioCarbon Fund's capital is from the private sector. Forestation projects in New South Wales

and the Australian Capital Territory (ACT) can earn credits for sale in the NSW–ACT GHG Abatement Scheme.

312. Annual investment of USD 0.1–0.5 billion in forestation projects in 2030 could be supported by the CDM.

Reduced deforestation

313. At COP 11, Papua New Guinea and Costa Rica, supported by several developing countries, tabled a proposal to include emissions from avoided deforestation in any kind of compensation scheme under the UNFCCC[28]. It leaves open whether that should happen under a separate forest protocol or as a part of an overall post-2012 protocol. Since then several proposals for supporting reduced deforestation have been submitted. The main features of the different proposals for voluntary approaches to reduced deforestation and degradation are presented in table 38 below.

Table 38. Proposal for policy approaches and positive incentives to reduce emissions from deforestation in developing countries

Country (or group of countries)	Brief description of proposal
Tuvalu[29]	Proposal for a policy approach called the Forest Retention Incentive Scheme (FRIS) based on projects implemented by local communities. There are three key elements under the FRIS: the establishment of a Community Forest Retention Trust Account that retains funds for the projects; the issuance of forest retention certificates (FRCs) as a result of emissions reductions from the projects; and the establishment of an International Forest Retention Fund under the UNFCCC for the redemption of the FRCs.
India[30]	Proposal based on the concept of Compensated Conservation as a policy approach to reducing deforestation. It is based on providing compensation to countries for maintaining and increasing their forests, and consequently their carbon stocks, as a result of effective forest conservation policies and measures. Such an approach would have to be supported by a verifiable monitoring system. For the operationalization of this approach, a new financial mechanism, linked to verifiable carbon stock increments and separate from the CDM, would have to be set up.
Congo Basin countries[31]	Establishment of a reducing emission from deforestation in developing countries (REDD) mechanism, which would provide positive incentives to support voluntary policy approaches to reducing emissions from deforestation and degradation. Establishment of a Stabilization Fund to support developing countries that have low rates of deforestation and want to maintain their existing forests. In addition, use of an Enabling Fund for developing national capacities to participate in the REDD mechanism and/or to stabilize forest stocks, as well as for pilot activities.
Brazil[32]	Provision of positive financial incentives for developing countries that voluntarily reduce their GHG emissions from deforestation. The arrangement would not generate future obligations or count towards emissions reduction commitments of Annex I Parties. Positive financial incentives would be given relative to a reference emission rate (calculated based on a pre-defined reference deforestation rate and an agreed carbon content). Parties included in Annex II to the Convention would voluntarily provide funds for this arrangement, taking into account their ODA commitments. The funds would then be divided among participating

[28] Report on the second workshop on reducing emissions from deforestation in developing countries, FCCC/SBSTA/2007/3.
[29] See also paper no. 3 in FCCC/SBSTA/2007/MISC.2/Add.1.
[30] See also paper no. 11 in FCCC/SBSTA/2007/MISC.2.
[31] See also paper no. 9 in FCCC/SBSTA/2007/MISC.2; and FCCC/SBSTA/2006/10, paragraph 36. The countries of the Congo Basin supporting this proposal include Cameroon, the Central African Republic, the Republic of the Congo, the Democratic Republic of the Congo, Equatorial Guinea and Gabon.

Country (or group of countries)	Brief description of proposal
	developing countries in the same ratio as the emission reductions they have achieved.
Group of Latin American countries[33]	Any mechanism to reduce emissions from deforestation should be based on a basket of incentives and any financial mechanism supporting this should include both non-market and market instruments. Call for "credit for early action" and suggested that any emission reductions generated by participating developing countries should be creditable post-2012. Setting up of an Avoided Deforestation Carbon Fund to cover specific activities that directly reduce emissions from deforestation and maintain forest cover in countries that have low rates of deforestation. Establishment of an Enabling Fund that would provide for capacity-building and pilot activities.
Coalition for Rainforest Nations[34]	Proposal based on a basket of instruments that include provision of sustainable financial resources (for which market instruments will be necessary); expanding existing efforts by building capacities and undertaking national pilot projects; and allowing credits for early action. Establishment of an REDD mechanism and two funds, the Enabling Fund and the Stabilization Fund. Under the REDD mechanism, credits generated must be fully fungible and measured against a national reference scenario.

Note: Information in the table below is based on the proposals presented by Parties at the two UNFCCC workshops on reducing emissions from deforestation in developing countries (30 August to 1 September 2006, Rome, Italy; and 7–9 March 2007, Cairns, Australia) as contained in the reports of these workshops (see documents FCCC/SBSTA/2006/10 and FCCC/SBSTA/2007/3). Additional information can be found in the latest submissions from Parties (see FCCC/SBSTA/2007/MISC.2 and Add.1). The order is the same as they appear in document FCCC/SBSTA/2007/3.

314. The World Bank has established the Global Forest Alliance, which focuses on forests and poverty reduction, forest management, and new financing mechanisms. Its targeted capital is about USD 100 million. It will build capacity and fund research rather then buy carbon.

315. The World Bank also has established the Forest Carbon Partnership Facility, as requested by the G8. The Bank envisions that this new facility. Although is designed to help reduce emissions from deforestation and degradation, may reach USD 250 million over five years, of which one forth to one third would be for capacity building, and the rest for carbon finance transactions. Most, but not all, of the funding is expected to come from ODA sources.

316. Sustainable Forestry Management and Credit Suisse have recently announced a new facility of USD 200 million for reforestation and avoided deforestation.

317. Together the Global Forest Alliance and Forest Carbon Partnership Facility may provide annual funding of about USD 100 million for reduced deforestation. While this is significant funding for a pilot phase, it is negligible relative to the projected annual need of USD 12 billion in 2030. Implementing reduced deforestation on such a scale will require access to a market so that it can be funded privately. The alternative is to have national governments implement policies to reduce deforestation.

Forest management

318. Forest management is estimated to need annual funding of USD 8 billion in 2030. At present, only the ITTO provides funding for forest management. Currently, funding for such projects averages about USD 10 million per year. Funding USD 8 billion per year would require another source of funds.

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[32] See also paper no. 4 in FCCC/SBSTA/2007/MISC.2; and FCCC/SBSTA/2006/10, paragraph 48.

[33] See also paper no. 7 in FCCC/SBSTA/2007/MISC.2. This submission was supported by Costa Rica, the Dominican Republic, Ecuador, Guatemala, Honduras, Mexico, Panama, Paraguay and Peru.

[34] See also paper no. 3 in FCCC/SBSTA/2007/MISC.2. This submission was supported by Bolivia, the Central African Republic, Costa Rica, the Democratic Republic of the Congo, the Dominican Republic, Fiji, Ghana, Guatemala, Honduras, Kenya, Madagascar, Nicaragua, Panama, Papua New Guinea, Samoa, Solomon Islands and Vanuatu.

4.5. Technology research and development

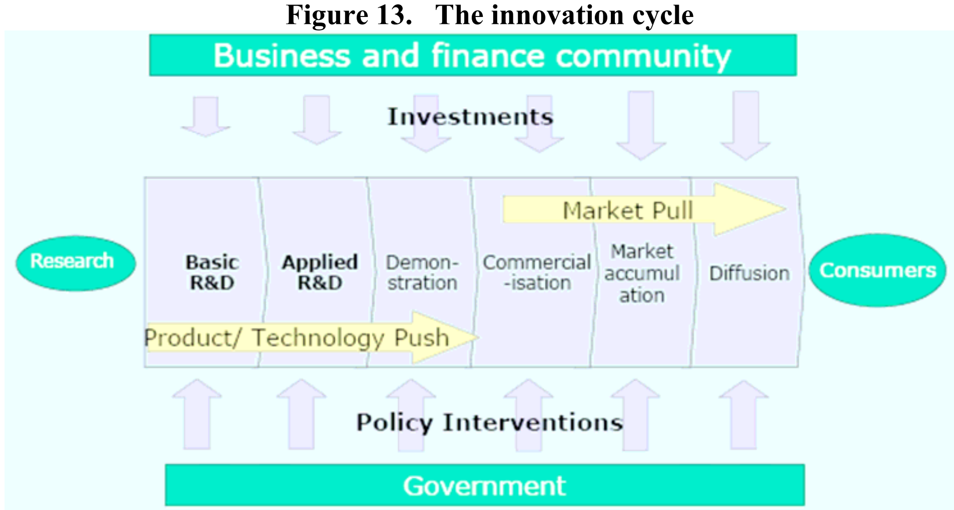
4.5.1. Introduction

319. GHG mitigation requires mechanisms that can help both push and pull low GHG emitting technologies onto the market. This chapter discusses research and development of those technologies.

320. No single technology – say nuclear power or solar power – can deliver the emission reductions needed to stabilize atmospheric concentrations of GHG. A range of technologies is already available, but most have higher costs than existing fossil fuel based options. Others are yet to be developed. The success of efforts to move these low GHG emitting technologies through the innovation cycle will be an important determinant of whether low emission paths can be achieved.

321. Innovation is typically a cumulative process that builds on existing progress, generating competitive advantages in the process. Grubb (2004) identifies the 'stages' of innovation as shown in figure 13. Although as with most models, this fails to capture many complexities of the innovation process, it is useful for characterizing stages of innovation. Transition between stages is not automatic (many products fail at each stage of development) and there are also linkages between them, as further progress in basic and applied R&D affects products already in the market, while subsequent learning also has an R&D impact.

Figure 13. The innovation cycle



Source: Grubb, 2004.

322. The graph refers to both push policies – where government supports innovation through grants and subsidies – as well as pull policies – where markets provide the incentives required to drive the innovation.

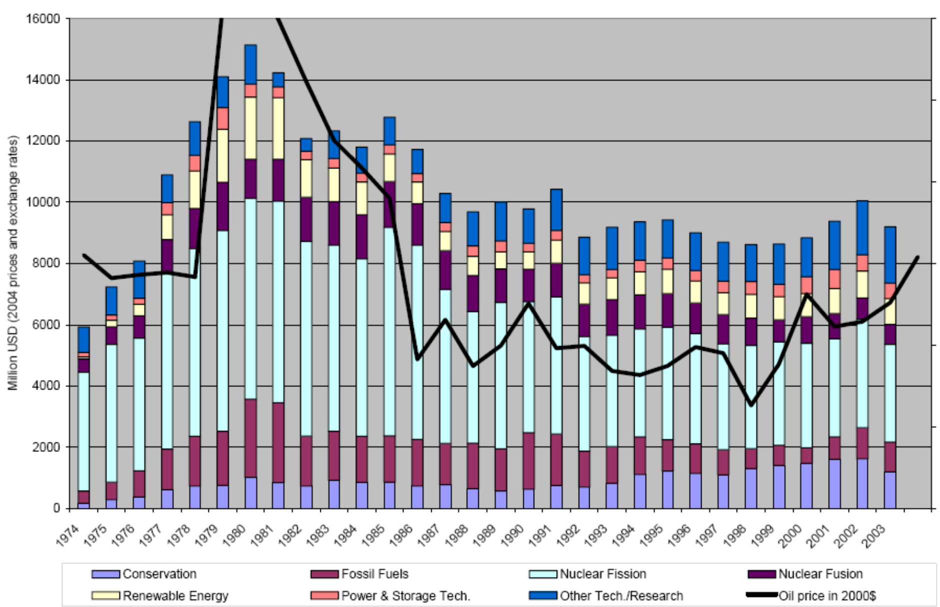
4.5.2. Current situation on technology research and development

323. Worldwide, nearly USD 600 billion was expended on R&D in all sectors in 2000. Nearly 85 per cent of that amount was spent in only seven countries[35] (IPCC, 2007c). Over the last 20 years, the government share of R&D funding has generally declined while the industry share has increased in these countries. Innovation varies dramatically across sectors. The information technology and pharmaceuticals sectors have high rates of innovation with private sector financing equal to 10–20 per cent sector revenue (Neuhoff, 2005). In the power sector private R&D has fallen sharply with privatization to around 0.4 per cent of revenue (Margolis and Kammen, 1999).

324. Between 1970 and 1998, R&D spending for agriculture rose from USD 3.3–4.9 billion. Since the mid 1980s, private sector research spending has exceeded and grown faster than the public component. By 2030 total investment in agricultural research is projected to reach USD 12 billion, with 60 per cent of this amount coming from the private sector. About 75 per cent of the USD 2.5 billion annual increase in research spending between 2005 and 2030 is expected to be funded by the private sector. No information is available on the difference in research spending needed between the reference and mitigation scenarios in agriculture sector.

325. The significant increase in energy prices after the 1970s oil crisis led to an expansion of R&D spending as shown in figure14. The subsequent collapse in prices in the 1980s led to a decline of R&D initiatives and support. Recent energy price increases have so far not translated into an expansion of R&D funding.

Figure 14. Government R&D expenditure in IEA countries and oil price from 1974 to 2004



Source: OECD, 2006.

326. Government spending on energy R&D worldwide has stagnated, while private sector spending has fallen. Total government expenditures of IEA member countries on energy R&D decreased from some USD 9.6 billion in 1992 to USD 8.6 billion in 1998, with a recovery to USD 9.5 billion in 2005. Over this period, two countries–Japan (34 per cent) and the United States (29 per cent)–accounted for more than

[35] Canada, France, Germany, Italy, Japan, the United Kingdom and the United States.

60 per cent of the total IEA government R&D spending. In the United States, federal funding for energy research has been falling steadily since 1980. Only Japan has maintained energy R&D spending relative to GDP. The historical trend in energy R&D spending contrasts with overall research spending in the OECD, which grew by nearly 50 per cent between 1988 and 2004 (Stern, 2006).

327. Spending on fossil fuels fell steadily during the second half of the 1990s, but rebounded at the start of the current decade (see figure 14). The share of nuclear fission and fusion in total spending has dropped since the early 1990s, but still accounts for about 40 per cent of the total. Spending on energy efficiency rose significantly in the 1990s and then fell back sharply after 2002. Research on renewables and power technologies – including hydrogen – has continued to grow steadily. Energy efficiency and renewables still receive only 12 per cent of government R&D spending on energy.

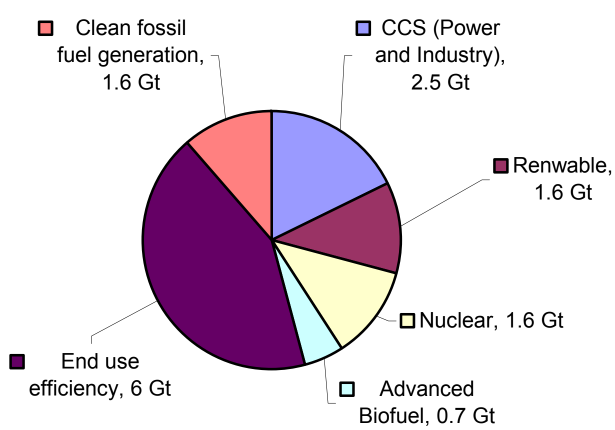
328. Insufficient resources have been allocated to energy R&D to meet medium- and long-term energy policy objectives, including global climate change mitigation. IEA consultative bodies have been suggesting that member governments should find a more balanced R&D budget mix that focuses on the longer-term policy objective of sustainable development.

329. Private R&D spending for energy is discouraged by energy subsidies, since they make commercialization of new technologies more difficult. In OECD countries, where most of the energy R&D occurs, fossil fuels are subsidized to the extent of USD 20–30 billion per year, double or triple the total government spending on energy R&D.

4.5.3. Estimated investment and financial flows needed

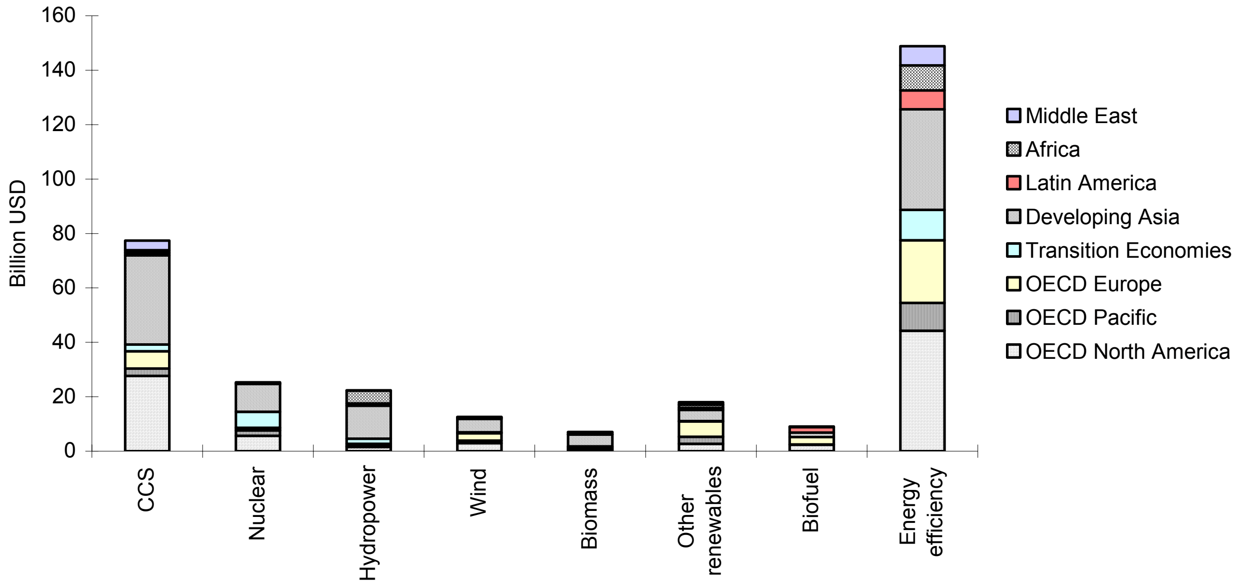
330. A portfolio of existing or well advanced low carbon technologies is assumed to be deployed under the mitigation scenario. Figure 15 shows the projected emission reductions under the mitigation scenario in 2030 by technology. The key technologies are end-use efficiency, CCS, renewables, nuclear energy, large hydropower and biofuels.

Figure 15. Emission reductions by technology under the mitigation scenario in 2030, in Gt CO_2 eq.



331. Figure 16 shows the annual investment by technology by region in 2030. For each of the technologies, a substantial share will be invested in developing countries. This suggests that developing country participation in R&D and deployment of these technologies could facilitate the projected investments.

Figure 16. Annual investment by technology by region in 2030



332. The IEA's Energy Technology Perspectives looks at the impact of policies to increase the rate of technological development. It assumes USD 720 billion of investment in deployment support occurs over the next two to three decades, an average of USD 24–36 billion per year. This estimate is on top of an assumed carbon price (whether through tax, trading or implicitly in regulation) of USD 25 per t CO_2. The TECH Plus scenario is closest to the mitigation scenario. It assumes faster rates of progress for renewable and nuclear electricity generation technologies, for advanced biofuels, and for hydrogen fuel cells, leading to global energy-related CO_2 emissions about 16 per cent below current levels in 2050.

333. The Stern review estimated existing deployment support for renewables, biofuels and nuclear energy at USD 33 billion each year. If the IEA figure is assumed to be additional to the existing effort, it suggests an increase of deployment incentives of between 73 and 109 per cent, depending on whether this increase is spread over two or three decades. The Stern Review also suggested that global public energy R&D funding should double, to around USD 20 billion.

Box 9. Summary of investment and financial flows for technology R&D

Investment and financial flows needed in 2030
Government energy R&D budgets should double to USD 20 billion per year and government support for deployment of renewables, biofuels and nuclear energy should double to USD 60 billion per year.

Current investment and financial flows
Government spending on energy R&D has stagnated, while private sector spending has fallen. Most of the government funding comes from Japan and the United States. Japan has maintained energy R&D spending relative to GDP while federal funding for energy research has fallen steadily falling since 1980 in the United States.

4.5.4. Assessment of the changes needed in investment, financial and policy arrangements to fill the gap under the mitigation scenario

334. An ambitious and sustained increase in the global energy R&D effort is required if the technologies reflected under the mitigation scenario are to be delivered within the time required. However, government funding for energy R&D has only recently recovered to the level of the early 1990s, while private funding has declined.

335. The available estimates suggest that government energy R&D budgets need to double from roughly USD 10–20 billion per year and that support for deployment of renewables, biofuels and nuclear energy needs to double from roughly USD 30–60 billion annually.

336. Private R&D spending for energy in OECD countries is discouraged by subsidies to fossil fuels, which are double or triple the total government spending on energy R&D, since they make commercialization of new technologies more difficult.

337. The scale of some low GHG emitting technologies is too large for countries to take along individually. International cooperation is essential in accelerating efficient and cost-effective progress towards a low carbon energy future. A number of international cooperation initiatives for R&D were undertaken and showing successful results in sharing information and development costs. Further enhanced international cooperation and collaboration would be key to promote technology R&D. This would need to also include participation of emerging and developing economies countries.

4.6. Conclusions

338. The global additional investment and financial flows of USD 200–210 billion will be necessary in 2030 to return global GHG emissions to current levels (26 Gt CO_2), see annex 5, table 6. In particular:

- **For energy supply,** investment and financial flows of about USD 67 billion would be reduced owing to investment in energy efficiency and biofuel of about USD 158 billion. About USD 148 billion out of USD 432 billion of projected annual investment in power sector would need to be shifted to renewables, CCS, nuclear energy and hydropower. Investment in fossil fuel supply is expected to continue to grow, but at a reduced rate;
- **For industry,** additional investment and financial flows are estimated at about USD 36 billion. More than half of the additional investment is for energy efficiency, one third for installation of CCS and the rest for reduction of non-CO_2 gases, such as N_2O and other high GWP GHGs;
- **For buildings,** additional investment and financial flows amount to about USD 51 billion. Currently commercial and residential energy efficiency investment comes from building owners and is financed domestically;
- **For transportation,** additional investment and financial flows amount to about USD 88 billion. Efficiency improvements for vehicles and increased use of biofuels are likely to require government policies, but the investment would come mostly from the private sector;
- **For waste,** additional investment and financial flows are estimated at about USD 1 billion. Capture and use of methane from landfills and wastewater treatment could reduce emissions by about 50 per cent in 2030 mainly in non-Annex I Parties;
- **For agriculture,** additional investment and financial flows are estimated at about USD 35 billion. Non-CO_2 emissions from agriculture production could be reduced by about 10 per cent at cost of USD 20 billion in 2030. With a concerted international effort and an annual investment of about USD 15 billion agroforestry could be expanded at a rate of about 19 million ha per year by 2030;

- **For forestry,** additional investment and financial flows are estimated at about USD 21 billion. An indicative estimate of the cost of reducing deforestation and forest degradation in non-Annex I Parties to zero in 2030 is USD 12 billion. The estimated investment and financial flows in 2030 to increased GHG removals by sinks through SFM is USD 8 billion and the estimated investment and financial flows needed for afforestation and reforestation is USD 0.1–0.5 billion;
- **For technology R&D and deployment,** additional investment and financial flows are estimated at about USD 35– 45 billion. Government spending on energy R&D worldwide has stagnated, while private sector spending has fallen. Government budgets for energy R&D and support for technology deployment need to double, increased expenditures in 2030 are expected at USD 10–30 billion respectively.

339. In many sectors the lifetime of capital stock can be thirty years or more. The fact that total investment in new physical assets is projected to triple between 2000 and 2030 provides a window of opportunity to direct the investment and financial flows into new facilities that are more climate friendly and resilient. The investment decisions taken today will affect the world's emission profile in the future.

340. Almost half of the additional global investment and financial flows need would occur in developing countries due to rapid economic and population growth. Mitigation actions are expected to be less expensive in non-Annex I Parties. Table 39 shows that 68 per cent of the projected global emission reductions occur in non-Annex I Parties while only 46 per cent of the additional investment and financial flows are needed in non-Annex I Parties. This reflects mitigation opportunities associated with the rapid economic growth projected for large developing countries, the relatively inefficient energy use, and the prevalence of low cost mitigation opportunities in the forestry sector. The data in table 39 should not be used to compare the cost per t CO_2 eq reduced by sector. The investment and financial flows for reducing electricity use in buildings and industry are reported in those sectors, while the emission reductions are counted in the power supply sector.

Table 39. Additional investment and financial flows and greenhouse gas emission reductions

	Global		Non-Annex I Parties			
	Emission Reduction Gt CO_2 eq	**Additional investment and financial flows in 2030 USD billion**	**Emission Reduction Gt CO_2 eq**	**Additional investment and financial flows in 2030 USD billion**	**Per cent of global emission reduction**	**Per cent of global additional investment and financial flows**
Power generation	9.4	148.5	5.0	73.4	53	49
Industry	3.8	35.6	2.3	19.1	60	54
Transport	2.1	87.9	0.9	35.5	42	40
Building	0.6	50.8	0.3	14.0	48	28
Waste	0.7	0.9	0.5	0.6	64	64
Agriculture	2.7	35.0	0.4	13.0	14	37
Forestry	12.5	20.7	12.4	20.6	100	99
Total	**31.7**	**379.5**	**21.7**	**176.2**	**68**	**46**

341. The estimated investment and financial flows for energy assume that the major reductions in emissions between the reference and mitigation scenarios rely on the increased energy efficiency and shifts in the energy supply from fossil fuels to renewables, nuclear energy and hydropower and large-scale deployment of CCS, although there are only a few CCS demonstration projects at the present time.

342. Currently most of the investment in mitigation measures is domestic; however, ODA plays an important role in Africa and the LDCs. With appropriate policies and/or incentives, a substantial part of the additional investment and financial flows needed could be covered by the currently available sources. However, there will be a need for new and additional external sources of funds dedicated to mitigation.

343. Renewable energy projects are financed largely by private investors at present. The scale of projected investment will require supportive government policies, financial incentives, such as feed-in tariffs and renewable energy credits, and secure markets for the power generated. It also will be necessary to ensure that the investment flows to the countries/regions that need it most. Africa probably faces the greatest challenge, needing to attract capacity investment of nearly USD 3 billion a year from a base of almost zero.

344. Currently most of the energy sector investment is made by government-owned or private, usually regulated utilities, and is made domestically in most regions.

345. More of the capital needed for energy projects in developing countries will have to come from private and foreign sources than in the past. Financing projects in developing countries, particularly in the poorer of them is a key challenge. The investment gaps are likely to remain in the poor developing countries deferring the time scale for widespread access to electricity.

346. Domestic savings — the single most important source of capital for investment in infrastructure projects — exceed by a large margin in total energy-financing requirements. But in some regions, energy-capital needs are very large relative to total savings (For e.g., in Africa and LDC). And energy investment has to compete for funds which might equally well be devoted to other social development sectors.

347. The entities that make the investment decisions are different in each sector, and the policy and/or financial incentives needed will vary accordingly. For example:

- Increased energy efficiency is best achieved through appropriate policies or regulations (the investments are internal and often incremental, and have short payback periods, but adoption is hampered by recognized barriers);
- Shifting investment in efficient motor vehicles need incentives to:
  - Introduce hybrid vehicles such as vehicle purchase subsidies, regulatory standards and higher taxes on the least efficient vehicles;
  - Expand the use of biofuels such as larger R&D programmes and minimum requirements for biofuels in conventional fuel blends;
- Shifting investment in the power sector to CCS and low GHG emitting generation technologies will need both policies and, financial incentives which make these technologies economically more attractive than high GHG emitting technologies. This requires large R&D programmes, incentives for large-scale demonstration plants, national or international policy frameworks, such as carbon markets, renewable portfolio standards or higher feed-in tariffs, loan guarantees to reduce the cost of capital, financial penalties on carbon emissions;
- Financial incentives will be needed to achieve significant reductions in emissions through agroforestry, agriculture waste, deforestation and forest management.

348. Policies are needed in Annex I and non-Annex I Parties. International coordination of policies by Parties in an appropriate forum will often be most effective. Areas where international coordination would be beneficial include:

- Technology R&D and deployment;
- Energy efficiency standards for internationally traded appliances, equipment.

349. Some mitigation measures, especially reduced deforestation and forest management, are likely to need significant external funding for large-scale implementation. Some countries may need assistance for the development and implementation of national policies.

350. As this paper provides only an overview of investment and financial flows based on existing data and models, it could be improved by further analytical work ensuring scenarios are more adequately developed for the purposes of estimating investment and financial flows. For example:

- **Energy efficiency** is the most promising means to reduce GHG emissions in short term. Specific analysis to promote investments for energy efficiency improvements, particularly the implication for improvements of the financial mechanism under the Convention and/or project based mechanisms under the Kyoto Protocol (CDM and JI) could be carried out at the regional and sectoral levels;
- There is need for better understanding of different national circumstances, specific analysis should focus on **different groups of countries** such as LDCs, rapid growth developing countries and economics in transition countries;
- The removal of energy subsidies and economically efficient pricing and taxation policies could play an important role in promoting renewable energy and energy efficiency and reducing GHG emissions. However, the role of energy subsidies and non-technical losses need further assessment in terms of their impact on GHG emissions and deterrence of investment in mitigation measures. Little data on this is currently available;
- More research is needed on the **role of different sources of funding** for specific sectors, current data cover investment flows for aggregated sectors. For example, investment data is reported for electricity, gas and water together, and it is often difficult to split the analyse for each of the sub sectors;
- The existing estimates of costs relating to mitigation options for **forestry** and for potential removals by sinks from agriculture are preliminary. There is also a lack of common understanding on assumptions to consider costs and a resulting high range of differences in estimate. More analytical and empirical work is needed;
- **CCS** is projected under the BAPS to play a key role to mitigate climate change in a medium or long term. There are, however, only a few CCS demonstration projects at the present time. Further analysis is needed on how investment from different sources such as private, public and multilateral development banks (MDBs) could collaborate to bring CCS into reality.

5. AN OVERVIEW OF INVESTMENT AND FINANCIAL FLOWS NEEDED FOR ADAPTATION

5.1. Introduction

351. Raising the standard of living of the poorest peoples in the world to meet the Millennium Development Goals will be challenging, particularly as populations in the developing world continue to increase. Climate change will make this task more challenging by increasing risks to human health, inundating low-lying areas, changing extreme weather events, altering water supplies, changing crop yields and ecosystems, and through many other impacts. The investment and financial flows needed for development in the midst of population growth and climate change will be substantial. It is important to be aware of how adaptation to climate change will affect the needs for investment and financial flows.

352. This analysis does not aim to provide a precise estimate of the total cost of adaptation, but assesses the order of magnitude of additional investment and financial flows that could be required in 2030 to adapt to the impacts of climate change. Although the intimate link between economic and population growth, human development and adaptation is acknowledged, this analysis focuses on the additional need for adaptation over and above the investment and financial flows required to address needs related to expected economic and population growth.

353. The investment and financial flows needed for adaptation to climate change have been estimated for five sectors identified by the Working Group II contribution to the Fourth Assessment Report of the IPCC:

- Agriculture, forestry and fisheries;
- Water supply;
- Human health ;
- Coastal zones;
- Infrastructure .

354. Adaptation of natural ecosystems (terrestrial and marine) was also analysed, however as there is very limited literature on adaptation in this sector, it was not possible to estimate the investment needs associated with adaptation to climate change. Instead, the need for investments to protect ecosystems from all current threats was analysed.

355. This report first presents the scenarios used to undertake the analysis and addresses limitations in estimating adaptation costs. For each sector included in this study, the report briefly reviews climate change impacts, the methods used for the analyses, current level of investment and financial flows in the sector, estimated future investment and financial flows needed in 2030 and a brief analysis of the adequacy of current investment and financial flows to meet the additional needs. Finally, an analysis of damages that can be avoided with mitigation measures is then presented.

5.2. Scenarios

356. The analysis of investment and financial flows needed for adaptation to climate change was based on emissions scenarios for which climate change impacts could be inferred and responses to the climate impacts could be projected, so that the associated investment and financial flows could be estimated. The scenarios were selected based on their suitability for the analysis, the detail they provide on estimated investment and financial flows, and how representative they are of the literature. The following scenarios have been used for different sectors:

- IPCC SRES A1B and B1 scenarios are used for the water supply and coastal zones sectors (Nakicenovic N. and Swart R. (eds). 2000);
- For the human health sector, the scenarios used were variation from the IPCC IS92a: a scenario resulting in stabilization at 750 ppmv CO_2 equivalent by 2210 (s750), and a scenario resulting in stabilization at 550 ppmv CO_2 equivalent by 2170 (s550) (Leggett et al., 1992). These scenarios were used in the context of a WHO study on the global and regional burden of disease (GBD) (McMichael AJ et al, 2004);
- Projected investment in physical assets for 2030 from the OECD ENV–Linkage model were used as the basis for estimating additional investment and financial flows needed in the AFF and infrastructure sectors.[36] The projected investment in physical assets for 2030 based on the OECD ENV–Linkage model corresponds to the projection of the IEA WEO reference scenario.

357. Higher GHG emission levels than projected under these scenarios are possible.

358. The impacts on needs for investment and financial flows for adaptation have not been modelled based on the reference and mitigation scenarios used for the mitigation analyses. Given the lack of data, this work could not be undertaken in the context of this study, so different scenarios had to be used for the adaptation analyses.

359. In 2030, the year for which needs for investment and financial flows are estimated in this study, the CO_2 concentrations and projected changes in temperature and thus the associated differences in the adverse impact of climate change between any scenarios can be expected to be quite small.[37] For some sectors, it was assumed that adaptation would only be to the realized impact of climate change in 2030 so there would be little difference across scenarios in investment and financial flows needed by then. However, in the water supply and coastal zones sectors, adaptation to climate change anticipates some change in climate for, respectively, another 20 and 50 years. In those sectors, it is assumed that those adapting have perfect information on changes in global and regional climate in 2050 and 2080. In those cases differences in greenhouse gas emissions across scenarios would be significant.

5.3. Limitations in estimating adaptation costs

360. There are many difficulties and limitations in estimating the costs of adapting under various scenarios as well as the ability of countries to self-finance adaptation. These include (1) differences in adaptive capacity; (2) the fact that most adaptations will not be solely for the purpose of adapting to climate change;

[36] OECD. ENV-Linkages Model calibrated to the IEA WEO 2006 Reference scenario. Personal communication with Philip Bagnoli at OECD.

[37] For example, in the SRES A1B and B1 scenarios by 2050, the CO_2 concentrations are almost 540 ppmv and 490 ppmv respectively. The global mean temperature increase differs only slightly between the two scenarios, about 1.6°C for the A1B scenario and 1.4° C for the B1 scenario. By 2100, the A1B scenario results in CO_2 concentrations of more than 700 ppmv, while the B1 scenario results in concentrations of about 550 ppmv. This yields a global mean temperature increase in 2100 of 2.8° C (with a range of 1.7 to 4.4° C) for the A1B scenario and 1.8° C (with a range of 1.1 to 2.9° C) for the B1 scenario (IPCC, 2007a).

(3) the uncertainties associated with any readily available methods to estimate adaptation costs and (4) the existence of an adaptation deficit.

5.3.1. Adaptive capacity

361. One of the key limitations in estimating the costs of adaptation is the uncertainty about adaptive capacity. Adaptive capacity is essentially the ability to adapt to stresses such as climate change. It does not predict what adaptations will happen, but gives an indication of the differing capacities of societies to adapt *on their own* to climate change or other stresses. Smit et al (2001) identified six determinants of adaptive capacity:

- Economic resources;
- Technology;
- Information and skills;
- Infrastructure;
- Institutions;
- Equity.

362. Unfortunately, all the scenarios used in this study leave many key aspects of adaptive capacity undefined. Although, in some cases, economic resources are specified and the level of technology is defined to some extent, the other four determinants of adaptive capacity are not defined. For example, institutions, which to some extent are a proxy for governance, a key factor in adaptive capacity, are not defined. It is not clear how this and other factors might differ across the scenarios.

363. A further limitation of the scenarios is that the socio-economic variables are defined at best, only at highly aggregated scales. Development paths are not projected for individual countries. Within any scenario, it is reasonable to expect that the development paths of individual countries will differ. Some may have economic or population rates of growth that are faster or slower than the regional averages. Thus, it is not possible to determine how adaptive capacity will change at the country level based on the selected scenario.

5.3.2. Adaptations are typically not solely climate change related

364. A second key limitation is that most adaptations to climate change will most likely not be made solely to adapt to climate change. Most activities that need to be undertaken to adapt to climate change will have benefits even if the climate does not change. For example, improvements in the management of ecosystems to reduce stresses on them or water conservation measures can typically be justified without considering climate change. Climate change provides an additional reason for making such changes because benefits of the adaptations are larger when climate change is considered. Indeed, the need for these adaptations may not depend on specific greenhouse gas concentration levels and thus climate change associated with scenarios. It may well be justified to introduce water use efficiency or reduce harm to coral reefs no matter what scenario is assumed.

365. However, some adaptations would happen solely on account of climate change considerations. Such adaptations are typically marginal adjustments to infrastructure or land use decisions. For example, flood protection infrastructure could be enlarged to account for additional risks from sea level rise or more intense precipitation (or both). Land use decisions such as defining flood plains, regulating and guiding land use or setbacks from the coast could be adjusted to account for future risks from climate change.

5.3.3. Methods for estimating adaptation costs

366. At least four methods for estimating global and regional adaptation costs could be used; these are briefly reviewed here. The latter three have been used in this study or in other studies. A discussion of the four methods and their limitations follows.

367. The first method is a complete bottom-up approach. It involves estimating the costs of specific adaptations across the world. Currently, partial information can be obtained from national adaptation programmes of action (NAPAs) and national communications. Where costs have been estimated, they can be used; where they are not estimated in the NAPAs or national communications, they can be derived. This approach has the advantage of building on adaptations identified by countries. Moreover, it is likely that different costing methods would be applied by different countries (or even within countries). The existing information on bottom-up adaptation needs is far from being comprehensive and complete. Therefore, it is impossible to assess needs entirely from the bottom within any reasonable time and resources constraints.

368. A second method is an extrapolation of the bottom-up method. Oxfam America (Raworth, 2007) extrapolates from estimated adaptation costs in NAPAs to the rest of the developing world using three factors: population, income and land. It estimates that adaptation costs will be more than USD 50 billion per year. This method has the advantage of using official estimates of adaptation costs as the basis for the extrapolation. However, as the report notes, only 13 NAPAs have been written. It is not known if these 13 NAPAs are representative of adaptation needs across the developing world or if the identification of adaptations is comprehensive. The NAPAs target only 49 LDC Parties to the UNFCCC and may not reflect needs in more developed countries. It is also important to note that the NAPAs focus on "urgent" needs, not all adaptation needs.

369. A third method, used for the AFF, natural ecosystems, and infrastructure sectoral analyses in this study, is to use current global expenditures in the sectors and apply a rule of thumb to estimate additional costs for meeting development needs and climate change adaptation. For example, the World Bank (2006) assumed that development costs will increase by USD 10 billion to USD 40 billion per year by assuming that climate-sensitive portions of the Bank's investment portfolio will need an additional 5 to 20 per cent in resources to adapt to climate change. This approach is akin to a sensitivity analysis and can help give an order of magnitude of adaptation costs. A key uncertainty is related to the need to use assumptions about additional costs. The assumptions could be based on experience or a wide and representative sample of studies of specific adaptations; or it could be an educated guess and may not reflect actual conditions or variance of adaptation needs. Because such assumptions may be applied to a large base (the current total level of investment), even small percentage changes can yield large differences in estimates of investment and financial needs.

370. The fourth approach is a top-down quantitative analysis and is used in the water resources, coastal resources, and human health analyses in this study. Models can be applied to estimate biophysical impacts and needs for adaptation such as infrastructure for water supply or coastal defences. Uniform cost rules (perhaps adjusted for different per capita income levels) can be applied to estimate costs. The advantage of the uniform approach is that differences across countries can reflect different conditions and needs. This approach can give a rough estimate of total costs, but typically will not capture site-specific differences. Actual investment and financial flows needed could vary quite substantially from the uniform rules. Furthermore, top-down approaches may not be comprehensive. For example, the model used to come up with estimates of needs for the water resources sector only includes water supply, not water quality, flood protection or the systems to distribute or treat the water. Models can be very expensive and time consuming. Finally, the use of different assumptions can result in quite different estimates of magnitudes. The water supply and coastal resources analysis consider the need for investment and financial flows associated with economic and population growth, while the health analysis does not consider these two factors.

5.3.4. The existence of an adaptation deficit

371. Before examining how development and climate change will affect needs for investment and financial flows, it is important to note that for all of the sectors examined herein, there is a substantial deficit in investment and financial flows. In many places property and activities are insufficiently adapted to current climate, including its variability and extremes. This has been labelled as the "adaptation deficit" (Burton, 2004).

372. Evidence for the existence and size of the adaptation deficit can be seen in the mounting losses from extreme weather events such as floods, droughts, tropical cyclones, and other storms. These losses have been mounting at a very rapid rate over the last 50 years. This increase is likely to be mostly due to the expansion of human populations, socio-economic activities, real property, and infrastructure of all kinds into zones of high risk. Moreover, much of this property is built at a substandard level and does not conform even to minimal building codes and standards. This widespread failure to build enough weather resistance into existing and expanding human settlements is the main reason for the existence of an adaptation deficit. Real property and socio-economic activities are just not as climate-proof as they could and arguably should be. The evidence suggests strongly that the adaptation deficit continues to increase because losses from extreme events continue to increase. In other words, societies are becoming less well adapted to current climate. Such a process of development has been called "maladaptation."

