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Working Group III – Mitigation of Climate Change

Chapter 16

Cross-cutting Investment and Finance Issues

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Chapter 16: Cross-Cutting Investment and Finance issues

Contents

Executive summary

For the first time an IPCC assessment report contains a chapter dedicated to investment and finance. This reflects the rising awareness of the importance of attracting, redirecting and allocating financial flows for mitigation. These are the chapter's key findings:

Current mitigation finance is estimated at USD 350 billion (2010/11 USD) per year using a mix of 2010 and 2011 data. This total is based on a mix of instruments and a variety of sources and intermediaries. It covers full investment in mitigation measures, such as renewable energy power plants. Of the total, developing countries raised USD 120-141 billion of which 34-41% were public funds. Developed countries raised USD 213-255 billion including 17-23% from public sources. *(limited evidence, medium agreement)* [16.2.1.1]

Climate finance reported under the UNFCCC accounts for less than 3% of current climate finance and about 15-25% of the public international climate finance flows to developing countries. Annex II countries reported an average of less than USD 10 billion per year from 2005-2010. From 2010-2012, developed countries committed USD 28 billion (2012 USD) in Fast Start Finance. *(medium evidence, medium agreement)* [16.2.1.1]

Current carbon-intensive investment patterns need to be changed significantly to become compatible with emission pathways commensurate with a 2°C objective. This is mainly due to continued high-carbon investment despite massive scale-up of renewable energy investments. *(limited evidene, high agreement)* The level of mitigation investment, by itself, thus provides little indication of the likelihood of reaching a specified stabilisation pathway due to the complex reallocation of investment required throughout the energy-related sectors. If accompanied by additional indicators like the carbon intensity of average new investments more robust conclusions can be drawn on the viability of certain stabilsation pathways. [16.2.2]

Ambitious climate policy is expected to induce a reallocation of investments in the power sector from fossil fuels to nuclear, to fossil fuels with CCS and to renewable power generation in all scenarios compatible with a 2°C objective in 2100. *(limited evidence, high agreement)* Investments in fossil fuels decline from 47% (39 to 60%) of total power plants investments to 22% (9 to 38%) in 2010-2029. Over the period 2010-2029 renewable power generation attracts an additional average annual investment of USD 134 (-3.8 to +332) billion ; nuclear power attracts additional USD 31 (1.4 to 117) billion per year; and power plants with carbon capture and sequestration (CCS) have marginal importance (2010 USD).

In scenarios commensurate with a 2°C target substantial incremental investments is expected to increase energy efficiency. *(limited evidence, high agreement)* In the building sector annual incremental investments of USD 215 (175 to 254) billion are expected until 2030, USD 267 (150 to 384) billion in the transport sector, and USD 104 (77 to 131) billion in the industry sector. Investments in transmission and distribution decline by -20 to -80 USD billion /yr in 2010-2029. Model results suggest that deforestation can be reduced against current deforestation trends by 10% with an investment of USD 0.4 to 1.7 billion per year and by 50% reduction with an investment of USD 17 to 28 billion per year. [16.2.2]

The size of a mitigation investment gap depends on what parts of the economy are considered. Findings from model studies vary in respect to the relevance of a reallocation of investment within the energy supply sector from high to low-carbon vis-à-vis a reallocation of investments from energy-supply to energy-efficiency. Model estimates of global total annual incremental investments for energy-related activities until 2030 range from a decline by USD -30 billion per year to substantial inceases by more than USD +500 billion per year, if energy efficiency is included (2010 USD). *(limited evidence, medium agreement)* [16.2.2] An assessment of needs and resulting changes of investment under a specific climate policy scenario ideally considers all sectors, on a per country basis.

The private sector plays a central role in investing in low carbon projects in industrialised and developing countries. *(medium evidence, high agreement)* Its contribution is estimated at USD 250-285 billion in 2010/2011, which represents around 75% of overall mitigation finance (2010/2011 USD). [16.2.1] At present, a large share of private sector climate investments relies on low-interest and long-term loans as well as partial risk guarantees provided by public sector institutions to cover the incremental costs and risks of many mitigation investments.