5.4. Analysis of investment and financial flows to address adaptation needs

5.4.1. Agriculture, forestry and fisheries

5.4.1.1. Introduction

Potential impacts of climate change on agriculture, forestry and fisheries

373. The effects of climate change on agriculture are different across regions and over time. Yields are projected to decline in low latitudes with any increase in temperature. In high latitudes, yields can increase with up to about 3° C of warming of local temperatures,[38] then start to decrease. For the first several degrees of increase in global mean temperature over 1990, global agricultural production could increase, driven by the increased yields in mid- and high latitudes. But, this will happen while yields in low-latitude areas decrease; thus, the potential for malnutrition in developing countries can rise. Malnutrition is projected to decline as a result of development, but the declines could be partially offset by climate change. Beyond several degrees of warming, global agricultural production is projected to decline (Easterling et al., 2007). That would involve widespread adverse economic impacts and greater levels of malnutrition.

374. There are many important caveats in these findings. Changes in extreme events could disrupt agricultural production with even just a few degrees of warming. Adaptative capacities will play a key role in determining vulnerability. The IPCC concluded that a 3° C regional warming would exceed the capacity of developing countries to adapt to climate change impacts on crop yields (Easterling et al., 2007). The potential for technological adaptations such as crop breeding to increase tolerance for heat and drought or taking better advantage of elevated atmospheric CO_2 concentrations has not been studied. Thus uncertainties about estimated impacts of climate change on agriculture mean that actual impacts could be more negative or more benign than projected. Whatever the climate change and its impacts, global agriculture will need to

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[38] Note that temperature increases in mid- and high-latitude land areas will be higher than increases in global mean temperature (IPCC, 2007a).

adapt by changing location and types of cropping systems. For example, increased agricultural output will require changes in locations of crops and expansion of agriculture into high-latitude areas. Such adaptations will require capital investment to be realized.

375. Meanwhile, Easterling et al. (2007) projected that global forestry would be affected modestly by climate, but that regional impacts could be more substantial. Generally, production of forests would shift from low-latitude to high-latitude areas. There could be significant changes in distribution and productivity of fisheries, with fish species in many locations becoming extinct, but fish productivity increasing for some species in some locations. Higher temperatures could adversely affect aquaculture, as could increased extreme weather, presence of new diseases and other factors (Easterling et al, 2007).

Adaptation

376. Many actors, varying from individual farmers, ranchers, herders, and fisherpeople to national governments, international research organizations and multinational corporations will be involved in adapting to climate change and in responding to the growing need for investment and financial flows in the agriculture, forestry, and fisheries sectors. Some of the fundamental forms of adaptation are as follows:

- **Change in mix of crop, forage, and tree species/varieties**. The mix of crop, forage grasses, or trees species employed, for example, growing crops, grasses, or trees can be changed toward varieties and species that are more heat, drought, or moisture tolerant. More generally, this involves replacing some proportion of the crop, forage, and tree species with alternative species better adapted to new climate regimes;
- **Change in mix of livestock and fish species/breeds.** This involves replacing some proportion of current species or breeds with alternative species or breeds that are more suitable for the altered climatic regime. For fisheries, this may mean harvesting species that have potentially migrated into the fishing grounds. In aquaculture and domestic animal raising this involves adopting livestock and fish species from areas that have had comparable climates;
- **Change in management of crops, forests, and fisheries**. Crops can be planted or harvested earlier to adjust to altered soil warm-up rates, soil moisture conditions, earlier maturity dates, and altered water availability regimes. Livestock and fish management changes can include altering aquaculture facility characteristics, changing stocking rates, altering degree of confinement, among many other possibilities. Adaptation in wild fish management may involve using species that migrate to fishing grounds or travelling farther to catch the same species being harvested now;
- **Moisture management/irrigation**. Climate change can increase crop water needs, decrease water availability, decrease soil moisture holding capacity, and increase flooding and water logging. Adaptation may involve using irrigation, which may require investing in irrigation facilities or equipment, changing drainage management regimes, altering tillage practices to conserve water, altering time of planting/harvesting to better match water availability, changing species to more drought tolerant plants/trees;
- **Pest and disease management**. Climate change is likely to exacerbate pest, disease and weed management problems. Adaptation could involve wider use of integrated pest and pathogen management or preventative veterinary care, development and use of varieties and species resistant to pests and diseases, maintaining or improving quarantine capabilities, outbreak monitoring programmes, prescribed burning, and adjusting harvesting schedules;
- **Management of natural areas**. Some AFF production such as livestock management relies on passively managed, natural ecosystems that may require more active management under climate change to introduce new, better adapted species or to deal with climate change enhanced pest, disease, or fire risks;

- **Fire management**. Forests, grasslands, and to some extent crop lands are vulnerable to climate change induced increases in fire risk. Such risks may stimulate adaptive actions like salvaging dead timber, landscape planning to minimize fire damage, and adjusting fire management systems;
- **Land use or enterprise choice change.** Climate change may make current land uses, such as cropping unsustainable, and it may be desirable to adapt by changing the land use from crops to pasture or trees, or from trees to grazing land. For fisheries, it may be desirable to abandon aquaculture or discontinue pursuing certain fish species in some regions. In some cases, loss of productivity in agriculture, forestry, or fisheries may lead to migration of people to areas such as cities or other countries that may offer better employment opportunities.

377. Governments, international organizations and NGOs have important roles to play in adaptation. The types of adaptation actions that can be pursued are as follows:

- **Research.** Public resources can be placed into research to provide adaptation strategies that could be adopted by the AFF producers, as discussed previously. These resources will be funding domestic government research organizations, international research organizations such as the Consultative Group for International Research, universities, or research oriented NGOs;
- **Extension and training**. Traditionally, substantial funding has gone into extension services and training to disseminate information to farmers, foresters, and fisherpeople on practices and technologies. Funding would need to go into rural training and extension programmes to disseminate adaptation options, by providing information and training on practices that could be adopted by AFF producers. Extension services may need to be enhanced to cope with the demands of development and climate change;
- **Transitional assistance**. Climate change may stimulate location changes and migration. There may be scope for identifying resources for creating job opportunities, supporting incomes, developing new infrastructure/institutions, relocating industry, providing temporary food aid, improving market functions and developing insurance;
- **Trade policy**. Governments may need to revise trade policies to adapt to new climate change conditions to allow imports and exports to mitigate lost AFF production or to sell or dispose of surpluses;
- **Infrastructure development**. Public investment may be needed to adapt to climate change conditions, including development of new transport and municipal infrastructure, development of new lands, protection or improvements of existing lands, construction of irrigation and water control structures, protection of coastal resources, and incubation of new industries, among other possibilities.

Method used to estimate need for investment and financial flows

378. Although extensive literature exists on the impacts of climate change on agriculture production, it tends to focus on the net effects on production, not on the costs of adaptation. Indeed, many of the studies related to AFF do not specify needed adaptation measures, not to mention costing them. In the face of these realities the approach used here relies on subjective statements about the current degree to which research expenditures are directed at climate related issues and a broad assumption about how capital formation might be affected.

379. The AFF sector estimated the additional investment and financial flows needed in the primary sector (e.g. the growing of crops, the farming of animals, logging and fish farms) and the secondary sector (e.g. food, wood product and pulp and paper manufacturing industries) to cope with expected economic and population growth and the impacts of climate change.

380. In order to assess investment and financial flows needed to cope with expected economic and population growth in 2030 based on the relevant literature, it is expected that the level of resources spent on research will continue to grow at about 2 per cent per year in both developed and developing countries. Total resources spent on extension are assumed to rise by 20 per cent in developing countries due to their current and emerging food issues and the current level of resources spent on extension in developed countries are assumed to be adequate and remain constant. The projected level of investment in physical assets needed in 2030 is based on the OECD ENV–Linkage model and corresponds to the projection of the IEA WEO reference scenario.

381. In order to meet climate change adaptation needs, the following was assumed:

- Based on a study of the implications of future agricultural research needs and subjective estimates of the amount research expenditures in the Consultative Group on International Agricultural Research (CGIAR) system related to climate, it is estimated that expenditures in research and extension to cope with expected economic growth in 2030 would need to increase by 10 per cent;
- It was assumed that there will be new capital needed to, for example, irrigate areas, adopt new practices, move fish timber processing facilities, etc. However, in 2030 the need for additional investment will be limited by the fact that most agricultural and fisheries capital tends to have a short life (10–20 years) and would be replaced and adapted as climate change proceeds. As a consequence, a low 2 per cent estimate was used to reflect the additional level of investment needed in new facilities for the development of new and larger land areas to cope with regionally diminished production plus expanded irrigation and other inputs, relocation of food, wood industry, and pulp and paper manufacturing facilities. Based on this, the additional investment in gross fixed capital formation between 2005 and 2030, as estimated by the OECD ENV–Linkage model, will need to increase by 2 per cent.[39]

5.4.1.2. Overview of current investment and financial flows by source of financing

382. Current expenditures on AFF are presented in table 40. Public expenditures on research are about two thirds of the total, but are more than 90 per cent of the expenditures in developing countries and less than half of the expenditures in developed countries.

[39] Actual investment needs could be somewhat lower (one can imagine costs being half as much) or substantially higher (one can also imagine costs being two to three times or more higher).

Table 40. Expenditures in agriculture, forestry and fisheries (millions of United States dollars)

Type of expenditures	Amount
Research in developing countries[a]	15 422
Research in high income countries[a]	25 111
Extension in developing countries[a]	3 083
Extension in high income countries[a]	4 161
Capital formation in developing countries[b]	190 102
Capital formation in high income countries[b]	354 017
Total developing countries	208 608
Total high income countries	383 288
Total	**591 896**

[a] Estimated for 2000
[b] Estimated for 2005

383. Annex 5, table 33 presents the total GFCF for the 3 AFF sub sectors (agriculture, forestry and fisheries) in 2005 and for 2030, as projected by the OECD ENV–Linkage model. About three fifths of the investment is for agriculture, one third is forestry, and the remaining 2 per cent is for fisheries. GFCF is projected to almost double in 25 years, but the shares devoted to the sub sectors are expected to remain about the same. Annex 5, table 35.1 and 35.3 presents the source of funding for the investments in GFCF in the AFF sector in 2000. Table 35.1 presents the source of financing for the investment related to AFF activities in the primary sector, growing of crops, farming of animals, logging and operation of fish hatcheries and fish farms, while table 35.3 presents the source of financing for the investment related AFF activities in the secondary sector, the food, wood product and pulp and paper manufacturing industries.[40] Domestic investment represents 97 per cent of the investment in the former sector and 84 per cent in the later, while ODA represents 1.2 per cent in the former and 0.1 per cent in the latter. In both cases, FDI is likely to play a more significant role than ODA, however FDI role is likely to be significantly greater in activities related to the manufacturing industries than in the primary sector.

384. The trend in ODA to AFF by region is displayed in annex 5, table 14. Total ODA to AFF reached USD 6.4 billion in 2005. Total ODA in AFF rose by 8 per cent from 2000 to 2005, but expenditures in extension increased by 38 per cent and expenditures in research increased by almost 80 per cent during the same period.

5.4.1.3. Estimated investment and financial flows needed

385. Table 41 presents estimates of additional investment and financial flows needed to address expected economic growth and population growth. Table 41 also presents the additional investment and financial flows needed to adapt to climate change.

386. Overall, a substantial increase in investment and financial flows will be needed to meet the growing demand due to expected economic and population growth in 2030. It is estimated that investment and financial flows into R&D, extension activities and physical assets will need to nearly double (an increase of about USD 575 billion) between 2005 and 2030. Adaptation to the adverse impacts of climate change is estimated to add about 2 per cent to this amount or about USD 14 billion in 2030. About 75 per cent of this latter amount will be required for investment in physical assets (capital formation related investment) and

[40] Annex 5, table 35.3 includes all manufacturing sectors. The source of financing for the food, wood product and pulp and paper manufacturing industries might thus differ to some extent.

25 per cent will be required in the form of financial flows for research and extension activities. Slightly more than half of this amount will be needed in developing countries.

Table 41. Investment and financial flows needed in 2030 for economic and population growth and for adaptation to the adverse impacts of climate change (millions of United States dollars)

Type of expenditures	Additional investment and financial flows needed due to economic and population growth	Additional investment and financial flows needed for adaptation to the adverse impacts of climate change
Research in developing countries	13 526	1 353
Research in high income countries	20 374	2 037
Extension in developing countries	617	62
Extension in high income countries	0	0
Capital formation in developing countries	291 093	5 822
Capital formation in high income countries	248 001	4 960
Total developing countries	305 236	7 237
Total high income countries	268 375	6 997
Total	**573 611**	**14 234**

5.4.1.4. Assessment of needed changes in investment, financial and policy arrangements to fill the gap in investment and financial flows

387. The additional investment and financial flows needed in 2030 to cope with the adverse impacts of climate change in the AFF sector is about USD 14 billion. Slightly more than half of this amount will be needed for developing countries alone. It is estimated that approximately USD 11 billion will be needed to purchase new capital; for example to irrigate areas, adopt new practices and to move processing facilities. The additional financial flows needed in the AFF sector for research and extension activities to facilitate adaptation would be about USD 3 billion.

388. Most of the additional investment in physical assets needed in the AFF sector is for assets that are currently financed by domestic private agents. ODA currently accounts for less than one per cent of the resources channelled to this sector in non-Annex I Parties and for about 3 per cent in LDC Parties. FDI is likely to play a more significant role than ODA, however its role is likely to be significantly greater in activities related to the manufacturing industries than in the primary sector. Consequently, it can be expected that the majority of the additional investment needed would come from private sources, such as domestic AFF producers and processing firms and multinational seed companies, chemical companies and companies in the manufacturing industries. It can be expected that additional public resources will be needed to provide the private sector with the necessary information and incentives for it to make the required additional investment in order to better adapt to climate change. The design of adequate and coherent national policies could play a key role and targeted support will be needed for this to happen. Substantial external public resources are already channelled into agricultural and forestry policies in developing countries, in particular in Africa and Latin America. A higher fraction of these resources might need to support the integration of adaptation in national policies; new resources might also be needed for this, depending on the region.

389. Public sources account for two thirds of the current funding for AFF research worldwide but for as much as 90 per cent of AFF research funding in developing countries. Thus, for the additional USD 3 billion needed in investment and financial flows in 2030 for research and extension in developing countries, most of the additional funding would need to come from public sources unless adequate incentives are provided to the

private sector. Assuming public spending continues to increase by slightly more than 2 per cent per year in developing countries, an additional USD 1.4 billion would need to come from new sources of external public financing in 2030 to cope with the adverse impacts of climate change.

Box 10. Agriculture, Forestry and Fisheries

Investment and financial flows needed in 2030:
To address climate change impacts in this sector, an additional USD 14 billion in investment and financial flows would be needed. About half of this amount is estimated to be needed in developing countries. It is estimated that approximately USD 11 billion will be needed to purchase new capital; for example to irrigate areas, adopt new practices and to move processing facilities. The additional USD 3 billion will be needed for research and extension activities to facilitate adaptation.

Current investment and financial flows:
Total current expenditure on AFF for capital formation, research and extension is estimated to be in the order of USD 591 billion. A large proportion of the investment in the AFF sector is made in privately own physical assets by AFF producers and processing firms and multinational seed companies, chemical companies and companies in the manufacturing industries. Public expenditures on research are about two-thirds of the total, but are more than 90 per cent of the expenditures in developing countries and less than half of the expenditures in developed countries. A relatively substantial level (2.9 USD billion in 2000) of external public resources are channeled into agricultural and forestry sector policies in developing countries as compared to other sectors, in particular in Africa and Latin America.

5.4.2. Water supply

5.4.2.1. Introduction

Potential impacts of climate change on water resources

390. The IPCC reports that water resources around the world will be highly sensitive to climate change. Higher temperatures, increased melting of glaciers, salinization from rising oceans, an increased speed of the hydrological cycle and changes in precipitation patterns will affect the supply, quality and demand for water resources around the world (Kundzewicz et al., 2007). One likely outcome from an increased hydrological cycle is precipitation falling in fewer but more intense events, thus increasing the likelihood of flooding in many regions and more days without precipitation, thus also increasing likelihood of drought (Tebaldi et al., 2006; IPCC, 2007a). One recently finding from the literature is the likelihood of certain regional patterns of precipitation. For example, most climate models project that the Mediterranean Basin, Southern Africa, many parts of northern Brazil and southwestern North America are likely to see a reduction in precipitation (Kundzewicz et al., 2007; Milly et al, 2005).

Adaptation

391. The IPCC also notes that there are many options for adaptation related to water resources and that many water bodies in municipalities (particularly, but not exclusively, in developed countries) are already beginning to take steps to prepare for climate change. Table 42, from Kundzewicz et al., (2007), summarizes some options for adaptation. The IPCC identified reservoir construction and decommissioning, increased waste water reuse and desalinization, more efficient waste water treatment, and application of water saving technologies as other options for adaptation.

Table 42. Adaptation measures in the water resource sector

Supply side	Demand side
Prospecting and extraction of groundwater	Improvement of water-use efficiency by recycling water
Increasing storage capacity by building reservoirs and dams	Reduction in water demand for irrigation by changing the cropping calendar, crop mix, irrigation method, and area planted
Desalination of sea water	Reduction in water demand for irrigation by importing agricultural products, i.e., virtual water
Expansion of rain water storage	Promotion of indigenous practices for sustainable water use
Removal of invasive non-native vegetation from riparian areas	Expanded use of water markets to reallocate water to highly valued uses
Water transfer	Expanded use of economic incentives, including metering and pricing to encourage water conservation

Source: Kundzewicz et al., 2007.

Method used to estimate need for investment and financial flows

392. Given the need to use readily available data for this analysis, estimates presented are only for changes in water supply and demand. The investment resources needed for water quality and flood control are not estimated. The supply costs also do not include estimates of needs for distribution systems. Consequently, the estimates in this study might be underestimating the cost of adaptation in the water resources sector.

393. Modelling was used to estimate changes in demand by each country for water supply for two scenarios: the SRES A1B and B1 scenarios. The estimates consider the needs of increasing populations and growing economies. Change in 2030 assumed planning for the next 20 years and perfect knowledge about climate change impacts in 2050. Estimates of demand for water supplies and estimates of change in supply (as affected by climate change) used by Kirshen (2007) were used. Uniform assumptions were used about how much water in basins could be used to meet offstream uses such as domestic consumption and irrigation. Some use of desalinated water in coastal cities and some use of reclaimed water for irrigation in countries facing particular water shortages were assumed. The cost of unmet irrigation demands have not been considered in the analysis.

394. Applying uniform rules of thumb is a practical method for generating estimates of financial costs. However, it implies that country by country variance in costs and approaches cannot be considered. In the context of this study, uniform assumptions were applied for costs for extracting groundwater, building additional surface water storage capacity, installing desalinization plants, and reclaiming water. However, the cost estimates considered differences in costs in developed and developing countries. Results for regions, and particularly countries, should be treated as preliminary.

395. The cost estimates for 2030 are the total costs associated with the construction of additional infrastructure (reservoirs, wells, desalination, re-use facilities) needed to meet the projected demand for water supplies because of projected population and economic growth and expected climate change under the two scenarios.

5.4.2.2. Overview of current investment and financial flows by source of financing

396. Briscoe (1999) estimates current annual expenditures for water-related infrastructure in developing countries to be USD 15 billion for hydropower, USD 25 billion for water supply and sanitation, and USD 25 billion for irrigation and drainage, for a total of USD 65 billion. GFCF for water is estimated at USD 38.4 billion in 2005. Winpenny (2003) and Briscoe (1999) both state that the majority of present financing for all aspects of water resources use comes from public sources, with Briscoe presenting estimates that 90 per cent is from mainly public sources and 10 per cent is from external sources. Annex 5, table 15

gives levels of ODA to water infrastructures in 2000 and 2005. In 2000, total ODA in the water sector infrastructure (USD 4.2 billion) accounted for about 6 per cent of the total annual expenditures estimated by Briscoe (1999).

397. As shown in annex 5, table 15, from 2000 to 2005, real ODA directed towards water infrastructure increased by approximately 40 per cent (from USD 4.2 billion in 2000 to USD 5.9 billion in 2005). The regional distribution changed markedly, with Latin America and the Caribbean receiving in 2005 only 32 per cent of the amount it received in 2000. Contributions to Asia, Africa and the Middle East increased significantly from 2000 to 2005.

5.4.2.3. Estimated investment and financial flows needed

398. Much has been written about the challenges of financing Target 10 of the MDGs for halving "by 2015 the number of people without sustainable access to safe drinking water and basic sanitation" (eg, Toubkiss, 2006, Winpenny, 2003). Eleven different estimates ranged from USD 9 billion to USD 100 billion per year. A commonly accepted estimate is that meeting the most basic domestic water and sanitation goals would require an annual expenditure of USD 10 billion through 2015 (Winpenny, 2003). It appears that none of the reports included climate change impacts on water supply or demand. This is reasonable, as domestic water demands are only a small portion of global water demands. The estimates presented below do not include the costs of meeting Target 10 of the MDGs, rather they complement it.

399. The estimated investment needs for the SRES A1B and B1 scenarios by region are summarized in table 43. The estimates of investment and financial flows needed represents the total flows needed for the construction of additional infrastructure required to meet the projected demand for water supply caused by population and economic growth and expected climate change by 2030.

400. The investment cost for meeting the A1B scenario, assuming climate change to 2050 is anticipated, is estimated to be USD 797 billion; the cost of meeting the B1 scenario is estimated to be USD 639 billion, some 20 per cent less. This 20 per cent reduction is mainly due to differences in socio-economic conditions between the two scenarios; there is significantly more economic growth in the A1B scenario.

Table 43. Investment and financial flows needed in 2030 for economic and population growth and for adaptation to the adverse impacts of climate change for the SRES A1B and B1 scenarios (billions of United States dollars)

Region	SRES A1B	SRES B1
Africa	233	223
Developing Asia	303	230
Latin America	23	23
Middle East	151	148
OECD Europe	87	25
OECD North America	41	16
OECD Pacific	3	1
Transition economies	57	54
World total	**898**	**720**
NAI Parties	720	628
Least Developed Countries	57	45

401. The fraction of the change in investment needs attributable to climate change alone is estimated to be 25 per cent under both the SRES A1B and B1 scenarios. Thus climate change is estimated to increase total investment needs by 2030 by USD 225 billion under the A1B scenario and USD 180 billion under the B1 scenario.

402. Assuming that funding is provided through grants for a 20-year period, the additional investment and financial flows needed for adaptation would be about USD 9–11 billion in 2030. About 85 per cent of the investment (USD 8–9 billion) is estimated to be needed in non-Annex I Parties. Interestingly this is of the same order of magnitude as the additional investment and financial flows needed to meet the MDG related to sustainable access to safe drinking water and basic sanitation.

5.4.2.4. Assessment of needed changes in financial and policy arrangements to fill the gap in investment and financial flows

403. For adaptation alone, the additional investment and financial flows needed would be about USD 9–11 billion in 2030. Winpenny (2003) describes three categories of obstacles to increasing the financing for water-related infrastructure and then presents many recommendations to overcome them. The major classes of obstacles include governance; particular funding risks of the water sector such as its low rate of return, capital intensity with long payback period; and the large number of projects that cannot obtain financing from any source because of project size or the credit risk of the borrower (called the "exposed segment"). Briscoe (1999) estimates that 90 per cent of funding for all aspects of water resources use is from domestic sources and 10 per cent is from external sources. Both sources might be inadequate to meet future challenges associated with climate change. If the increase in investment needs solely related to climate change in non-annex I Parties (USD 8–9 billion) is to come entirely from ODA, which is currently USD 5.9 billion per year, then ODA would need to rise by about 50 per cent to meet the additional requirements. Despite the important recent increases in ODA allocated to the water and sanitation sector, it is unlikely that this is indicative of the expected change from the present to 2030. New domestic and external public resources will be needed.

Box 11. Water supply

Investment and financial flows needed in 2030:
The total cost associated with the construction of additional infrastructure needed to meet the projected demand for water supply is estimated to increase investment needs in 2030 by USD 11 billion. About 85 per cent of the investment is estimated to be needed in non-Annex I Parties.

Current investment and financial flows:
In 1999, expenditures for water-related infrastructure in developing countries were estimated at USD 65 billion. Total investment in physical assets only in this sector was estimated at USD 38.4 billion in 2005. Most of this investment is undertaken by governments. About 90 per cent of the cost for all aspects of water resource use is currently covered by domestic funding sources and 10 per cent by external funding sources. ODA for water infrastructure increased by approximately 40 per cent from 2000 to 2005 which currently

5.4.3. Human health

5.4.3.1. Introduction

Potential impacts of climate change on human health

404. Climate change is likely to have widespread, diverse, and on the whole negative impacts on human health across the world. The impacts include changes in the location and incidence of infectious and diarrhoeal diseases, increases in air and water pollution in many locations, increase in risk of heat stress, increases in intensity and frequency of many extreme events, and increased risks of malnutrition and other

consequences of poor food quality. In addition, disruption of natural ecosystems could enable the further spread of infectious diseases, and climate change induced human migration can be injurious to mental and physical health. On the positive side, there could be reductions in some cold-related health outcomes. On the whole, the Human Health chapter of the IPCC AR4 concluded that climate change has begun to negatively affect human health, and that projected climate change will increase the risks of climate-sensitive health outcomes (Confalonieri et al., 2007).

Adaptation

405. The fundamental adaptation requirement for the health sector in relation to climate change is to improve the capacity of the public health system. There is tremendous disparity in health risks between the developing and developed world. The main reason is that, on average, the public health systems in the developed world function at much higher levels than do the systems in the developing world. Improving the delivery of health care in the developing world would go a long way toward helping developing countries develop and could substantially reduce vulnerability to climate change. Without substantial improvement in the public health systems, human health in developing countries will be highly vulnerable to climate change. However, even with significant improvements in health care, climate change is projected to increase the burden of climate-sensitive health determinants and outcomes.

406. Beyond this, there are many specific measures that can be taken to reduce vulnerability to climate change. These include, for example, improved monitoring systems to detect the arrival or presence of infectious diseases and heat-watch warning systems to warn urban populations about heat waves.

Method used to estimate need for investment and financial flows

407. The Global Burden of Disease (GBD) study conducted by the WHO (McMichael et al., 2004) was used to estimate the total increase in health cases in 2030. The GBD study is the most comprehensive study of the total impacts of climate change on global human health that has been conducted to date. The study used internally consistent estimates of incidence, health state prevalence, severity and duration, and mortality for more than 130 major health outcomes, and estimated change in disability adjusted life years (DALYs) lost compared with the base period 1961 to 1990. Twenty-six risk factors were assessed, including major environmental, occupational, behavioural and lifestyle risk factors. The analysis for this adaptation study focuses on three human health outcomes: diarrhoeal disease, malnutrition and malaria. Models were used to estimate risks for each outcome. The model output is reported as a mid-range estimate. As with the study of water investment needs, the advantage of this approach is that a consistent and comprehensive framework is applied across the globe.

408. The limitations of this approach are similar to the limitations of the water assessment. What is essentially top-down modelling typically does not account for many varying local and regional factors that affect results at these scales. But, such top-down approaches are useful for providing a consistent and approximate estimate of impacts.

409. The GBD study uses two scenarios. The first scenario is the 750 ppmv stabilization scenario from the GBD analysis; this results in CO_2 concentrations in the atmosphere slightly higher than the SRES A1B scenario. The second scenario is the 550 ppmv stabilization scenario from the GBD analysis. This CO_2 concentration is similar to that from the SRES B1 scenario. The GBD relied on climate change estimates from one general circulation model, the HADCM2 model (Johns et al., 2001).

410. A further limitation is the estimated costs for treating health outcomes. The cost estimates are low because they consider only the cost of treating one case of each health outcome, thus assuming that there is sufficient public health infrastructure to administer the treatment. The estimates do not include the costs of setting up new infrastructure (such as the ability to distribute bed nets) when a health outcome increases its

geographic range. In addition, some estimated costs are low. For example, the average cost of intervention per child to combat malnutrition is estimated to be about USD 20, whereas more recently published studies estimated costs of one order of magnitude higher.

411. Other human health impacts such as increased heat stress, exposure to air and water pollution, exposure to many other diseases such as dengue fever, and exposure to increased intensity of many extreme weather events are not examined. So the total estimated number of cases caused and the costs associated with climate change are not complete.

412. Based on Rosenzweig and Parry (1994), malnutrition is projected to increase despite its vintage, it is perhaps the most comprehensive study of climate change impacts on agriculture done to date. The study assumed global population growing to USD 10.8 billion by the middle of the century, whereas the SRES A1B and B1 scenarios assumed global population peaks at about 8 billion. The agriculture estimates do not account for the effect of potential increases in extreme weather on agricultural production or distribution of food. Further, the estimates are of crop yields, not food security. Micronutrient deficiencies are a major source of ill health, even in regions with sufficient crop yields. On the other hand, the study did not account for adaptations such as the development of more heat and drought-tolerant crops or crops that can take better advantage of higher atmospheric CO_2 levels. Finally, for malnutrition, stunting and wasting were analysed, but not all the health impacts. Stunting and wasting are a small percentage of the impacts of climate change, so this can represent a significant underestimate.

5.4.3.2. <u>Overview of current investment and financial flows by source of financing</u>

413. Health expenditures are from both the public and private sectors. In many countries, government spending is the majority of total expenditures on health, whereas in many countries, government spending is less than half of total expenditures. External expenditures on health are typically a small share of total expenditures. However, for very poor countries, external expenditures are a large share of total expenditures and even up to 30 to 50 per cent in a few cases. Table 44 below provides regional details on the above.

Table 44. Selected indicators of health expenditure ratios for the year 2000

Region	Total expenditure on health (millions of United States dollars)	Government expenditure on health as a percentage of total expenditure on health (percentage)	Private expenditure on health as a percentage of total expenditure on health (percentage)	External resources for health as of total expenditure on health (percentage)	Out-of-pocket expenditure as percentage of private expenditure on health (percentage)
Africa	34 813	43	57	5	63
Developing Asia	122 935	36	64	1	93
Latin America	119 458	50	50	1	66
Middle East	37 252	63	37	2	79
OECD Europe	862 604	75	25	0	63
OECD North America	1 572 296	45	55	0	29
OECD Pacific	477 591	78	22	0	86
Other Europe	257	70	30	0	82
Transition Economies	33 526	60	40	1	79
WORLD Total	**3 260 733**	**58**	**42**	**0**	**45**
NAI Parties	355 384	46	54	2	81
Least developed countries	8 330	37	63	17	85

Source: WHO 2006

414. Annex 5, table 16 gives details on ODA by region for the health sector in 2000 and 2005. Total real ODA rose by two thirds from 2000 to 2005, with bilateral aid doubling. Total ODA for health reached USD 5.5 billion in 2005. Africa received the largest share of aid in both years, with South Asia second. Hecht and Shah (2003) estimated development assistance for health for the Disease Control Priorities in Developing Countries project (table 45). Although aid in the health sector is still dominated by multilateral and bilateral sources, NGOs such as the Bill and Melinda Gates Foundation are becoming a relatively more important source of funding and research.

Table 45. Development assistance for health, selected years (millions of United States dollars)

Source	**Annual average 1997 to 1999**	**2002**
Bilateral agencies	2 560	2 875
Multilateral agencies	3 402	4 649
European Commission	304	244
Global Fund to fight AIDS, Tuberculosis, and Malaria	0	962
Bill and Melinda Gates Foundation	458	600
Total	6 724	9 330

Source: Michaud (2003) and OECD (2004)

5.4.3.3. <u>Estimated investment and financial flows needed</u>

415. The increased health risks for the middle scenario from the 750 ppmv and 550 ppmv stabilization scenarios relative to 1990 are presented in table 46. Regions are based on WHO classification. The groupings are not based on income level but rather on child and adult mortality rate (see annex 3 for details on WHO regional groupings).

Table 46. Projected excess incident cases (in thousands) in 2030 of diarrhoeal diseases, malnutrition, and malaria for the 750 ppmv and 550 ppmv stabilization scenarios (middle estimates)

Region	Diarrhoeal diseases		Malnutrition		Malaria	
	750 ppmv scenario	550 ppmv scenario	750 ppmv scenario	550 ppmv scenario	750 ppmv scenario	550 ppmv scenario
Africa	50 343	41 952	437	328	17 703	14 170
Americas-A	0	0	0	0	0	0
Americas-B	1 465	1 465	200	86	323	258
Eastern Mediterranean	5 779	5 779	533	335	3 211	2 535
Europe	785	785	0	0	0	0
Southeast Asia-A	0	0	225	113	0	0
Southeast Asia –B	73 608	63 092	3 067	2165	70	0
Western Pacific-A	0	0	0	0	2	1.5
Western Pacific-B	0	0	211	70	478	404
Total	**131 980**	**113 073**	**4 673**	**3 097**	**21 78**	**17 369**

416. Based on model output, under the 750 ppmv stabilization scenario, there would be about 132 million additional cases of diarrhoeal disease, 5 million additional cases of malnutrition, and 22 million additional cases of malaria for these three health outcomes alone. Although virtually all of the malnutrition and malaria cases would be in developing countries, 1–5 per cent of the diarrhoeal disease cases would be in developed countries.

417. The number of additional cases in the 550ppmv stabilization scenario is lower than in the 750ppmv stabilization scenario. For example, additional cases of diarrhoeal disease would drop from 132 million per year to 113 million. Incidences of malnutrition would drop from 4.7 million additional cases to 3.1 million additional cases per year.

418. The estimated total global financial flows needed to cover the cost of the additional number of cases of diseases are reported in table 47.

419. The annual financial flows needed under the two scenarios to cover the cost of these three health outcomes arising from the adverse impacts of climate change would be USD 4–5 billion. Although the additional financial flows needed could not be allocated to different region in a meaningful way, it is assumed to be all in developing countries.

Table 47. Estimated additional financial flows needed in 2030 to cover the cost of additional cases of diarrhoeal diseases, malnutrition, and malaria due the adverse impacts of climate change (millions of United States dollars)

	Diarrhoeal diseases		Malnutrition		Malaria		Total	
	750 ppmv scenario	**550 ppmv scenario**	**750 ppmv scenario**	**550 ppmv scenario**	**750 ppmv scenario**	**550 ppmv scenario**	**750 ppmv scenario**	**550 ppmv scenario**
financial flows needed	2235	1923	92-122	61-81	2173-3033	1773-2418	4500-5390	3757-4422

420. The 550 ppmv stabilization scenario results in fewer cases and lower financial flows needed than the 750 ppmv stabilization scenario. The needs are about USD 1 billion lower, from USD 5 billion down to USD 4 billion.

421. Although an estimate of the increased financial flows needed resulting from the socio-economic changes has not being developed for this study, an estimate of current financial needs can be derived by comparing the increase in health cases from climate change with the current number of cases. This can give an indication of the magnitude of financial flows that may be needed. Table 48 presents the current number of cases of the three health outcomes, the projected number of cases under the two scenarios used, and the percentage increase.

Table 48. Comparison of current diarrhoeal disease, malnutrition, and malaria cases with estimated climate change impacts in 2030 for the 750 ppmv and 550 ppmv stabilization scenarios (thousands of cases)

Scenario		**Diarrhoeal diseases**	**Malnutrition**	**Malaria**
Current		4 513 981	46 352	408 227
750 ppmv scenario	Climate change impacts	131 980	4 673	21 787
	Percentage increase	3	10	5
550ppmv scenario	Climate change impacts	131 073	3 097	17 369
	Percentage increase	2.5	7	4

422. Assuming the cost per case remains unchanged, under the reference scenario, the total financial flow would need to increase by 3 per cent to treat diarrheal disease, by 10 per cent to treat malnutrition, and by 5 per cent to treat malaria.

423. Although this study did not estimate the costs of improving health to meet the development needs associated with the 750ppmv and 550ppmv stabilization scenarios, Stenberg et al. (2007) estimated the costs to scale up essential child health interventions to reduce child mortality by two thirds under the four MDGs aimed at children's health by 2015 in 75 countries; the countries chosen accounted for 94 per cent of death among children less than five years of age. The interventions focused on malnutrition, pneumonia, diarrhoea, malaria and key causes of death of newborns. Costs included programme-specific investment and financial flows needed at national and district levels. The authors estimated that an additional USD 52.4 billion would be required for the period 2006–2015. This averages about USD 5 billion per year. It is interesting to note that this is of the same order of magnitude as the estimated additional level of resources needed to treat additional cases of diarrhoea, malnutrition and malaria due to climate change in 2030. Projected costs in

2015 were equivalent to increasing the average total health expenditures from all financial resources in the 75 countries by 8 per cent and raising general government health expenditure by 26 per cent over 2002.

5.4.3.4. Assessment of needed changes in financial and policy arrangements to fill the gap in investment and financial flows

424. The estimated additional financial flows needed for the health sector to treat the additional number of cases of diarrhoea, malnutrition and malaria due to climate change in developing countries are about USD 4–5 billion, the same order of magnitude as current ODA. Based on current financing trends of health care, this amount is likely to be paid for mainly by the families of those affected, with some domestic public funds paying for the operation of health care facilities. Whether the resources available will be adequate to meet the additional needs will vary a lot from one country to another, depending on the burden the additional needs represent compared with the availability of public and private resources. In countries where private individuals cannot cope with the additional cost of treatment, new and additional public financing will be necessary. Not being able to treat these diseases will increase morbidity and mortality. Countries that are already currently highly reliant on external sources for health care, such as LDCs, may need new and additional external support to cope with climate change.

Box 12. Human health

Investment and financial flows needed in 2030:
The financial flows needed in 2030 to cover the cost of treating the additional number of cases of diarrhoeal disease, malnutrition and malaria due to climate change is estimated to be USD 4–5 billion. By assumption, all of this amount will be needed in developing countries.

Current investment and financial flows:
Total expenditure on health were in the order of USD 3.3 trillion in 2000. Government expenditure on health as a percentage of total expenditure on health varies from 36 per cent in developing Asia to 75 per cent in Europe. In several countries still, the cost of treating a particular health condition is paid for mainly by the families of those affected, with some domestic public funds covering the costs of operating health care facilities. Least developed countries are particularly highly reliant on external funding sources for health care. Aid in the health sector is still dominated by multilateral and bilateral sources (total real ODA rose by two thirds from 2000 to 2005 and reached USD 5.5 billion in 2005), NGOs are becoming a relatively more important source of funding and research.

5.4.4. Natural ecosystems (terrestrial and marine)

5.4.4.1. Introduction

Potential impacts of climate change on natural ecosystems

425. Climate change has already been linked to impacts on species across the world (e.g., Parmesan and Yohe, 2003; Root et al., 2005; Cassassa et al., 2007). Migration patterns, productivity, location, and other changes are being observed. In one dramatic example, the Fish and Wildlife Service of the United States of America proposed listing polar bears as a threatened species because of declining Arctic ice cover (United States Fish and Wildlife Service, 2007).

426. The future impacts of climate change on ecosystems are likely to be profound and dramatic. The IPCC notes that the resilience of many ecosystems is likely to be exceeded by the combination of climate change and other socio-economic influences (in particular land-use change and overexploitation). A 1.5–2.5° C warming over 1990 could bring approximately 20 per cent to 30 per cent of plant and animal species to extinction (Thomas et al. 2004). A 3° C warming would transform about one fifth of the world's ecosystems

(Fischlin et al., 2007). There will also likely be substantial impacts on marine ecosystems with a 3° C warming.

Adaptation

427. The term "adaptation" needs be applied in a relative sense to natural ecosystems. In the so-called managed sectors such as coastal and water resources, agriculture and health, adaptation has the potential to substantially maintain most of the services currently provided in these sectors, particularly in the developed countries. It is not clear, however, that human intervention can substantially offset the impacts of climate change and other socio-economic drivers on natural ecosystems. At best, based on what we know now, adaptation could reduce some of the harmful impacts of climate change.

428. The IPCC concluded that human intervention to assist ecosystem adaptation should consist of actions to reduce the impacts of other threats to ecosystems, such as habitat degradation, pollution and introduction of alien species. For example, diminished or lost ecosystems could be enhanced or replaced (e.g., ecosystem re-creation, manual speed dispersal, pollinator reintroduction and use of pesticides for pest outbreaks). In addition, captive breeding and reintroduction and translocation or provenance trials in forestry could be used. Adaptation for natural ecosystems can be put into the following categories:

- Reduce and manage stresses from other sources and activities, such as pollution; overharvesting, habitat conversion, and species invasions;
- Restore habitats;
- Increase size and/or number of reserves;
- Increase habitat heterogeneity within reserves, for example, by including gradients of latitude, altitude, and soil moisture and by including different successional states;
- Maintain ecosystem structure and function as a means to ensure healthy and genetically diverse populations able to adapt to climate change;
- Increase landscape connectivity using corridors/stepping stones to link areas of habitat or reserves;
- Increase landscape permeability through reduction of unfavourable management practices and increasing area for biodiversity;
- Translocate/reintroduce species, especially those having essential functions such as pollination;
- Conserve threatened and endangered species ex situ, for example, using seed banks or collecting germplasm and zoos, including captive breeding for release into the wild.

Method used to estimate needs for investment and financial flows

429. There is very limited literature on adaptation of natural ecosystems to the adverse impacts of climate change. What tends to exist in the literature are ideas of ways to reduce vulnerability of natural ecosystems to climate change. There is virtually no information on the effectiveness of these adaptations in reducing the damage to ecosystems from climate change, or on the costs of adaptation to climate change.