The role of private sector climate finance varies between industrialised countries/emerging economies and developing countries. Industrialised countries and emerging economies frequently combine substantial energy related greenhouse gas emission reduction potential with good investment conditions. Among the 30 largest emitting industrialised and developing countries, 21 countries covering 75% of global CO_2 emissions had investment grade sovereign or trade credit insurance ratings at the end of 2012. They are thus attractive to foreign private investors. In many other countries, including virtually all least developed countries, low carbon investment will often have to rely mainly on domestic sources or international grant finance. *(limited evidence, medium agreement)* [16.4.2]

Barriers to low-carbon vis-a-vis high carbon investments include the following: lower returns on investment, higher investment costs, higher perceived risks, and small project size. Policy and financial instruments **ensuring a stable cash-flow, enhanced provision of equity, reduction of the cost of investment capital and risk-mitigation are crucial to scale up private low-carbon investments.** *(medium evidence, high agreement)* [16.4.2, 16.4.3] The public sector also has a major role in establishing an enabling environment for mitigation technologies, especially in reducing political uncertainty *(medium evidence, high agreement).* Factors of the broader investment climate such as cost of fossil energy sources, interest rate levels or institutional capacity influence low-carbon investment decisions substantially. [16.3]

By collecting carbon taxes or by auctioning carbon allowances the public sector can raise revenues. *(high confidence)* [16.2.1.2, 16.2.3] These carbon-related sources are already sizable in some countries and have the potential to generate very large financial flows under ambitious stabilization targets *(medium evidence, high agreement).* [16.2.1.2] The use of other innovative sources of public revenues like taxes on international bunker fuels or aviation ticket charges specifically for climate financing are still in their infancy. A contraction of fossil fuel subsidies, not compatible with low-emission trajectories, could be an additional source of funding *(high confidence).* [16.2.3]

Appropriate governance arrangements at the national, regional and international level need to be in place for an efficient, effective and sustainable implementation of mitigation measures. These are essential to ensure that financing to mitigate and adapt to climate change responds to national needs and priorities. The national level ensures attention to an efficient implementation of funds and risk mitigation using national funds or national development banks. *(high confidence)* [16.5]

Important complementarities and trade-offs between financing mitigation and adaptation exist. *(medium evidence, medium agreement)* Available estimates show that adaptation projects presently get only a minor fraction of international climate finance. However, economic analysis currently does not provide conclusive results on the most efficient temporal distribution of funding on adaptation vis-à-vis mitigation. Given that optimal balance of mitigation and adaptation actions and investments depends on the uncertain magnitude and pathways of climate change, it is important to emphasize that neither mitigation nor adaptation should be delayed. [16.6]

Scientific literature on investment and finance for low-carbon activities is still very limited and knowledge gaps are substantial. To date there are no common definitions for central concepts related to climate finance. Quantitative data are limited, covering only parts of the overall investment, and are not comparable due to differing assumptions. Empirical performance data of different policy and financial instruments exist on a case study basis only.

16.1 Introduction

Under the UNFCCC, countries have agreed that by the end of 21st century the increase in global average temperature should be no more than 2°C above pre-industrial levels. This requires significant reductions from current levels of global emissions (see AR5 WGI). Adaptation to the climatic changes will also be needed. Moving the world to a low-carbon, climate-resilient society will involve large flows of finance and investment – climate finance.

There is no agreed definition of climate finance (Haites, 2011; Stadelmannnnn et al., 2011; Buchner et al., 2011; Forstater and Rank, 2012). For this chapter *climate finance is defined to consist of all financial flows whose expected effect is to reduce net greenhouse emissions or to enhance resilience to the impacts of climate variability and the projected climate change*. This is a broad definition covering private and public funds, domestic and international flows, expenditures for mitigation and adaptation, and the costs of adaptation to current climate variability as well as future climate change. It covers the full value of the financial flow rather than the share associated with the climate change benefit; e.g. the entire investment in a wind turbine rather than the portion attributed to the emission reductions.

This chapter focuses on mitigation finance; estimates of the finance needed for adaptation are assessed in Working Group II. Many agriculture and REDD+ mitigation options involve current expenditures for labour, periodic transfer payments and other operating costs rather than investments. Most other mitigation actions mainly involve an investment, e.g. a purchase of long-lived equipment, and the entire investment is usually counted as climate finance. Although the financial flows triggered by the investment – grants, subsidies, interest on and repayment of loans, dividends on equity and guarantees – could also be considered, the most comprehensive data are usually available for investment sums. Ideally, all types of transactions i.e. consumptive expenditures, investments and associated financial transfers need to be considered to provide a complete picture of climate finance.

Many mitigation investments yield benefits other than emission reductions e.g. the electricity produced by a wind turbine. Conceptually, the *incremental investment is the portion of the total investment related to the expected mitigation and adaptation benefits*.[1] Many mitigation investments, energy efficiency and renewable energy for example, involve a higher investment and lower operating cost than the conventional options they replace. This is captured in the *incremental cost which is the difference between the net present values of projects with and without the desired mitigation or adaptation benefit*.

Under the UNFCCC the term climate finance is not well defined. However, it is much narrower in scope. It is limited to international flows from Annex II governments to developing countries to cover the agreed full incremental costs of mitigation actions, assistance in meeting the costs of adaptation to the adverse effects of climate change, and the full cost of various reports and activities.

Flows of climate finance – in particular in their broader definition – have grown in recent years but will need to expand substantially to shift the world to a low-carbon, climate-resilient development pathway commensurate with the 2°C objective. Innovative mechanisms have the potential to mobilize additional public and private investment. Businesses will invest in mitigation actions to reduce their energy costs, optimize logistics and avoid reputational risks (Kauffmann and Tébar Less, 2010). However, if governments do not implement broad, consistent and long-term policies to make mitigation investments more attractive for business climate finance flows will be insufficient to achieve substantial emission reductions.

[1] The incremental climate investment is the climate investment less the investment that would occur in the absence of the mitigation action.

Section 16.2 reviews estimates of current climate finance, projections of future climate finance needs, incremental investments and incremental costs and proposed options for raising public funds for climate finance. Enabling factors that influence the ability to efficiently generate and disburse climate finance are discussed in section 16.3. Section 16.4 considers opportunities and key drivers for low-carbon finance. Institutional arrangements for mitigation finance are addressed in section 16.5. Synergies and trade-offs between financing mitigation and adaptation are discussed in section 16.6. The chapter concludes with sections devoted to financing mitigation activities in developed (16.7) and developing countries (16.8) and a review of important gaps of knowledge (16.9)

16.2 Scale of financing at national, regional and international level in short-, mid- and long-term

16.2.1 Current financial flows and sources

This subsection reviews estimates of current financial flows, current sources of climate finance and the effects of recent developments on climate finance. Most climate finance involves an investment. The funds are generated and invested by the public or private sector (Jain, 1989). Climate finance, as defined in section 16.1, flows from numerous sources to recipients in developed and developing countries via intermediaries using a variety of instruments.

Recent analyses (Buchner et al., 2011, 2012; Jürgens et al., 2012) have shown that sources and intermediaries typically use multiple instruments and investors frequently combine funds from more than one instrument. Figure 16.1 intends to illustrate the full complexity of the interplay between finance sources, intermediaries, instruments, recipients and uses. Almost all public sector funds flow through government budgets and development banks while private sector funds originate from private and public financial institutions, capital markets, corporate cash flow and households.