430. As a consequence, information on current investments and financial flows going to natural ecosystem protection and how much might be needed to protect ecosystems from current threats was used as the basis for analysis. James et al. (2001) estimated the additional costs needed to protect biodiversity. The results of the analysis are discussed below.

431. Although the method used by James et al (2001) may be the best method to estimate adaptation costs for protecting natural ecosystems, the approach is quite approximate and indirect. The James et al. study is an attempt to estimate the investment and financial flows needed to protect natural ecosystems from current threats. But, as is discussed below, the authors use educated guesses as to how much additional land needs to

be set aside as biodiversity protection areas. This study is not able to rely on bottom-up or top-down (e.g., modelling) estimates of natural ecosystem protection needs.

432. Furthermore, the James et al. study does not estimate the additional protection needs that climate change might require. Given the potential for massive disruption of habitats and ecosystems, the need for many species to migrate hundreds of kilometres and the limited options for adaptation for many species, it is possible that the additional costs for addressing adaptation to climate change would be quite substantial. There is insufficient information to hazard even an educated guess as to the magnitude of the additional resources, not to mention their effectiveness in protecting natural ecosystems and biodiversity.

5.4.4.2. <u>Overview of current investment and financial flows by source of financing</u>

433. Between 1991 and 2000, the GEF provided about USD 1.1 billion in grants and leveraged an additional USD 2.5 billion in co-financing for biodiversity-related projects. Most of these grants were channelled thorugh developing-country governments and NGOs and used to support more than 1,000 protected sites covering 226 million hectares in 86 countries. OECD data show only USD 198 million in biodiversity projects from the World Bank system (including the GEF) in 2000 and USD 267 million in 2005.

434. James et al. report that in the mid-1990s an average of USD 6.8 billion per year was spent on global protected areas, with about 89 per cent of that amount spent in developed countries.

435. The private sector resources allocated to biodiversity protection have been relatively limited and focused in areas such as ecotourism, agroforestry and conservation of medicinal and herbal plants.

5.4.4.3. <u>Estimated investment and financial flows needed</u>

436. James et al. examined what they called a relatively modest goal by the International Union for the Conservation of Nature and Natural Resources (IUCN) to increase protected areas by 10 per cent (but noting that some scientists call for increasing protected areas by 50 per cent). They examined two options for such an expansion, one more ambitious than the other. James et al. estimate that improving protection, expanding the network in line with IUCN guidelines, and meeting the opportunity costs of local communities could all be achieved with an annual increase in expenditures of USD 12–22 billion. The range is based on different options for redressing the current lack of resources going to conservation. Note that this estimate does not consider the level of resources needed to reduce other threats to natural ecosystems, such as pollution. It also does not consider any additional requirements for protecting natural ecosystems from climate change. Such requirements could include developing migration corridors for species to migrate as climate zones shift.

437. It does not appear possible to estimate how resources needed for the protection of natural ecosystems would increase as a result of the reference or mitigation scenarios. However, it is clear that the larger the magnitude of climate change, the greater the harm to natural ecosystems. Therefore, the resources needed for protecting natural ecosystems will in all likelihood be higher for the reference scenario than for the mitigation scenario.

5.4.4.4. Assessment of needed changes in financial and policy arrangements to protect ecosystems from current threats

438. The James et al. analysis indicates that just to meet current natural ecosystem protection needs, current levels of investment and financial flows would have to increase by a factor of three to four. This would require increasing public sources of funds and leveraging private sector funding as well.

439. However, so far, attempts at leveraging private sector financing for ecosystem protection have had limited success. Demonstrating that there is a business case for ecosystem protection is a difficult endeavour. ODA for ecosystem protection is currently two orders of magnitude below the identified level of investment and financial flows needed. Clearly, a substantial increase in public domestic and external funding will be needed to address not just the current lack of resources going to ecosystem protection but also the additional needs of climate change.

Box 13. Natural ecosystems

Investment and financial flows needed in 2030:
Estimates in the literature indicate that improving protection, expanding the network of protected areas and compensating local communities that currently depend on resources from fragile ecosystems could be achieved for an increase in annual expenditure of USD 12-22 billion.

Current investment and financial flows:
Current annual spending to ensure natural ecosystem protection is of the order of USD 7 billion from public domestic and external funding.

5.4.5. Coastal zones

5.4.5.1. Introduction

440. The IPCC (Nicholls et al., 2007) reports that hazards relating to human development of coastal areas are quite high. About 120 million people are exposed to hazards from tropical cyclones each year, and on average these events kill more than 12,000 people a year. Climate change will result in higher sea levels, increased intensity of coastal storms and the destruction of many coral reefs and coastal wetlands. The combination of this and continued expansion of human settlements in coastal areas is likely to lead to an increasing need for protection from coastal hazards.

Adaptation

441. Nicholls et al. note that, in general, the costs of adaptation to sea level rise (e.g., through protection of threatened areas) are far less than the losses associated with not protecting coastal areas. It is not clear if it is feasible to adapt to more than a few metres of sea level rise. Protection of natural ecosystems such as wetlands and coral reefs can increase their resilience to climate change. The three basic options for adaptation are:

- Protect – to reduce the risk of the event by decreasing the probability of its occurrence;
- Accommodate – to increase society’s ability to cope with the effects of the event;
- Retreat – to reduce the risk of the event by limiting its potential effects.

442. Table 49 summarizes major adaptation options for coastal resources.

Table 49. Major physical impacts and potential adaptation responses to sea level rise

Physical impacts		Examples of adaptation responses (P – Protection; A – Accommodation; R – Retreat)
1. Inundation, flood and storm damage	a. Surge (sea)	Dykes/surge barriers (P) Building codes/ buildings (A) Land use planning/hazard delineation (A/R)
	b. Backwater effect (river)	
2. Wetland loss (and change)		Land use planning (A/R) Managed realignment/forbid hard defenses (R) Nourishment/sediment management (P)
3. Erosion (direct and indirect change)		Coast defenses (P) Nourishment (P) Building setbacks (R)
4. Saltwater Intrusion	a. Surface waters	Saltwater intrusion barriers (P) Change water abstraction (A)
	b. Groundwater	Freshwater injection (P) Change water abstraction (A)
5. Rising water tables and impeded drainage		Upgrade drainage systems (P) Polders (P) Change land use (A) Land use planning/hazard delineation (A/R)

443. The benefits of mitigation of GHG emissions could be quite substantial over the very long term. The IPCC found that a sustained warming of 1–4° C above 1999–2000 levels could result in the deglaciation of Greenland. This would lead to many metres of sea level rise over many centuries. Such an amount of sea level rise appears to be beyond the capacity of societies to adapt through coastal protection. Abandonment of coastal areas would be necessary in response to such an outcome. The costs of abandoning coastal development around the world would be a few orders of magnitude above protection costs for a metre or two of sea level rise and entail major implications for human migration and cultural heritage.

Method used to estimate the need for investment and financial flows

444. The dynamic interactive vulnerability analysis (DIVA) tool was used for this analysis. DIVA is a very detailed model of the world's coasts. It divides the world's coasts into more than 12,000 segments and can account for the effect of different adaptation options. The study examined protection only from coastal flooding through the building of dykes or the use of beach nourishment. A benefit–cost test was applied to estimate whether the costs of coastal protection were less than the value of lost economic output should no protection measures be used. Although use of benefit–cost analysis could favour protection of wealthier coastal areas, coastal lands in many developing areas apparently had a high enough value to justify use of protection measures. The results are provided globally, for the IPCC regions, and at a finer resolution.

445. DIVA analyses a limited set of adaptations in a uniform manner. This has the advantage of applying a uniform method that can account for local and regional differences in conditions such as value of threatened areas. However, it has the disadvantage of not accounting for unique local circumstances or varying decision criteria that may be applied around the world. Such a top-down approach was also used in the water supply analysis and has similar limitations.

446. Socio-economic conditions for all scenarios were assumed to be the conditions in the SRES A1B scenario (Nakićenović and Swart, 2000). The estimated additional investment and financial flows associated with the SRES A1B and B1 scenarios presented in this analysis are exclusively to cover the cost of adaptation measures to address sea level rise itself, not socio-economic development. However, the value of protected

economic output is based on the A1B scenario. The A1B scenario assumes the highest GDP growth of all of the SRES scenarios.

447. DIVA estimates investment needs without a sea level rise. This considers the costs of adapting to subsidence and flooding. The SRES scenarios incorporate sea level rise. The difference between the SRES scenarios and no sea level rise is the effect of climate change alone.

448. DIVA estimates a number of impacts from sea level rise including beach nourishment costs, land loss costs, number of people flooded, costs of building dykes, and losses from flooding. Of these, only the costs of beach nourishment and the costs of building dykes will be counted as adaptation costs. The other categories are damages. In reality, adaptation costs would likely be involved in responding to the damages.

449. Investment needs in 2030 were analysed assuming that decision makers can project future rates of sea level rise and plan for a 50- to 100-year time frame. This study assumes that decision makers plan for sea level rise out to 2080. Planning for a shorter time frame is likely to result in lower adaptation costs in 2030, whereas planning for a longer time frame (such as for expected sea level rise in 2130) would result in higher costs in 2030. Planning for 100 years rather than 50 is estimated to increase costs by about two thirds.

450. Table 50 gives sea level rise projections to 2130. These projections were taken from the IPCC Third Assessment Report (Houghton et al, 2001). There is virtually no difference between SRES emissions scenarios in 2030 A1B and B1. However, by 2080, there is a substantial difference between the two scenarios.

Table 50. The range in sea level rise by 2030 (relative to 1990) expected for each SRES scenario (cm)

	SRES emissions scenario	
	A1B	**B1**
Minimum rise	3	3
Mean rise	9	9
Maximum rise (2030)	15	15
Maximum rise (2080)	53	44
Maximum rise (2100)	69	57
Maximum rise (2130)	96	75

5.4.5.2. <u>Overview of current investment and financial flows by source of financing</u>

451. While there is significant interest in elaborating coastal adaptation measures and understanding their costs (e.g., Klein et al., 2001; Bosello et al., 2007), the level of investment in coastal adaptation is difficult to assess as there is never a single agency with published accounts in any country. However, there is some information on the level of investment and actions to protect vulnerable coastal areas in some countries and regions:

- **European Union**. The Eurosion (2004) review reported that the total annual cost of coastal adaptation for erosion and flooding across the European Union was an estimated EUR 3.2 billion (in 2001EUR; using current exchange rates this would be about USD 4 billion). These measures mainly involved protection;
- **United Kingdom**. The Flood and Coastal Management budget increased substantially since 2000/2001 from approximately GDP 300 million to more than GBP 500 million per year in 2005/2006 (about USD 400 million to USD 700 million using current exchange rates). However, coastal investment is not directly defined and is only an element of this budget;

- **Netherlands**. This is the archetypal country threatened by sea level rise, and it invests large sums in erosion and flood management. They amount to 0.1 to 0.2 per cent of GDP at present;
- **Bangladesh**. Bangladesh has experienced the highest death toll from coastal flooding of any country on earth (Nicholls, 2006), and is a good example of a vulnerable deltaic country. Following the 1970 and 1991 cyclones, when at least 400,000 people died, an accommodation strategy was implemented via a system of flood warnings and the construction of more than 2,500 elevated storm surge shelters. Despite recent severe storms, the death toll for people (and their animals via associated raised shelters) has fallen markedly;
- **The Maldives.** These islands are a good example of a vulnerable atoll nation where sea level rise could literally extinguish the nation over the coming century without adaptation. However, significant adaptation is occurring on the island. After a significant Southern Ocean swell event that flooded much of the capital Male in the 1980s, a large wall was built around the city with aid from Japan (Pernetta, 1991). However, the costs are not known. More recently, after the Indian Ocean tsunami of 2004, there has been interest in developing tsunami shelters, which may also have a function against climate change.

5.4.5.3. Estimated investment and financial flows needed

452. The estimated investment needs for the SRES A1B and B1 scenarios are displayed in table 51. Beach nourishment, land loss and flooding costs are estimated for 2030. There is no anticipation of future climate change impacts in these categories. The estimated investment required for dykes in 2030 assumes that the coastal infrastructure built in that year is sufficient to adapt to the maximum amount of sea level rise anticipated in 2080. The cost of dykes is very sensitive to the length of the planning horizon. For instance, under the A1Bscenario, if the dykes were built only for the sea level observed in 2030, the costs would be USD 11.7 billion. If, however, the dykes are built to adapt to projected sea level rise 100 year hence (to 2130), the annual cost in 2030 would be USD 16.8 billion. Since the cost of dykes represents more than half of the total costs, the selection of a planning horizon is a critical assumption affecting total costs.

453. Total costs including investment costs (beach nourishment and sea dykes) and losses (inundation and flooding) are estimated to be USD 21–22 billion in 2030.

Table 51. Investment and financial flows needed in 2030 for adaptation to sea level rise assuming anticipation to 2080 for the SRES A1B and B1 scenarios (millions of United States dollars)

Impact category	Investment and financial flows needed with no sea level rise	A1B scenario		B1 scenario	
		Investment and financial flows needed with sea level rise	Investment and financial flows needed with sea level rise	Investment and financial flows needed with sea level rise	Investment and financial flows needed with sea level rise
Beach nourishment costs	573	3 042	2 469	2 888	2 316
Sea dyke costs	5 601	13 803	8 202	12 815	7 214
Total investment costs	**6 174**	**16 845**	**10 681**	**15 703**	**9 529**
Land loss costs	0	6	6	6	5
Sea flood costs	6 385	8 119	1 734	7 853	1 467
Total loss costs	**6 385**	**8 125**	**1 740**	**7 859**	**1 472**
Total cost (investment and losses)	**12559**	**24971**	**12422**	**23562**	**11002**

454. Table 52 examines the increase in investment needed by region. About half of the required investment will be in non-Annex I Parties.

Table 52. Estimated additional investment needed in coastal infrastructure for the SRES A1B and B1 scenarios in 2030 by region (millions of United States dollars)

	A1B scenario		B1 scenario	
	Mean 2030	Maximum in 2080	Mean 2030	Maximum in 2080
Africa	612	1 319	528	1 197
Developing Asia	951	2 181	801	1 928
Latin America	680	1 597	573	1 414
Middle East	72	171	60	153
OECD Europe	737	1 785	624	1 587
OECD North America	1 002	2 022	882	1 838
OECD Pacific	460	1 080	388	958
Transition Economies	189	479	158	421
Total	**4 702**	**10 634**	**4 014**	**9 496**

455. The estimated investment needs for the A1B and B-1 scenarios differ by USD 1 billion per year, or about 10 per cent.

5.4.5.4. Assessment of needed changes in financial and policy arrangements to fill the gap in investment and financial flows

456. Additional investment in worldwide coastal infrastructure of about USD 10–11 billion will be required in 2030 for adaptation to sea level rise. Adaptation of coastal resources to climate change is highly dependent on public sources of funding. Although much coastal infrastructure may be private (e.g., buildings and homes), efforts to protect coastal areas from coastal storms and sea level rise are typically undertaken by governments. In the developed world and in parts of the developing world, the necessary financial resources are likely to be available to adapt coastal resources to climate change. However, certain settings and regions

present particular challenges, as identified in the recent IPCC AR4 assessment of coastal areas (Nicholls et al., in preparation). Deltaic regions, particularly the large coastal deltas in Asia and in Africa and small island states may have significant problems responding to sea level rise and climate change. In these countries, additional sources of external public financing will be needed.

457. Development and integration of coastal zone management institutions and processes, while in itself not demanding large amount of resources, could increase the efficiency of adaptation to climate change and sea level rise. GEF-funded initiatives such as the Caribbean Planning for Adaptation to Climate Change project, the Mainstreaming Adaptation to Global Change in the Caribbean project and the Pacific Islands Climate Change Assistance Programme are contributing to build the capacity in this area.

Box 14. Coastal Zones

Investment and financial flows needed in 2030:
With sea level rise, the investment needed is estimated to represent an additional USD 11 billion in 2030. This estimate assumes that decision makers take into account the expected sea level rise in 2080. About half of the required investment will be needed in non-Annex I Parties.

Current investment and financial flows:
Although much of the infrastructure in coastal areas may be private (e.g. buildings and homes), efforts to protect coastal areas from coastal storms and sea level rise are typically undertaken by governments.

5.4.6. Infrastructure

5.4.6.1. Introduction

458. Climate change is likely to have substantial consequences for the integrity, performance, lifetime and design criteria for much of the world's infrastructure. Infrastructure for water supply, sanitation, flood control, hydropower, and coastal development and defences could be substantially affected by climate change. Changes in average climate, but also changes in extreme events, will affect infrastructure. For example, sea level rise threatens to inundate coastal infrastructure. In addition, the potential for more intensive tropical cyclones would put more coastal infrastructure at risk. Changes in runoff-patterns and water supplies will affect water supply, flood control, water supply and sanitation. Changes in intense precipitation, flooding and droughts will affect and most likely have major implications for construction of water supply infrastructure. Even changes in peak high and low temperatures may require adjustments to buildings and their heating and cooling systems.

Adaptation

459. In general, there are two types of climate change adaptation in infrastructure. The first involves making modifications to or changes in operations of infrastructure that would be directly affected by climate change. This applies to infrastructure used to manage natural resources such as water or coastal resources infrastructure. For example, coastal defences may be raised or otherwise strengthened to adapt to higher sea levels and the potential for more intense coastal storms. Infrastructure for water resource management applications such as flood protection, water supply, water quality treatment, hydropower production, and other uses may be modified to adapt to changing runoff-patterns and water quality conditions. For example, the size of reservoirs could be increased to provide more storage for water supply or flood protection. It will also apply to infrastructure such as heating and cooling systems that will be directly affected by climate change.

460. The second type of adaptation affects infrastructure needed to support activities that cope with climate-affected sectors or resources. Provisions of public health services, agriculture extension, research and many

other applications require supporting infrastructure. Hospitals, clinics, disease monitoring systems, buildings for extension services, laboratories, and so on may need to be built to enhance the capability to adapt to climate change.

Method used to estimate the need for investment and financial flows

461. The analysis of climate change impacts on infrastructure estimates the share of infrastructure investment that is currently vulnerable to climate variability and then estimates the additional investment in infrastructure that may be necessary to adapt to climate change. It addresses only the first type of adaptation mentioned above.

462. The share of infrastructure vulnerable to the impacts of climate change is estimated based on losses due to extreme weather events.

463. Munich Re provided a data set of "Great Weather Disasters" from 1951 to 2005, from which annual regional losses were estimated. The value of overall losses for each major event from 1951 through 2005 by region and/or country is included in the database. These were summed and averaged over the 55-year record of the database to obtain average annual losses by region. Since the Munich Re data set is only for large catastrophes and does not include damages from smaller climate events, it might underestimate total losses from weather extremes. Furthermore, the analysis in this study does not consider other infrastructure costs such as damages from inundation, erosion, melting of permafrost and other causes. On the other hand, although the vast majority of the "Great Weather Disasters" are likely to be made more intense by climate change (e.g., cyclones, droughts and floods), some, but not all, are cold weather events that could be less severe with climate change. The Munich Re data were used to obtain an estimate of the minimum additional investment needed to adapt infrastructure to climate change. The Munich Re data were scaled up to cover all weather related losses and accounts to get an estimate of the potential upper bound on the level of additional investment needed. The adjustment used is 4.3, and corresponds to the ratio of the Association of British Insurance (ABI) data on total weather related losses for the period 2000–2006 to the Munich Re losses for the same period. The average annual loss is thus estimated at between USD 21.1.billion and USD 87.7 billion.

464. To estimate the share of infrastructure vulnerable to the impacts of climate change, the annual infrastructure investment in the middle of the period 1951–2005, that is for 1978, was used. Global GFCF data are not available for that year. The GFCF for 1980 is estimated by assuming that the growth rate projected for the period 2005–2030 by OECD (3.65 per cent per year) can be applied to period 1978–2005. That yields a global GFCF for 1978 of about USD 3,025 billion. Based on the average annual loss estimated above, the average annual loss is estimated to be between 0.7 per cent (based on Munich Re data) and 2.9 per cent (based on ABI data) of the estimated 1978 GFCF. Note that the World Bank estimates that 2 to 10 per cent of gross domestic investment could be sensitive to climate change, although it uses a much lower figure for the annual investment.

465. To estimate the potential additional costs of adapting vulnerable infrastructure to the impacts of climate change, the World Bank estimate of a 5 to 20 per cent (as cited by Noble, 2007) increase in investment was used. The infrastructure analysis implicitly assumes that the incremental cost of 5 to 20 per cent covers the cost of adapting to all climate change impacts over the life of each facility. The upper end was not adjusted, although some studies (e.g. Kirshen et al., 2006; Smith et al., 2006) indicate that some infrastructure investment needs might be 30 per cent higher.

466. The projected level of investment in physical assets needed in 2030 is based on the OECD ENV–Linkage model and corresponds to the projection in the IEA WEO reference scenario.

5.4.6.2. Overview of current investment and financial flows by source of financing

467. As can be seen in annex 5, table 35.11, total GFCF was USD 7.8 trillion in 2000. It is unclear what is the fraction of private and public infrastructure that is vulnerable to climate change. Total ODA for infrastructure is estimated at more than 15 billion in 2005; this represents a 36 per cent increase in real terms from 2000 (annex 5, table 17). Multilateral assistance increased by almost 60 per cent in the same period. South Asia was the largest recipient on ODA in this sector in 2005 and Africa was close behind.

5.4.6.3. Estimated investment and financial flows needed

468. In 2030, projected total GFCF is USD 22.3 trillion. When this number is multiplied by the estimated share of infrastructure vulnerable to the impacts of climate change (0.7 and 2.9 per cent) this yields a value of between USD 153 billion and USD 650 billion of infrastructure investment vulnerable to climate change.

469. Assuming adaptation to the impacts of climate change requires a 5 to 20 per cent increase in capital costs, the adaptation costs would be USD 8–31 billion per year in 2030 based on the Munich Re data and USD 33–130 billion per year in 2030 based on the ABI data. Although the share of infrastructure vulnerable to climate change is higher in some developing country regions, total infrastructure investment is higher in developed countries, hence most of these adaptation costs are in developed countries. Table 53 presents the investment needed to adapt infrastructure to the adverse impact of climate change by region in 2030. About two thirds (68 per cent) of the investment would be in OECD countries.

470. The World Bank (2006)/Stern Review (Stern et al., 2006) estimated the added costs necessary to adapt investments to climate change risks at 2000USD 40 billion, with a range of USD 10–100 billion. The range estimated in this study above is very much in line with this estimate.

Table 53. Additional investment needed to adapt infrastructure to climate change risks in 2030 (millions of United States dollars)

	Estimate based on Munich Re data		Estimate based on ABI data	
Region	**5 per cent additional investment**	**20 per cent additional investment**	**5 per cent additional investment**	**20 per cent additional investment**
Africa	22	87	92	371
Developing Asia	1 901	7 605	8 106	32 424
Latin America	405	1 620	1 726	6 906
Middle East	66	264	282	1 127
OECD Europe	1 000	3 999	4 262	17 050
OECD North America	3 736	14 943	15 925	63 702
OECD Pacific	473	1 892	2 017	8 067
Transition Economies	24	97	102	412
World Total	**7 627**	**30 508**	**32 514**	**130 058**

471. The costs of adapting infrastructure to cope with climate change are estimated to range from about USD 8–130 billion, depending on the climate change scenario and assumption of sensitivity. As noted above, the additional investment needed to adapt infrastructure to climate change could be larger than the upper-end estimate used here. Two third of the investment is expected to be in developed countries.

5.4.6.4. Assessment of needed changes in investment, financial and policy arrangements to fill the gap in investment and financial flows

472. The investment needed to adapt new infrastructure to climate change is estimated to be USD 8−130 billion. This corresponds to less than 0.6 per cent of total GFCF in 2030. About a third of the investment needed will be in non-Annex I Parties of which more than 80 per cent are in developing Asia. The potential sources of financing depends on the nature of the new infrastructures that are vulnerable to climate change and whether they are typically financed by the private or the public sector and with domestic or external resources. Although it is unclear what is the fraction of private and public infrastructure that is vulnerable to climate change, the amount is likely to be financed by all types of sources that is domestic and external, and public and private. The additional investment is assumed to be on average a small fraction of the total cost of each new infrastructure vulnerable to climate change. Therefore the additional investment is likely to be financed in the same manner as the overall infrastructure: from private sources for infrastructure such as commercial buildings and industrial plants, and from public sources for infrastructure such as roads and public buildings. Public resources will also be needed to provide adequate support and incentives for new private infrastructures that are vulnerable to climate change to be adequately adapted. The latter might be necessary in order to avoid severe damages that can have important impacts on sectoral or overall economic development. The design of adequate national policies including the integration of adaptation considerations into sectoral agencies might have an important role to play in ensuring that an optimal amount of resources both domestic and private are available to cover the cost of adaptation.

473. The World Bank/Stern Review estimated the share of ODA and concessional finance investments sensitive to climate change to be higher (20 per cent) than the global average (2−10 per cent). They estimated the annual cost of adapting such infrastructure to the impacts of climate change at 2000USD 1−4 billion. This would be equivalent to as much as a 30 per cent increase in the ODA infrastructure spending between 2005 and 2030.

Box 15. Infrastructure

Investment and financial flows needed in 2030:
The additional investment needed to adapt new infrastructure vulnerable to climate change is estimated at 5 to 20 per cent of its cost. The additional investment needed is estimated at USD 8-130 billion, or less than 0.5 per cent of global investment in 2030. About one third of the additional investment would be needed in non-Annex I Parties, and more than 80 per cent of that in Asian developing countries.

Current investment and financial flows:
Total investment in physical assets was estimated to be about USD 6.8 trillion in 2000. Current sources for investment in infrastructure are private sources for infrastructure such as commercial buildings and industrial plants, and from public sources for infrastructure such as roads and public buildings. Total ODA for infrastructure is estimated at more than USD 13 billion in 2005, this represents a 36 per cent increase in real terms from 2000. South Asia was the largest recipient in 2005, although Africa was close behind.

5.5. Avoided damages

474. Although the adaptation costs described in the previous chapters may seem significant, it is clear that the value of the climate change impacts these expenditures would avoid could be as large or greater. This study does not estimate the total value of impacts avoided by adaptations to climate change. However, the adaptation costs can be put in perspective by looking at the cost associated with extreme events and reviewing the literature on total damages from climate change, even though it is unlikely that the adaptations discussed in this study would avoid all of these damages.

475. A major component of the total impacts from climate change is likely to be losses from extreme weather events. Climate change is projected to increase the intensity of storms, cyclones, droughts, heat waves and other events. Estimating how losses from extreme events will change as a result of climate change is challenging for a number of reasons including:

- Since there is considerable variability in year to year damages from extreme climate (e.g. Hurricane Katrina dramatically increased weather related losses in 2005), establishing a baseline for extreme weather damages can be difficult;
- Estimating the change in total infrastructure stock over time is challenging. For example it is not clear whether infrastructure investments will grow proportionately with output or fixed capital investment or another set of data;
- It is very difficult to estimate how extreme climate events will change and how they will affect infrastructure;
- Clearly a lot of present infrastructure will be replaced over coming years. Whether climate change is factored into the replacement or redesign of infrastructure is not clear, nor is it clear how effective such adaptations would be in reducing risks from climate change.

476. In the context of this study, an attempt is made to estimate expected changes in damages due to extreme weather events. The analysis is based on different sources of data from the insurance industry on current losses. As mentioned in the infrastructure sector above, Munich Re catalogued "great natural catastrophes" which involve the loss of thousands of lives or severe economic impacts from extreme events. Such a database can substantially underestimate damages from climate because only large events are included. Taking into account differences in various insurance industry estimates of losses, estimates of current losses to climate range from about USD 160 billion to as much as USD 330 billion, and most likely between USD 200 and 300 billion. The estimates are in the order of 0.5 per cent of current gross world product.

477. The Munich Re data suggest that damages are increasing at a rate of 6 per cent per year in real terms. A paper by Risk Management Solutions (RMS) estimates that the contribution to the increase in damages of climate change is 2 per cent per year in real terms, although it is a weak signal.[41] Accounting for the under-reporting of losses in the Munich Re "great disaster" data and extrapolating the trend at 6 per cent per year, or at 2 per cent plus economic growth results in a range of estimates of annual climate damages in 2030 of approximately USD 850–1,350 billion. This corresponds to approximately 1.0–1.5 per cent of gross world product. These estimates consider climate change and make no allowance for reduced losses following new adaptation strategies. Losses are very likely to escalate non-linearly when events become more extreme. Thus, a reduction in the increase in global mean temperature through mitigation would probably have a greater proportional effect reducing losses from extreme events.

478. Estimating the total damages from climate change is very difficult because all potential adverse impacts need to be not only identified but also costed. This is relatively more straightforward for impacts of climate change on sectors such as agriculture and infrastructure, but is more challenging for non-market impacts such as human health and ecosystem impacts. Indeed the term "damages" includes financial impacts of climate change such as building sea walls, but also includes impacts on services such as those provided by ecosystems. These services are often not offered in markets and can be challenging to monetize.

479. In spite of these challenges, several economists have developed estimates of the total damages from climate change. The magnitude of these estimates differs quite substantially across studies. However, in spite of these differences, there are two important common findings across the studies:

[41] Even if trends in regional climate could be isolated, attributing them to anthropogenic climate change could be difficult if not impossible for many regional trends.

- Damages increase with the magnitude of climate change. The more climate changes, with climate change typically measured as the average increase in global mean temperature, the greater the total damage. Some studies anticipate initial net benefits with up to 1 to 3° C of increase in global mean temperature, whereas others studies anticipate net damages with any increase in temperature. Even those studies estimating initial benefits find that benefits peak and become net damages at some level of climate change. Net damages keep rising with greater magnitudes of climate change;
- On average, developing countries are estimated to have larger damages as a percentage of their gross product (i.e., relative to their national incomes) than developed countries. This implies that damages and benefits are not spread evenly. In some studies, developed countries are estimated to have benefits up to some level of warming, whereas developing countries suffer damages. Note that there will probably be variation among individual countries.

480. The IPCC 4AR (Yohe et al, in preparation) reported findings from numerous studies, including those from Mendelsohn et al. (2000), Nordhaus and Boyer (2000), and Tol (2002). It also cited in the Stern Review (Stern et al., 2006). In a comparison of damage estimates from these studies,[42] the IPCC reported the following range of possible outcomes:

- A 0.5°C increase in global mean temperature could lead to negligible damages, or a possible increase in welfare equivalent to between 0.5 and 2 per cent of world GDP;
- A 2°C increase in global mean temperature could lead to negligible damages, or damages equivalent to between a 0.5 per cent and 1.5 per cent loss in world GDP;
- A 4°C increase in global mean temperature could lead to negligible damages, or damages equivalent to between a 1 per cent and 6 per cent loss in world GDP.

481. Mendelsohn et al. (2000) reported country-specific results according to which a 2° C global-mean warming would result in net market benefits for most OECD countries and net market damages for most non-OECD countries. The study applies response (to climate change) functions that were developed empirically for the United States of America to all countries in the world. The two types of response functions used (reduced-form and Ricardian) yield different results.

482. The more recently released Stern Review (Stern et al, 2006) estimated substantial losses, particularly for large amounts of warming. Their findings suggest that the economic effects of a 5−6° C increase in global mean temperature by 2100 could reduce welfare by an amount roughly equivalent to an average reduction in GDP of 5−10 per cent.[43] Estimates in the Stern Review increase to:

- 11 per cent of GDP when nonmarket impacts are included (e.g., environment, human health);
- 14 per cent when evidence indicates that the climate system might be more responsive to GHG emissions than previously thought;
- 20 per cent when using weighting that reflects the expected disproportionate share of damages that will fall on poor regions of the world.

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[42] Mendelsohn et al. (2000) estimate aggregate regional monetary damages (both positive and negative) without equity weighting. Nordhaus and Boyer (2000) estimate track aggregated regional monetary estimates of damages with and without population-based equity weighting; they do include a "willingness to pay (to avoid)" reflection of the costs of abrupt change. Tol (2002) estimates aggregated regional monetary estimates of damages with and without utility-based equity weighting.

[43] Based on the recently released IPCC report on the science of climate change, such a warming by 2100 is possible but unlikely (IPCC, 2007a).

483. The Stern Review has been criticized for relying on the most pessimistic literature on climate change impacts and for using very low discount rates for estimating the present value of climate change impacts (e.g., Tol, 2006; and Yohe, 2006).

484. Although there is uncertainty about whether there will be initial net benefits or damages with a small amount of warming and about the magnitude of damages with a large amount of warming, there is agreement across the economic studies that the effects of climate change will be uneven and will on average hurt developing countries the most, and that the damages will eventually increase as warming continues.

5.6. Conclusion

485. The sectoral analysis demonstrates that for all sectors and regions covered, several tens of billions of dollars of additional investment and financial flows will be needed for adaptation to the adverse impacts of climate change.

486. In the sectors dependent on privately owned physical assets (such as the AFF sector and a portion of the infrastructure sector), private sources of funding may be adequate to meet adaptation needs, especially in developed countries. The additional spending likely to be required will be for climate proofing physical assets or to shift investment to infrastructure or productive activities that are less vulnerable to the adverse impacts of climate change. Policy changes, incentives and direct financial support will be needed to encourage a shift in investment patterns and additional spending of private resources.

487. In all sectors at least some additional external public funding will be needed. This will be particularly the case in sectors and countries that are already highly dependent on external support, such as the health sector in LDCs or for coastal infrastructure in developing countries vulnerable to sea level rise.

488. National policies may play an important role in ensuring that the use of resources, both public and private, is optimized. In particular there is a need for:

- Domestic policies that provide incentives for private investors to adapt new physical assets to the potential impacts of climate change;
- National policies that integrate climate change adaptation in key line ministries;
- Local government adaptation policies in key sectors.

489. Bilateral donors and multilateral lenders have been directing financial resources to support the design of policies in developing countries in the sectors analyzed in this study. A particularly high amount of resources is allocated to support agricultural policies when compared with other sectors (see annex 5, table 13). It is not possible to determine how much of these financial resources address climate change issues let alone adaptation issues. However, the current level of support channelled explicitly for adaptation purposes is likely to be suboptimal.

490. These estimates should be treated as indicative of adaptation needs but may represent a lower bound of the amount actually required for adaptation because some activities that are likely to need additional financial and investment flows to adapt to climate change impacts have not been included. For example, the water supply sector does not address other aspects of water resource management. The estimate for the health sector does not include many diseases that are expected to become more widespread because of climate change. The estimates for coastal zones are based on the additional cost related to investment in dykes and beach nourishment. The estimate for infrastructure includes only the cost of building new infrastructure with a design that takes climate change into account.

491. There are other reasons why the estimates of costs of adapting to climate change presented in this work should be considered preliminary and be treated with caution. One of the most important reasons is that simple assumptions were used to develop all of the specific estimates. On the ground adaptations may vary considerably in type and their costs. In addition, cost estimates may be too high, as there might be some amount of double counting. This may be the case with the estimate for infrastructure investment, which may overlap with some of the estimates for water supply and coastal zones. Also, the estimates do not take into account the potential for learning to do adaptation better. The analysis assumes a fixed cost. With a significant need for adaptation, there will probably be lessons learned on how society will adapt more efficiently. In addition, new technologies or technological applications will probably be developed which could reduce costs. The costs of adaptation by people resulting from migration, loss of employment and switching of livelihoods, have not been estimated for this study.

492. Although the additional investment and financial flows needed for adaptation described above are significant, the value of the climate change impacts that those expenditures would avoid could be larger. This study does not estimate the total value of impacts avoided by adaptation to climate change and therefore does not determine whether benefits of avoided damage exceed the adaptation costs. Existing estimates of the future damages caused by climate change vary substantially; however, available studies yield three important common findings:

- Damages increase with the magnitude of climate change;
- Investment needs for adaptation would almost certainly increase substantially in the latter decades of the twenty-first century. They will be particularly high if no mitigation measures are implemented;
- On average, developing countries suffer more damage as a percentage of their GDP than developed countries, which implies that damages and benefits are not distributed evenly.

493. The global cost of adaptation to climate change is difficult to estimate, largely because adaptation measures to climate change will be widespread and heterogeneous. More analysis of the costs of adaptation at the sectoral and regional levels is required.

6. PRIORITIES FOR MITIGATION AND ADAPTATION AS REPORTED BY DEVELOPING COUNTRIES UNDER THE CONVENTION

494. This chapter summarizes priority areas for climate change mitigation and adaptation as identified by non-Annex I Parties under the Convention process. It should be noted that, as these priorities have been identified in different contexts, they do not comprise a comprehensive view of the priorities and needs of non-Annex I Parties. However, they complement the discussions of investment and financing needs in chapters 4 and 5 by highlighting particular mitigation and adaptation areas/activities important for non-Annex I Parties. These priorities should also be considered when discussing the role of different sources of investment and financial flows and their future potential.

495. Information on priority areas for mitigation and adaptation provided by developing countries under the Convention has been mostly of a qualitative nature, as Parties were not required to calculate costs of priority actions. Therefore, the analysis in this chapter does not include an assessment of total costs of mitigation and adaptation measures. It should also be noted that the priority rankings in this summary correspond to the rankings provided by Parties in different reporting contexts and, because the data is only qualitative, it is difficult to compare these priorities with priorities for funding when costs are considered, as in the previous chapters.

496. This chapter provides information contained in initial national communications (INCs), technology needs assessments (TNA), NAPAs, reports from regional workshops and expert meetings on adaptation and response measures, and submissions from Parties under the Nairobi Work Programme on impacts, vulnerability and adaptation to climate change, in particular on climate-related risks and extreme events.

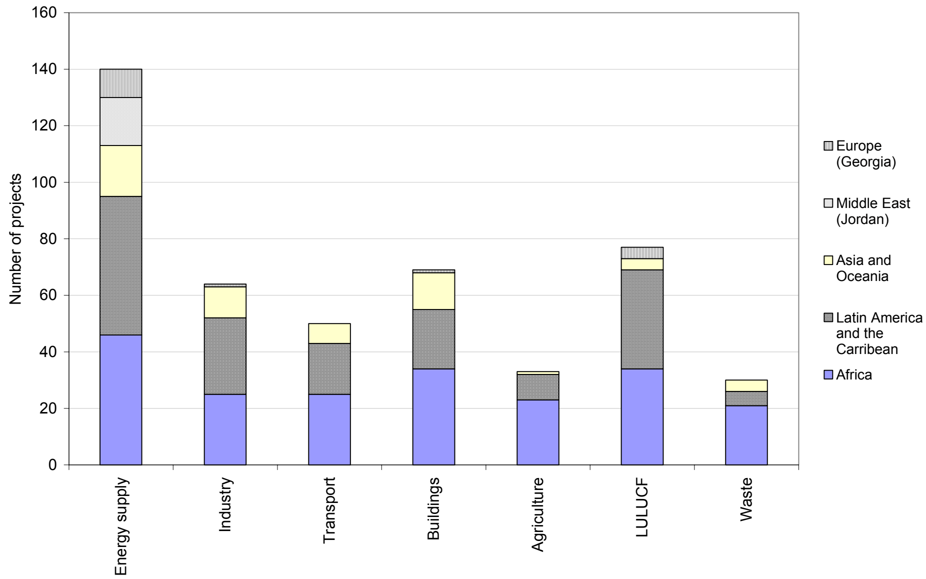
6.1. Priority areas for mitigation

497. Two thirds of non-Annex I Parties[44] reported on the need for mitigation measures in the energy sector. Roughly half of the Parties identified measures to limit emissions and enhance removals by sinks in the LULUCF sector. About a third of the Parties reported on measures to abate GHG emissions in the agriculture and waste sectors. Figure 17 shows the distribution of mitigation project proposals by sector and region[45].

[44] Information here and further is based on the Sixth compilation and synthesis of initial national communications from Parties not included in Annex I to the Convention (FCCC/SBI/2005/18). Additional 12 initial national communications submitted since then are still to be examined by the Consultative Group of Experts.

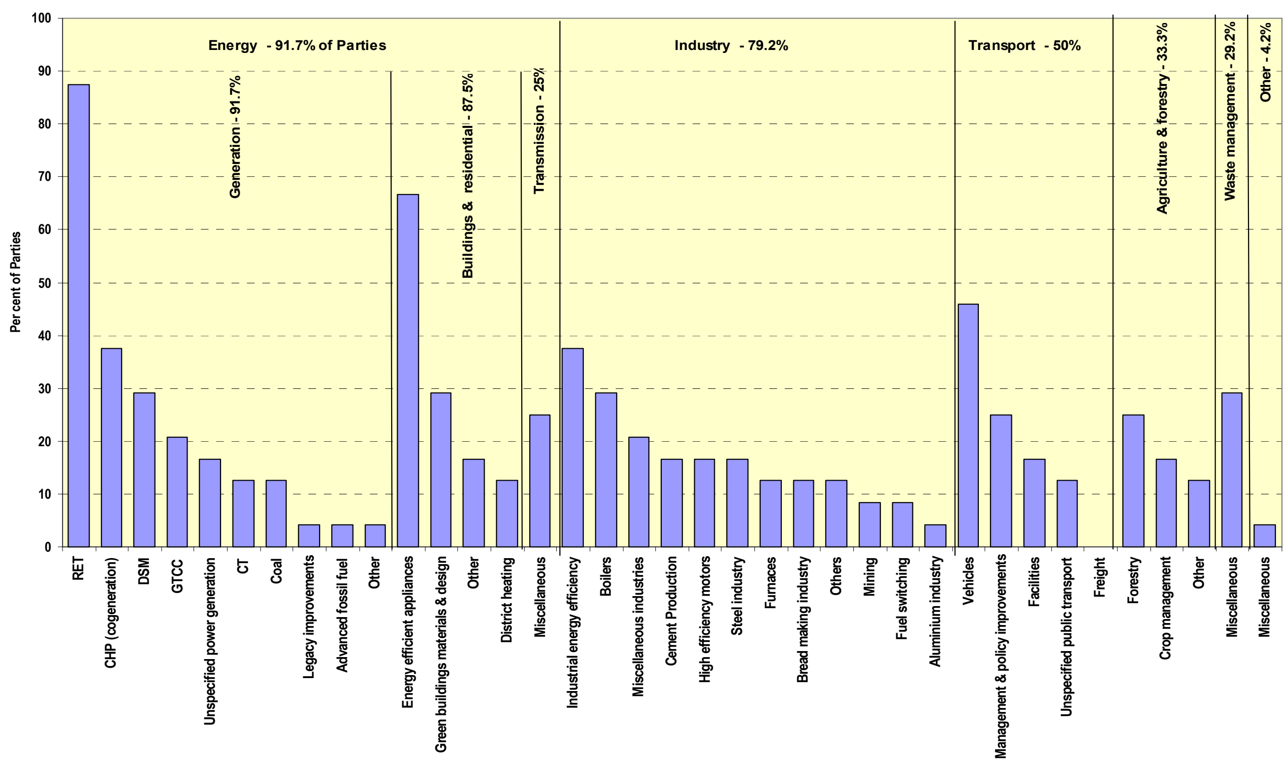
[45] FCCC/SBI/2005/18/Add.3. From Europe, only Georgia, and from Middle East, only Jordan, submitted project proposals.

Figure 17. Regional and sectoral distribution of mitigation project proposals



498. Figure 18 summarizes the needs for mitigation technologies identified in TNAs by sector.

Figure 18. Mitigation sectors, sub-sectors and technologies commonly identified by Parties in technology needs assessments



Source: FCCC/SBSTA/2006/INF.1
Abbreviations: CHP = combined heat and power; CT = combustion turbine; DSM = demand side management; RET = renewable energy technology; GTCC = gas turbine combined cycle.

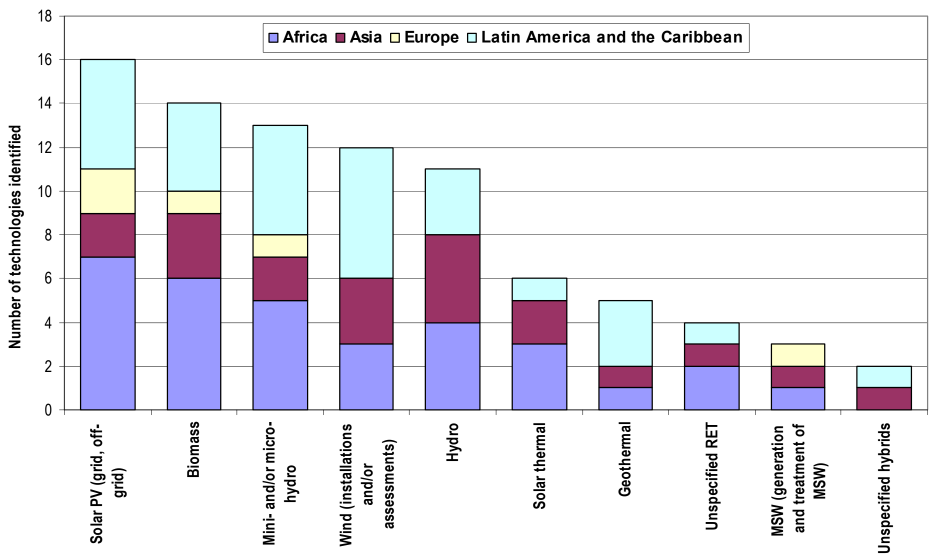
6.1.1. Sectoral analysis of priority areas

6.1.1.1. Energy supply

499. In INCs, nearly half of reporting Parties reported that they are implementing, or considering the implementation of small hydropower applications to increase their energy supply in order to meet their pressing needs for power, and considering alternative fuels in the transportation sector. Many Parties reported that they do have measures in place to encourage the use of cleaner alternative fuels[46].

500. Of the 140 mitigation project proposed by Parties in the energy sector, 103 involve switching to renewable sources of energy, 25 deal with the efficient conversion of fossil fuels to electricity and 11 suggest a switch to lower-carbon fossil fuels. This distribution of projects matches the technology needs most commonly identified in TNAs. Solar photovoltaic (grid and off-grid), wind farms, biomass, and micro and mini hydro plants were the most frequently mentioned renewable energy technology needs. Figure 19 below provides an overview of commonly identified renewable energy technology needs.

Figure 19. Needs for renewable energy technology commonly identified by non-Annex I Parties



Source: FCCC/SBSTA/2006/INF.1.

6.1.1.2. Industry

501. Priority areas identified in INCs and TNAs in the industrial sector were in the cement and steel production industries. Mitigation options considered by Parties include the modernization of industrial processes and equipment, and the promotion of energy efficient technologies. Examples of specific measures proposed are the introduction of efficient fuel for boilers and the introduction of efficient coal-fired boilers, electrical motors and lighting in industrial buildings.

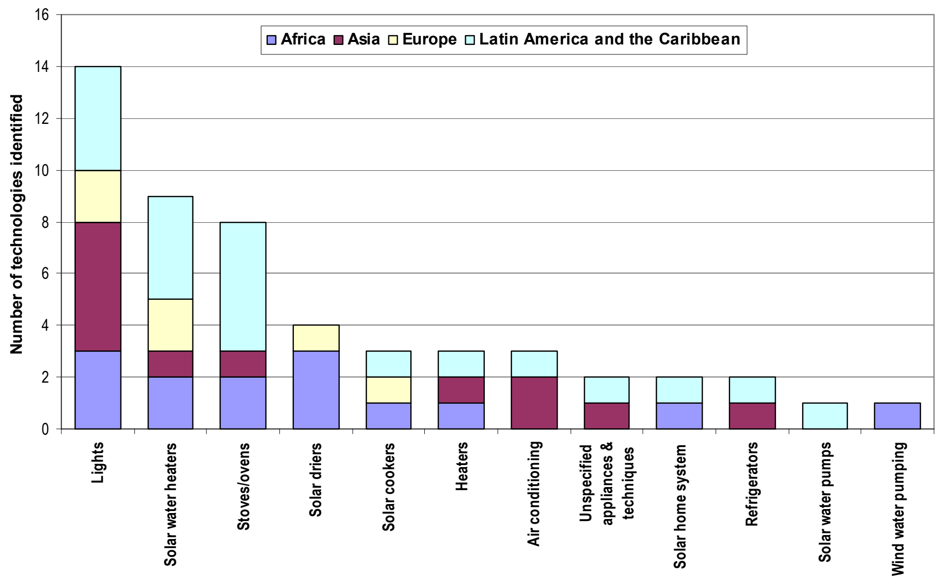
502. Sixty-five mitigation projects proposed by Parties in their INCs fall in the industry category. Twenty-nine involve the introduction of new technologies and processes (e.g., technology in the cement industry) and 18 target non-energy-related process improvements to reduce GHG emissions.

[46] FCCC/SBI/2005/18/Add.3

6.1.1.3. Residential and commercial sector

503. In INCs Parties identified the following mitigation measures in the residential and commercial sector improving efficiency of cooking stoves; promoting more efficient household appliances; enhancing efficiency of lighting; increasing efficiency in the building sector; promoting solar energy for water heating in the residential sector; and implementing demand-side management programmes. Half of the mitigation projects in this category are proposed by African countries mostly targeting improved cooking stoves and more efficient lighting. Figure 20 below provides details on needs for energy efficient technology in the buildings and residential sector.

Figure 20. Needs for energy efficient technology in the buildings and residential sectors commonly identified by non-Annex I Parties



Source: FCCC/SBSTA/2006/INF.1.

6.1.1.4. Transportation

504. In INCs nearly two thirds of the Parties identified mitigation measures in the transportation sector that focussed on technologies, such as the introduction of electric or compressed natural gas vehicles and hybrid vehicles, and the implementation of vehicle emission standards, and measures focused on mode switching and other behaviors affecting transportation. Almost half of the Parties reported that they are considering alternative fuels in the transportation sector, with the greatest interest coming from Latin America. Thirty-four of the 50 mitigation project proposed by parties in the transportation sector include the promotion of public transport and the use of bicycles.

6.1.1.5. Waste sector

505. In INCs most mitigation measures identified focussed on solid waste. Measures focuses on the reduction of waste generation at the source and on the promotion of integrated waste management, waste recycling and composting. Mitigation measures dealing with waste water focused on the recycling and treatment of municipal waste water, and on the recovery of methane from waste-water treatment as biogas. Most mitigation project proposals in the waste sector (14 out of 32) focus on methane recovery from solid-waste disposal and methane reduction from waste water.

6.1.1.6. Agriculture and LULUCF

506. Frequently identified mitigation measures in the agriculture sector in INCs relate to changes in cattle management practices, rice cultivation and the use of fertilizers. Fourteen mitigation project out of 33 proposed in the agriculture sector involve improvement in the management of ruminant livestock and six involve improvement in rice production practices.

507. Mitigation measures mentioned in the INCs for the LULUCF sub-sector include the promotion of forest conservation and restoration, afforestation and reforestation activities; improvement of forest management practices and the promotion of sustainable forest development; the promotion of conservation and substitution of fuelwood; and the promotion and development of agroforestry.

508. Eighty-six mitigation projects are proposed by parties in their INC in the LULUCF sector. Thirty of these aim at the reduction of deforestation and assistance with regeneration, 12 of these target fuel conservation and substitution (all in African countries). Fifty-six project proposed target reforestation or afforestation of lands, with 28 focusing on the development of production forestry or agroforestry (mostly in Latin American countries).

509. The technology needs related to these sectors identified in TNAs included better land processing techniques, forest fire monitoring and prevention, mechanization of timber processing and logging, valuation of forest waste (for biomass energy) and tree planting. As for avoided deforestation, Parties highlighted needs for capacity-building and technology transfer to implement adequately their policies and measures to reduce emissions from deforestation[47].

6.2. Priorities areas for adaptation

510. Overall, Parties emphasized the need for a holistic approach to adaptation planning, as many adaptation measures can simultaneously address vulnerabilities in several sectors. Parties also noted that adaptation measures are country specific. Among the sources of information reviewed, only NAPAs contain financial estimations of needs. These estimates are indicative only. Parties used different methodologies to calculate costs of NAPA priority activities. Of the 17 NAPAs submitted by June 2007, 16 contain cost estimates of NAPA projects amounting to a total of USD 292 million (see figure 21).[48] As of June 2007, eight NAPA activities have been formulated as PIFs and submitted to the Least Developed Countries Fund (LDCF) (and its co-financing) and the total funding expected from the GEF is USD 21.56 million.

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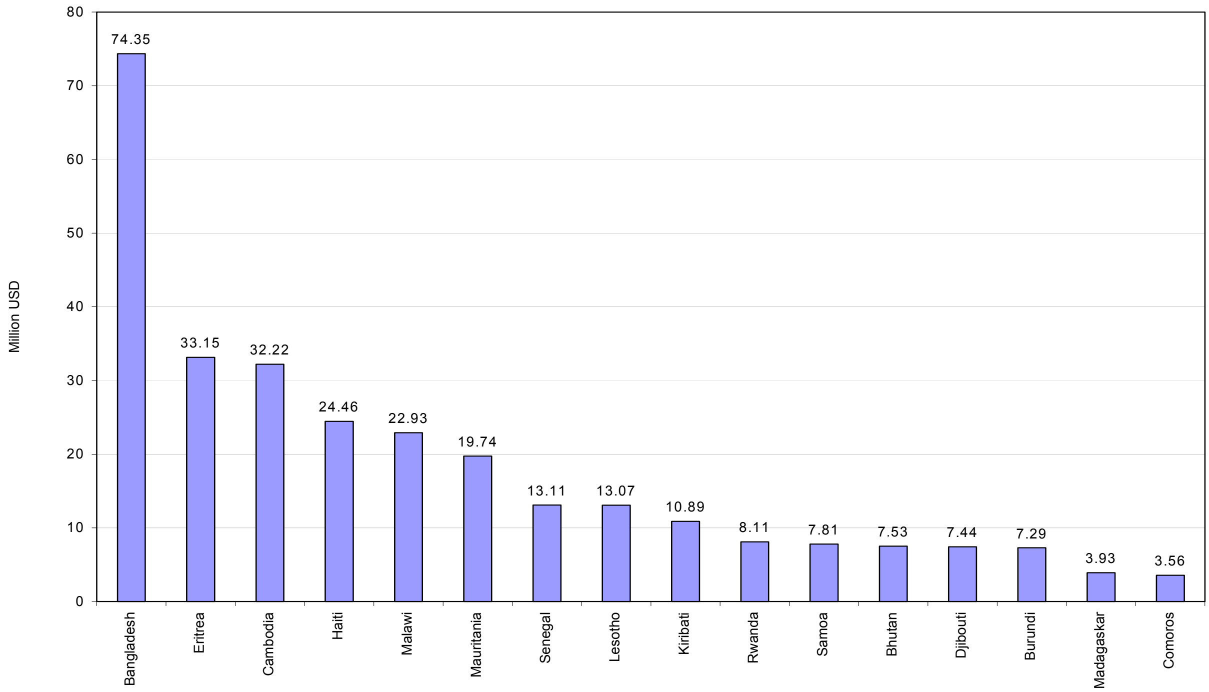
[47] Submissions from Parties. FCCC/SBSTA/2007/MISC.2 and Add.1.

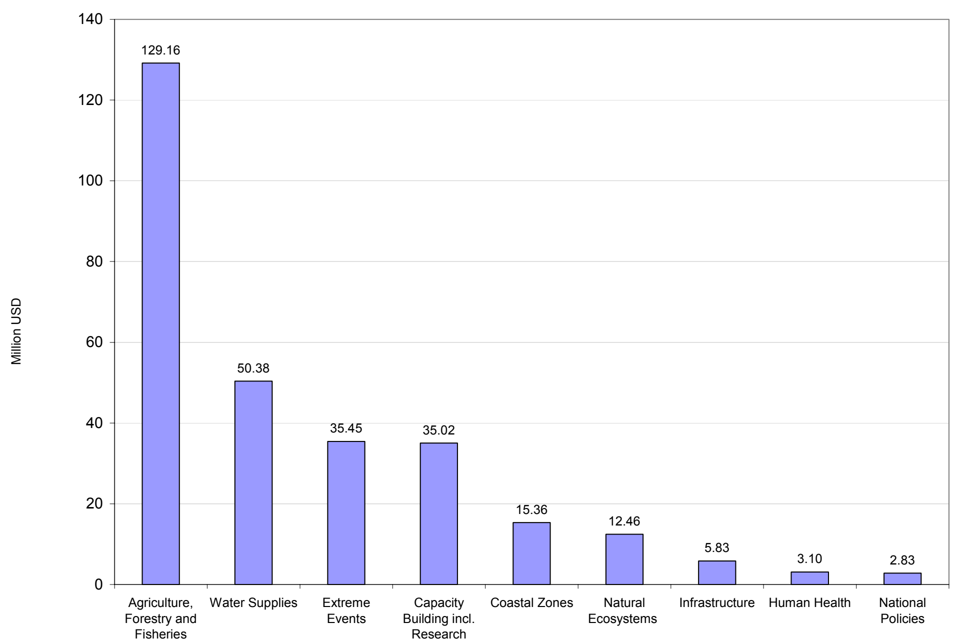
[48] This does not include Niger, which did not provide an estimation of project costs.

Figure 21. Cost of priority activities identified in national adaptation programmes of action, by country



511. Figure 22 shows the costs of NAPA priority activities by sector. Actual project proposals submitted for GEF funding may comprise priority activities across several sectors.

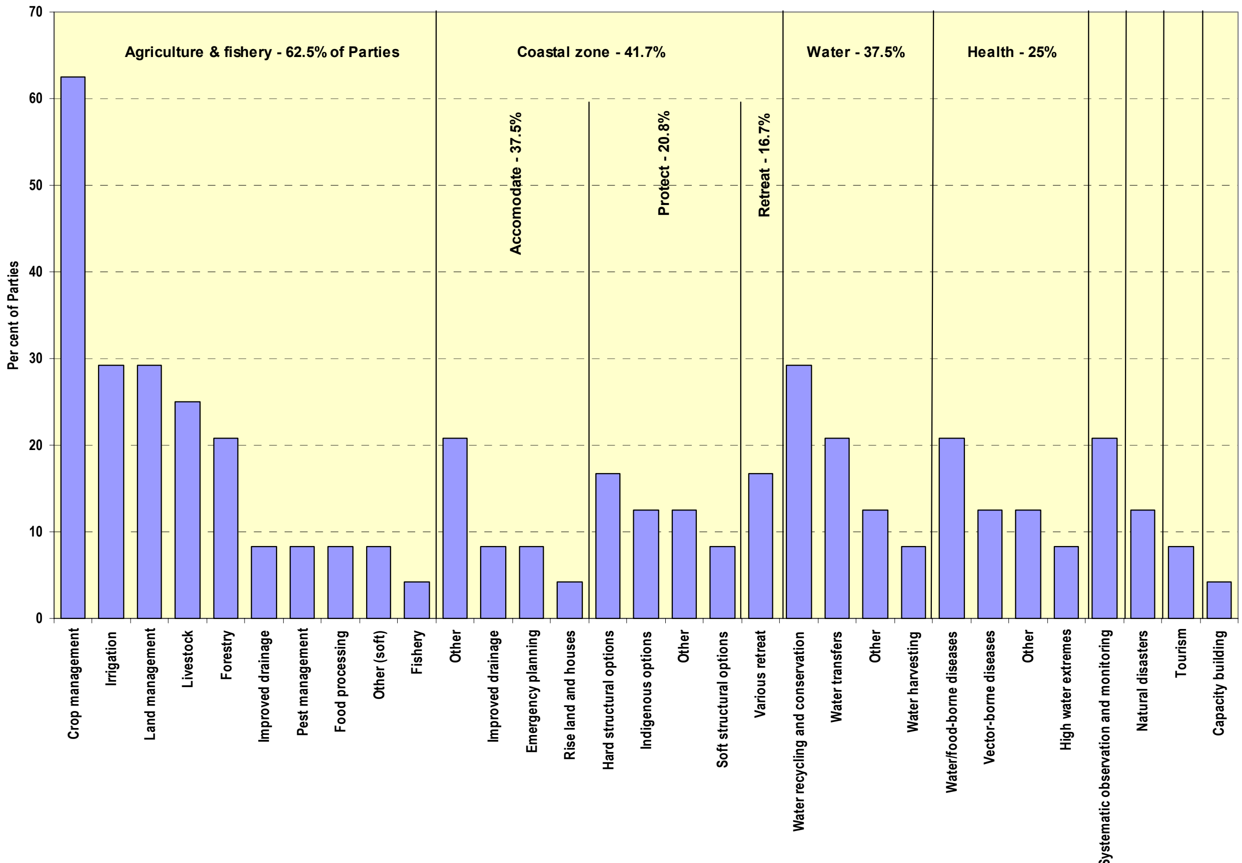
Figure 22. Costs of priority activities identified in national adaptation programmes of action, by sector



Note: National policies include enabling activities other than capacity building such as integration of adaptation into national policies.

512. With regard to technology needs for adaptation, agriculture, fisheries and coastal zones were identified as priority sectors by most Parties, according to the INCs and TNAs. Figure 23 lists the technologies for adaptation which were prioritized in TNAs.

Figure 23. Adaptation sectors, sub-sectors and technologies commonly identified by Parties in technology needs assessments



Source: FCCC/SBSTA/2006/INF.1.

6.2.1. Sectoral analysis

6.2.1.1. Agriculture, forestry and fisheries

513. In agriculture, needs reported by countries in INCs and TNAs relate to crop management (with a clear emphasis on developing and using tolerant/resistant crop varieties), land management and soil and water conservation.

514. In their INC, for the forestry and terrestrial ecosystems sector Parties in their INCs referred to the need for the protection of forest areas, through targeting forests under stress, forest expansion and the preservation of genetic resources and biological diversity and by promoting sustainable forest management. Parties also suggested the need for measures to combat mud torrents, forest fires, pests and diseases.

515. In the fisheries sector, Parties called for improved understanding of climate change effects on the pelagic fishery resources.

516. Technologies identified by countries in TNAs included early warning systems for forest fires, afforestation and reforestation and development of fast-growing species to adapt to new conditions.

517. The cost of NAPA projects in this sector amounts to USD 122 million. Priority activities included developing resistant crop and livestock varieties, promoting diversification of activities for rural communities, advancing food security (seed and food banks), community-based forest management and afforestation projects, improving veterinary services as well as promoting agricultural techniques and irrigation methods to fight salinity in coastal countries. As for fisheries, developing the culture of salt tolerant fish and fish conservation were considered as adaptation options. NAPA projects to protect ecosystems included establishing conservation programmes for terrestrial and marine ecosystems, coral reef restoration and sustainable use of natural resources.

6.2.1.2. Water supply

518. This sector was prioritized in all regions in all sources examined. Adaptation measures identified in INCs include: increasing water supply; promoting water conservation; water demand management; establishing flood and drought monitoring, forecast, control and protection systems; improving watershed management; ensuring long-term integrated water management with land use, cropping pattern, and zoning and improving water monitoring. At the Asian adaptation workshop, representative from Azerbaijan estimated the cost of construction of new water reservoirs and the increase in efficiency of existing ones at USD 305 million[49].

519. Technologies identified in TNAs included those related to water transfers, water recycling and conservation, water harvesting and water management (mostly research and monitoring).

520. Projects reported in NAPAs included protecting the water supply infrastructure, improving management of surface water, constructing storage facilities, water-harvesting, improving watershed management as well as improving water monitoring system and raising community awareness on sustainable use of water resources. Coastal LDCs also submitted projects aimed at slowing down salinization of water stemming from sea-level rise. The indicative total cost of priority activities is about USD 59 million.

6.2.1.3. Coastal zones

521. Measures to protect coastal areas reported in INCs include preventing soil erosion, limiting the development of coastal areas, building coastal infrastructure, restoring beach vegetation, and waste management. This sector was a priority for small island developing states (SIDS) and countries with long coastlines and low-lying areas.

522. For coral reef protection Parties identified the creation of protected areas, sustainable harvesting and fishing practices as necessary measures.

523. As an example of indicative costs, the representative from Sierra Leone reported at the African adaptation workshop that that country would need USD 590 million for the protection of its coastal areas (the cost involves only the design and construction of a seawall and does not include the cost of maintenance). The representative also noted that the cost of protection may be far more than the cost of relocation of the population in the long-term[50].

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[49] Presentation by Azerbaijan at the Asian adaptation workshop: <http://unfccc.int/files/adaptation/adverse_effects_and_response_measures_art_48/application/pdf/verdiyev_water.pdf>

[50] Presentation by Sierra Leone at the African adaptation workshop: <http://unfccc.int/files/adaptation/adverse_effects_and_response_measures_art_48/application/pdf/200609_sierra_leone_coast_paper.pdf>

524. The NAPA priority activities included integrated management of coastal zones, the construction and upgrading of coastal defences and causeways, and mangrove planting. The total cost of the NAPA projects is estimated at USD 13 million.

6.2.1.4. Extreme events

525. Adaptation priorities related to extreme events were highlighted by SIDS and countries with long coastlines and low-lying areas. Insurance as an adaptation policy was prioritized by SIDS, especially for coastal communities and the tourism sector.

526. The main strategies reported in INCs are disaster management, efficient warning systems, and enhancing adaptive capacity through various measures in education and communication. Asian countries emphasized the need for adaptation planning in mountainous regions which are particularly vulnerable to extreme events such as Glacial Lake Outburst Floods. Adaptation measures included an inventory of glacial lakes, hydrological monitoring and forecasting.

527. As an indicative estimate of costs, mainstreaming disaster risk reduction and disaster management in the Pacific region would require USD 3.8 million according to the presentation by the Pacific Islands Forum at the SIDS adaptation expert meeting[51].

528. NAPAs prioritized the installation of early warning systems, measures for flood prevention (e.g., construction of flood dykes) and coping with droughts as well as strengthening of community disaster preparedness and response capacity. The cost of these activities is about USD 29 million.

6.2.1.5. Human health

529. In INCs Parties reported on general options for adaptation such as the improvement of living standards, increase in the awareness about hygiene, and strategies to control disease vectors. Specific health sector measures included vaccination and chemical prevention measures, and monitoring of risk groups, especially in exposed areas.

530. Technology needs for adaptation included disease monitoring, disease prevention/treatment options, access to health services and health alert information systems.

531. Priority actions reported in NAPAs included the development of health infrastructures, increasing immunization against common diseases, various measures to combat the spread of malaria (e.g., by disseminating bed nets) as well as training of and raising awareness among medical personnel. The total cost of NAPA projects on public health is among the lowest across sectors (USD 3.15 million).

[51] Presentation by Dr. Padma Lal: <http://unfccc.int/files/adaptation/adverse_effects_and_response_measures_art_48/application/pdf/200702_pifs_-_ms._padma_lal.pdf.>

6.2.1.6. Infrastructure

532. In their INCs Parties gave special attention to protecting tourism infrastructure as well as the enhancing resilience of urban infrastructure to the impacts of climate change including floods and cyclones. Adaptation options listed in NAPA projects also included development of communications and telecommunications infrastructure and road protection. These activities would cost about USD 5.8 million.

6.3. Capacity-building needs

533. Capacity-building needs cut across all sectors in climate change mitigation and adaptation.

534. On the mitigation side, many Parties reported insufficient human and institutional capabilities and financial resources to prepare mitigation project proposals for funding, including the identification and development of CDM projects. Many Parties mentioned the need for better institutional arrangements to facilitate data collection and analysis, et al indicated the need for further capacity-building and human resource development to prepare national communications. Parties also indicated the need to improve the capabilities of national climate change coordinators and national institutions to manage climate change programmes. Some Parties expressed the need to improve research and systematic observation through capacity-building in scientific research.

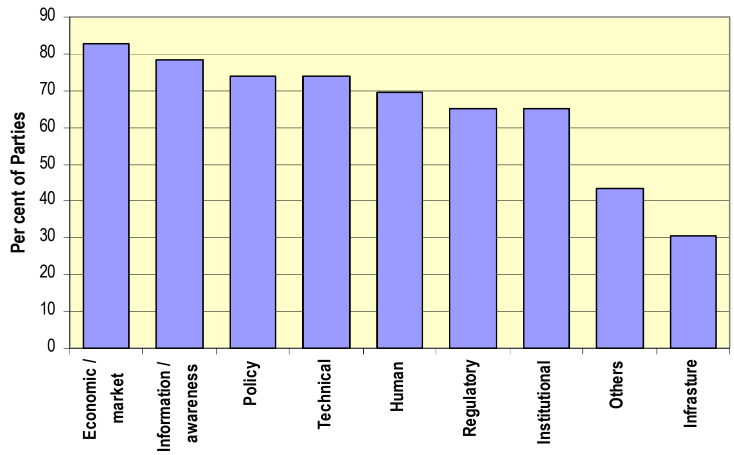
535. In adaptation, many Parties identified the need for capacity-building in human resources development, institutions, methodologies, technology and equipment, and information and networking. Participants of the regional adaptation workshops and expert meeting recognised the need for strengthening environmental and sectoral institutions (in particular, existing regional centres and hydrometeorological networks), establishing regional centres of excellence, and training for stakeholders to aid the development of specialized tools for planning and implementing adaptation activities. Parties also reported insufficient human and institutional capabilities, and financial resources, to formulate and prepare adaptation project proposals for funding. Some Parties expressed the need to improve research and systematic observation through capacity-building in scientific research, particularly in modelling. Overall, participants of the regional adaptation workshops and expert meeting called for a long-term programmatic and comprehensive approach in external support activities to capacity-building.

536. LDCs submitted several NAPA priority activity proposals in capacity-building to address immediate adaptation needs. Those projects included upgrading meteorological services, exploring options for insurance to cope with enhanced climatic disasters, research on drought, flood and saline tolerant varieties of crops, as well as raising awareness and disseminating information to vulnerable communities for emergency preparedness. The indicative total cost of priority activities amounts to USD 35.5 million.

6.4. Barriers to technology transfer

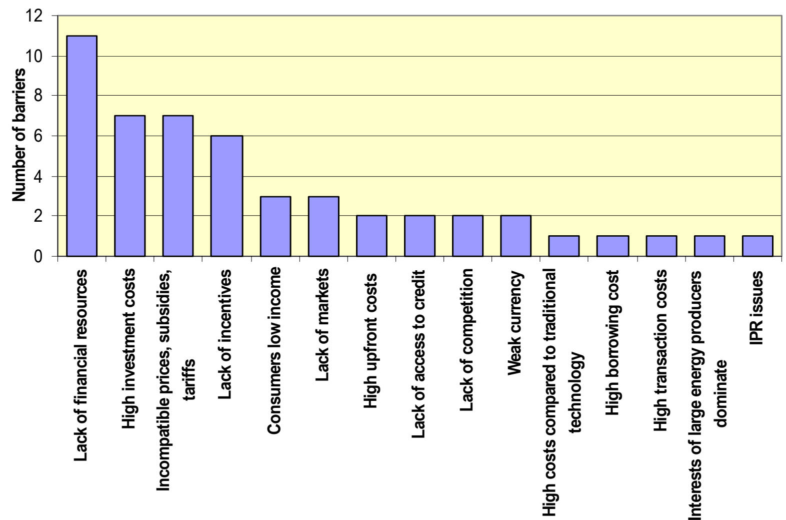
537. Technology transfer plays an important role in addressing climate change. The biggest barrier to technology transfer identified in TNAs and INCs was the lack of financial resources. High investment costs, subsidies and tariffs were also considered important economic/market barriers. Other barriers included insufficient information and awareness as well as those related to policy. The measures identified by Parties to address existing barriers to technology transfer were most commonly placed in the following categories: regulatory and policy options, information and awareness building, and economic and market measures. A detailed summary is provided in figures 24 and 25 below.

Figure 24. Barriers to technology transfer identified by Parties



Source: FCCC/SBSTA/2006/INF.1.

Figure 25. Economic and market barriers to technology transfer



Source: FCCC/SBSTA/2006/INF.1.

6.5. Impact of the implementation of response measures

538. Information from Parties on measures necessary to address risks from the impact of response measures is very limited. They include outcomes of the expert meetings[52] on response measures and economic diversification[53], and submissions by Parties under the agenda item 3 "Analysis of mitigation potentials and ranges of emission reduction objectives of Annex I Parties of the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol"[54]. Four INCs (from Saudi Arabia, Islamic Republic of Iran, South Africa and Singapore) also contain some information on this issue.

[52] Pre-sessional Expert Meeting on Response Measures, Montreal, Canada, 23–24 November, 2005; Pre-sessional Expert Meeting on Economic Diversification, Bonn, 16–17 May 2006. Reports available at: <http://unfccc.int/adaptation/adverse_effects_and_response_measures_art_48/items/2535.php>.

[53] Decision 1/CP.10 paragraph 16.

[54] FCCC/KP/AWG/2007/MISC.1.

539. Two main strategies have been identified under the Convention: insurance and risk management, and economic diversification. The first is believed to serve for short-term goals whereas the second is considered as a long-term solution. Parties recognize a knowledge gap for both options.

540. Participants in the expert meeting[55] on response measures also acknowledged the role of technology transfer. Proposed technological measures include developing low-cost carbon capture and sequestration technologies, promoting renewable energy, development of GHG-friendly energy technologies and implementing energy efficiency measures.

541. During the expert meeting on response measures, the following financial risk management approaches were identified: commodity price hedging; economic shock funds; commodity price insurance; alternative risk transfer; hedge funds; alternative risk financing; structured risk financing mechanisms; effective use of developed captive insurance, credit and political risk coverage; hybrid insurance products; and catastrophe bonds.

542. For economic diversification[56], areas in need of technical and financial support include development of the key infrastructure necessary for economic activity, promotion of FDI, labour-intensive exports (manufacturing and services), access to markets in developed countries, price and ownership reforms in the energy-related industry, capacity-building , and activities and projects that promote synergy between poverty reduction, adaptation and economic diversification.

543. Saudi Arabia reported that it would require assistance from Annex I Parties in the areas of power generation, desalinization of seawater, expansion of petrochemical industry, and education in order to diversify its economy.

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[55] FCCC/SBI/2006/13.
[56] FCCC/SBI/2006/18.

7. POTENTIAL OF CARBON MARKETS

7.1. Introduction

544. This chapter provides an analysis of the carbon market to 2030. The carbon market is the market for GHG emission reductions (credits) and rights to release GHG emissions (allowances).[57]

545. Chapter 7.2 below reviews the existing markets. The largest markets are those established by the Kyoto Protocol and Parties that have emissions limitation commitments under the Protocol. Chapter 7.3 focuses on prospects for those markets in the short term – 2008 to 2012. Chapter 7.4 develops estimates of the potential size of the carbon market in 2030.

7.2. Carbon markets

7.2.1. Existing carbon markets

546. The Kyoto Protocol established emissions limitation commitments for industrialized country (Parties included in Annex B to the Kyoto Protocol or Annex B Parties) Parties for the period 2008 – 2012 and established three mechanisms – the CDM, JI and International Emissions Trading – they can use to help meet those commitments. Most Annex B Parties plan to use emissions trading systems to regulate the emissions of fossil-fired electricity generators and large industrial emitters to help comply with their Kyoto Protocol commitments for the period 2008–2012. Those emissions trading systems are already operational in the Member States of the EU and Norway. The United Kingdom of Great Britain and Northern Ireland has sources that participate in the emissions trading scheme (ETS of the EU) and that participate in a domestic scheme.

547. The EU ETS is by far the largest market in terms of number of participants and trading activity. Trading activity is shifting from allowances that can be used for compliance during Phase I (2005–2007) to allowances that can be used for compliance during Phase II (2008–2012). Credits created by CDM projects (certified emissions reductions or CERs) are the second largest market. The CDM was the first of the three Kyoto mechanisms to be implemented.

548. Emissions trading systems are also operating in Australia (the New South Wales–Australian Capital Territory GHG abatement scheme) and the United States (the Chicago Climate Exchange). The quantities traded in the markets established by these systems and the voluntary market[58] are much smaller than those in the EU ETS and the CDM market.

549. Figure 33 at the end of this sub-chapter (7.2.8) and annex 5, table 18 provide an overview of the existing carbon markets in 2006.

7.2.2. Kyoto Protocol markets

550. Annex B Parties can meet their Kyoto Protocol commitments for the period 2008–2012 through a combination of domestic emission reduction and sink enhancement actions and purchases of various allowances and credits from other countries, through the three Kyoto mechanisms. Each of these mechanisms

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[57] Allowances and credits are also called permits, quotas, offsets, and names unique to the specific market.

[58] For details, see chapter 7.2.8

creates a market for specific units (allowances/credits). These markets are at different stages of development, with the CDM market being the most advanced.

7.2.2.1. Clean development mechanism

551. The CDM enables a project to mitigate climate change in a non-Annex I Party to generate CERs.[59] The CDM was launched in November 2001, the first project was registered about three years later, and the first CERs were issued in October 2005. CERs can be issued for verified emission reductions achieved since 1 January 2000. Rules for some categories of CDM projects were adopted later; afforestation and reforestation projects (December 2003), small-scale afforestation and reforestation projects (December 2004) and programmes of emission reduction activities (December 2005).

552. CDM projects must use an approved methodology and be validated by an accredited designated operational entity (DOE). CERs are issued by the CDM Executive Board only after the emission reductions achieved have been verified and certified by an accredited DOE. Thus a CDM project incurs costs (validation of the project) before it can be registered, and further costs (certification of the emission reductions) before CERs are issued[60] .

Annual emissions reductions and revenue from CERs

553. To help defray the cost of implementing the project, proponents often agree to sell some of the expected CERs before the project has been implemented. Capoor and Ambrosi (2007) indicate that expected CERs from projects at an early stage command 2006USD 10.40–12.40, registered project transactions command close to 2006USD 14.70 and issued CERs are trading at 2006USD 17.75. The lowest prices reflect risks that the proposed project might not be registered and might not deliver the expected emission reductions.[61] Once a project is registered the uncertainty is limited to the timing and size of the emission reductions. Once CERs are issued, delivery to an Annex B Party registry where they can be used for compliance is the only uncertainty and they therefore command the highest prices.[62]

554. At the end of 2006 the 1,468 projects in the CDM pipeline were expected to yield annual emission reductions of 251 Mt CO_2 eq.[63] Experience to-date suggests that CDM projects achieve about 85 per cent of the projected emission reductions (Fenhann, 2007).

555. Figures 26 and 27 provide the sectoral distribution of projects under the CDM pipeline and related emission reductions.

556. Because the CDM is still in its infancy, the number of projects registered and the projects entering the CDM pipeline (having a public project design document) are used as measures of activity.[64] The distribution

[59] Afforestation and reforestation projects under the CDM can generate temporary certified emission reduction (tCERs) or long term certified emission reduction (lCERs), which have limited lifetimes. For ease of exposition CERs will include tCERs and lCERs unless explicitly stated.

[60] This staged approach to issuing CERs increases environmental integrity and reduces financial risks for project proponents.

[61] In each, the price also depends on how the risks are shared between the buyer and the seller, through penalty provisions or requirements to replace CERs that could not be delivered.

[62] CERs issued are delivered to the buyer in a special account in the CDM registry by the CDM Executive Board, but they cannot be transferred to an account in an Annex B Party national registry until the International Transaction Log (see chapter 2.2.2) is operational.

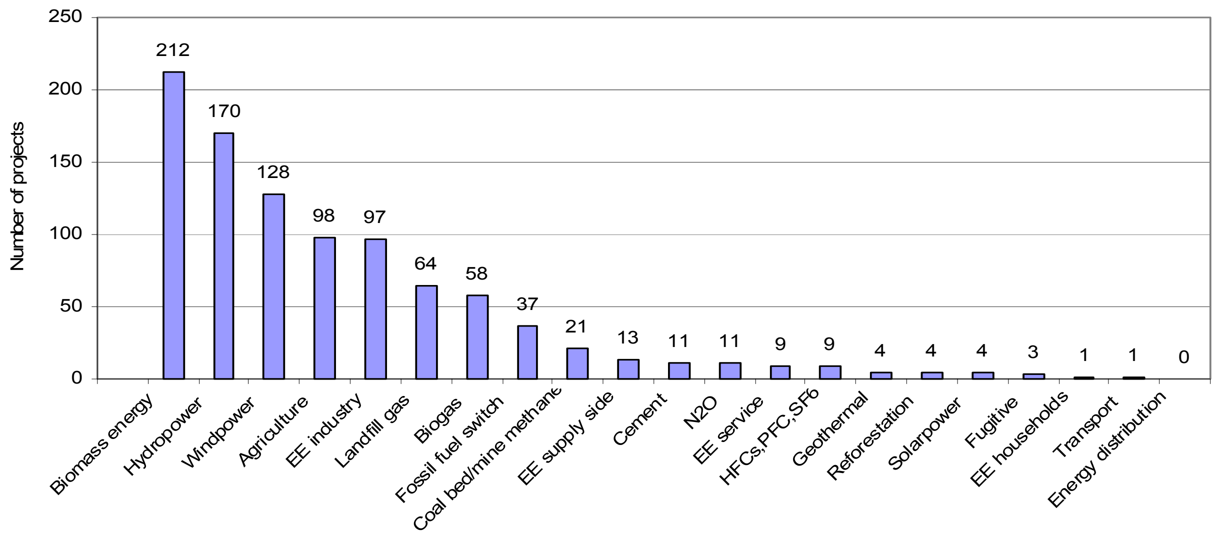
[63] The number of projects in the pipeline at the start of the year was 513, with estimated annual emission reductions of 107 Mt CO2 eq.

[64] Almost all projects that enter the pipeline get registered. Only 10 of the 1,478 projects to enter the pipeline by the end of 2006 had been rejected or withdrawn.

of projects registered and those that entered the pipeline during 2006 are shown in annex 5, table 19 together with the estimated annual emission reductions, and potential revenue from the sale of the CERs (see figures 28 and 29).