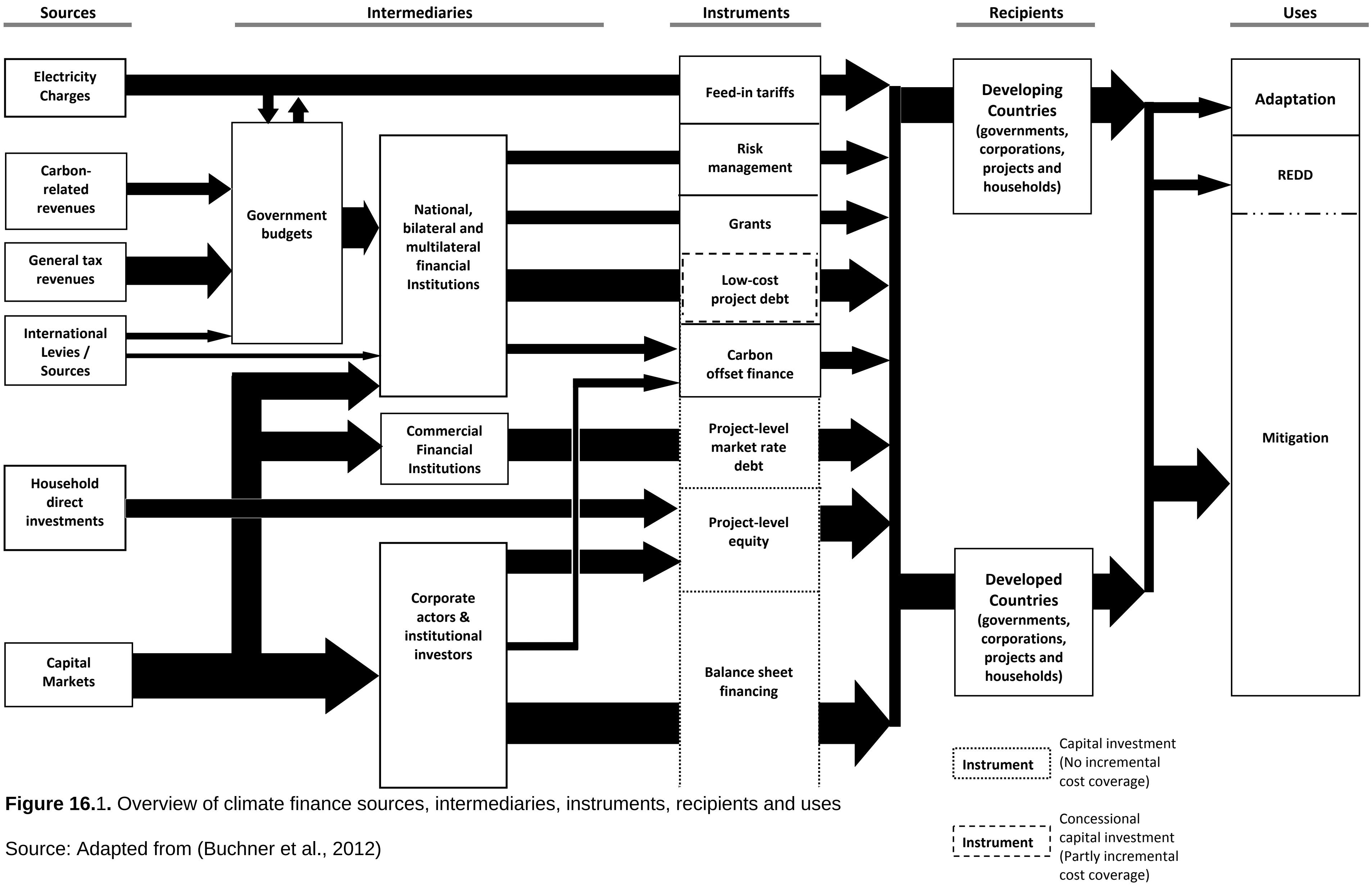

Figure 16.1. Overview of climate finance sources, intermediaries, instruments, recipients and uses

Source: Adapted from (Buchner et al., 2012)

Figure 16.2 aims to aggregate the variety of interrelation between sources and public and private actors in a highly simplified fashion. Arrows represent the financial flow and its direction. The public sector's main source is tax revenue. Public funds are then either directly invested in climate related activities or provided to development banks. These intermediaries may borrow additional private money from the capital market to leverage the public funds before they invest them directly or channel them to private investors. For some private climate investments these public funds are decisive in the investment decision; however the private sector is predominantly sourced by the capital markets. The figure does not distinguish between developed and developing countries sources and actors.