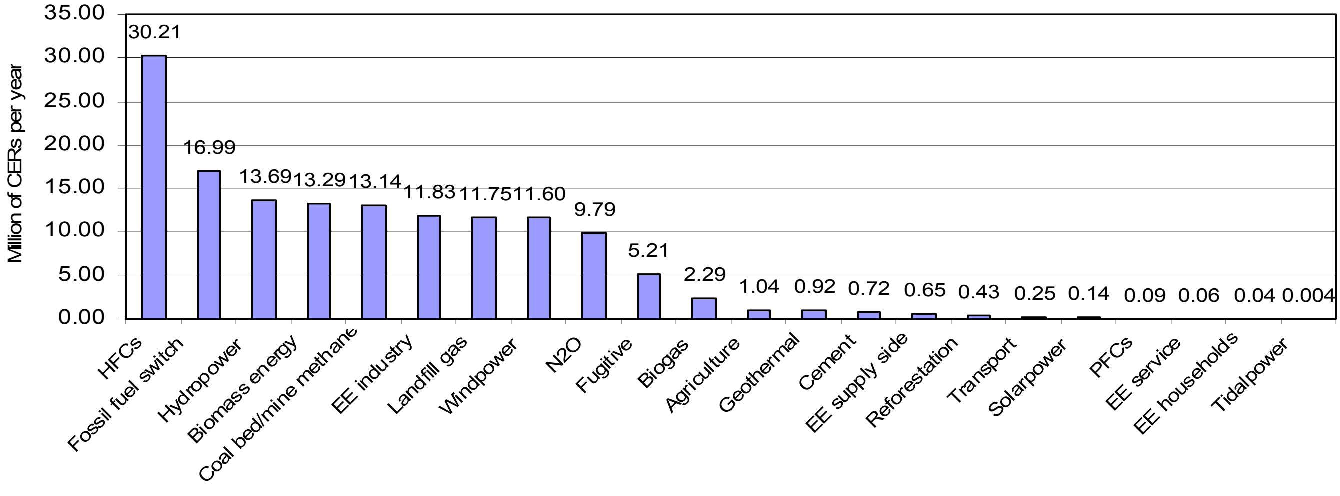
557. The estimated annual emission reduction from the projects registered during 2006 is 88 Mt CO_2 eq and from projects that entered the pipeline during 2006 is 144 Mt CO_2 eq. The estimated revenue from the sale of CERs generated by the CDM projects registered during 2006 is USD 1–1.5 billion per year and the estimated revenue from the sale of the CERs generated by the CDM projects that entered the pipeline during 2006 is USD 1 billion higher. Capoor and Ambrosi report transactions for about 450 Mt CO_2 eq in this market during 2006 at an average price of about USD 10.70 per t CO_2 eq. Thus the transactions averaged about three to five years of projected emission reductions for the new projects.

Figure 26. Projects that entered the clean development mechanism pipeline in 2006, by project type/sector



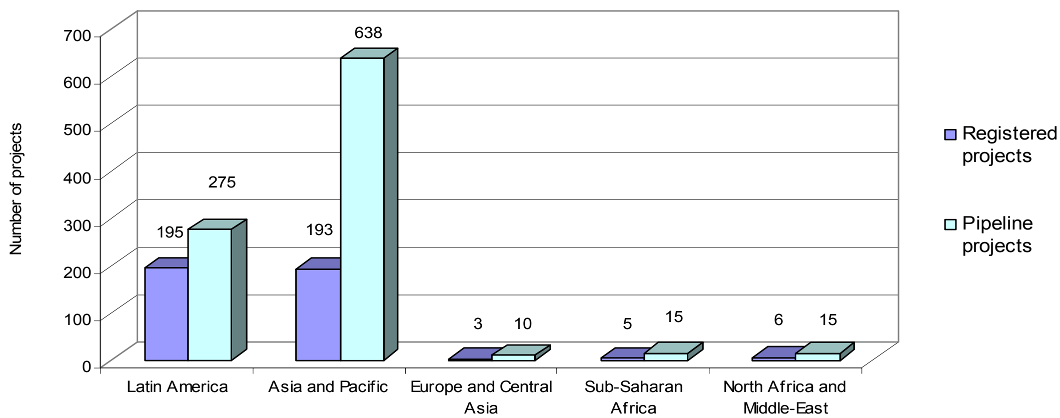
EE = energy efficiency

Figure 27. Estimated certified emission reductions from projects that entered the clean development mechanism pipeline in 2006, by project type/sector



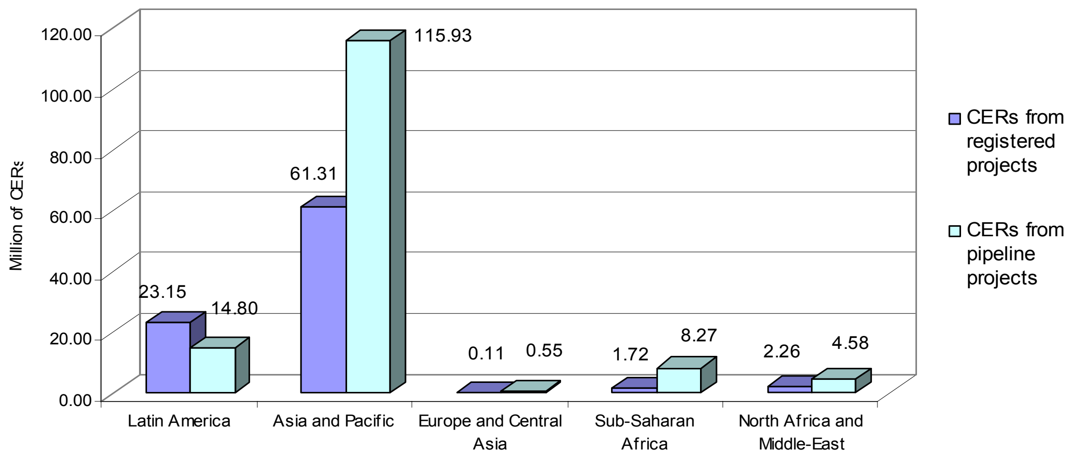
EE = energy efficiency

Figure 28. Regional distribution of clean development mechanism project activities registered and in the pipeline in 2006



Note: Central Asia includes Kyrgyzstan, Tajikistan and Uzbekistan and that are not considered under Asia and Pacific.

Figure 29. Volume of certified emission reductions from clean development mechanism project activities registered and in the pipeline in 2006, by region



Note: Central Asia includes Kyrgyzstan, Tajikistan and Uzbekistan and that are not considered under Asia and Pacific.

558. China dominates the CDM market, as it is the source of over 53 per cent of the estimated annual emission reductions of the projects that entered the pipeline during 2006. Capoor and Ambrosi note that, as the dominant supplier in the CDM market, China's informal policy of requiring a minimum acceptable price (around USD 10.40–11.70 or EUR 8–9 in 2006) before providing approval to projects had a significant stabilizing impact on the market price.

Annual Investment in CDM projects

559. The capital[65] that is, or will be, invested in CDM projects registered during 2006 is estimated at about USD 7 billion whereas the capital that is, or will be, invested in projects that entered the CDM pipeline during 2006 is estimated at over 2006USD 26.4 billion (annex 5, table 19).[66]

560. Of the USD 26.4 billion approximately 50 per cent represents capital invested in unilateral projects by host country project proponents. Unilateral projects are these for which the project proponent in the developing country Party bears all costs before selling the CERs. At the end of 2006, about 60 per cent of the projects, representing about 33 per cent of the projected annual emission reductions, were unilateral projects.[67] India is home to the most unilateral projects (33 per cent of projected annual emission reductions of projects in the pipeline at the end of 2006), followed by China (20 per cent), Brazil (11 per cent) and Mexico (6 per cent).

561. Over 80–90 per cent of the capital, USD 5.7 billion for registered projects and almost USD 24 billion for projects that entered the pipeline, went into renewable energy and energy efficiency projects. Although these projects represent only about 20 per cent of emission reductions, as can be seen in annex 5, table 20, they have high capital costs per unit of emission reductions.

[65] Capital costs as reported in PDDs (data from 250 projects and from the World Bank).
[66] Many of the projects that entered the pipeline during 2006 will not have been completed by the end of the year, so some of the investment will occur during 2007 and 2008. For further information, see Ellis and Kamel, 2007.
[67] These figures indicate that unilateral projects are about half the size of the average CDM project.

562. The estimated investment of USD 5.7 billion for CDM renewable energy and energy efficiency projects registered during 2006 is roughly triple the ODA support for energy policy and renewable energy projects in the same countries – about USD 2 billion (annex 5, table 20). It is almost as much as the private investment in renewable energy and energy efficiency (2006USD 6.5 billion) in the same countries.[68] China and India receive most of the CDM investment and private investment.

563. The capital invested in afforestation and reforestation has been very low. Only three afforestation and reforestation projects were among the 1,468 projects in the pipeline at the end of 2006. The recent authorization of such projects is part of the explanation. But the attractiveness of these projects is reduced by uncertainty stemming from the temporary nature of temporary CERs (tCERs) and long term CERs (lCERs) and the fact that installations in the EU ETS can use CERs, but not tCERs or lCERs, for compliance.

564. The revenue earned from the emission reductions credits has very different impacts on the profitability of different types of projects. Table 54 shows the effect of different CER prices on the profitability, measured by the internal rate of return, of HFC-23, methane from landfill, and renewable energy projects. The sale of CERs makes HFC-23 projects, which have a low capital cost per unit of emissions reduced, much more profitable. In contrast, the sale of CERs has little effect on the profitability of renewable energy projects, which have a high capital cost per unit of emissions reduced. Thus the carbon market alone is unlikely to provide a significant stimulus to the deployment of renewables in developing countries.

[68] This does not mean that most private investment in renewable energy and energy efficiency in developing countries took the form of CDM projects. The investment for CDM projects registered during 2006 may not have been made during 2006.

Table 54. Incremental impact of the CER price on the internal rate of return (IRR) of the project (percentage)

Renewable energy IRR						
Purchase period	Five years (2008 to 2012)	Seven years	Ten years	Fourteen years	Twenty-one years	Impact per unit (in USD)
CER prices (in USD)						
5	0.5	0.6	0.8	1.0	1.2	3.16/MWh
10	1.0	1.4	1.7	2.1	2.3	6.33/MWh
15	1.6	2.1	2.7	3.1	3.3	9.49/MWh
20	2.2	2.9	3.6	4.1	4.5	12.65/MWh
Solid waste IRR						
Purchase period	Five years (2008 to 2012)	Seven years	Ten years	Fourteen years	Twenty-one years	Impact per unit (in USD)
tSW (ton solid waste)	tSW	tSW	tSW	tSW	tSW	
CER prices (in USD)						
5	17.9	24.1	29.2	31.7	32.8	41/MWh
10	52.3	59.1	62.4	63.5	63.8	82/MWh
15	88.2	93.3	95.4	95.9	96.0	124/MWh
20	123.7	127.3	128.6	128.8	128.9	165/MWh
HFC/23 IRR*						
Purchase period	Five years (2008 to 2012)	Seven years	Ten years	Fourteen years	Twenty-one years	
CER prices (in USD)						
5	110.8	112.3	112.7	112.7	112.7	
10	176.7	177.3	177.4	177.4	177.4	
15	227.3	227.6	227.7	227.7	227.7	
20	270.0	270.2	270.2	270.2	270.2	

Source: World Bank.
Note: * Sixty-five per cent tax applied on revenue from sale of CERs.

Technology transfer as identified in CDM project design documents (CDM-PDDs)

565. Roughly one-third of all CDM projects accounting for almost two thirds of the annual emission reductions in 2006, identify some technology transfer in their project design documents (CDM-PDDs)[69] (Haites, et al., 2006). Annex 5, table 21 shows that technology transfer varies widely across project types: cement, coalbed/coalmine methane, fossil fuel switching, and transport involve very little technology transfer whereas almost all energy supply, household energy efficiency and solar projects claim technology transfer. Technology transfer is more common for larger projects and projects with foreign participants. Equipment transfer only is more common for larger projects whereas smaller projects involve transfers of both equipment and knowledge or knowledge only.

[69] See chapter A.4.3 of the CDM-PDD, available at: <http://cdm.unfccc.int/Reference/Documents/Guidel_Pdd_most_recent/English/Guidelines_CDMPDD_NM.pdf>

566. Statistical analyses reported by Haites, et al. (2006) find that the host country has a significant impact on technology transfer for 12 of the 23 countries analysed. Technology transfer was found to be more likely for projects in China, Ecuador, Guatemala, Honduras, Malaysia, Mexico, Peru, South Africa, Thailand and Viet Nam and less likely for projects in Chile and India. The reasons for the higher or lower level of technology transfer are not given.[70] Since the host country must approve each project, it can influence the extent of technology transfer involved in its CDM projects.

Secondary market[71]

567. Trades of CERs issued do not involve project or registration risks. The higher price, USD 17.75 per t CO_2 eq, reflects the absence of these risks. The first CERs were issued during 2005 and many of these had already been purchased (through forward contracts). The volume traded is approximately equal to the quantity of CERs issued.

568. The secondary market has been growing rapidly and this is expected to continue as more CERs are issued and as the international transaction log links the CDM and Annex B Party national registries in 2007.[72]

569. As the quantity of CERs issued rises, exchanges are beginning to trade them. This will facilitate trades of CERs on an exchange, with the assistance of a broker, or directly between the buyer and seller.

7.2.2.2. Joint Implementation

570. Joint implementation (JI) enables a project to mitigate climate change in an Annex B Party to generate emission reduction units (ERUs) 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 (JISC) (Track 2). The JISC was established in December 2005 and no national track 1 process had been established by the end of 2006, therefore JI is just starting.[73]

571. At the end of 2006 there were 146 JI projects in the pipeline with expected annual emission reductions of 25 Mt CO_2 eq[74] (see figures 30 and 31). Of these, 53 projects with estimated annual reductions of 15 Mt CO_2 eq entered the pipeline during 2006. No JI projects had yet been approved. Capoor and Ambrosi report JI transactions totaling 16 Mt CO_2 eq at an average price of USD 8.80 per t CO_2 eq. In effect, the purchases were equivalent to the expected annual emission reductions of the projects that entered the pipeline during the year.

572. ERUs are equivalent to CERs for purposes of compliance with Annex B Party commitments under the Kyoto Protocol and for compliance use by industry during Phase II of the EU ETS. Thus the price of ERUs is expected to be very similar to that of CERs. During 2006 the price of ERUs was lower than the primary market[75] price for CERs because the regulatory structure for JI was still being developed, and therefore the risks were higher.

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[70] The results are based on a statistical analysis which cannot explain the causes. The analysis includes project size and type therefore the result is not due to the project mix of the different countries. Other analyses indicate that host country population, GDP and per capita GDP are not statistically significant.

[71] The secondary market is the resale of CERs that have already been purchased.

[72] Transfers of issued CERs are governed by the rules for international emissions trading. Annex B Parties must meet specified conditions before they are eligible to participate in international emissions trading.

[73] Contracts to purchase ERUs generated by projects that expect to be approved as JI projects have been announced since 2002.

[74] A current list of JI projects is available at: http://cdmpipeline.org/.

[75] The primary market is the initial purchase of CERs or ERUs.

573. The distribution by country of the 53 JI projects that entered the pipeline during 2006 is shown in annex 5, table 22 together with the estimated annual emission reductions, potential revenue from the sale of ERUs and estimated capital invested. The Russian Federation dominates the market, being the source of over 80 per cent of the estimated annual emission reductions of the new projects in 2006. The Russian Federation's dominance of the supply of ERUs does not have much impact on the overall market price because ERUs and CERs are substitutes and the JI emission reductions are much smaller than those for the CDM.

574. The estimated revenue from the sale of the ERUs generated by the JI projects that entered the pipeline during 2006 is 2006USD 0.1–0.3 billion per year. Applying the same estimation method for investment by project type for CDM projects to the JI projects that entered the pipeline during 2006 yields an estimated capital investment for JI projects of 2006USD 6 billion.

575. Only about 30 per cent of the JI investment, almost USD 2 billion, was for renewable energy and energy efficiency projects. This compares with 2006USD 4.5 billion of private investment in renewable energy and energy efficiency in the same countries during 2005 (see annex 5, table 22). However, this comparison is distorted by Germany, which accounts for over 90 per cent of the total private investment in renewable energy and energy efficiency in these countries. In all of the other countries renewable energy and energy efficiency JI projects generate more investment. The only JI host country to receive ODA for renewable energy and energy efficiency during 2005 was Ukraine, which received USD 143 million.

Figure 30. Number of joint implementation projects that entered the pipeline in 2006, by type of project/sector

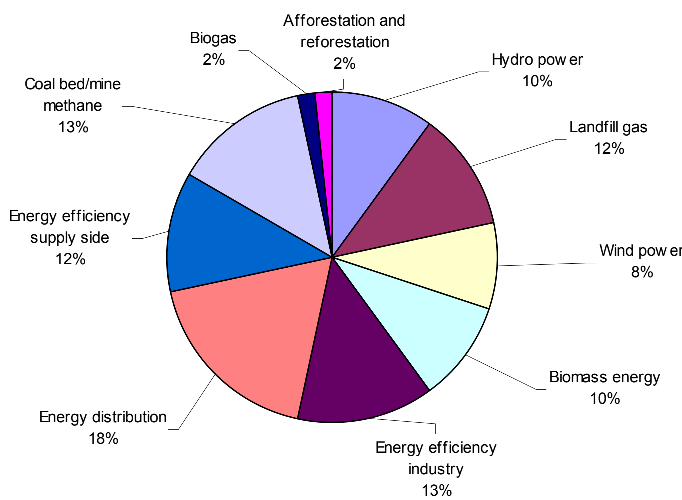
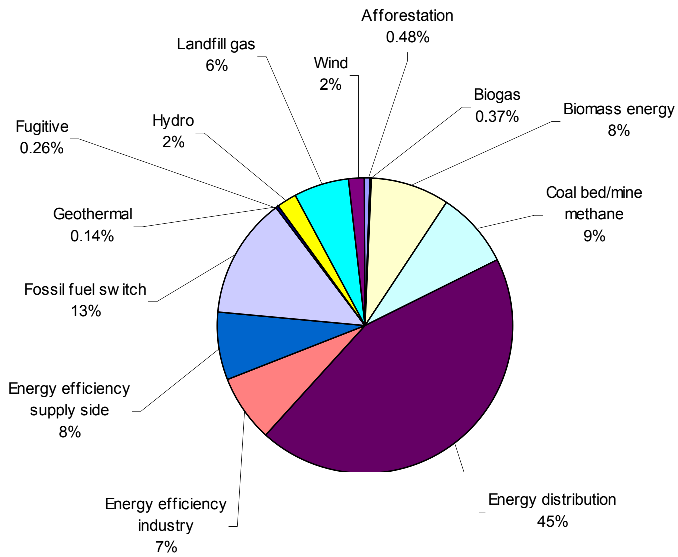


Figure 31. Annual emission reduction units from joint implementation projects that entered the pipeline in 2006, by type of project/sector



7.2.2.3. International emissions trading

576. International emissions trading allows an Annex B Party to transfer some of its allowable emissions to another Annex B Party. This is enacted through transferring Kyoto units (assigned amount units (AAUs), ERUs, CERs, lCERs, tCERs and removal units (RMUs)), from one Party's national registry to that of another, and may include units originally issued by that Party or any units acquired earlier from another Party. Some Parties have allowed the participation of companies and other entities in trading by establishing national or regional trading schemes.

7.2.3. European Union emissions trading scheme

577. Almost all EU Member States are Annex B Parties and hence have emission limitation commitments for 2008–2012. To help meet those commitments, each Member State is required to implement an ETS covering CO_2 emissions by electricity generators and specified industrial sources. Allowances issued by a Member State can be used for compliance by an installation in any Member State.

578. The ETS is being implemented in phases: from 2005 to 2007, and from 2008 to 2012 and in five-year periods thereafter. To facilitate compliance with Kyoto Protocol commitments, surplus Phase I allowances cannot, with very limited exceptions, be carried over to Phase II.[76] Beginning in 2008, surplus allowances can be carried over indefinitely with no restrictions. During Phase I, installations can use CERs, but not tCERs or lCERs, for compliance. During Phase II, installations can also use ERUs for compliance.

[76] If installations can bank surplus Phase 1 allowances for use after 2007, their emission reductions during the period 2008–2012 can be smaller. That would make compliance with the Kyoto Protocol commitments for 2008–2012 more difficult.

7.2.3.1. Phase I: 2005–2007

579. During 2005 the ETS covered about 10,500 installations responsible for about 45 per cent of the EU's CO_2 emissions,[77] and approximately 2,088 million allowances were issued. Actual emissions were about 2,007 Mt CO_2, leaving about 80 million surplus allowances (Ellerman and Buchner, 2006). The 2005 emissions data, released in April 2006, confirmed the likelihood of a surplus of Phase I allowances causing the price to drop from over EUR 30 to EUR 12 and to decline to EUR 4 by the end of the year (see figure 32).

580. During 2006 actual emissions increased to 2,028 Mt CO_2, but that still left a surplus of about 61 million allowances for the year (Point Carbon, 2007b). With only one year remaining, this confirmed that a surplus of allowances was virtually certain for Phase I. Since Phase I allowances cannot be carried over for use in Phase II, surplus allowances at the end of the compliance period for 2007 will have no value. As a result, the price of Phase I allowances continued to decline, reaching EUR 0.25 on 1 June 2007.

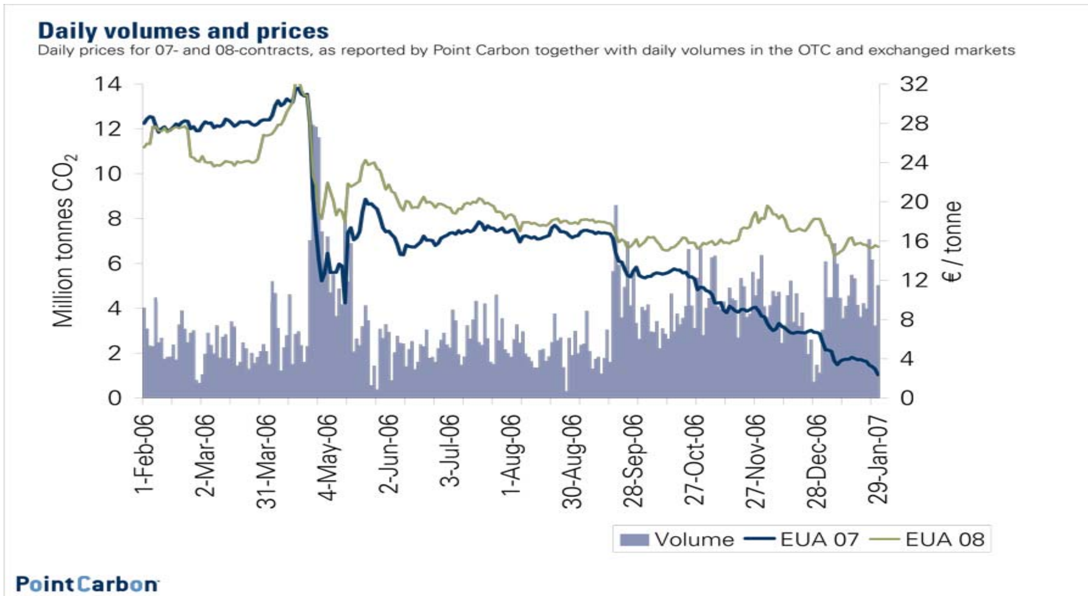
581. Was the surplus due to allocation of too many allowances or due to larger than anticipated emission reductions? Ellerman and Buchner (2006) estimate that emissions were reduced by between 50 and 200 Mt CO_2 and that up to 100 million excess allowances were issued. They conclude that at least part of the price decline is due to the excess allocation, but over half, and perhaps all, of the surplus is due to emission reductions. Responses to surveys conducted by Point Carbon suggest that 65–75 per cent of installations have implemented some emission reduction measures, but that the reductions are not large (Point Carbon, 2007b).

582. As can be seen in figure 32, with the decline in the price of Phase I allowances, trading started to shift to Phase II allowances.[78] Of the 1,101 million allowances traded during 2006, about 820,000 were Phase I allowances and 220,000 were Phase II allowances. Phase I allowances traded at prices ranging between EUR 4 and EUR 30 whereas the Phase II allowances traded at prices between EUR 16 and EUR 30.

[77] New installations increased the total allocation for 2006 and 2007. In addition, Bulgaria and Romania joined the ETS when they entered the European Union on 1 January 2007.

[78] Phase II allowances had not yet been issued. These trades are contracts to deliver Phase II allowances in December 2008.

Figure 32. EU allowance prices and traded volumes, February 2006 – January 2007



Source: Point Carbon, 2007c.

7.2.3.2. Phase II: 2008–2012

583. As shown in figure 32, the price of Phase II allowances remained between EUR 16 and EUR 20, whereas the price of Phase I allowances declined, reflecting the expectation that allocations for Phase II would be more stringent. Based on national allocation plans approved through 15 May 2007, Phase II allocations will be about 8 per cent lower than in Phase I. As a result, a shortage of Phase II allowances expected, which has kept the price of Phase II allowances over EUR 20 through 18 May 2007.

584. Installations will be able to use CERs and ERUs for compliance in Phase II.[79] The limits established by the 21 national allocation plans approved by 18 May 2007 would allow the use of over 200 million CERs or ERUs per year.[80] If the price of CERs or ERUs is lower than the price of Phase II allowances, an installation can profit by selling some of its allowances and buying as many CERs or ERUs as it can use for compliance.[81] Given this incentive, the use of CERs and ERUs could approach the overall limit even though the quantity each installation can use is limited. As a result, the prices of Phase II European Union allowances (EUAs) and those of CERs and ERUs in the secondary market are expected to converge, but not necessarily become equal.

[79] In Phase I CERs can be used for compliance, but this option is unlikely to be used because the price of allowances is much lower than the price of CERs.

[80] Point Carbon, *Carbon Market Europe*, 18 May 2007a estimates the limit as 217.23 million per year relative to emission caps of 1,859.27 Mt CO_2.

[81] Actual emissions are expected to exceed the EUA allocation by more than the overall limit on the use of CERs and ERUs. Therefore CERs and ERUs are expected to be purchased for compliance during Phase II. Currently there are no restrictions on carry over of EUAs after 2008, but there are limits on carry over of both CERs and ERUs, therefore CERs and ERUs should be used before EUAs for compliance. If the price of CERs or ERUs is lower, net of transaction costs, than the price of EUAs it will be profitable for an installation to sell (or bank) surplus EUAs and purchase CERs or ERUs for compliance.

7.2.4. Norway

585. Norway implemented an emissions trading system, the design of which is very similar to that of the EU ETS on 1 January 2005 for 51 onshore installations with annual emissions of about seven Mt CO_2. Actual emissions were lower than the allocations for both 2005 and 2006. There has been little trading. Prices are not disclosed, but were probably equal to or lower than those for Phase I EU allowances. On 1 January 2008 Norway's ETS is expected to be integrated into the EU ETS, with coverage expanded to 104 installations with annual emissions of about 23 Mt CO_2.

7.2.5. United Kingdom of Great Britain and Northern Ireland

586. At the start of 2002 the United Kingdom launched an emissions trading system with two components – Direct Entry and Climate Change Levy Agreements (CCLA).[82]

587. Direct Entry participants submitted bids for declining absolute emission targets for the years 2002 through 2006 in return for incentive payments. The 32 successful bidders promised emission reductions of 20.78 Mt CO_2 eq over the five years.[83] Actual allocations declined from slightly over 30 Mt CO_2 eq for 2002 to just over 20 Mt CO_2 eq for 2005 (Enviros, 2006). The Direct Entry component of the scheme concluded at the end of 2006 and many of those participants are now covered by the United Kingdom component of the EU ETS.

588. CLAS with energy efficiency improvement or GHG emission reduction targets for two-year intervals through 2012 were negotiated with roughly 10,000 establishments in 43 energy-intensive sectors. Compliance with the target reduces its climate change levy, an energy tax, for the period by 80 per cent. CCLA participants can earn tradable allowances for the difference between their target and their actual CO_2 emissions.

589. The number of trades peaks every two years in advance of the compliance deadline for CCLA participants. Direct Entry participants have annual compliance deadlines and are, on average, much larger emitters so the quantity traded has an annual peak. The price increased from GBP 5 in April 2002 to GBP 12 in September 2002, and then fell to GBP 4 by the end of the year, and has remained between GBP 2 and GBP 4 since. The price spike was due to a limited supply of allowances, caused by administrative delays, at the time of its first compliance deadline.

7.2.6. New South Wales–Australian Capital Territory Greenhouse Gas Abatement Scheme

590. This scheme establishes a cap on GHG emissions associated with electricity consumption in New South Wales, and since 1 January 2005, the ACT.[84] Electricity retailers and industries supplied directly by the grid (33 firms) must purchase GHG abatement certificates equal to the emissions associated with the electricity they sell/use. Abatement certificates can be generated by accredited projects that reduce emissions or enhance removal of GHG. During 2005 about 10 million certificates were generated by 206 accredited

[82] During the first four years of the scheme, Direct Entry participants received about 96 per cent of the 122 million allowances allocated (Enviros, 2006).

[83] Establishments not covered by a CCLA were eligible to offer emission reduction commitments in return for incentive payments through an auction. Bids by 32 firms promised emission reductions of 11.88 mt CO2 eq over the five years. At the end of 2004 six of the firms agreed to revised commitments, bringing the total emission reduction to 20.78 mt CO2 eq.

[84] See also IPART, 2006.

projects and about eight million were used for compliance. About 20 million certificates were traded during 2006 at an average price of USD 11.25.[85] This price is close to the non-compliance penalty.[86]

7.2.7. Chicago Climate Exchange

591. Members of the Chicago Climate Exchange (CCX) made a voluntary, legally-binding commitment to reduce their GHG emissions by 1 per cent per year from their 1998 to 2001 baseline, a 4 per cent reduction during 2006.[87] The members had an overall emissions limit of 221 Mt CO_2 eq for 2006.[88] The CCX transacted 10.3 Mt CO_2 in 2006 at an average price of about USD 3.80.[89]

7.2.8. Voluntary market

592. Many companies and non-profit organizations offer to offset emissions from vehicle use, air travel, and other energy consumption for individuals and entities not subject to a regulatory obligation to reduce their emissions (Bayon et al, 2007). The integrity of the offsets offered varies significantly and is determined by:

- Additionality of the project (making sure the project is not claiming reductions that would already occur);
- Actual existence of the emission reductions (making sure the project activity is monitored and the emission reductions claimed are verified);
- Exclusion of double-counting (making sure the same emission reductions are not sold to several buyers);
- Permanence of the reduction, and;
- Existence of community benefits.

593. To address these issues a voluntary standard for emission reductions is being developed and regulations are being considered in some countries.

594. The voluntary market has existed for more than a decade, but grown significantly since 2003 to 2004. Bellassen and Leget report that prices range from USD 1–78 per t CO_2 eq. Capoor and Ambrosi estimate the size of the market during 2006 at about 20 million tonnes with an average price of about USD 10 per t CO_2 eq. Hamilton, et al. (2007) estimate that 13.4 Mt CO_2 eq were traded at an average price of USD 4.10 during 2006 for a total value of USD 54.9 million.

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[85] See in annex 5, table 18.

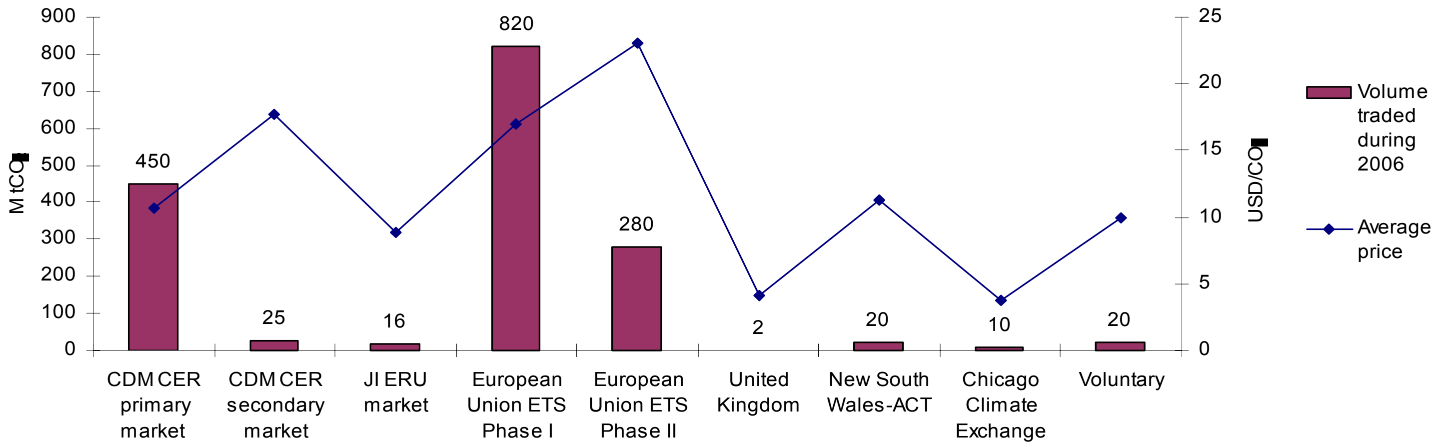
[86] The average price of USD 11.25 is equal to about AUD 14.95. The non-compliance penalty is AUD 11 which is not tax deductible. The cost of purchasing certificates is a tax deductible business expense. Given the 30 per cent corporate income tax rate, the penalty of Australia AUD 11 is equivalent to a purchase price of AUD 15.70. This is only 5 per cent above the average price.

[87] CCX Members who emit above the targets comply by purchasing CCX Carbon Financial Instrument™ (CFI™) contracts.

[88] About 33 of the 237 members have emissions limitation commitments. Their actual emissions during 2005 were about 197 Mt CO_2 eq and over 70 Mt CO_2 eq were banked from previous years.

[89] When trading began in 2003 the price was about USD 1 per t CO_2. The price remained roughly constant for about a year and then rose to USD 1.70 per t CO_2 at the end of 2004 and remained at that level through 2005. During 2006 the price rose to USD 4 per t CO_2.

Figure 33. Trade volumes and prices in the world's carbon markets in 2006



7.2.9. Links among emissions trading systems

595. Although there are a number of different carbon markets, they can be, and to a limited extent are, linked. At present the trading systems are linked as follows:

- The national systems that comprise the EU ETS are fully linked with each other and all allow the use of CERs, but not tCERs or lCERs, and, beginning in 2008 to use of ERUs;
- Norway's ETS allows the use of Phase I EU allowances and CERs, but not tCERs or lCERs, for the period 2005–2007. It is expected to become part of the EU ETS in 2008;
- The NSW–ACT greenhouse gas abatement scheme has no links to other systems;
- The United Kingdom domestic scheme has no links to other systems;
- The CCX allows the use of CERs and EU allowances for compliance, but suspended imports of Phase I EU allowances in December 2006.

596. The surplus of Phase I allowances in the EU ETS means that participants will not use CERs for compliance during the period 2005–2007. During Phase II of the EU ETS participants are expected to use CERs and ERUs for compliance, which should cause the prices of CERs, ERUs and Phase II allowances to converge.

7.2.10. Carbon funds

597. Carbon funds are a significant feature of the carbon market, especially the market for CERs and ERUs. A carbon fund is a vehicle to pool investments in the carbon market. The first fund, the Prototype Carbon Fund (PCF), was established by the World Bank in 1999. Its investors, national governments and private firms from several Annex B Parties, provided capital of USD 180 million. The PCF played an important role in the development of the CDM and JI.

598. The number of funds has grown rapidly from three, with capital of EUR 351 million in 2000, to 54, with capital of over EUR 6,250 million early in 2007 (ICF International, 2007). Investors include Annex B governments (24 per cent), private firms (29 per cent) or both (47 per cent) (ICF International, 2007). Their structure and role vary. Some focus exclusively on purchasing CERs and/or ERUs for compliance use by

their investors. Others purchase allowances and credits and hope to resell them at a higher price. More recent funds take equity stakes in emission reduction projects and provide both financial returns and credits to their investors.

599. The importance of carbon funds in the carbon market is illustrated in annex 5, table 23. It shows the annual increase in secured capital relative to the market value of transactions for verified emission reductions for Kyoto compliance and the voluntary market. The capital contributed in 2003 was almost double that for previous years as the pace of CDM project development accelerated. Entry into force of the Kyoto Protocol in 2006 brought another doubling of the capital contributed.

600. From 2000 through 2004 the annual increase in contributed capital exceeded the value of the market transactions by a large margin. During the past two years the value of the transactions has exceeded the capital contributed to carbon funds, suggesting that the diversification and expertise provided by the funds has become less important for project development as the market has grown.

601. It is not possible to determine the quantities of CERs and ERUs that have been purchased by carbon funds because virtually all funds keep this information confidential for competitive reasons.

7.3. Prospects for the carbon market for the period 2008–2012

602. The Kyoto Protocol mechanisms (CDM, JI and international emissions trading) and the emissions trading systems established by Annex B Parties (EU ETS) will be the dominant carbon markets for the 2008 to 2012 period. They are already the largest markets by far. The EU ETS is expected to expand to include Norway, Iceland and Liechtenstein in 2008, to link with a Swiss emissions trading system, incorporate Turkey if it joins the EU, and to cover aviation beginning in 2011.

603. The Regional Greenhouse Gas Initiative (RGGI), covering the CO_2 emissions of electricity generating units in 10 states in the northeastern United States, is scheduled to begin in 2009. Canada has announced a system for 2010. Proposals for a national emissions trading system are under consideration in Australia. New Zealand is working on the design of a system. And various regional and national systems have been proposed for the United States. Those systems are unlikely to begin operation before 2011.

604. Since the EU ETS allows Kyoto Protocol mechanisms to be used for compliance, this chapter focuses on the market for Kyoto Protocol compliance units. Capoor and Ambrosi conclude that the current projected demand–supply balance, excluding Canada, implies that the price of CERs/ERUs is likely to help set the market equilibrium price for EUAs during this period (Capoor and Ambrosi, 2007). The analysis considers 2010 as a representative year for the 2008 to 2012 compliance period.

7.3.1. Demand

605. Annex B Parties can use Kyoto Protocol units to help meet their commitments. The demand for these units is the difference between the actual emissions and the commitment for each Party whose emissions exceed its commitment. Thus the forecast demand depends on the forecast emissions of individual Annex B Parties and respective success of their policies and measures.

606. Three recent estimates of the demand are presented in annex 5, table 24. The estimates vary widely, from about 400 Mt CO_2 eq per year to over 850 Mt CO_2 eq per year. The Canadian demand is a significant uncertainty for the estimates. In April 2007 the Canadian government stated that it does not plan to purchase Kyoto units, but firms covered by the emissions trading system will be able to use specified types of CERs

for up to 10 per cent of their total emissions.[90] If purchases by the Canadian government are excluded, the Point Carbon and Capoor and Ambrosi estimates are virtually identical at 400 Mt CO_2 eq, whereas the ICF International range of 500–671 Mt CO_2 eq is somewhat higher.

607. Annex B governments have already committed to purchase CERs and ERUs equivalent to 917 Mt CO_2 eq, 183 Mt CO_2 eq per year, which is over 45 per cent of the demand as estimated by Point Carbon and Capoor and Ambrosi (2007).

608. The estimates of the demand by EU ETS installations are all close to the maximum use of CERs and ERUs allowed by the national allocation plans.

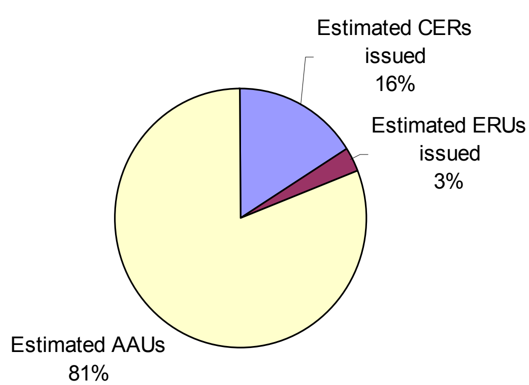
609. The demands estimated in table annex 5, table 24 are unlikely to change significantly. Canada's decision reduced the projected demand substantially, but no further reductions are anticipated. Any growth in demand will be limited and come after 2010. Expansion of the EU ETS to include aviation could increase the demand for CERs/ERUs and new emissions trading systems in Australia or the United States could allow the use of Kyoto units, which might also increase the demand. ICF International estimates an average demand of zero to 30 Mt CO_2 eq per year for CERs/ERUs from the United States (RGGI) during the period 2008–2012 (ICF International, 2007).

610. Capoor and Ambrosi estimate that half of the potential demand has been contracted or is yet to be contracted.

7.3.2. Supply

611. Figure 34 shows Kyoto units supplied by CDM projects in 2010, JI projects and Annex B Parties with surplus allowances (AAUs). Detailed estimates of the supply are presented in annex 5, table 25.

Figure 34. Estimated supply of Kyoto units in 2010 (Mt CO_2 eq per year)



612. The flow of new projects and the CERs/ERUs they can generate by 2012 is uncertain because of delays in negotiating the post-2012 regime. Until a new international agreement is negotiated, the ability of

[90] Canada, 2007, p.14, "The Government of Canada will not purchase credits or otherwise participate in the carbon market." The proposed emissions trading system will begin in January 2010. It will allow participants to use approved CERs to cover up to 10 per cent of their total emissions. The Government will determine which types of CERs will be approved. Participants will use CERs only if their price is less than the price cap of CAD 15 per t CO_2 eq.

emission reductions after 2012 to earn CERs or ERUs is uncertain. This means delays in negotiating a post-2012 regime will progressively reduce the period during which investors can recover their costs (Capoor and Ambrosi, 2007; Haites, 2004). Soon, only the most profitable projects, such as HFC and N_2O destruction projects, will be able to recover their investment prior to 2013.

613. The Russian Federation, Ukraine and some eastern European countries will have surplus AAUs they can sell to other Annex B Parties. Some of these countries are establishing green investment schemes, which use the revenue from the sale of AAUs to fund emission reduction measures. ICF International assumes that only AAUs from green investment schemes will be purchased by other Annex B Parties. Point Carbon and Capoor and Ambrosi estimate the surplus AAUs available, but do not assume they will be sold.

614. Point Carbon and Capoor and Ambrosi find that the projected supply of CERs and ERUs is almost sufficient to meet the estimated demand, excluding Canada. The supply of surplus AAUs is huge relative to the residual demand. In its mid-case, ICF International projects that, in addition to CERs and ERUs, some AAUs from green investment funds will be used to meet the estimated demand. All of the estimates suggest that supply will exceed the demand.

615. The supply of Kyoto units could increase further due to:

- CDM projects for "programmes of emission reduction activities". No project of this type has been registered yet, but such projects could generate relatively large emission reductions;
- HFC-23 destruction projects at new HCFC-22 plants. The eligibility of such projects has been under negotiation for a few years. If approved, they could generate large quantities of CERs;
- CO_2 capture and storage. The eligibility of such projects has been under negotiation for a few years. If approved, they could generate large quantities of CERs, although the time needed to implement such projects would limit the quantity issued before the end of 2012;
- Tradable credits for reduced deforestation. This has been proposed, but it now appears unlikely during the period 2008–2012;
- Emissions limitation commitments proposed by Belarus and Kazakhstan. The proposed commitments probably would leave each country with surplus AAUs, although it could take some time for them to meet the eligibility conditions to sell AAUs.

616. In summary, the analyses suggest the supply will be abundant relative to the demand. Demand for the period 2008–2012 is unlikely to change significantly, but the supply of Kyoto units could increase substantially.

617. The supply of CERs and ERUs will be affected by several factors over the next few years, including:[91]

- Uncertainty about the post-2012 regime. The value of emission reductions after 2012 is uncertain, so projects with longer payback periods become progressively less attractive, reducing the flow of new projects;
- Administrative uncertainty. Inconsistent decisions, possible review upon registration, and possible review on issuance present relatively small risks for project developers. Owing to the relative lack of experience, the risks are higher for JI projects than for CDM projects;
- Market liquidity. The secondary market for CERs is still small so accurate price information is not readily available. This should change over the coming year as the number of issued CERs rises. The secondary market for ERUs will lag by a year or more;

[91] See also Capoor and Ambrosi, 2006; Point Carbon, 2007; and ICF International, 2007.

- Possible changes to the rules. The rules for the CDM could be changed to generate a wider geographic distribution of projects and/or to favour projects that have more development benefits.

7.3.3. Prices

618. Will the surplus supply lead to a collapse of CER/ERU/AAU prices, as happened during Phase I of the EU ETS? Probably not. Phase I EU allowances cannot be carried over for use beyond 2007, so they have no value after the end of the period. In contrast, Kyoto units can be carried over (banked), so they should have a value at the end of the period provided they can be used for compliance after 2012. The EU ETS will allow the use of CERs and ERUs after 2012. A post-2012 international agreement is also expected to retain the Kyoto mechanisms and thus maintain the market for those units.

619. To date, all government purchases have been CERs and ERUs and participants in the EU ETS can only use CERs and ERUs for compliance. The supply of CERs and ERUs is still less than the demand, even without Canada. So long as these policies continue, the demand for AAUs from the Russian Federation, Ukraine and Eastern European countries will be limited to the demand not supplied by CERs and ERUs, causing them to carry over most of their surplus AAUs.

620. Banking (carry over) of different units by an Annex B Party is restricted as follows:[92]

- RMUs may not be carried over;
- ERUs which have not been converted from RMUs may be carried over up to a maximum of 2.5 per cent of the Party's assigned amount;
- CERs may be carried over up to a maximum of 2.5 per cent of the Party's assigned amount;
- tCERs and lCERs may not be carried over;
- AAUs may be carried over without restriction.

621. There are no provisions governing carry over of CERs, tCERs and lCERs by non-Annex I Parties or legal entities.

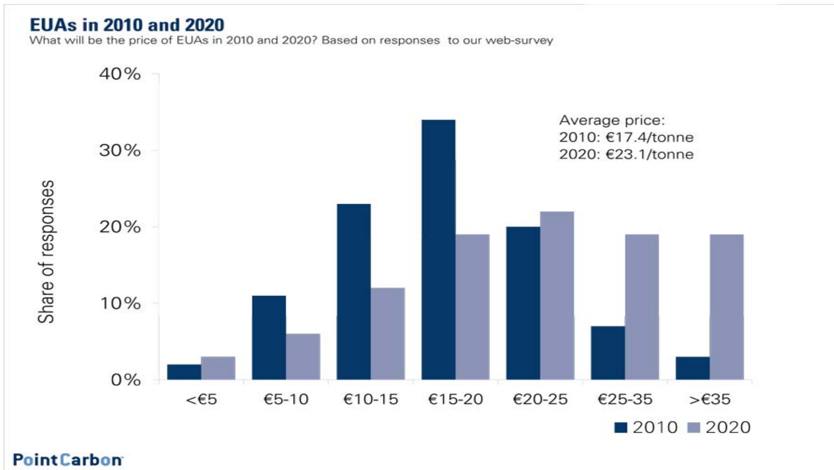
622. To comply with these rules EU ETS participants should use any issued CERs or ERUs they own for compliance by the end of 2012[93] and Annex B governments should comply by submitting CERs, RMUs, and ERUs and carrying over AAUs.

623. If the uncertainty relating to carry over by non-Annex I Parties and their legal entities is not resolved, it could cause the price to decline in 2012 as they try to sell the CERs they own. Early resolution of this uncertainty to avoid such a price drop is desirable.

[92] Decision 19/CP.7, annex paragraphs 15 and 16.

[93] Each installation has a limit on the quantity of CERs and ERUs it can use for compliance. An installation that owns fewer CERs/ERUs than its limit could buy more CERs/ERUs and sell or bank its surplus EU allowances.

Figure 35. Expected prices for EU allowances in 2010 and 2020, based on response to Point Carbon survey



Source: Point Carbon, 2007c.

624. Since CERs and ERUs can, and probably will, be used for Phase II compliance by EU ETS installations the prices for issued CERs, ERUs and Phase II EU allowances should be similar if not identical. As of May 2007 there is still a substantial difference in the prices; CERs issued trade at EUR 12–13 whereas Phase II EU allowances trade at EUR 19. Figure 35 shows the price expectations for EU allowances in 2010 and 2020 of participants in an online survey conducted early in 2007. For 2010 the average is EUR 17.40, with a roughly symmetrical distribution ranging from less than EUR 5 to over EUR 35.

625. ICF International forecasts the price for CERs/ERUs/Phase II EU allowances at EUR 8, with a range of EUR 8–20 (ICF International, 2007, table 3). ICF recognizes, however, that market behaviour may lead to an average price over the period higher than forecast by market fundamentals. For example, industrial installations with surplus EUAs have tended to bank them, rather than sell them, and there may be delays in the delivery of CERs or ERUs into the EU ETS.

626. Based on the above information, the market price of issued CERs, ERUs and Phase II EU allowances is estimated to average EUR 17.50 (USD 23.60) with a range of EUR 10 (USD 13.50) to EUR 25 (USD 33.75) for the period 2008–2012.

7.3.4. Market size

627. With an annual demand of 400 to 600 Mt CO_2 per year (excluding the Canadian government) the price of 2006USD 23.60 suggests a market of USD 9.4–14.2 billion per year, say 2006USD 10–15 billion per year (see figure 36).

628. The above calculation assumes that all CERs, ERUs and AAUs bought for compliance are purchased at the market price. Many CERs and ERUs have already been purchased by Annex B governments in the primary market at lower prices, so the annual compliance cost should be somewhat lower. CERs and ERUs purchased by other buyers could be sold multiple times, so the annual value of transactions could be higher or lower.[94]

[94] The total value of primary and secondary CER and ERU transactions during 2006 is reported as USD 5.4 billion by Capoor and Ambrosi, 2007, annex 5, table 18.

7.3.4.1. Annual investment

629. Annual sales of CERs are projected to be between 300 and 450 million. With an average capital cost of USD 137.39 per 1000 t CO_2 eq of annual emission reductions (see annex 5, table 21), that represents an annual investment of 2006USD 40–60 billion. However, the remaining scope for low cost projects – HFC-23 and N_2O destruction – is limited. If such projects are excluded, the average capital cost rises to about USD 200 per 1000 t CO_2 eq of annual emission reductions, and the annual investment would be 2006USD 60–90 billion. Thus, the annual investment in CDM projects is estimated at 2006USD 40–90 billion. At present about half of the capital invested in CDM projects is invested in unilateral projects by host country project proponents.

630. Annual sales of ERUs are projected to be between 40 and 100 million. Assuming the same range of capital costs per 1000 t CO_2 eq of annual emission reductions yields an estimated annual investment in JI projects of 2006USD 5–USD 20 billion.

7.3.5. Share of proceeds for the Adaptation Fund

631. The Adaptation Fund receives a "share of proceeds" equal to 2 per cent of the CERs issued for a CDM project activity to assist developing country Parties that are particularly vulnerable to the adverse effects of climate change to assist in meeting the costs of adaptation.[95] With annual sales of CERs of 300–450 million and a market price of USD 23.60 per t CO_2 eq (range USD 13.50–33.75) the Adaptation Fund would receive 2006USD 80–300 million per year for 2008 to 2012[96] (see table 55).

Table 55. Possible levels of funding for the Adaptation Fund trustee account to 2012

Total quantity of CERs issued through 2012 (million)	Total quantity of CERs collected by the Adaptation Fund holding account through 2012 (million)	Total revenue received by the Adaptation Fund trustee account at various prices per CER (million Euro)		
		Assumed price per CER		
		EUR 10	EUR 17.5	EUR 25
1 500	30	N.A.	525	750
2 000	40	400	700	1 000
2 500	50	500	875	N.A.

Note: N.A. This combination of price and quantity is considered to be very unlikely.

7.3.6. Voluntary market

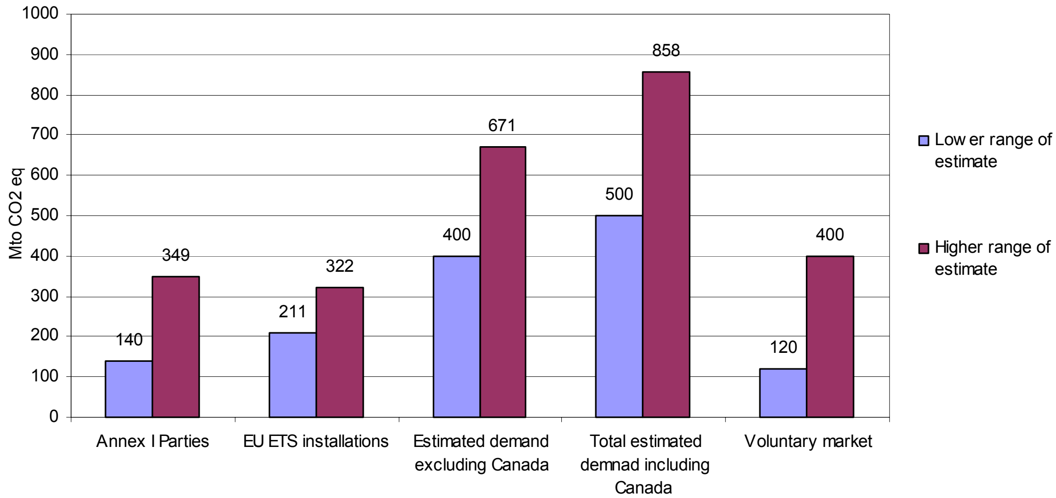
632. The voluntary market accounted for sales of about 20 Mt CO_2 eq globally in 2006. Trexler estimated that United States demand for voluntary offsets could almost double annually to 250 Mt CO_2 eq by 2011 (Trexler, 2007).[97] ICF International projects an annual demand in the voluntary market of 250 Mt CO_2 eq (range 120–400) for the period 2008–2012 (ICF International, 2007). Assuming an average price of USD 10 per t CO_2 eq this represents an annual market of 2006USD 1–4 billion. With a compliance market of

[95] Decisions 3/CMP.1 and 28/CMP.1. CDM projects in least developed country Parties are exempt from the share of proceeds levy and small-scale afforestation and reforestation projects are exempt from the share of proceeds regardless of their location.
[96] The quantity of CERs issued for projects exempt from the share of proceeds is assumed to be negligible relative to the uncertainty of the estimates.
[97] This would be less than 1 tonne per person when per capita emissions are over 20 tonnes, offsetting about 4 per cent of total emissions.

2006USD 5–25 billion the voluntary market would represent about 15 per cent of the total market. This growth is contingent on satisfactory resolution of the integrity issues discussed in chapter 7.2.8.

633. Figure 36 summarizes the estimates for demand for emission reduction units in 2010.

Figure 36. Estimated demand for emission reduction units in 2010



7.4. Potential size of the carbon market to 2030

634. Apart from the voluntary market, the carbon market depends on the demand for compliance units by national governments or entities that subject themselves to a regime with compliance obligation (e.g. the Chicago Climate Exchange) and the supply of units from countries with commitments or without commitments.

635. Analyses of the future carbon market focus on the potential demand by Annex I Parties that can be met cost-effectively with credits purchased from non-Annex I Parties.

636. This chapter begins with estimates of the potential demand in 2050. It then it reviews demand estimates for earlier periods. After the demand estimates are reviewed, the potential to expand the supply to meet the demand in 2030 is considered.

7.4.1. Estimated demands

7.4.1.1. Estimated demand in 2050

637. Two estimates of demand for credits from developing countries in 2050 are available.

7.4.1.2. Reductions at 60–80 percent

638. Assuming emission reductions by industrialized countries in the order of 60–80 per cent of their 1990 emissions by mid-century, half of which we anticipated to be met through investment in developing countries, generates emission reduction purchases of up to USD 100 billion per year, this reduction would correspond to stabilization of greenhouse gas concentrations at 450–500 ppmv CO_2 eq (i.e. multigas) or 350–400 ppmv CO_2 only.

639. Greenhouse gas emissions by all Annex I or Annex B Parties, including Australia and the United States, in 1990 were about 18,100 Mt CO_2 eq. A reduction of 60–80 per cent is 10,900–14,500 Mt CO_2 eq. If half of the reduction is purchased from developing countries, the annual purchases are 5,400–7,200 Mt CO2 eq. Assuming the price of CERs issued remains at the current level of EUR 12–13, about USD 17 per t CO2 eq, this represents a market value of USD 92 to USD 122 billion.

7.4.1.3. World Bank (2006)[98]

640. The future flows to developing countries depend on four parameters:

- The objective and scope of post-Kyoto climate policies;
- Baseline emissions in each region of the world;
- Abatement costs in each region;
- The burden-sharing agreement between Parties.

641. IPCC stabilization paths for 450 and 550 ppmv are used as the objective of post-Kyoto climate policies. The 450 ppmv path allows total emissions of 272 GtC between 2000 and 2050, whereas the 550 ppmv path allows 333 GtC between 2000 and 2050.

642. The six IPCC SRES scenarios provide the baseline emissions. Cumulative emissions range between 392 and 574 GtC from 2000 through 2050.

643. Two sets of abatement costs are used – the emissions prediction and policy analysis (EPPA) model and higher costs based on bottom-up studies. Abatement costs are assumed to rise by 1 per cent per year from 2000 through 2050.

- Total discounted (at 4 per cent) abatement costs for the 450 ppmv path from 2000 through 2050 are between 1995USD 1.2 and 14.9 trillion – annualized costs of USD 72–775 billion;
- For the 550 ppmv path total abatement costs from 2000 through 2050 are between 1995USD 0.2 and 8.2 trillion – annualized costs of USD 12–427 billion.

644. Efficiency dictates that half to two-thirds of total abatement spending between 2000 and 2050 occur in developing countries (EPPA 67–72 per cent, other cost curves 58–65 per cent). This is due to existing opportunities and high growth of emissions in developing countries.

645. Distributing abatement expenditures on the basis of GDP yields annualized payments by developed countries between 2013 and 2050 of 1995USD 20–130 billion for the 450 ppmv path; and 1995USD 3-68 billion for the 550 ppmv path.

7.4.1.4. Estimated demand in 2030

646. The Energy Modeling Forum[99] (EMF) examines topics to which many existing models can be applied. EMF 21 analysed the importance of non-CO_2 greenhouse gases and land use in climate policy.[100]

647. Each participating model developed a reference scenario that excludes any climate policies, including the Kyoto Protocol. Each model also developed a multi-gas mitigation scenario to stabilize radiative forcing

[98] Annex H, World Bank (2006).
[99] The EMF (Energy Modeling Forum) was established at Stanford University and provides for a forum for discussing energy and environmental issues, see: <http://www.stanford.edu/group/EMF/>.
[100] See de la Chesnaye and Weyant, 2006 for results of EMF 21.

at 4.5 Wm^2 relative to pre-industrial times by 2150 or to a comparable global emissions trajectory.[101] This corresponds to an equilibrium temperature increase of 3.8° C, for a climate sensitivity of 3° C per CO_2 doubling, which corresponds to a stabilization scenario under the IPCC of 650 ppmv.[102]

648. Results for 16 models with a regional structure were analysed. For each model developing countries were assumed to sell credits equal to the difference between their reference scenario and multi-gas mitigation scenario to Annex I Parties, including Australia and the United States. The implied commitments of Annex I Parties as a group are the sum of their reductions from the reference scenario plus their credit purchases. These are expressed as reductions from their 1990 emissions.

649. Annex 5, table 26 shows the results for 2030; the implied commitment of Annex I and/or Annex B Parties as a group, their annual purchases, the projected market price, and the market size. The analysis ignores trading among Annex I and/or Annex B Parties – JI and international emissions trading – since this depends on arbitrary assumptions of how the overall commitment would be shared among these Parties.

650. The results correspond to the maximum demand for the mitigation scenario. Current Annex I and/or Annex B Parties, including Australia and the United States, are assumed to have commitments that induce them to purchase all cost-effective emission reductions available in non-Annex I Parties. Rules for credit creation, transaction costs, and other considerations would prevent all cost-effective reductions estimated by the models being realized in practice. Failure of some Annex I and/or Annex B Parties to ratify the agreement in place in 2030, or adopt equivalent commitments, would reduce the demand. Adoption of targets by some current non-Annex I Parties would reduce the estimated supply and hence the maximum demand.[103]

651. The results vary enormously due to differences in the reference scenario, marginal abatement costs and model structure. Estimates of the annual sales range from less than 2000USD 1 billion to over USD 1,850 billion and estimates of the price range from less than USD 1 to over USD 100 per t CO_2 eq. The low estimate is due to both a small quantity and a low price, indicating that the reference scenario and mitigation scenario emissions are very similar. The high estimate is due to a reference scenario that has much higher emissions than the mitigation scenario, leading to a high marginal abatement cost and large purchases. The high estimate implies a commitment of Annex I and/or Annex B Parties greater than their 1990 emissions.

652. The median quantity traded is roughly 6,400 Mt CO_2 eq per year.[104] The corresponding commitment is a 30 per cent reduction from 1990 emissions for all Annex I and/or Annex B Parties including Australia and the United States. The market price is modelled to about 2000USD 16.50 per t CO_2 eq,. This is a little lower than the current price for issued CERs and in the lower half of the range estimated for 2010. The size of the market in 2030 is estimated at USD 107 billion with three quarters of the estimates falling between 2000USD 17 and USD 314 billion.

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[101] The emissions trajectory depends on the emissions sources covered by the model. For models that cover CO_2 emissions from fossil fuel use, cement and land use, CH_4 emissions and N_2O emissions, but exclude HFCs, PFCs and SF_6, global emissions are slightly below 40 GT CO_2 eq in 2030.

[102] When the scenario was developed, a climate sensitivity of 2.5° C per CO_2 doubling was assumed, resulting in an equilibrium temperature increase of 3.0° C.

[103] The targets of non-Annex I Parties could take a variety of forms including “no lose” targets, sectoral targets, and national commitments similar to those of Annex I Parties. Such targets should represent a reduction from reference case emissions, so only the emission reductions beyond compliance with the target could be sold to current Annex I and/or Annex B Parties. To estimate the impact on the market price would require new model runs.

[104] When values cannot be symmetrically distributed as in this case – market size and price can not be less than zero – the median is a better indicator of the central value than the average. Half of the values are higher and half are lower than the median. The average (mean) is the sum of the values divided by 16 (the number of values).

7.4.1.5. Estimated demand in 2020

653. Potential demand in 2020 can be estimated from the EMF 21 model results in the same manner as described in Annex 5, table 26. The median estimate of the market size is about 3,150 Mt CO_2 eq per year. The corresponding commitment is about a 20 per cent reduction from 1990 emissions for all Annex I Parties including Australia and the United States.

654. Because the EMF 21 scenarios exclude the Kyoto Protocol, emission reductions and marginal abatement costs rise gradually from 2000. The 2020 marginal abatement cost (price) – 2000USD 6.50 per t CO_2 eq – is lower than both the current and projected 2010 price. Given the bias introduced by the scenarios, the best assumption is that prices remain roughly constant from 2010 through 2030 at 2000USD 23.60 (range USD 13.50–33.75).

655. The annual purchases in 2020 estimated from the EMF 21 scenarios are 2000USD 25 billion (USD 2.5–70 billion). The low end of the range up to 2006USD 25 billion per year is the same as the estimate for 2010.

7.4.1.6. Estimated demand in 2015

656. ICF International projects the average demand of Annex I and/or Annex B Parties for the period 2013–2017 at 2,600 Mt CO_2 eq per year (1,200 to 3,100 Mt CO_2 eq per year) (ICF International, 2007). The high demand case includes additional demand of 4,400 Mt CO_2 eq per year by non-Annex I Parties that adopt sectoral targets. ICF International projects the 2013 to 2017 price at 2006EUR 30 per t CO_2 eq (range EUR 18–40 per t CO_2 eq).[105] The implied annual purchases by Annex I and/or Annex B Parties are about 2006EUR 75 billion (range EUR 2–120 billion) (ICF International, 2007 table 3).

7.4.1.7. Summary of demand estimates

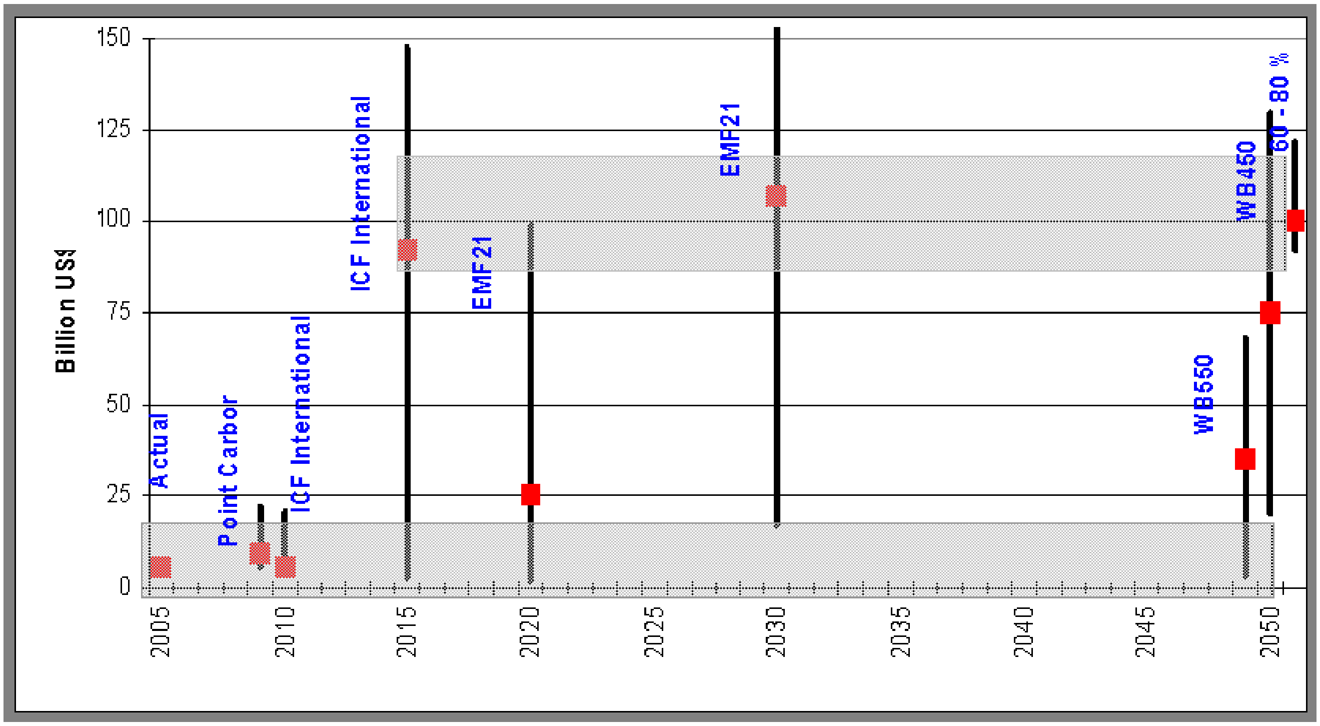
657. The foregoing estimates of demand are shown in figure 37. The estimates cover only purchase credits by Annex I and/or Annex B Parties from non-Annex I Parties. The estimates do not include trades between Annex I and/or Annex B Parties, such as JI and international emissions trading. To estimate the size of those mechanisms requires arbitrary assumptions about the commitments of different Annex I and/or Annex B Parties. The estimates assume that all cost-effective emission reductions in Annex I and/or Annex B Parties are implemented as domestic actions or for sale to other Annex I and/or Annex B Parties through JI or international emissions trading.

658. Each estimate spans a wide range. The low end of the ranges suggests that the demand remains in the range of 2006USD 5–25 billion per year. Annex 5, table 18 indicates that CDM transactions during 2006 were a little over USD 5 billion and the demand estimated in chapter 7.3.4 for 2010 is USD 10–15 billion with a range 2006USD 5 to USD 25 billion per year. The value of credit purchases by Annex I and/or Annex B Parties from non-Annex I Parties could remain in that range through 2050.

659. The high end of the ranges suggests that annual demand could reach USD 100 billion, but probably not much more. The high demand assumes commitments – 30 per cent below 1990 by 2030 and 60–80 per cent below by 2050 – by all current Annex I and/or Annex B Parties including Australia and the United States, no commitments of any type by any current non-Annex I Party, and purchase of all cost-effective emission reductions available in non-Annex I Parties.

[105] ICF International, 2007.

Figure 37. Comparison of demand estimates



7.4.2. Potential supply

660. The demand estimates presented above are for purchases of emission reduction credits by Annex I and/or Annex B Parties from non-Annex I Parties. At present the only mechanism for such purchases is the CDM. The demand could also include credit sales under other mechanisms suggested in the literature, such as "no lose" targets and sectoral targets.

661. The potential supply is assessed relative to both the low and the high estimates of demand. The low demand of USD 5–25 billion represents purchases of 400–600 Mt CO_2 per year, ranging up to 1,000 Mt CO_2 per year. The high demand of about USD 100 billion corresponds to purchases of ten times the volume– about 4,000 Mt CO_2 per year at a price of USD 23.60 per t CO_2 eq and about 6,000 Mt CO_2 per year based on the model results presented in annex 5, table 26.

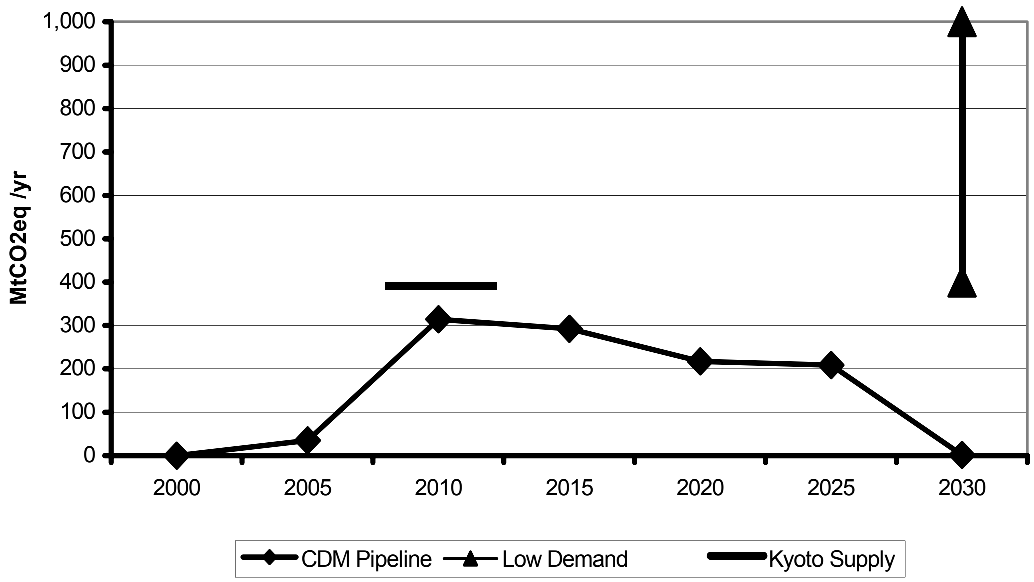
7.4.2.1. Low demand estimate

662. A 20–200 per cent increase in emission reductions appears manageable. The existing project pipeline has developed largely in the past two years, so maintaining the current trend for a few months to a few years would be sufficient. Growth of the pipeline will involve a shift in the mix of projects because the potential of a few project types, notably HFC-23 destruction and N_2O destruction at adipic acid plants, has been largely exhausted. On the other hand, project types approved more recently, afforestation, reforestation and programmes of activities, are virtually absent from the pipeline.

663. Figure 38 shows the estimated emission reductions of projects in the CDM pipeline as of May 2007 as a function of time. It assumes that each project with a renewable crediting period earns the same annual emission reductions for each renewable. The estimated annual reductions rise rapidly beginning in 2005 as new projects are implemented, reaching 315 Mt CO_2 eq in 2010. The emission reductions achieved by these projects decline between 2010 and 2020 as the projects with 10-year crediting periods lose their eligibility.

After 2025 most of the remaining projects lose their eligibility as their third seven-year crediting period concludes.

Figure 38. Estimated supply from current CDM pipeline, 2000–2030



664. The data in Figure 38 are based on the estimated annual emission reductions reported in the PDDs. The experience to-date is that CERs are issued for approximately 85 per cent of the estimated reductions (Fenhann, 2007).

665. Figure 5 also shows the estimated average annual emission reductions available for the period 2008-2012, which includes reductions during the period as well as reductions prior to 2008. This is almost 400 Mt CO_2 eq, the low end of the range for 2030. Taking the experience to-date into account, meeting the low demand in 2030 would mean a 20–200 per cent increase in the emission reductions of projects already in the pipeline and then replacing the reductions in those projects as they come to the end of their crediting periods.

666. In summary, it appears that the current flow of projects under the CDM would be sufficient to meet the low demand estimate for 2030 although with some changes in the mix of projects.

7.4.2.2. High demand estimate

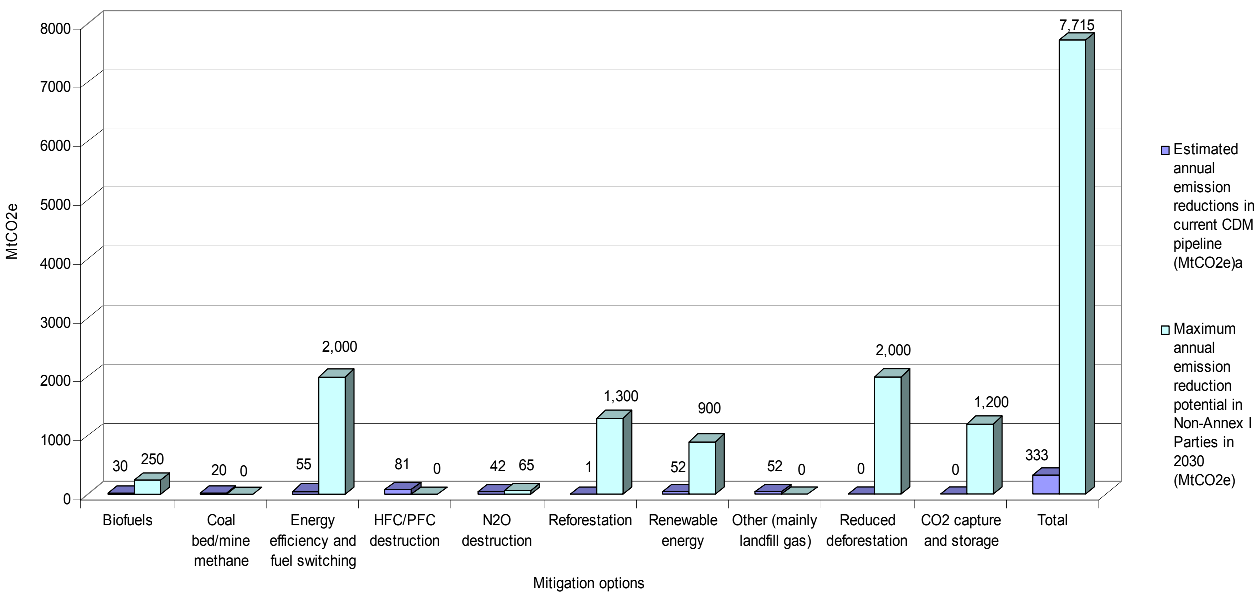
667. The high demand would require credits for a large fraction of the potential emission reductions, from existing and some new categories of project types. To process the volume of emission reductions cost-effectively is likely to require new mechanisms, such as "no lose" targets, sectoral targets and policy CDM, in addition to the current types of CDM projects.[106]

668. The high demand is about ten times higher; some 4,000–6,000 Mt CO_2 eq per year in 2030. Estimates of the maximum annual emission reduction potential in non-Annex I Parties in 2030 are provided in annex 5, table 27. The estimates indicate that current non-Annex I Parties could supply the high demand if a large fraction, 50-75 per cent, of the maximum potential is realized and additional categories of emission reductions, reduced deforestation and CCS, are included (see figure 39).

[106] As discussed above, such mechanisms have the effect of reducing the potential supply somewhat.

669. Currently the average CDM project estimates an annual emission reduction of 165,000 t CO_2 eq per year. Annual reductions of 4,000–6,000 Mt CO_2 eq per year would require 25,000–35,000 registered projects. Roughly 1000 projects entered the pipeline during 2006.[107] To have 25,000–35,000 registered projects would mean a four to five–fold increase in the flow of registration and renewal requests.

Figure 39. Estimated carbon market size for high demand estimate



7.4.2.3. AAUs carried over from the period 2008–2012

670. It is expected that AAUs carried over by the Russian Federation, Ukraine and other Eastern European countries can be used to meet the commitments of Annex I and/or Annex B Parties for subsequent periods.[108] The amount carried over at the end of 2012 is projected to be 2,500–5,500 million AAUs. Under the high demand estimate, that surplus could be absorbed relatively quickly. With the low demand estimate, it could affect the market for a decade or more.

7.4.3. Summary

671. Estimates of credit purchases by Annex I and/or Annex B Parties from non-Annex I Parties span a wide range. The low end of the ranges suggests that the demand remains in the range of USD 5–25 billion per year, with purchases of 400–600 Mt CO_2 eq. The current flow of projects under the CDM, with some changes in the mix of projects, would be sufficient to meet that demand. That would represent an annual capital investment of 2006USD 50–120 billion. At 2 per cent the annual contribution to the Adaptation Fund would be 2006USD 100–500 million.

[107] The average crediting period is seven-and-a-half years (Fenhann, 2007, analysis sheet shows 86 per cent choose a seven-and-a-half year crediting period and 14 per cent a 10-year crediting period, giving an average of seven-and-a-half years). Thus the current flow yields about 7,500 registered projects, thereafter crediting periods need to be renewed.

[108] Some, or all, of the surplus could be used by those countries to meet their post-2012 commitments and the balance could be sold to other Annex I and/or Annex B Parties.

672. The high end of the ranges suggests that annual demand could reach 4,000–6,000 Mt CO_2 eq per year with a market value of USD 100 billion, by 2030, but probably not much more. It assumes commitments by all current Annex I and/or Annex B Parties including Australia and the United States, and no commitments of any type by any current non-Annex I Party. To supply this demand a large fraction of the potential emission reductions from all existing and some new categories of projects would need to earn credits. That is likely to require new mechanisms in addition to the current types of CDM projects. The high demand would represent an annual capital investment of 2006USD 500–1,200 billion. At 2 per cent the annual contribution to the Adaptation Fund would be 2006USD 1–5 billion.

8. FINANCIAL COOPERATION UNDER THE CONVENTION AND ITS KYOTO PROTOCOL

8.1. Introduction

673. The Convention and its Protocol foresee financial assistance from developed country Parties to developing country Parties. Developed country Parties (Annex II Parties) shall provide new and additional financial resources to assist developing country Parties implement the Convention (Article 4.3)[109] and its Protocol (Article 11). This assistance may be through bilateral or multilateral channels or through a financial mechanism defined in Article 11 of the Convention and referred to in Article 11 of the Kyoto Protocol.

674. Financial assistance through bilateral and multilateral channels is addressed in chapter 3. Annex II Parties are to provide details of measures taken to give effect to their commitments under Articles 4.3, 4.4, and 4.5 of the Convention as part of their national communications. Owing to gaps and inconsistencies in reporting approaches in the third and fourth national communications from Annex II Parties, it is difficult to reach specific funding figures. However, it is possible to discover trends. The analysis of bilateral and multilateral funding in this paper therefore corresponds mainly to information relating to ODA.

675. The GEF was assigned as an operating entity of the financial mechanism of the Convention on an on-going basis, subject to review every four years. The financial mechanism is accountable to the COP, which decides on its climate change policies, programme priorities and eligibility criteria for funding, based on advice from the SBI.

676. In addition to the guidance to the financial mechanism, Parties have established two special funds[110]: the SCCF and LDCF, under the Convention. These two funds are managed by the GEF.

677. The Adaptation Fund, under the Kyoto Protocol, was also established[111] by Parties in order to finance concrete adaptation projects and programmes in developing countries that are Parties to the Kyoto Protocol.

678. Chapter 8.2 below provides an overview of the funding available under the financial mechanism of the Convention (through the GEF, SCCF and LDCF). Chapter 8.3 provides an overview of the Adaptation Fund under the Kyoto Protocol.

8.2. Financial mechanism under the Convention

679. As an operating entity of the financial mechanism of the Convention, the GEF receives guidance from the COP on policy, programme priorities, and eligibility criteria related to the Convention. The COP has provided general guidance with regard to operation of the financial mechanism, and has also provided specific guidance in the following areas:

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[109] Article 4.3 stipulates that developed country Parties shall provide new and additional financial resources to meet the agreed full costs incurred by developing country Parties to prepare national communications and to meet the agreed full incremental costs of implementing measures that are covered by paragraph 4.1 of the Convention. Article 4.4 further stipulates that developed country Parties shall assist particularly vulnerable developing country Parties to meet the costs of adaptation and Article 4.5 stipulates that developed country Parties shall take all practicable steps to promote, facilitate and finance the transfer to, or access to, environmentally sound technologies and know how.

[110] Decision 7/CP.7.

[111] Decisions 10/CP.7 and 28/CMP.1.

- Support to national communications of non-Annex I Parties;
- Capacity-building;
- Public awareness and outreach (Article 6 activities);
- Development and transfer of technologies;
- Support to adaptation;
- Support to activities referred to in Article 4, paragraph 8(h) of the Convention;
- Support to mitigation.

680. The GEF has responded to COP guidance through the climate change focal area[112] of the GEF Trust Fund (in support of enabling activities, operational programmes relating to mitigation and the strategic priority on adaptation), the SCCF and the LDCF.

681. Article 11, paragraph 3(d) of the Convention calls for arrangements to determine in a predictable and identifiable manner the amount of funding necessary and available for the implementation of the Convention. In accordance with decision 11/CP.1, "in mobilizing funds, the operating entity or entities should provide all relevant information to developed country Parties and other Parties included in Annex II to the Convention, to assist them to take into full account the need for adequacy and predictability in the flow of funds. The entity or entities entrusted with the operation of the financial mechanism should take full account of the arrangements agreed with the Conference of the Parties, which, inter alia, shall include determination in a predictable and identifiable manner of the amount of funding necessary and available for the implementation of the Convention, as provided for in Article 11.3(d) of the Convention".

682. In accordance with the annex[113] to the memorandum of understanding (MOU) between the COP and the GEF (decision 12/CP.3), "in anticipation of a replenishment of the GEF, the COP will make an assessment of the amount of funds that are necessary to assist developing countries, in accordance with guidance provided by the COP, in fulfilling their commitments under the Convention over the next GEF replenishment cycle, taking into account":

- The information communicated to the COP under Article 12 of the Convention;
- National programmes formulated under Article 4, paragraph 1(b) of the Convention and progress made by Parties in the implementation of such national programmes and towards the achievement of the Convention's objective;
- Information communicated to the COP from the GEF on the number of eligible programmes and projects that were submitted to the GEF, the number that were approved for funding, and the number that were turned down owing to lack of resources;
- The GEF replenishment negotiations should take into account the assessment by the COP.

683. The replenishments of funds in the GEF depend on voluntary contributions from donors. The trust fund contributions follow a pre-defined "basic" burden share (GEF, 2005a). The amount of funding under the GEF after 2010 will depend on negotiations on the fifth replenishment of the GEF (GEF 5). The trustee will probably need to start making arrangements for the fifth replenishment in 2008. Negotiations and conclusion of the GEF 5 should occur in 2009.