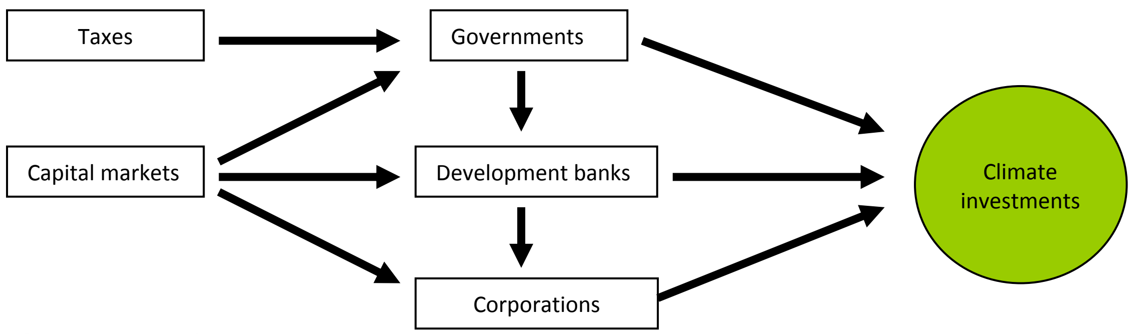

Figure 16.2. Schematic representation of current climate investment flows

Domestically, government funds are disbursed directly as financial incentives or tax credits or through national financial institutions. Internationally, most climate finance from government budgets flows through bilateral institutions sponsored by one nation, e.g. JICA, AFD, KfW, or through multilateral institutions funded by several countries, e.g. World Bank and regional development banks, which leverage these funds with funds from international capital markets. These institutions can borrow and lend at favourable interest rates because government ownership gives them an excellent credit rating. Domestically and internationally private financing may be channelled through a fund (infrastructure, carbon, venture capital, etc) and/or a project entity (a corporate structure for a single project).

16.2.1.1 Current financial flows

There is no comprehensive system for tracking climate finance, Therefore estimates must be compiled from disparate sources of variable quality and timeliness, sources that use different methodologies and have gaps and may duplicate coverage. Even with complete data the amount committed by sources and intermediaries during a given year will differ from the amount received by recipients due the time lag between commitments and disbursements. Changes in exchange rates and costs of risk mitigation further complicate the picture. For these and other reasons estimates of current climate finance remain uncertain.

Current climate finance is estimated at USD 343 to 385 billion (2010/11 USD) per year globally, with mitigation finance at USD 350 billion (Buchner et al., 2012). This total includes a mix of instruments, e.g. grants, concessional loans, commercial loans and equity, as well as the full investment in mitigation measures such as renewable energy generation technologies that also produce other goods or services. The figures reflect commitments by sources and intermediaries using a mix of 2010 and 2011 data. Over 70% of the total is private finance. Investment in renewable generation technologies dominates the mitigation investment (UNEP, 2012a).

Reasonably robust estimates of **domestic climate finance** are available for only a few countries. Data from the 19 development banks of the International Development Finance Club (IDFC) for 2011 indicate that the five developed country banks allocated USD 28 billion of their USD 45 billion (2011 USD) of climate finance to domestic projects. The 14 developing country banks devoted all USD 44 billion (2011 USD) of climate finance to domestic projects (Höhne et al., 2012). Concessional funding provided by public development banks plays an important role in financing domestic climate projects such as those in Brazil, China and Germany.

Consistent and comprehensive estimates of current climate investment and current incremental climate change cost are not available in the literature.

Developed countries raised USD 213 to 255 billion including USD 43 to 50 billion (2010/2011 USD) from public sources in 2010/2011. Funds committed to climate change in developed countries in 2010/2011 amounted to USD 160 to 208 billion (Buchner et al., 2013). **Developing countries** raised USD 120 to 141 billion including USD 48 to 50 billion (2010/2011 USD) of public funds in 2010/2011. Funds committed to climate change in developing countries in 2010/2011 amounted to USD 162 to 202 billion (Buchner et al., 2013).

Stadelmann et al. (2012) estimate private finance for climate action in developing countries at USD 27 to 124 billion (2010 USD) per year for 2008-2010. That amount includes USD 10 to 40 billion per year that flows from developed to developing countries. They also estimate that USD 20 to 105 billion per year is mobilized by developed countries and invested domestically or in other developing countries, so there is some overlap with the developed to developing country flow of USD 10 to 40 billion per year.

Climate Finance under the UNFCCC refers to the commitment by developed country parties to cover the 'agreed full incremental costs' of mitigation measures implemented by developing countries (Article 4.3), in order to 'assist the developing country Parties that are particularly vulnerable to the adverse effects of climate change in meeting costs of adaptation' (Article 4.4) and to cover the agreed full costs incurred by developing countries for the preparation of their national communications (UNFCCC, 1992, Art. 4.3). None of these terms are operationally defined (Machado-Filho, 2011). These commitments are reaffirmed by the Kyoto Protocol (Article 11).