684. The fourth review of the financial mechanism should start at COP 13 (December 2007) and it is expected that the COP will make an assessment of the amount of funds that are necessary to assist developing countries and provide an input to GEF 5.

[112] The GEF's climate change programme is one of six focal areas managed by the entity, and is the second largest after its biodiversity focal area. Most of the GEF's climate change activities are financed by a trust fund (GEF Trust Fund). The LDCF and SCCF were established by decision 7/CP.7 and are managed by the GEF.
[113] FCCC/CP/1996/9.

8.2.1. GEF Trust Fund

8.2.1.1. Level of funding

685. As of July 2007 the GEF had allocated (since its inception)[114] a total of just over USD 3.3 billion to climate change projects from the GEF Trust Fund. Further co-financing in excess of USD 14 billion has been leveraged for these GEF projects, or USD 4.2 per dollar of GEF grant.[115] However, in the last reporting period (from September 2005 to August 2006), this ratio was higher – USD 6.4 per GEF dollar.[116] Six project proposals approved in the recent Work Programme (June 2007) leveraged an exceptionally high amount of co-financing, making this ratio USD 21.6 per GEF dollar.

686. The total GEF climate change funding allocations (including enabling activities[117]) and co-financing amounts are shown below for the different replenishment periods (table 56).

Table 56. GEF Trust Fund allocations and co-financing (millions of United States dollars)

GEF phase	GEF grant [118]	Co-financing amount
Pilot phase	280.60	2 402.89
GEF 1	507.00	2 322.10
GEF 2	667.20	3 403.40
GEF 3	881.80	4 609.69
GEF 4	990.00	
From which in 2007	76.35	1 651.82
Total	**3 326.60**	**14 389.90**

Source: GEF secretariat (2007).

687. The proposed programming for GEF 4 (for the period 2006–2010) climate change activities amounts to USD 990 million. Most of the resources will go to mitigation activities. The balance will be allocated to the remainder of the strategic priority on adaptation (Piloting an Operational Approach to Adaptation or SPA), the SGP, cross-cutting capacity-building activities and support to LDCs and SIDS (GEF, 2006).[119] A revised climate change strategy and climate change programming framework (GEF, 2007) is being discussed currently by the GEF Council and provides for a set of links between the GEF's mission, its strategic approach, priorities, operational programmes and project areas (see more detail in the discussions on the climate change portfolio below).

688. As shown in table 57 below, GEF funding represented 1.6 per cent of funds from bilateral and multilateral sources for energy projects during the period 1997–2005 (Tirpak and Adams, 2007).

[114] Not all of these funds have been fully disbursed as projects are in various stages of implementation.
[115] GEF/C.31/10, annex 2, "Climate Change Focal Area Strategy and Strategic Programming for GEF-4".
[116] Total allocations were USD 355 million, with leveraged funds more than USD 2.3 billion (FCCC/CP/2006/3).
[117] Excludes project development facility (PDF) grants. A total of USD 14.7 million has been approved for PDF-Bs, for the information gathering necessary to complete full project proposals and the essential supporting documentation.
[118] FCCC/CP/2006/3.
[119] See chapter 8.2.1.3. below for more detail on allocations across sectors.

Table 57. Multilateral and bilateral funding for energy during the period 1997–2005 (millions of United States dollars)

Type of funding	Total 1997–2005	Percentage of Total Multilateral and Bilateral Funding
Bilateral Development Assistance	20 104	31.0
World Bank Group	24 898	38.4
EBRD	5 158	8.0
GEF	1 054	1.6
Asian Development Bank	6 593	10.2
Inter-American Development	6 987	10.8
Total	**64 794**	**100.00**

Abbreviation: EBRD=European Bank for Reconstruction and Development
Source: Tirpak and Adams, 2007

689. As noted in chapter 4.2.5 on forests, even if not focused on climate change, the forestry activities financed through the biodiversity focal areas of the GEF account for an important part of financing of forestry mitigation activities and acts as an important catalyst for additional resources (see in annex 5, table 12). The focal areas for biodiversity, land degradation and international water are also important catalysts of financing for adaptation, as acknowledged in different sectors analysed in chapter 5.

8.2.1.2. <u>Resource allocation framework</u>

690. A major element of the GEF 3 replenishment reform agenda was the establishment of a framework for allocation to countries based on global environmental priorities and performance.

691. The resource allocation framework (RAF) was adopted by the GEF Council in September 2005. The RAF is designed to increase the predictability and transparency in the way the GEF allocates resources. The resources each eligible country can expect from the GEF will be specified for the four years of the replenishment period, and initial allocations will be updated in the middle of the replenishment period. The RAF began implementation in GEF 4. Each eligible country can expect to receive a minimum allocation of USD 1 million. The total amount that a country receives from the GEF climate change focal area cannot exceed a ceiling of 15 per cent of the resources available. Two indices, the GEF Benefits Index and the GEF Performance Index, will be used in combination to determine the share of resources that each country is allocated. The GEF Benefits Index measures the potential of a country to generate global environmental benefits,[120] and the GEF Performance Index measures a country's capacity, policies and practices relevant to successful implementation of GEF programmes and projects. The GEF Performance Index relies on World Bank Country Policy and Institutional Assessment data.

692. The RAF does not change the GEF project cycle. Each country still needs to work with a GEF implementing/executing agency to develop and prepare concepts for review, pipeline entry and inclusion in a work programme.

693. China, India and the Russian Federation are likely to receive the most under the RAF formula, followed by Brazil, Mexico and South Africa, followed by a group of countries that includes Argentina, Egypt, Indonesia, Islamic Republic of Iran, Kazakhstan, Malaysia, Pakistan, Romania, Thailand, Turkey, Ukraine and Venezuela (GEF, 2005b). In the past, the GEF tended to provide a higher level of resources to those countries with a greater potential for GHG emission reduction. This trend continues in GEF 4.

[120] For climate change, the global environmental benefit index (GBI) weights the baseline emissions of a country with the carbon intensity adjustment factor. GHG emissions from land-use change and forestry are not included in this calculation.

694. There will be an independent mid-term review of the RAF to be considered by the GEF Council in November/December 2008.

695. The COP, by its decision 5/CP.11, requested the GEF to include in its regular annual reporting information on the initial application of the RAF in the allocation of resources in the fourth replenishment period and inform the COP as to how the RAF is likely to affect funding available to developing countries for the implementation of their commitments under the Convention.

696. The COP, by its decision 3/CP.12, also requested the GEF to give a detailed report on the resources available to each developing country Party in the initial implementation of the resource allocation framework, including a list of activities funded with these resources during this initial period in the climate change focal area.

8.2.1.3. Climate change portfolio

697. The largest share of GEF climate change resources has been assigned to long-term mitigation projects. These were envisaged by the GEF to have "much greater impact because the projects would drive down costs, build capacity, and start to put in place the technologies that can ultimately avoid GHG emissions".[121] A key element of the GEF Trust Fund is its requirement that projects meet agreed incremental costs for delivering global environmental benefits. Climate change mitigation projects fell so far within four operational programmes (OP) approved by the GEF Council:

- Removal of barriers to energy conservation and efficiency (OP5);
- Promotion of the adoption of renewable energy by removing barriers and reducing implementation costs (OP6);
- Reduction of the long-term costs of low-GHG-emitting energy technologies (OP7);
- Promotion of environmentally sustainable transport (OP11).

698. A further programme, integrated ecosystem management (OP12), also encompasses climate change objectives, such as removals by sinks. Most of the GEF climate change funds have been spent on OP5 and OP6 (figure 1). To date, a smaller proportion of the GEF's resources have been allocated to adaptation activities, through the SPA.

699. The GEF Council is revising the GEF focal priorities under the fourth replenishment period. A proposal for focal area strategies and strategic programming for GEF 4 has been prepared by the GEF secretariat and is under consideration. The following priorities for climate change mitigation are proposed in the paper (GEF, 2007a).

- Promoting energy efficiency in residential and commercial buildings;
- Promoting energy efficiency in the industrial sector;
- Promoting market approaches for renewable energy;
- Promoting sustainable energy production from biomass;
- Promoting sustainable innovative systems for urban transport.

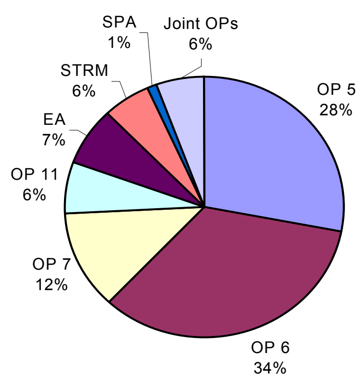
700. The proposal also outlines priorities and issues relating to enabling activities and adaptation. The GEF Council is considering the inclusion of another priority focusing on LULUCF.

[121] FCCC/CP/1995/4.

701. The largest number of projects has been in the renewable energy portfolio. Although fewer projects have been approved in energy efficiency, these projects have tended to be larger and hence the overall amount allocated for energy efficiency is only slightly less than that allocated for renewable energy. An almost equivalent amount has been allocated for a small number of large projects on solar thermal electricity, power production and fuel cells. Within the energy efficiency portfolio, projects have concentrated on energy efficient buildings, appliances and industry. A relatively new focus has been projects that aim to increase the efficiency of power plants. Within the renewable energy portfolio, there has been a marked shift away from photovoltaic projects (although these have not entirely disappeared) and a greater emphasis on a range of resource and technology options, including biomass, hydropower and wind. Although there are some grid-connected renewable energy projects, most of the portfolio is oriented towards rural energy services. There are fewer isolated, one-off rural interventions, and more emphasis on integrated, sustainable national programmes.

702. Figure 40 below provides a breakdown of GEF resources allocated to climate change activities by OPs from the pilot phase through the three replenishment periods and including six projects approved under GEF 4 so far (as at June 2007). One third of the resources (USD 861.1 million) has been allocated to support renewable energy (OP6). A comparable amount (USD 719.8 million) has been approved for energy efficiency (OP5). Funding for low GHG-emitting energy technologies (OP7) equalled USD 318.2 million, whereas support for sustainable transport activities (OP11) – a relatively new but rapidly growing operational programme – came to USD 160.6 million. To date, 1 percent of GEF resources has been allocated to adaptation activities, through the SPA.

Figure 40. Allocation of funds available through the Global Environment Facility among its operational programs



Source: GEF, 2007b.[122]
Abbreviations: EA = Enabling Activity, Joint OPs = Joint operational programmes, OP5 = Removal of Barriers to Energy Efficiency and Energy Conservation, OP6 = Promoting the Adoption of Renewable Energy by Removing Barriers and Reducing Implementation Costs , OP7 = Reducing the Long Term Cost of Low Greenhouse Gas-emitting Energy Technologies, OP11 = Sustainable Transport, SPA = Strategic Priority on Adaptation, STRM = Short Term Response Measures.

703. As for trends, table 58 below illustrates that from the pilot phase to GEF-3, the share of the energy efficiency portfolio (OP5) in the GEF climate change focal area saw a steady increase from 25 per cent to nearly 34 per cent. The share of the GEF renewable energy portfolio, including OP6 and OP7, also

[122] FCCC/CP/2006/3.

experienced an increase from less than one third to nearly 47 per cent (OP6 saw a decrease from 39 per cent to 34 per cent, whereas OP7 saw an increase from less than 4 per cent to nearly 13 per cent). Short-term response measures (STRMs) were the only area among all GEF climate change activities that saw a sharp decline in financing over time, from 25 per cent during the pilot phase to less than 1 per cent during GEF 3. Among the first the projects approved for funding under GEF 4 in June 2007, three aim at energy efficiency, one at renewables and two at sustainable transport.

Table 58. Allocation of GEF resources to climate change activities for the period 1991–2007 (millions of United States dollars)[123]

	Pilot phase (1991 to 1994)	GEF 1 (1995 to 1998)	GEF 2 (1999 to 2002)	GEF 3 (2003 to 2006)	GEF 4 (June 2007)[a]	Total
OP 5: Energy efficiency	70.6	128.6	200.1	286.7	33.8	719.8
OP 6: Renewable energy	108.8	191.3	251.8	299.2	10	861.1
OP 7: Low GHG-emitting energy technologies	10.1	98.4	98.6	111.1		318.2
OP 11: Sustainable transport			46.4	82.2	32	160.6
Enabling activities	20.2	46.5	45.3	73.9		185.9
Short Term Response Measures	70.8	42.2	25.1	3.7		141.8
Strategic pilot approach to adaptation				25		25.0
Total	**280.5**	**507**	**667.3**	**881.8**	**75.8**	**2412.4**

Abbreviations: OP5 = Removal of Barriers to Energy Efficiency and Energy Conservation, OP6 = Promoting the Adoption of Renewable Energy by Removing Barriers and Reducing Implementation Costs , OP7 = Reducing the Long Term Cost of Low Greenhouse Gas-emitting Energy Technologies, OP11 = Sustainable Transport.
[a] As of July 2007, six project proposals have been approved under GEF 4.

704. **Enabling activities:** Total funding for enabling activities amounted to USD 186 million. The GEF has provided financing to support 139 non-Annex I Parties in preparing their initial national communications.[124] As of July 2007, About 110 countries received assistance to undertake stocktaking in preparation for their second national communications. The National Communication Support Programme, phase II, is currently assisting 106 countries in preparing their second national communications.

705. **Small grants programme:** According to information provided by the GEF secretariat in July, cumulative funding allocations for the SGP since 1992 have amounted to USD 365.8 million. The ratio of projects for climate change is increasing, starting from 15 per cent in the 1990s to more than 20 per cent currently.

706. **Strategic Priority on Adaptation (SPA):** In response to guidance by the COP,[125] the GEF established the strategic priority "Piloting an Operational Approach to Adaptation (SPA)". An allocation to the pilot of USD 50 million was included in the GEF business plan in November 2003. As of June 2007, eleven projects have been approved with financing from the SPA, totalling USD 28 million. The remaining

[123] FCCC/CP/2006/3.
[124] FCCC/CP/2006/3.
[125] Decision 6/CP.7.

funds of the pilot programme have been carried over to GEF 4. According to information provided by the GEF secretariat, there are now six projects in the pipeline.[126]

8.2.2. Special Climate Change Fund

707. The SCCF finances activities, programmes and measures relating to climate change that are complementary to those funded by the resources allocated to the climate change focal area of the GEF and by bilateral and multilateral funding, in the following areas: (a) adaptation, (b) transfer of technologies, (c) energy, transport, industry, agriculture, forestry and waste management; and, (d) activities to assist developing countries whose economies are highly dependent on income generated from the production, processing and export, and/or on consumption of fossil fuels and associated energy-intensive products in diversifying their economies (GEF, 2004).

708. As of June 2007, the original pledges to the SCCF totalled USD 67 million. Of this sum, USD 57 million was pledged for the SCCF Programme for Adaptation and USD 10 million for the SCCF Programme for Transfer of Technology. The total amount available for allocation was USD 43.67 million.[127]

709. To date, eight projects (four medium size projects and four full size projects) have been approved under the SCCF adaptation programme[128]. Annex 5, tables 28 and 29 summarizes the approved projects and the projects currently in the pipeline.

8.2.3. Least Developed Countries Fund

710. The LDCF is designed to support projects addressing the urgent and immediate adaptation needs of the LDCs as identified by their national adaptation plans of action (NAPAs). The LDCF contributes to the enhancement of adaptive capacity to address the adverse effects of climate change, including, as appropriate, in the context of national strategies for sustainable development. The priority sectors that are expected to receive the most attention under the NAPA are water resources, food security and agriculture, health, disaster preparedness and risk management, infrastructure and natural resources management. Community-level adaptation may also be a cross-cutting area of concern (GEF, 2007b).

711. As of 30 June 2007, the LDCF had received USD 160 million in contributions and investment income. Allocations of USD 20.7 million had been made and USD 139.3 million remained available for allocation[129].

712. According to information provided by the GEF Secretariat, to date, 44 out of 49 eligible LDCs have been allocated funds to prepare their NAPAs, as well as for two global support programmes, for a funding total of USD 9.6 million.

713. As of July 2007, there is 6 approved NAPA implementation projects under LDCF. These projects are country driven, presenting a differentiated range of options to address urgent and immediate risks due to adverse impacts of climate change, and demonstrate links between adaptation and development. The six projects in the pipeline are summarized in annex 5, table 30 a.

8.3. Adaptation Fund

714. The Adaptation Fund, under the Kyoto Protocol was established to finance concrete adaptation projects and programmes in developing country Parties that are Parties to the Kyoto Protocol, in particular

[126] Information has been received from personal communication with the GEF Secretariat.
[127] Personal communication with the GEF Secretariat
[128] "LDCF and SCCF Programming Update", in GEF/LDCF.SCCF.2/Inf.3.
[129] Personal communication with the GEF Secretariat.

those that are particularly vulnerable to the adverse effects of climate change. This fund shall function under the guidance of, and be accountable to, the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP).

715. Although initial guidance from the CMP on principles, modalities and some key governance elements for the operationalization of the Adaptation Fund was agreed upon in December 2006,[130] negotiations on the details for operationalizing the Adaptation Fund, in particular institutional arrangements, are currently ongoing.

716. The Adaptation Fund is to be financed with a share of proceeds from CDM project activities and other sources of funding. The share of proceeds amounts to 2 per cent of CERs issued for a CDM project activity, with exemptions for some project types.[131]

717. The level of funding for the Adaptation Fund depends on the quantity of CERs issued and the price of CERs. Assuming annual sales of 300–450 million CERs and a market price of EUR 17.50 (range of EUR 10–25) the Adaptation Fund would receive USD 80–300 million per year for 2008 to 2012.

718. Funding for the Adaptation Fund for post-2012 depends on the continuation of the CDM and the level of demand in the carbon market. Assuming a share of proceeds for adaptation of 2 per cent continues to apply post-2012, the level of funding could be USD 100–500 million per year in 2030 for low demand by Annex I Parties for credits from non-Annex I Parties and USD 1 to USD 5 billion per year for high demand. The level of CERs issued in the account from the CDM registry for the Adaptation Fund, as of July 2006, is 1,264,201.[132]

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[130] Decision 5/CMP.2.

[131] Article 12, paragraph 8 of the Kyoto Protocol and decisions 17/CP.7 and 3/CMP.1.

[132] For updated information on the number of CERs issued in the Adaptation Fund account in the CDM registry please see: <http://cdm.int/Issuance/SOPByProjectsTable.html>.

9. POTENTIAL FOR ENHANCED INVESTMENT AND FINANCIAL FLOWS

9.1. Introduction

719. This chapter provides an overview of the key findings of the paper and considers how future investment and financial flows can be shifted, optimized and scaled up to meet the needs for mitigation and adaptation to climate change.

9.2. Key findings

720. The **estimated additional investment and financial flows needed in 2030** to address climate change is large compared with the funding currently available under the Convention and its Kyoto Protocol, but small in relation to estimated global GDP (0.3–0.5 per cent) and global investment (1.1–1.7 per cent) in 2030.

721. In many sectors the lifetime of capital stock can be thirty years or more. The fact that total **investment in new physical assets is projected to triple between 2000 and 2030** provides a window of opportunity to direct the financial and investment flows into new facilities that are more climate friendly and resilient. The investment decisions that are taken today will affect the world's emission profile in the future.

722. When **considering means to enhance investment and financial flows to address climate change in the future**, it is important to focus on the role of private-sector investments; as they constitute the largest share of investment and financial flows (86 per cent). Although ODA funds are currently less than 1 per cent of investment globally, ODA represents a larger share of the total investments in some countries such as the LDCs (6 per cent).

723. Particular attention will need to be given to **developing countries**, because although they currently account for only 20–25 per cent of global investments, their expected rapid economic growth means that they will require **a large share of investment and financial flows.**

724. With **appropriate policies and/or incentives**, a substantial part of the additional investment and financial flows needed could be covered by the currently available sources. However, **improvement in, and an optimal combination of, mechanisms**, such as the carbon markets, the financial mechanism of the Convention, ODA, national policies and, in some cases, **new and additional resources**, will be needed to mobilize the necessary investment and financial flows to address climate change.

725. The **carbon market**, which is already playing an important role in shifting private investment flows, would have to be significantly expanded to address needs for additional investment and financial flows. **National policies** can assist in shifting investments and financial flows made by private and public investors into more climate-friendly alternatives and optimize the use of available funds by spreading the risk across private and public investors. **Additional external funding for climate change mitigation and adaptation will be needed,** particularly for sectors in developing countries that depend on government investment and financial flows.

726. If the funding available under the **financial mechanism** of the Convention remains at its current level and continues to rely mainly on voluntary contributions, it will not be sufficient to address the future financial flows estimated to be needed for mitigation and adaptation.

727. Several **other options** for generating additional funds have been suggested. Some of these options, such as the expansion of the carbon market and the auction of allowances for emissions from international bunkers, could generate revenues commensurate with the additional needs.

9.2.1. Overview of current investment and financial flows

728. As indicated in chapter 3 and annex 5, tables 1–4, most investment (75–80 per cent) occurs in Annex I Parties. Globally, corporations are responsible for about 60 per cent of total investment, but this varies from 50 to 75 per cent in different regions, with Africa at the low end and developing Asia at the high end. Households, individuals, farmers and small businesses are responsible for 26 per cent of global investment, ranging from 20 per cent in developing countries to 30 per cent in OECD countries. Governments are responsible for 14 per cent of total investment, ranging from 10 per cent in some regions to 25 per cent in Africa.

729. Globally, about 60 per cent of total investment comes from domestic sources, and about 20 per cent each from FDI and international debt. The domestic share ranges from 20 per cent in the EU to 90 per cent in Africa and the Middle East. ODA funds less than 1 per cent of investment globally, but this rises to over 2 per cent in Africa and over 6 per cent in LDCs.

730. In almost every sector and region, domestic sources account for most of the funds invested. FDI tends to be invested in mining, including oil and gas production; manufacturing; and financial services. Only small amounts of FDI are invested in agriculture, forestry and construction. ODA is invested in energy and water supply in LDCs.

731. The Convention and its Kyoto Protocol have established mechanisms that provide investment and financial flows for adaptation and mitigation. These include the CDM, JI, the GEF, LDCF, SCCF, and the Adaptation Fund of the Kyoto Protocol. The table 59 provides an overview the current investment and financial flows generated by these mechanisms.

Table 59. Overview of current sources of financial flows relevant to climate change

Sources	Amount (in millions of United States dollars)	Notes
Mitigation		
Clean development mechanism	2006USD 5 259	Value of trades during 2006
	2006USD 947 to 1 572	Value of estimated annual emission reductions for projects registered during 2006
	2006USD 1 569 to 2 602	Value of estimated annual emission reductions for projects that entered the pipeline during 2006
	2006USD 6 939	Investment by projects registered during 2006
	2006USD 26 467	Investment by projects that entered the pipeline during 2006
Joint implementation	2006USD 140	Value of trades during 2006
	2006USD 132 to 266	Value of estimated annual emission reductions for projects that entered the pipeline during 2006
	2006USD 6 269	Investment by projects that entered the pipeline during 2006
Carbon funds	2006USD 6 996	Subscribed capital at end of 2006
	2006USD 2 110	Increase in subscribed capital during 2006
Global Environment Facility (GEF)	3 326.6	Cumulative funding allocated since GEF inception for operational programmes (OPs) 5, 6, 7, 11, EA, STRM and joint OPs. Pilot phase and three replenishment periods and six projects approved under the fourth GEF replenishment (GEF 4) as at June 2007
	990	Targeted allocations as per GEF 4 to be spent between 2006 and 2010
Adaptation		
GEF strategic priority "Piloting an Operational Approach to Adaptation (SPA)"	50 (over 3 years)	Pilot to be evaluated
Least Developed Countries Fund (LDCF)	160 (pledged)	
Special Climate Change Fund (SCCF)	67 (pledged)	Adaptation part only
Adaptation Fund (AF)	2006USD 80–300	Estimated annual revenue during 2008 to 2012 from 2 per cent share of proceeds levy on CERs issued

Source: Chapters 7 and 8.
Note: Activity under the clean development mechanism and joint implementation is relatively recent and growing rapidly, so data for 2006 are presented.

732. The financial mechanism of the Convention, including the LDCF and SCCF, depends on replenishments through voluntary contributions from donors, and in particular, on how much Annex II Parties allocate to the financial mechanism in accordance with their obligations in Article 4, paragraph 3, of the Convention. The target for GEF 4 is USD 990 million over 2006 to 2010. The LDCF and SCCF are replenished on an ongoing basis with total pledges to date amounting to USD 227 million.

733. The revenue received by the Adaptation Fund depends on the quantity of CERs issued and the price of CERs. Assuming annual sales of 300 million to 450 million CERs and a market price of USD 24 (range of USD 14–34) the Adaptation Fund would receive USD 80 to 300 million per year for 2008 to 2012.

734. The current and projected size of the international **carbon markets** is analysed in detail in chapter 7 and summarized in table 60.

Table 60. Current and projected size of the international carbon markets

Year	Market	Sales (2006 USD billion per year)	Quantity (Mt CO_2 eq)	Average price and range (2006 USD/t CO_2 eq)
		Trading activity		
2006	Clean development mechanism (CDM)	5	475	11 (6–27)
	Joint implementation (JI)	<1	16	9
	European Union emissions trading scheme allowances	24	1 101	22 (5–40)
		Compliance needs		
2010	Compliance by Parties to the Convention that are also Parties to the Kyoto Protocol with commitments inscribed in Annex B to the Kyoto Protocol (mainly CDM and JI)	10–15 (5–25)	400–600 excluding Canada	24 (14–34)
2030	Purchases by Parties currently included in Annex I to the Convention			
	Low estimate	10–15 (5–25)	400–600	24 (14–34)
	High estimate	100 (90–125)	4 000–6 000	24 (14–34)

9.2.2. Key findings on investment and financial flows needed for mitigation in 2030

735. It is estimated that global additional investment and financial flows of USD 200–210 billion will be necessary in 2030 to return global GHG emissions to current levels (see tables 61–63 below). In particular:

- **For energy supply**, investment and financial flows would be reduced by about USD 59 billion for fossil fuel supply and by USD 7 billion for power supply owing to increased investment in energy efficiency and biofuels of about USD 158 billion. Investment in fossil fuel supply is expected to continue to grow, but at a reduced rate. About USD 148 billion out of USD 432 billion of projected annual investment in power sector is predicted to be shifted to renewables, CCS nuclear energy and hydropower. Currently most of the power sector investment is made by government-owned or private, usually regulated, electric utilities, and is made domestically in most regions;
- **For industry,** additional investment and financial flows are estimated at about USD 36 billion. More than half of the additional investment is for energy efficiency, one-third for installation of CCS and the rest for reduction of non-CO_2 gases. Implementation of these measures is likely to require government policies, but the investment would come mostly from the private sector;
- **For buildings,** additional investment and financial flows amount to about USD 51 billion. Currently, commercial and residential energy efficiency investment comes from building owners and is financed domestically;
- **For transportation,** additional investment and financial flows amount to about USD 88 billion. Efficiency improvements for vehicles and increased use of biofuels are likely to require government policies, but the investment would come mostly from the private sector;
- **For waste,** additional investment and financial flows are estimated at about USD 1 billion. Capture and use of methane from landfills and wastewater treatment could reduce emissions by about 50 per cent in 2030, mainly in non-Annex I Parties;
- **For agriculture,** additional investment and financial flows are estimated at about USD 35 billion. Non-CO_2 emissions from agriculture production could be reduced by about

10 per cent at a cost of USD 20 billion in 2030. With a concerted international effort and an annual investment of about USD 15 billion, agroforestry could be expanded at a rate of about 19 million ha per year by 2030;

- **For forestry,** additional investment and financial flows are estimated at about USD 21 billion. An indicative estimate of the cost of reducing deforestation and forest degradation in non-Annex I Parties to zero in 2030 is USD 12 billion. The estimated investment and financial flows in 2030 to increased GHG removals by sinks through sustainable forest management is USD 8 billion and the estimated investment and financial flows needed for afforestation and reforestation is USD 0.1–0.5 billion;
- **For technology R&D and deployment,** additional investment and financial flows are estimated at about USD 35–45 billion. Government spending on energy R&D worldwide has stagnated, while private sector spending has fallen. Government budgets for energy R&D and support for technology deployment need to double, increased expenditures in 2030 are expected at USD 10 and 30 billion respectively.

Table 61. Investment for energy supply under the reference and mitigation scenarios in 2030 (billions of United States dollars)

	Global			Non-Annex I Parties		
Sector	**Reference scenario**	**Mitigation scenario**	**Additional investment**	**Reference scenario**	**Mitigation scenario**	**Additional investment**
Fossil fuel supply						
Coal	20	12	-8	13	8	-5
Oil	154	125	-29	85	69	-16
Natural gas	148	126	-22	58	47	-11
Total	**322**	**263**	**-59**	**156**	**124**	**-32**
Power supply						
Coal-fired generation	75	24	-51	40	13	-27
Oil-fired plants	2	1.5	-1	1	1	0
Gas-fired plants	39	36	-3	17	13	-4
Nuclear energy	15	40	25	3	14	11
Hydropower	37	59	22	28	46	18
Renewable	41	79	38	12	30	18
CO_2 capture and storage facility coal-fired plants	-	40	40	0	21	21
CO_2 capture and storage facility gas-fired plants	-	23	23	0	6	6
Transmission and distribution	231	130	-101	149	101	-48
Total	**439**	**432**	**-7**	**251**	**245**	**-6**

Abbreviations: Non-Annex I Parties = Parties not included in Annex I to the Convention

Table 62. Additional investment for emission reductions under the mitigation scenario for related sectors in 2030 (billions of United States dollars)

	Additional investment	
Sector	**Global**	**Non-Annex I Parties**
Industry		
Electrical equipment	10.8	3.8
Stationary fuel consuming equipment	8.7	3.1
CO_2 capture and storage	14.1	11.0
Non-CO_2 gases	2.0	1.2
Total	**35.6**	**19.1**
Buildings		
Electrical equipment	42	10.0
Stationary fuel consuming equipment	8.8	4.0
Total	**50.8**	**14.0**
Transportation		
Hybrid vehicles and efficiency improvement in vehicles	78.7	31.5
Biofuel	9.2	4.0
Total	**87.9**	**35.5**
Waste total	**0.9**	**0.6**

Abbreviations: Non-Annex I Parties = Parties not included in Annex I to the Convention
Note: Additional investments are calculated based on the capital costs of different measures to achieve the emission reductions projected for the mitigation scenario as compared with the reference scenario.

Table 63. Additional investment and financial flows under the mitigation scenario for forestry and agriculture in 2030 (billions of United States dollars)

Sector	**Global**	**Non-Annex I Parties**
Agriculture		
Non-CO_2 gases[a]	20	13
Agroforestry	15	N.A.[b]
Grassland management	N.A.	N.A.
Forestry		
Reduced deforestation [a,c]	12	12
Forest management[a,d]	8	8
Afforestation and reforestation	0.12–0.50	0.1–0.4

Abbreviations: Non-Annex I Parties = Parties not included in Annex I to the Convention
Note: Additional investments are calculated based on the capital costs of different measures to achieve the emission reductions projected for the mitigation scenario. Additional financial flows are calculated based on the marginal costs of the measures to achieve the emission reductions projected for the mitigation scenario.
[a] Financial flows, minimum investments required.
[b] Only global estimates are currently available.
[c] Reducing emissions from deforestation in developing countries as defined in SBSTA Agenda Item 5.
[d] Part of this investment might also be considered in Reduced deforestation.

736. **Mitigation actions are expected to be more cost-effective in non-Annex I Parties**. Table 64 shows that 68 per cent of the projected global emission reductions occur in non-Annex I Parties while only 46 per cent of the additional investment and financial flows are needed in non-Annex I Parties. This reflects mitigation opportunities associated with the rapid economic growth projected for large developing countries,

the relatively inefficient energy use, and the prevalence of low cost mitigation opportunities in the forestry sector.

Table 64. GHG emission reductions and additional investment and financial flows

	Global		non-Annex I Parties			
	Emission Reduction Gt CO_2 eq	**Additional investment and financial flows in 2030 USD billion**	**Emission Reduction Gt CO_2 eq**	**Additional investment and financial flows in 2030 USD billion**	**Percent of global emission reduction**	**Percent of global additional investment and financial flows in**
Power supply	9.4	148.5	5.0	73.4	53	49
Industry	3.8	35.6	2.3	19.1	60	54
Transport	2.1	87.9	0.9	35.5	42	40
Building	0.6	50.8	0.3	14.0	48	28
Waste	0.7	0.9	0.5	0.6	64	64
Agriculture	2.7	35.0	0.4	13.0	14	37
Forestry	12.5	20.7	12.4	20.6	100	99
Total	**31.7**	**379.5**	**21.7**	**176.2**	**68**	**46**

Note: The data should not be used to compare the cost per ton of CO_2e reduced by sector. The costs for reducing electricity use in buildings and industry are reported in those sectors, while the emission reductions are counted in the power supply sector.

737. The **entities that make the investment decisions are different in each sector, and the policy and/or financial incentives needed will vary** accordingly. For example:

- Increased energy efficiency is best achieved through appropriate policies or regulations (the investments are internal and often incremental, and have short payback periods, but adoption is hampered by recognized barriers);
- Shifting investment in efficient motor vehicles need incentives to:
  - Introduce hybrid vehicles such as vehicle purchase subsidies, regulatory standards and higher taxes on the least efficient vehicles;
  - Expand the use of biofuels such as larger R&D programmes and minimum requirements for biofuels in conventional fuel blends;
- Shifting investment in the power sector to CCS and low GHG emitting generation technologies will need both policies and financial incentives which make these technologies economically more attractive than high GHG emitting technologies. This requires large R&D programmes, incentives for large scale demonstration plants, national or international policy frameworks, such as carbon markets, renewable portfolio standards or higher feed-in tariffs, loan guarantees to reduce the cost of capital, financial penalties on carbon emissions;
- Financial incentives will be needed to achieve significant reductions in emissions through reduced deforestation and forest management.

738. Currently most of the investment in mitigation measures is domestic; however, ODA plays an important role in Africa and the LDCs. **With appropriate policies and/or incentives, a substantial part of the additional investment and financial flows needed could be covered by the current sources. However, there will be a need for new and additional external sources of funds dedicated to mitigation**.

739. The share of the **GEF, as an operating entity of the financial mechanism of the Convention**, of total multilateral and bilateral funding between 1997 and 2005 is 1.6 per cent.

740. The **carbon market** and policies to promote renewables are already playing an important role in shifting investment flows. This is indicative of how quickly investment flows can respond to changes in policies and incentives.

741. It is estimated that the CDM project activities that entered the pipeline in 2006 will generate investment of about USD 25 billion, of which approximately 50 per cent represents capital invested in unilateral projects by host country project proponents. Renewable energy and energy efficiency projects account for 90 per cent of the overall investment.

742. The supply of Kyoto units will be abundant compared with the level of compliance demand for the period 2008–2012. The voluntary market could represent about 15 per cent of the total carbon market.

743. The low estimate of compliance demand by Annex I Parties in 2030 is a market of USD 5–25 billion per year, which is basically a continuation of the current flow of projects. The high estimate of compliance demand is a market of USD 100 billion per year; to meet this demand, a large fraction of the potential emission reductions, from all existing and some new categories of projects, would need to earn emission reduction credits.

744. All Parties need to adopt **climate change policies**. International coordination of policies in an appropriate forum is often effective. Areas where international coordination would be beneficial include:

- Technology R&D and deployment;
- Energy efficiency standards for internationally traded appliances and equipment.

745. Funding from external sources will play an important role in helping developing countries formulate and implement national policies.

9.2.3. Key findings on investment and financial flows needed for adaptation in 2030

746. The global cost of adaptation to climate change is difficult to estimate, largely because climate change adaptation measures will be widespread and heterogeneous. More analysis of the costs of adaptation at the sectoral and regional levels is required to support the development of an effective and appropriate international response to the adverse impacts of climate change. Nevertheless it is clear that a large amount of new and additional investment and financial flows will be needed to address climate change adaptation.

747. Estimated overall **additional investment and financial flows needed for adaptation in 2030** amount to several tens of billion United States dollars (see table 65 below). In particular:

- About USD 14 billion in investment and financial flows are estimated to be needed for **agriculture, forestry and fisheries** (AFF);
  - About USD 11 billion is estimated to be needed for production and processing, most of which is expected to be financed by domestic private sources;
  - About USD 3 billion is estimated to be needed for R&D and extension activities. Based on current trends, it can be expected that public sources of funding will need to cover a large part of this additional need.
- The additional investment needed in **water supply** infrastructure in 2030 is estimated at USD 11 billion, 85 per cent of which will be needed in non-Annex I Parties. About 90 per cent of the cost for all aspects of water resource use is currently covered by public domestic funding sources and 10 per cent by external public funding sources, and this pattern is unlikely to change significantly by 2030;

- The costs of treating the increased cases of **diarrhoeal disease, malnutrition and malaria** due to climate change are estimated at USD 5 billion in 2030. This need for additional financial flows will occur solely in developing countries and corresponds to the current annual ODA for health. The additional cost is likely to be borne mainly by the families of those affected. Where private individuals cannot cope with the additional cost of treatment, additional public financing will be necessary;
- The investment needed in 2030 for **beach nourishment and dykes** is estimated to be about USD 11 billion. About half of the global investment would be needed in non-Annex I Parties. Efforts to protect **coastal areas** from coastal storms and sea level rise are typically undertaken by governments. The necessary public resources for coastal zone adaptation are likely to be available in developed and some developing countries. However, deltaic regions, particularly the large coastal deltas in Asia and Africa as well as the small island developing States, may have significant problems in raising the required investment and financial flows to respond to sea level rise;
- The additional investment needed to adapt **new infrastructure** vulnerable to climate change is estimated at USD 8–130 billion, which is less than 0.5 per cent of global investment in 2030. The extra cost is likely to be met in the same manner as the overall infrastructure cost.

748. The change in investment and financial flows for adaptation that will need to occur in developed and developing countries varies by sector. **A significant share of the additional investment and financial flows will be needed in non-Annex I Parties (USD 28–67 billion)**.

Table 65. Estimated additional investment and financial flows needed for adaptation in 2030 (billions of United States dollars)

Sector	Global	Non Annex-I Parties
Agriculture, forestry and fisheries	14	7
Water supply	11	9
Human health	5	5
Coastal zones	11	5
Infrastructure	8 to 130	2 to 41

749. Private **sources** of funding can be expected to cover a portion of the adaptation costs in sectors (such as **AFF and infrastructure**) with privately owned physical assets, in particular in developed countries. However, public resources will be needed to implement policies or regulations to encourage the private investment of private resources in adaptation measures, especially in developing countries. Public domestic resources will be needed to cover adaptation costs related to climate change impacts on public infrastructure in all countries.

750. **Additional external public funding is likely to be needed for adaptation measures**. Such additional funding will be needed in particular for sectors and countries that are already highly dependent on external support, for example in the health sector in LDCs, or for coastal infrastructure in developing countries that are highly vulnerable to sea level rise. **Current mechanisms and sources of financing are limited and it is likely that new sources of funding will be required**.

751. The **funds managed by the GEF** that are available for adaptation projects, including the SPA of the GEF Trust Fund, the SCCF and the LDCF, amount to over USD 275 million. Since 2005 the GEF has provided USD 110 million for adaptation projects.

752. The **revenue received by the Adaptation Fund** under the Kyoto Protocol depends on the quantity of CERs issued and their price. Assuming annual sales of 300–450 million CERs and a market price of USD 24 (range USD 14 to 34), the Adaptation Fund would receive USD 80-300 million per year for the period 2008–2012. Funding for the Adaptation Fund post 2012 depends on the continuation of the CDM and the level of demand in the carbon market. Assuming a share of proceeds for adaptation of 2 per cent continues to apply post 2012, the level of funding could be USD 100-500 million per year in 2030 for a low demand by Annex I Parties for credits from non-Annex I Parties, and USD 1–5 billion per year for a high demand. This will still be less than the amount likely to be needed.

753. **Bilateral contributions** for adaptation are estimated to have been in the order of USD 100 million per year between 2000 and 2003.

754. **National policies** could play an important role in ensuring that the use of resources for adaptation purposes, both public and private, is optimized. In particular, there is a need for:

- Domestic policies that provide incentives for private investors to adapt new physical assets to the potential impacts of climate change;
- National policies that integrate climate change adaptation in key line ministries;
- Local government adaptation policies in key sectors.

755. Although the additional investment and financial flows needed for adaptation described above are significant**, the value of the climate change impacts that those expenditures would avoid could be larger.** This study does not estimate the total value of impacts avoided by adaptation to climate change, so it does not determine whether benefits of avoided damage exceed the adaptation costs. Existing estimates of the future damage caused by climate change vary substantially; however, available studies yield two important common findings:

- Damage increase with the magnitude of climate change. The more that the climate changes, typically measured as the increase in global mean temperature, the greater the damage;
- Investment needs for adaptation would almost certainly increase substantially in the latter decades of the twenty-first century. They will be particularly high if no mitigation measures are implemented;

756. On average, developing countries suffer more damage as a percentage of their GDP than developed countries, which implies that damages and benefits are not distributed evenly.