Developed country (Annex II) Parties report the financial resources they provide to developing countries through bilateral and multilateral channels for climate change action. The latest summary of the Annex II reports on their provided climate finance indicates that they provided a total of USD 58.4 billion for the period 2005 through 2010, an average of less than USD 10 billion per year (UNFCCC, 2011a).[2] Most of the funds provided are concessional loans and grants. Climate finance reported under the UNFCCC, thereby accounts for less than 3% of current climate finance and 15 to 25% of the international climate finance flows to developing countries.

Operating entities of the financial mechanism of the UNFCCC deal with less than 10% of the climate finance reported under the Convention, although that could change once the Green Climate Fund becomes operational. Annex II Party contributions to the Trust Fund of the Global Environment Facility (GEF), the Special Climate Change Fund (SCCF) and the Least Developed Countries Fund (LDCF) amounted to about USD 3.3 billion for 2005 through 2010, an average of less than USD 0.6 billion per year ('as spent' dollars). Most of the funds are used for mitigation. The Adaptation Fund derives most of its funds from the sale of CERs issued for CDM projects.[3]

[2] Although there is an agreed reporting format, the UNFCCC secretariat notes that many data gaps and inconsistencies persist in the reporting approaches of Annex II Parties. These amounts are 'as spent' dollars over the six years.

[3] Two per cent of the CERs issued for most CDM projects are provided to the Adaptation Fund. The Fund sells the CERs and uses the proceeds for adaptation projects in developing countries.

16.2.1.2 Current sources of climate finance with mitigation benefits

Climate finance can come from any source of government or private revenue. Most government funding comes from general revenue and most private funding is balance sheet finance.[4] Some revenue sources – carbon taxes, auctioned greenhouse gas emission allowances, and the Kyoto mechanisms – also have mitigation benefits. Estimates of the revenue currently raised from these sources are discussed in this subsection. Fuel taxes, fossil fuel royalties and electricity charges, although they can be converted to CO_2 equivalent charges, are excluded here because they are usually implemented mainly for revenue reasons.

Carbon taxes in selected European countries – Denmark, Finland, Germany, Ireland, Italy, Netherlands, Norway, Slovenia, Sweden, Switzerland, and the UK – generated about USD 7.3 billion in 2010 (Andersen, 2010; Sumner et al., 2011; Elbeze and De Peethuis, 2011). India[5] and Australia introduced carbon taxes in July 2010 and July 2012. Sub-national carbon taxes exist in the Canadian provinces of Quebec and British Columbia, Montgomery County (Maryland) and the San Francisco Bay Area Air Quality Management District. In some jurisdictions part or all of the revenue is dedicated to environmental purposes or reducing other taxes; none is used for international climate finance.

Jurisdictions with an emissions trading system may raise revenue by **auctioning allowances** and/or a fixed price compliance option. Among the 30 countries participating in the EU emissions trading scheme (ETS), Austria (1.3%), Germany (about 9%), Hungary (2%), Ireland (0.5%), the Netherlands (3.7%), Norway (30%) and the United Kingdom (7%) auctioned some allowances during the second (2008-2012) phase (European Commission, 2012). During 2009 Germany (€528 million) and the United Kingdom (€337 million) raised about USD 1.12 billion suggesting total auction revenue of approximately USD 1.25 billion.[6] Buchner et al. (2011, 2012) estimate auction revenue at USD 1.4 and USD 1.6 billion for 2010 and 2011. Germany earmarked a portion of its auction revenue for international climate finance (Germany Federal Ministry for the Environment Nature Conservation and Nuclear Safety, 2012).

The revenue raised through auctions for the nine American states that participate in the Regional Greenhouse Gas Initiative (RGGI) declined from USD 349 million to USD 283 million to USD 175 million between 2009 and 2011 as allowance prices fell (Regional Greenhouse Gas Initiative, 2012). The Alberta (Canada) and New Zealand systems have fixed price compliance options of CAD 15 and NZD 25per ton CO_2 respectively. The revenue collected by Alberta declined from CAD 82 million in 2008 to CAD 55 million in 2011 (Government of Alberta, 2012). New Zealand collected USD 1.25 and 1.42 million for 2010 (six months) and 2011 respectively (New Zealand Ministry for the Environment, 2012).

Several eastern European countries expect their 2008-2012 emissions to be lower than their commitment under the Kyoto Protocol (Estonia, Czech Republic, Poland and Russia) and are selling surplus assigned amount units (AAUs) to raise revenue. Others such as Bulgaria, Latvia, Lithuania, Slovakia and Ukraine, sell their surplus AAUs to fund Green Investment Schemes that support domestic emission reduction measures (Linacre et al., 2011).[7] Revenue rose from USD 276 million in 2008 to USD 2,003 million in 2009 and then declined to less than USD 1,100 million in 2010 (Kossoy

[4] General revenue includes revenue collected from all taxes and charges imposed by a government. Balance sheet finance means that a new investment is financed by the firm rather than as a separate project. The firm may seek external funding (debt and/or equity) but that funding is secured by the operations of the firm rather than the new investment.

[5] In India the carbon tax was on coal only.

[6] Germany and the UK account for 89.26% of the allowances proposed for auction during phase II.

[7] The Green Investment Schemes are a source of climate finance for these countries.

and Ambrosi, 2010; Linacre et al., 2011). Buchner at al. (2011, 2012) estimate the revenue at USD 580 and USD 240 million for 2010 and 2011 respectively.

Through the **Kyoto mechanisms**, emission actions in developing countries (Clean Development Mechanism (CDM)) and developed countries (Joint Implementation (JI) and land-use and forestry actions) earn credits (CERs, ERUs and RMUs respectively) that can be used for compliance by installations regulated by domestic emissions trading systems, such as the EU ETS and NZ ETS. The credits can also be used by Annex I governments for compliance with their emissions limitation commitments under the Kyoto Protocol.

This international market for compliance credits generates both revenue from the sale of credits and investment flows. Most data relate to the CDM, by far the largest of the mechanisms. Revenue from the sale of CERs increased from USD 1.3 to 1.8 billion in 2010 to USD 3.3 to 4.3 billion in 2011 (UNFCCC, 2012a). The estimated value of issued ERUs increased from USD 0.24 to 0.34 billion in 2010 to USD 0.78 to 1.03 billion in 2011.[8] Buchner et al. (2011, 2012) estimate the revenue from the sale of CDM and JI credits at USD 2.2 to 2.3 billion and USD 4.65 to 4.75 billion for 2010 and 2011 respectively. Because of the decline of CER prices, these revenues have at least temporarily lost relevance in 2012 and 2013.

Two percent of the CERs issued for most CDM projects go to the Adaptation Fund. Sale of CERs generated revenue of over USD 90 million for FY 2010 and over USD 50 million for FY 2011 (World Bank, 2012a).

The estimated investment in registered CDM projects has grown from USD 1 billion in 2005 to USD 72 billion in 2011 (UNEP Risø, 2012). Annual investment probably peaked in 2008, at between USD 13.9 for operational projects and USD 40.4 billion for all projects (Spalding-Fecher et al., 2012). However, a large number of projects are undergoing validation leading to further substantial investments in subsequent years. About 90% of renewable energy CDM projects and 65% of similar projects in developed countries are domestically financed (Spalding-Fecher et al., 2012).[9] In both developed and developing countries the share of foreign investment has increased over time with the growth of the renewable energy industry and increasing project size (Spalding-Fecher et al., 2012).

16.2.1.3 Recent developments

Climate finance has been affected by the financial crisis of late 2008, the subsequent stimulus packages and the fast start finance commitment of USD 30 billion made by developed countries in December 2009 for climate action in developing countries for 2010-2012.

The **financial crisis** in late 2008 reduced investment in renewable energy (Justice, 2009). In late 2008 and early 2009, investment in renewable generation fell disproportionately lower than that in other types of generating capacity (IEA, 2009). Global investment in renewable energy fell 3% during 2009 but rebounded strongly in 2010 and 2011. In developed countries, where the financial crisis hit hardest, investment dropped 14% while renewable energy investment continued to grow in developing countries (UNEP, 2012a).

In response to the financial crisis, G20 governments implemented **economic stimulus packages** amounting to USD 2.6 trillion dollars. Of that amount, USD 180 to 242 billion was low-carbon funding (IEA, 2009; REN21, 2010). The stimulus spending supported the rapid recovery of renewable energy investment by compensating for reduced financing from banks. Some countries facing large public

[8] Data on RMUs is limited, but over 3 million RMUs with a value between USD 15 and 45 million were surrendered in New Zealand for 2011 compliance.