9.2.4. Priorities identified by developing country Parties in the UNFCCC process

757. In addition to the needs identified above, when tailoring incentives for financial and investment flows it is important to take into account priority areas for climate change mitigation and adaptation identified by non-Annex I Parties under the Convention process. Although these priorities have been identified in various contexts and do not constitute a comprehensive view of non-Annex I Parties priorities and needs, they complement the discussion of investment and financing needs.

758. In their INCs two-thirds of non-Annex I Parties reported energy supply measures as a priority, and a majority of the mitigation project proposals in the energy sector submitted by Parties in their INCs involve switching to renewable sources of energy. Other mitigation measures identified as priorities include

switching to less carbon intensive fuels, installing more efficient industrial boilers, improving cooking stoves for the residential/commercial sector, promoting electric and compressed natural gas vehicles, reducing waste generation at source, making changes in cattle management practices and promoting forest conservation and restoration.

759. Adaptation measures related to water supply were reported as a priority in all regions. Measures proposed in this sector are aimed at increasing water supply, improving water management and improving flood, drought, and water level monitoring. Other adaptation measures identified as priorities by Parties include the development of resistant crop and livestock varieties and salt-tolerant fish species. Measures related to the prevention of soil erosion and to the integrated management of coastal areas were also highlighted, along with the need for early warning systems for extreme events and measures for flood prevention. Development of health infrastructure and protection of tourism infrastructure were also identified as priorities. The need for an integrated approach to adaptation was emphasized by Parties.

760. With regard to the adverse impacts of response measures, measures prioritized by parties include the development of low GHG emitting technologies, financial risk management such as commodity price hedging and economic shock funds, and the development of key infrastructure needed to diversify economic activity.

9.3. Key factors and options determining future investment and financial flows

761. The previous chapters illustrate that addressing climate change will require significant changes to in patterns of investment and financial flows. Such changes fall into three categories:

- ***Shift investments and financial flows*** made by private and public investors to more sustainable climate-friendly alternatives, for example, by redirecting investments from traditional energy supply sources and technologies to low GHG emitting ones;
- ***Scale-up*** international private and public capital dedicated to investments and financial flows in mitigation or adaptation activities or technologies, for example by expanding the carbon market, by increasing contributions from Annex II Parties or by identifying new sources of funding;
- ***Optimize the allocation of the funds*** available by spreading the risk across private and public investors, for example by providing incentives for private investment in the early deployment of new technologies or by improving the capacity of the insurance market

9.3.1. Shift investments and financial flows

762. Substantial shifts in investment patterns will be required to mitigate and adapt to climate change. About half of these shifts should occur in developing countries, which will require incentives and support for policy formulation and implementation.

763. Shifting investment is particularly important for the power supply. About USD 148 billion needs to be shifted from fossil-fired generation to renewables, CCS, nuclear energy and hydropower. Currently investment in the power sector is mostly domestic (about 70 per cent) with significant international FDI and international borrowing in some regions. Shifting domestic investments into more climate-friendly alternatives may require national policies and/or financial incentives.

764. Investment in improved efficiency by energy consumers and biofuel (USD 158 billion) would reduce the investment required in energy supply by USD 67 billion in 2030. Such a shift will require appropriate policies to encourage consumers to implement energy efficiency measures.

765. Adaptation in the infrastructure and AFF sectors will require a shift in public- and private-sector investment patterns and associated production activities. In both sectors, investment in physical assets will need to be shifted towards assets that are less vulnerable to the adverse impacts of climate change. The shift can be characterized, for example, by a change in location, design, building material or primary input in the case of manufacturers. The optimal shift will occur only with adequate policies and incentives. In the case of poor populations, direct financial support may also be required.

766. Shifting investments into high-cost, low GHG emitting technologies poses additional challenges. Since the risks and costs are higher than those of conventional technologies, private investors need financial incentives or other arrangements to enable them to earn a comparable risk-adjusted return. This means it will be necessary, in particular in developing countries, to scale up funding (in the form of grants, concessional loans, promotional programmes, demonstration projects, etc.) to shift the investments (see chapter 9.3.2 on scaling up funding below).

9.3.1.1. Shifting private investments and financial flows

767. Private investors pursue opportunities to earn risk-adjusted returns that meet their investment preference. As a consequence of the increasing public and government attention to climate change, there has been an increase in private investment in the area – the opportunities to make a profit are clearer and more immediate. More attention is also being paid to the risks of climate change – the need to consider the impacts of climate change on the projected returns from proposed investments. While these shifts in private investment are most welcome, they are not sufficient to offset the much larger, continuing investments in traditional, long-lived, fossil fuel consuming, GHG emitting facilities.

768. **Governments** – primarily those at the national level – set the rules for the markets in which investors seek profits. If current market rules are failing to attract – or drive – private investors into lower GHG emitting, more climate-proof alternatives, there are a variety of steps governments can take to help address these market failures, including:

- **Overcoming policy-based barriers to entry** by: (1) requiring regulated, monopoly providers (such as electricity grids) to provide access to and purchase power from providers that use lower carbon sources of energy on financially attractive terms; (2) reducing or removing subsidies to dirtier, less efficient energy production and/or use (such as subsidies for fossil fuel consumption or production); and (3) reducing or removing standards that inhibit implementation of lower carbon solutions (such as the building codes and energy efficiency or zoning codes and higher density, mixed use developments);
- **Making the polluter pay (internalizing externalized costs)** by: (1) imposing GHG emission limits or performance standards on production operations and products (such as vehicle emission standards); (2) imposing taxes or other charges on GHG emissions or fossil fuel use (such as a tax on coal use); and (3) holding polluters liable for the climate damage they cause;
- **Paying the innovator (internalizing externalized benefits)** by: (1) creating tradable rights to reward investments in reducing GHG emissions (such as a cap and trade regime); (2) offering fiscal incentives for investing in lower carbon methods (such as production tax credits for renewable energy); and (3) providing direct public support for lower carbon activities (such as funding for research and development);
- **Filling information gaps** by: (1) requiring disclosure of data on GHG emissions from production operations or energy use by products; (2) supporting voluntary efforts to make such data available; and (3) directly providing data helpful to potential investors (such as on wind resources or investment incentives)′.

Box 16. Brazilian government initiatives to leverage private sector financing

PROINFA (the Brazilian Alternative Energy Sources Incentive Programme) was implemented in 2004 in order to diversify the Brazilian electricity generation portfolio. Phase A of the programme established a target 3.3GW of installed capacity through wind, biomass and mini-hydro projects by the end of 2008. A further 3.3GW is due to be added by 2012, The Brazilian National Bank for Social and Economic Development (BNDES) earmarked USD 2.5 billion to finance up to 80 per cent of the total cost of contracted projects through indirect and direct loans with a maximum 12-year tenor. Eletrobras (Public Electricity Utility) guarantees PPA contracts for 20 years for projects using alternative sources and established generous feed-in tariffs.

769. Such policy mechanisms are being adopted by governments around the world – at the international level (Kyoto Protocol – carbon markets), regional level (EU support for renewable energy), national level (China's renewable energy goal), state level (state and regional GHG cap and trade programmes in the United States) and local level (municipal procurement requirements for cleaner buses) levels. Examples of developing countries applying these approaches in the renewable energy sector are provided in annex 5, table 31. These policy tools can also be used across many different sectors – as shown in annex 5, table 32.

770. By using these policy mechanisms to tilt the playing field toward lower carbon, more climate-proof investments, governments can encourage private investors to shift their investments to attractive opportunities in more climate-friendly assets.

771. The carbon markets and policies to promote renewables are already playing an important role in shifting investment flows. This is indicative of how quickly investment flows can respond to changes in policies and incentives.

772. Some of the existing **funding sources under the Convention and its Kyoto Protocol** are already providing incentives for the development and implementation of climate change related policies. The financial mechanism of the Convention may be used to support the development of such policies. The programme of activities in the CDM has the potential to promote the implementation of policies to a larger number of investors. The potential of these mechanisms would need to be enhanced significantly to leverage the needed shifting from private sector investments.

Box 17. Example of projects by the GEF supporting shifts in private financing

The **India Alternate Energy project** was started in 1991 by the World Bank and the GEF to promote commercialization of wind power and solar PV technologies in India. The project was designed to strengthen government policies to promote wind power through special tax incentives. In just a few years, 968 MW of wind farms were installed and operating in India, almost all commercial and privately operated. Highly favorable investment tax policies strongly influenced these commercial installations. The wind industry jumped from three companies to 26, many of them joint ventures. Technology development and exports accelerated and costs declined.

The GEF-sponsored **China Energy Conservation Project** implemented by the World Bank started in 1998 and established three pilot energy service companies (ESCOs) in Beijing, Liaoning, and Shandong to promote investments in energy efficiency projects through energy performance contracting. Currently the project is replicating the initial experience and promote the development of new ESCOs in China through the creation of a self-sustaining ESCO Association and by establishing a commercial loan guarantee program to provide partial risk guarantees to local financial institutions which lend to the ESCOs. By end of 2006, almost 1,500 energy efficiency projects had been completed, with total investments exceeding USD 550 million. These projects have resulted in the reduction of energy use by 2.8 million tons of coal equivalent a year. More importantly, the China Energy Conservation Project has been instrumental in promoting the market-based energy performance contracting mechanism in China and in creating an ESCO industry that has flourished rapidly. Membership in ESCO Association has grown rapidly and reached more than 200 by the end of 2006.

773. **Additional options** that could be considered at the intergovernmental process could include efforts to:

- Collect and disseminate the experience of governments, particularly those in developing countries, to use policies to increase private investment in climate-friendly approaches;
- Promote dialogue with investors on how policy approaches affect their investments and how they might be changed to increase their investment further.

774. **MDBs** can stimulate shifts of private investments in clean energy and more climate resilient development, for example, by providing guarantees for investment risks that private investors would not take. The IFC is developing "the Carbon Delivery Guarantee" to guarantee delivery of carbon credits from projects in developing countries, thus eliminating project delivery risk for buyers. Under the Clean Energy and Investment Framework, MDBs have been collaborating to develop proposals for partial risk (credit) guarantees to private lenders and bondholders to cover debt service payments for clean energy projects based on future carbon credit cash flows (World Bank, 2006).

775. MDBs can also promote demonstration projects for commercialization of new clean technologies.

776. As further elaborated below in the chapter on optimizing resources, sharing risks among private and public, domestic and external sources can also shift investment flows.

9.3.1.2. Shift of public investments and financial flows

777. **Governments** also need to shift their own investments. Governments are responsible for 10–25 per cent of the investment in new physical assets. Most of those investments are driven by local development priorities, whether they are jobs, power, transport, education, health or other public benefits. For developing countries, in particular, shifting funding to climate change has to take social and development priorities into account.

778. The challenge is to shift more public investment into lower carbon, more climate-proof measures without sacrificing development priorities. Integrating climate change adaptation and mitigation considerations into national planning (such as considering investments in clean technology in energy planning or costs associated with climate change impacts in new infrastructure, such as bridges or roads) is part of the solution.

779. Targeted measures can also help shift public investment while contributing to development priorities, for example:

- Removing existing subsidies from fossil fuels and promoting cleaner and more efficient energy use;
- Removing existing subsidies from unsustainable land uses;
- Integrating energy efficiency into new government buildings and facilities.

Box 18. Examples of government funding to promote renewable energy

The government of China is supporting a wide range of renewable technologies, including small hydropower, biogas, solar hot water systems, photovoltaic and wind generation. It provides subsidies of about USD 125 million a year for household biogas systems, and is investing heavily in its Village Electrification Programme, aiming to provide electricity to 27 million people by 2010 at an estimated cost of USD 2.5 billion.

India, too, has renewable energy programmes coordinated by the Ministry for New and Renewable Energy (MNRE). In 2005, the MNRE had a budget of USD 137 million, 35 per cent of which was destined for rural electrification.

Egypt, Malaysia, Mexico, the Philippines, South Africa and Thailand also have government funding programmes for renewable energy. In December 2006, Thailand's Ministry of Natural Resources and Environment set up a USD 300 millions fund to support small renewable energy projects under the Very Small Power Producers Programme.

780. The mechanisms of **the Convention and its Kyoto Protocol** and carbon markets can also play an important role. The CDM can, for example, provide an opportunity for governments to implement GHG emissions mitigation projects**.** The financial mechanism can assist developing countries in integrating climate change adaptation and mitigation into long-term national planning.

Box 19. Example of a clean development mechanism project activity implemented by a local government - São João Landfill Gas to Energy Project

The São João Landfill Gas to Energy is a project between the municipality of São Paulo and Biogás Energia Ambiental S.A. It is designed to explore the landfill gas produced in Aterro Sanitário "Sítio São João", which is one of the biggest landfills in Brazil. The annual average emission reductions over the crediting period is estimated 816,940 tonnes CO_2 eq emission reductions.

The landfill is located in the metropolitan region of São Paulo, Brazil's biggest and heavily indebted city with liability today around USD 9,2 billion. The administration of the city has been seeking partnerships and new ways to boost investment and improve life quality in the area. As a participant in this project, the municipality will receive 50 per cent of revenues to be earned through emissions reductions commercialization, an income to be used for new investments in landfill installations and rubbish dumps recovery.

781. **Additional options** that could be considered in the intergovernmental process could include efforts to:

- Publicize examples of the co-benefits of investments in lower GHG emitting, more climate-proof projects;
- Shared experiences, particularly South–South, on the benefits and risks associated with shifting more investment into lower GHG emitting, more climate-proof projects.

782. **MDBs** can shift their own investments by integrating climate change risks and costs of adaptation and mitigation into their lending practices. The World Bank has estimated that 20 to 40 per cent of ODA and public concessional finance (USD 20 to USD 40 billion per year) is subject to climate risk and only a small portion of ODA takes this risk into account in project planning. The Bank is currently developing a climate risk assessment tool to assess development projects for their potential sensitivity to climate change.

783. Shifting MDB investment and financial flows to more climate-resilient and cleaner energy can complement and reinforce development goals. Examples of their recent initiatives include (World Bank, 2007):

- The African Development Bank is developing a Clean Energy Investment Framework that is to be combined with support to increase access to energy;

- The Asian Development Bank is supporting the development of sustainable transport systems in Asia and has developed a USD 1 billion annual Energy Efficiency Initiative through a proposed Asia Pacific Fund;
- The Inter-American Development Bank has launched a Sustainable Energy and Climate Change Initiative to promote renewable energy and energy efficiency, biofuels, access to carbon finance, and adaptation;
- The European Bank for Reconstruction and Development launched a Sustainable Energy Initiative to more than double its energy efficiency and cleaner energy investments to EUR 1.5 over the next three years;
- The European Investment Bank is supporting research, development and demonstration in renewable energy.

784. To promote further initiatives of this type from MDBs, it will be important to consider at the intergovernmental level means for:

- Developing country Party access to the new types of support being offered by the MDBs;
- MDBs to cover the additional costs of climate change in lending/support programmes to provide incentives for cleaner technologies and more climate-proof projects.

9.3.2. Scale up funding

785. A significant increase (USD 248–381 billion) will be needed in investment and financial flows to mitigate and adapt to climate change. Much of this will be reuired in for adaptation (USD 49–171 billion), but substantial amounts are also required for mitigation measures (such as technology development and deployment (USD 35–45 billion), forestry (USD 21 billion) and agriculture (USD 35 billion)).

786. The capacity of national governments, in developing countries in particular, to increase pools of financing is limited. For private investment and finance, expansion of the international carbon markets or provision of other economic incentives to invest more in specific sectors, particularly in developing countries, will therefore be needed. For public investment, expansion of the climate-focused funding from Annex II Parties (in accordance with Article 4, paragraph 3 of the Convention), as well other potential sources of funding to address climate change, will be needed.

9.3.2.1. <u>Expanded international carbon market</u>

787. Although the international carbon market has generated a large amount of investment (about USD 30 billions including CDM and JI) for cleaner technologies in a very short period, its scale would need to be increased considerably to finance the additional investments needs for mitigation (USD 200–210 billion) in 2030.

788. Proposals to expand the international carbon market should consider the following factors:

- The increase in the demand is largely determined by the aggregate emission reduction resulting from limits on GHG emissions established at the national and international level and by the national policies implemented to comply with these limits;
- The increase in the investment flows to developing countries is limited by the potential and costs of eligible mitigation measures in those countries and requirements to maintain the environmental integrity of the system (additionality, preventing double counting, etc.);
- The carbon market directs investment to mitigation measures for which the revenue from the sale of credits has the biggest impact on profitability. The investment flows stimulated will differ across mitigation measures. Stimulating specific types of mitigation measures may

require complementary measures or different mechanisms, as explained in the chapter 9.3.3 on optimizing investments and financial flows below;

- Policy certainty is important for investors. A longer agreement increases the range of mitigation measures that are attractive investments.

789. Most proposals for expansion of the international carbon market for non-Annex I Parties focus on the CDM, increasing the supply of credits from countries with a non-binding target or none at all. The suggestions include both expansion of the types of projects eligible under the CDM and possible new mechanisms.

790. Suggestions for expansion of the CDM include:

- HFC-23 destruction projects at new HCFC-22 plants;
- CO_2 capture and storage;
- Tradable credits for reduced deforestation (REDD);
- Tradable credits for sustainable development policies and measures (SD-PAMs);
- Sectoral CDM;
- Policy CDM.

791. Other options for REDD, SD-PAMs and sectoral targets propose financial or other incentives, rather than tradable credits.

792. Numerous new mechanisms, such as no lose targets, sectoral targets and REDD targets, have been proposed. The mechanisms would differ from the CDM in terms of the process for approving the target and/or issuing the tradable credits, or they would create tradable credits that are not fully fungible with CERs. The operational details of most of these proposed mechanisms remain to be developed. If Parties agree to any of these mechanisms, there would be a need for modalities to define baseline emissions and verify the actual emissions to determine the credits earned.

793. If the international market in 2030 involves an annual demand of 400–600 Mt CO_2 eq from non-Annex I Parties – the low estimate – the scope for expansion or new mechanisms is small.

794. If the international market in 2030 involves an annual demand of 4,000–6,000 Mt CO_2 eq from non-Annex I Parties – the high estimate – all of those options could be accommodated. To supply such a demand, a large fraction of the potential emission reductions, from all existing and some new categories of projects, would need to earn credits. It would probably require enhanced mechanisms to capture many of the reductions cost-effectively.

795. Experience with the CDM to date indicates that a market mechanism is very effective at identifying the most cost-effective mitigation measures. It is also clear that the stimulus provided by the market varies significantly across project types, owing to the inherent economics of, and the administrative, operational and management challenges raised by, each project type. For example, HFC-23 destruction projects have been more profitable and easier to implement than transportation efficiency projects.

796. Any market mechanism will provide a differential stimulus across eligible project types. Therefore there is merit in considering different mechanisms for different project types, whether reduced deforestation, CCS, SD-PAMs, or sectoral targets. That allows the methodology and administrative process to be tailored to the needs of the projects. The disadvantage of adopting different mechanisms for different project types is possible fragmentation of the market.

797. A consultative event with private sector investors held in London on 21 June 2007 revealed that expansion of global carbon markets is constrained primarily by the absence of long-term political certainty over the existence and stringency of the GHG reduction targets to post 2012.

798. Among the options that the COP might consider for the international carbon market are the following:

- Taking a long-term perspective (i.e. adopting policies with 20–30 year time horizons) to stimulate investments with significant sustainable development benefits;
- Strengthening existing governance institutions by making them more independent of political processes and more attuned to the needs of private carbon market actors;
- Addressing technology and country risks by supporting the development of risk guarantees and other risk sharing mechanisms;
- Reducing the transaction costs associated with project-by-project approvals where possible.

9.3.2.2. Adaptation Fund

799. The revenue generated for the Adaptation Fund by the share of proceeds depends on the quantity of CERs issued and the price of CERs. Funding for the Adaptation Fund for post 2012 depends on the continuation of the CDM and the share of proceeds and the level of demand in the carbon market. Assuming that the share of proceeds for adaptation continues to apply post 2012, the level of funding could be of USD 100–500 million per year for a low demand by Annex I Parties in 2030 for credits from non-Annex I Parties and USD 1–5 billion per year for a high demand.

800. In either case, the revenue generated for the Adaptation Fund would be small in relation to the estimated needs for adaptation. The Adaptation Fund could be further expanded with additional sources of funding.

9.3.2.3. Financial mechanism of the Convention

801. The role of the financial mechanism as a source of funding has been mainly as a catalyst for adaptation and mitigation actions. While the funding for the climate change focal area in the GEF Trust Fund and in the LDCF and SCCF is small relative to the other sources of public investment in climate change, they have demonstrated the ability to catalyse larger investments (about 5 times as large). Other GEF focal areas (biodiversity, land degradation and international waters) also play an important catalytic role in financing adaptation and mitigation activities, such as the protection of ecosystems.[133]

802. Funding from the GEF is available as a grant and can be used for higher risk, longer term projects (such as the commercialization of new technology) and project development costs for which other sources of funding are typically very difficult to obtain. The GEF can also play an important role in promoting capacity-building on the ground.

803. As mentioned in chapter 8, replenishment of the GEF depends on voluntary contributions from donors and, in the case of the Convention, on how much Annex II Parties allocate to the financial mechanism in accordance with their obligations under Article 4, paragraph 3, of the Convention. The fourth review of the financial mechanism should start at COP 13 and as part of this review, the COP is expected to make an assessment of the amount of funds necessary to assist developing countries and provide an input to GEF 5.[134]

[133] Please refer to chapters 4.2.5 and 5.2.4 of this paper.
[134] Decision 2/CP.12.

804. If the funding available to the financial mechanism remains at its current level and continues to rely mainly on voluntary contributions, it will not be sufficient to address the future financial flows estimated to be needed for adaptation and mitigation. In that context, in addition to addressing the need for increased resources it will be key to define what role the GEF as financial mechanism of the Convention should play.

9.3.2.4. Expanded climate funds from donor countries

805. In addition to increasing their contributions to the financial mechanism of the Convention, Annex II Parties can increase their bilateral aid and contributions to multilateral funds to address climate change. According to information available in the fourth national communications of Annex II Parties, about USD 11.5 billion was made available to multilateral funds and USD 8.5 billion to bilateral funds between 2001 and 2003.[135]

806. While ODA investments were only 0.23 per cent of global investment in year 2000, ODA plays an important role in countries with little capacity to leverage domestic and international private investments (rising to over 2 per cent in Africa and over 6 per cent in LDCs) and for technologies or project types where risks are still high for private sector investments (for example in sectors such as health, coastal zones and water supply, most of the financial flows needed for adaptation cannot consist of simple shifts of investment flows and will need to rely on additional external sources of financial flows).

807. Increased financial flows from bilateral donors and multilateral lenders to governments in developing countries for policy development and implementation in sectors that can mitigate and adapt to climate change is also important. Data on ODA, official aid and other lending to developing countries and countries in transition for policy and administration is summarized in annex 5, table 34. Funding for policies in the agriculture and energy alone accounts for half f of the total flow to all nine sectors. Asia received over two-third of the total ODA for policy development and administration, while Africa and Latin America received 23 per cent and 31 per cent respectively.

9.3.2.5. Other potential sources of financial flows

808. Other potential options to generate additional funds to address climate change could be considered, including possibilities originally suggested for other purposes (see table 66). Brief descriptions of the options are provided in annex 4.

[135] Because the information in the national communication reports of Annex II Parties is limited, the exact amount of multilateral and/or bilateral contributions oriented to climate change activities is difficult to estimate. Detailed information can be found in the upcoming compilation and synthesis report of fourth national communications of Annex II Parties (in preparation).

Table 66. Illustrative options for raising additional revenue for addressing climate change

Option	Revenue	Notes
Application of a levy similar to the 2 per cent share of proceeds from the CDM to international transfers of ERUs, AAUs and RMUs	USD 10 to USD 50 million	Annual average for 2008 to 2012
	Depends on size of carbon markets post-2012	Any estimate for post 2012 requires assumptions about future commitments
Auction of allowances for international aviation and marine emissions	USD 10 to USD 25 billion	Annual average for aviation rises from 2010 to 2030
	USD 10 to USD 15 billion	Annual average for marine transport rises from 2010 to 2030
International air travel levy	USD 10 to USD 15 billion	Based on charge of USD 6.50 per passenger per flight
Funds to invest foreign exchange reserves	Fund of up to USD 200 billion	Voluntary allocation of up to 5 per cent of foreign exchange reserves to a fund to invest in mitigation projects determined by the investors to diversify foreign exchange reserve investments
Access to renewables programmes in developed countries	USD 500 million	Eligible renewables projects in developing countries could earn certificates that could be used toward compliance with obligations under renewables programmes in developed countries to a specified maximum, such as 5 per cent
Debt-for-efficiency swap	Further research needed	Creditors negotiate an agreement that cancels a portion of the non-performing foreign debt outstanding in exchange for a commitment by the debtor government to invest the cancelled amount in clean energy projects domestically
Tobin tax	USD 15 to USD 20 billion	A tax of 0.01 per cent on wholesale currency transactions to raise revenue for Convention purposes
Donated special drawing rights	USD 18 billion initially	Special drawing rights are a form of intergovernmental currency provided by the IMF to serve as a supplemental form of liquidity for its member countries. Some special drawing rights issued could be donated to raise revenue for Convention purposes

Abbreviations: CDM = clean development mechanism, ERU = emission reduction units, AAU = assigned amount units, RMU= removal units, IMF = International Monetary Fund

809. Any of these options would, of course, require further analysis and agreement at the intergovernmental process. The main value of this list is to illustrate the availability of possible new sources of funds to address climate change that could generate revenues commensurate with the additional needs. Negotiations on a future regime could consider, inter alia, new commitments, new funding options, and needs that would be funded by the Convention.

9.3.3. Optimize the allocation of the funds

810. In addition to shifting and scaling up funding, the allocation of available resources needs to be optimized. How the available funds are allocated across different projects depends on three major factors:

- ***The sources of investment***, as public and private investors differ in their preference for risk and return over time;

- ***The technology/project*** into which the investment is going, as opportunities vary in the risks they present, both generally (technology risk) and specifically (project risk);
- ***The host country*** of the investment, as countries vary in their attractiveness to investors (country risk).

811. Understanding the interplay among these factors and their implications with regard to how different sources of capital can be used to cover the risks facing different investments is critical to optimizing the use of the available funds.

9.3.3.1. Optimizing sources of investments – opportunities for partnerships

812. Each type of investor – public or private – has its own preference for risk and reward over time. Each investment involves technology, project (sector and location), country and other risks. Different private investors are prepared to bear these risks if the expected return is commensurate. If the risks are too high or the returns are too low, public investment or financial support may be needed. Major differences in preferences for risk and return over time are shown in table 67.

Table 67. Investment preferences

Investor capacity/ preference	**Direct public investment**	**Grants**		**Debt**		**Equity**	
		Public	**Private**	**Public**	**Private**	**Public**	**Private**
Total pool	**Large**	**Small**	**Small**	**Medium**	**Large**	**Small**	**Large**
Returns sought							
Social	High	High	High	High	Low	High	Low
Financial	None	None	None	Low	Medium	Medium	High
Risks taken							
Project	Yes	Yes	Yes	Some	Little	Some	Yes
Technology	Little	Yes	Yes	Some	No	Yes	Yes
Country	Yes	Yes	Yes	Some	Some	Yes	Some
Duration of investment	1-100+ years	1 to 5 years	1 to 3 years	1 to 100+ years	1 to 10+ years	1 to 100+ years	3 to 7 years

Source: Gentry, B. 2007.

813. Allocating investment risks across the parties/sources most willing and able to manage them is a key feature of successful investment in any sector. For example, an investment in a wind farm in a developing country could involve equity investment coming from privately held or publicly listed companies; debt financing from the banks or bond markets; export credits and other insurance from public or private sources, and possibly public grants.

814. Investment partnerships to distribute the risks to the entities best able to bear them while providing each with a reasonable return over time is the key to optimizing the use of the funds available.

815. Some risks are best borne by the private investors involved (e.g. commercial risks). Some can be addressed by governments through the policy and investment frameworks they set. Still others can be taken by MDBs and other sources of public money.

816. The large number of different sources of capital, with varying preferences for risk and return, creates opportunities to bring different sources of capital together to cover the cost of any particular investment, in particular using the public sector's focus on social returns to attract private investors to activities that generate both social and financial returns.

817. Understanding these drivers will be key in defining what new mechanisms need to be developed under the Convention and how existing mechanisms can better complement each other

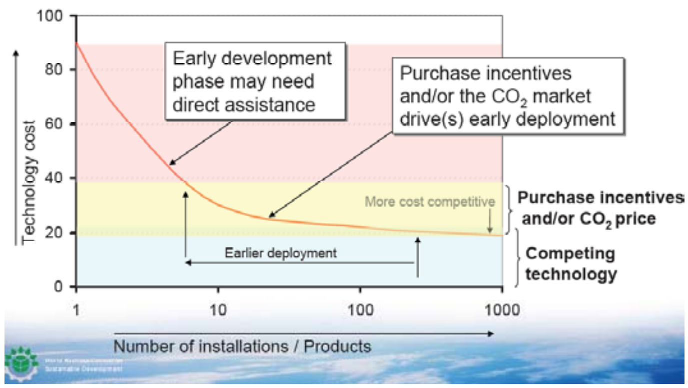
9.3.3.2. Optimizing sources to technologies and projects

Technologies

818. While many of the **technologies** needed to help mitigate climate change are already available, new technologies still need to be developed, and both existing and new technologies will have to be installed in new locations. The risks associated with the state of development of a technology (technology risk) and the specific risks facing the project that deploys a technology (project risk) need to be addressed.

819. Each technology presents different risks at different points in its lifecycle. As shown in figure 41, early stage technologies often require some form of public R&D funding before a private venture capitalist may step in for commercialization. Even proven technologies require purchase incentives to overcome the higher costs during early deployment.

Figure 41. Technology cost and financing curve



Source: Kirkman A et al, 2007.

820. **The process and financing of innovation varies radically across sectors**. For information technology and pharmaceuticals, for instance, the rapid technological change is largely financed by the private sector. However, private investors may not consider research into treatments for diseases whose prevalence may be increased by climate change to be a priority. Public funding might then be required for research into the treatment of such diseases.

821. **Public** funding makes a significant contribution to energy R&D. Since the early 1990s, private sector funding for energy R&D has declined, while public funding declined and then recovered to roughly the same level. Much higher levels of energy R&D will be needed to develop the technologies needed to mitigate GHG emissions.

822. Research for the agriculture sector also involves a mix of public and private investment. Governments provide more than 90 per cent of the funds in developing countries and less than half of the funds in developed countries.

823. The risks facing any particular technology change as it moves through its **lifecycle** – from research to development, demonstration and deployment. The sources of investment also change according to the life cycle. The returns to public investment in a technology shift from entirely social to both social and financial as it moves closer to commercialization and the private investment share of research investment typically increases.

Projects

824. Efforts to install and operate a technology will face risks associated with the sector and the location (project risk).

825. **Different sectors** present different risks at the project level, for example:

- The major obstacles to private investment in water supplies include: the low rates of return; the capital-intensive nature of the sector; and the political sensitivity of the sector. Renewable energy projects linked to the electricity grid need long-term agreements for the purchase of their output;
- Although energy efficiency measures can be financed from the energy savings through performance contracts, most efficiency improvements are financed internally by the industry or building owner. As a result implementation of energy efficiency measures must overcome barriers related to the initial financial investment, as well as lack of knowledge about, and availability of the appropriate technologies;
- Most of the abatement opportunities from methane capture in developing countries still face barriers related to lack of awareness of, and experience with, alternative technologies; poor economics at smaller landfills; and limited infrastructure for use of the captured gas use in some regions. Over 100 landfill gas projects have been proposed under the CDM, but the emission reductions achieved have been far lower than projected;
- Before large-scale implementation of CCS can occur, further technology development is required, mainly in CO_2 capture. Public funding will be needed for early installations to help reduce costs. Finally, the long-term liability issues will need to be resolved. The expectation is that the CO_2 will remain in the reservoir for thousands of years. The legal responsibility of entities operating CCS reservoirs must be clearly defined if they are to be able to attract the required investment.

826. **Vulnerable locations:** As the impacts of climate change become more obvious, particularly through extreme weather events, more investors are starting to ask how those risks can be shared. The damage caused by climate related events can be financed in various ways, from within the country or internationally. Funds can be provided by public finances, or the private sector, and within those through contractual arrangements like insurance, or informally through charitable relief. In the last resort, the damage may be taken as a loss of assets or income by the victims.

827. The increased risks due to climate change have led insurers to make major modifications to their risk profiling and coverage strategies. Catastrophic risk insurance has been treated as a yearly business, with premiums being reviewed every year based on the most recent experience. Insurers have also withdrawn from high-risk zones or areas recently struck by catastrophic events. Increasing insurance costs and declining coverage have led to protests by consumers and political interventions on their behalf.

828. As a result, interest is growing among **governments and MDBs** in using a wider range of risk management instruments, particularly catastrophe bonds and weather derivatives, to help address the macro-economic financial impact of disasters. This is because it has become clear that ex-post financing is inefficient for several reasons (e.g. tardiness, impact on other projects, uncertainty), while insurance also has some deficiencies, principally lack of continuity of coverage and terms. A particular example of this new approach is the Caribbean Climate Risk Insurance Facility (see box 20).[136]

[136] Dlugolecki A. 2007.

Box 20. Caribbean Catastrophe Risk Insurance Facility

The Caribbean Catastrophe Risk Insurance Facility (CCRIF) is being established under the coordination of the World Bank to provide member states with index-based insurance (cat bonds) against government losses caused by natural disasters. It represents an important shift from disaster response to ex-ante disaster management and mitigation. Governments will purchase catastrophe coverage to provide them with a cash payment within one month after a major hurricane or earthquake. These funds are intended to meet a portion of the immediate liquidity problems that face governments in the aftermath of a disaster.

Pooling risk among 15 countries has enabled the premiums to be reduced by about 50 per cent from the aggregate value of the individual premiums, due to the benefit of non-correlated risks, even within a relatively small area like the Caribbean. The Facility will be created with the premiums from participating countries and substantial assistance from donors (USD 47 million). For poorer countries, the fees will be subsidized or contributed by donors. For tax efficiency, CCRIF will be domiciled in the Cayman Islands.

829. As exemplified by the CCRIF, a public-private partnership seems to be an appropriate model for insuring climate risk in many developing countries – as public resources are limited and there are significant barriers to private investment. The most important attractions for the private sector are the prospects for a positive profit margin and scale.

9.3.3.3. Optimizing sources by host country capacity

830. Country risks play a major role in investment decisions by foreign investors and lenders. Different regions vary dramatically in the types of investment capital they attract and the returns expected. Many of these differences can be explained by the characteristics of the national investment markets involved. UNCTAD has developed an investment compass to help countries understand how they rate on factors relevant to investment decisions by foreign direct investors.[137] The key variables include:

- Resource assets, including human and natural (raw materials, resources) capital, as well as market size;
- Infrastructure, including both basic (transport, water, power) and telecommunications;
- Operating costs, reflecting items such as wages, rents and electricity tariffs;
- Economic performance and governance, including economic growth rates, current account balance, unemployment, country debt rating, rule of law and political stability;
- Taxation types and levels, along with investment incentives;
- Regulatory framework for foreign investors, including entry, operating and exit requirements.

831. A similar analysis by Ernst & Young ranks countries according how attractive they are to investors in renewable energy projects (Ernst & Young, 2007). The ranking criteria include measures of both natural and social capital, such as:

- The "Renewables Infrastructure Index", covering items such as: electricity market regulatory risk; planning and grid connection issues; and access to finance;
- "Technology Factors", including: power offtake attractiveness; tax climate; grant/soft loan availability; market growth potential; current installed base; resource quality; and project size.

832. Similarly, the mitigation or adaptive capacity of countries is now being measured by factors such as: economic resources; technology; information and skills; infrastructure; institutions; and equity. Such factors are increasingly being considered by private investors as they choose locations for their projects, as well as

[137] <http://compass.unctad.org/Page1.egml?country1=&country2=&region=&sessioncontext=202061216&object=SC.app.objects.methodology> (accessed July 19, 2007).

by national governments as they review their development and adaptation goals. Such differences in institutional structures and basic infrastructure increase the difficulties of adapting to climate change in many poor communities.

833. The result is a spectrum across countries, from those able to attract substantial investment from the global capital markets to those more dependent on domestic capital and ODA. A country that can tap a range of investment sources has many more options for financing a large clean power generating facility.

834. This spectrum of capacity means different roles for public and private capital across different countries. Countries with good access to global capital markets can focus public investment on priority areas and attract private capital for other investments. Countries with little or no access to private capital – locally or globally – need to use domestic and international public capital for a much wider range of investments.

Box 21. Example of possible assistance by MDBs in addressing country risks – The Multilateral Investment Guarantee Agency

As a member of the World Bank Group, the Multilateral Investment Guarantee Agency (MIGA) mission is to promote FDI into developing countries to help support economic growth, reduce poverty, and improve people's lives. Concerns about investment environments and perceptions of political risk often inhibit foreign direct investment, with the majority of flows going to just a handful of countries and leaving the world's poorest economies largely ignored. MIGA addresses these concerns by providing three key services: political risk insurance for foreign investments in developing countries, technical assistance to improve investment climates and promote investment opportunities in developing countries, and dispute mediation services to remove possible obstacles to future investment.

Since its inception in 1988, MIGA has issued nearly 850 guarantees worth more than USD 16 billion for projects in 92 developing countries. MIGA specializes in facilitating investments in high-risk, low-income countries – such as in Africa and conflict-affected areas.

9.3.3.4. What can be done to improve the complementarity of available funds

835. As shown in this chapter it is important to optimize allocation of funding and factor in various preferences by different sources of funding for risks and returns. Some can be addressed by governments through the policy and investment frameworks they set and some can be taken by IFIs and other sources of public money.

836. **Governments** can increase the diversity of the sources of capital available through the policy and investment frameworks they establish. Attracting more private (domestic and foreign) investment to climate mitigation and adaptation projects means that they require less government funding, and ODA in developing countries, which can then be redirected to social needs. Policy and investment frameworks that can attract more private capital include:

- Tailored policies for different types of projects, such as secure access with fair prices for renewables supplying the electricity grid and mandatory energy efficiency standards for buildings, appliances and equipment;
- Policies that promote diversification of the domestic financial market;
- Measures to make the country more attractive to foreign private investors.

837. In considering how to enhance existing sources of funding and what new sources could be developed, it will be important that **Parties**:

- Understand what roles different sources can play and how they can best complement each other. The sources of funding in the Convention and its Kyoto Protocol could be better focused and made more effective by considering where:
  - The investment markets are failing to deliver sufficient public and private investment;
  - The global structure of the COP and the Convention provides a comparative advantage.
- Support and participate in the efforts to bring government officials, investors and NGO representatives together to find new financing and policy approaches to bringing more investment to addressing climate issues.

838. **MDBs** can play also play an important role in layering- in funding in areas where risks are likely not to be taken by other sources.

9.4. Conclusions

839. In developing options for long-term cooperative action for improving the potential of investments and financial flows to address climate change, it will be important to consider that:

- Future actions to address climate change have to consider measures to increase global investment and financial flows. This increase is large compared with the existing funding in the Convention and its Kyoto Protocol but is small compared with global GDP (0.3–0.5 per cent) and investments (1.1–1.7 per cent) in 2030;
- Needs for future investment and financial flows to address climate change are very different across sectors and regions. Solutions to provide the necessary incentives to address needs will require better use and complementarity of sources of available investment and financial flows;
- Changes in patterns in future investments and financial flows need a combination of actions by the intergovernmental process (including under the UNFCCC process and under other processes such as International Financial Institutions), national governments and private sector (including corporations and households);
- Solutions will also require a combination of:
  - Policy frameworks, national and international, that increase the economic and financial attractiveness of investments in clean energy technologies and emission reduction measures, such as carbon markets or feed in tariffs;
  - Incentives and assistance to developing countries in establishing environments to change investment and financial flows towards addressing climate change;
  - Policy frameworks, national and international, that regulate GHG emissions and promote their reduction;
  - Options for scaling up additional financial flows, from existing and new sources, that allow adequate and sustainable financing of developing country needs, in particular in areas such as adaptation, forestry and technology deployment;
- Collaborative efforts in R&D on low GHG emitting technologies and better understanding the costs and opportunities of adaptation and mitigation measures.

840. As the first ever effort to collect and present data on projected, climate-related investments under reference and mitigation scenarios, it is not surprising that this study encountered many gaps in the existing data. The questions of whether and how to fill any of these gaps should also be considered by the Parties.

841. The results of this analysis present the complexity of the systems involved – across investors, sectors, technologies, locations and other factors. This is to be welcomed, as a more nuanced view of the opportunities and barriers facing investments in a more sustainable climate future is important to making progress.

842. At the same time, Parties cannot be expected to engage in detailed investment analyses when negotiating the post-2012 climate agreement. Parties could negotiate an international framework that enhances international mechanisms, such as the international carbon market, the financial mechanisms of the Convention and its Kyoto Protocol, and other sources of funding, and encourages Parties to develop and implement national policies that shift private and public investment and financial flows toward lower GHG emitting and more climate proof options.

843. While it is important for the Parties to be aware of and consider the implications of these complexities in their deliberations, it is even more critical that some widely supported, relatively simple and actionable themes be developed around which the structure of the post-2012 agreement can be shaped. Doing so will give the investment community both the rules it needs to predict risks and returns, as well as the room it needs to innovate for realizing both financial and social returns.

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