[9] Renewable energy projects account for over 67 % of the total investment in CDM projects.

sector deficits scaled down green spending when the economy started recovering (Eyraud et al., 2011).

At the UN Climate Change Conference in Copenhagen in 2009, developed countries committed to provide USD 30 billion of '**fast start finance**' to support mitigation and adaptation action in developing countries during 2010-2012. The sum of the announced pledges is about USD 30 billion.[10] By November 2012 about USD 28.1 billion had been committed by developed countries (WRI, 2012). Investment projects typically take several years from commitment to disbursement because of lead times for feasibility studies, project approvals and procurement and permitting in developing countries. The fast start commitment promised balanced funding for mitigation and adaptation. Data on commitments through June 2011 indicate that 21% has been directed to adaptation. Most of the allocated funds (51%) are being disbursed bilaterally (Brown et al., 2011).

The announced pledges triggered questions as to whether they were "new and additional" as promised (Fallasch and De Marez, 2010; BNEF, 2011). Some countries explain the basis on which they consider their pledge to be "new and additional". Researchers have proposed various criteria that, when applied to the pledges, indicate that proportions ranging from virtually none to almost all are new and additional (Brown et al., 2010a; Stadelmann et al., 2010; Stadelmann, Roberts, et al., 2011) [TSU NOTE: Format of citation style will be corrected by TSU].

16.2.2 Future low-carbon investment

As noted in chapter 6, "Stabilization (of GHGs) will ultimately require dramatic changes in the world's energy system, including a dramatic expansion in the deployment of low-carbon energy sources." This change can only occur through finance and re-investment in the global energy sector as well as land use, transportation and infrastructure. The assessment of future investment flows provided in this section is based on several large-scale analyses conducted over the past few years. For the most part these are modeling exercises looking forward to the end of the century and as such the estimates of investment flows drawn from these studies should not be interpreted as forecasts, but rather, as some probable future states of the world. Table 16.1 presents estimates of baseline investment in energy supply sub-sectors as a reference for the following considerations. It illustrates the very substantial nature of investments in today's energy sector with very strong roles for investments in fossil fuel extraction, transmission and distribution and electricity generation.

Table 16.1: Model reference investments in 2010 (2010USD billion/year) – not market data

Region	Energy Supply											
			Power sector						Liquids			
				Power plants								
	Total Energy	Other Energy	Total Power	Power plants	Renewables	Nuclear	Total Fossil Fuels	Transmission and distribution	Total Liquids	Fossil Fuels	Biofuels	Total Fossil Extraction
Annual investment - 2010												
nOECD	540 - 604	29 - 45	210 - 307	100 - 158	42 - 89	1.1 - 4	57 - 65	109 - 148	17 - 41	15 - 36	1.8 - 5.6	187 - 319
OECD	537 - 747	23 - 85	247 - 344	119 - 202	58 - 84	2.2 - 25	59 - 94	128 - 143	14 - 28	9 - 18	5.2 - 10	208 - 349
World	1,076 - 1,351	52 - 129	465 - 643	227 - 352	100 - 173	3.3 - 29	124 - 150	237 - 291	31 - 69	24 - 54	7.0 - 16	396 - 668

Notes: OECD and nOECD stand for OECD and non-OECD countries, respectively. The interval for aggregates may not be equal to the interval obtained summing the components because differences in the sub-sectors between data sources may compensate each other.
Source: From McCollum et al. (2013) based on data from IEA World Energy Outlook 2011 (IEA, 2011) and GEA (Riahi et al., 2012)

[10] Fallasch and De Marez (2010) estimates the total at USD 31.2 billion; WRI (2012) estimates the total at over USD 33 billion; Project Catalyst (2010) estimates the amount at approximately USD 28 billion; Bloomberg New Energy Finance (2011) estimates the amount pledged at USD 27.3 billion.

16.2.2.1 Investment needs

While a large number of studies and many modeling comparison exercises have assessed technological transformation pathways and the macroeconomic cost of transforming the economies, only a handful of studies transform emission and technological trajectories into investment needs. Section 16.2.2.2 summarize, with the highest possible detail, estimates of investment needs under climate policy between 2010-2029 and 2010-2050, for the world as a whole and for non-OECD countries.

Adaptation costs and economic losses from future climate change are not considered in any of these estimates. A discussion of respective financing and investment needs for adaptation can be found in the Working Group II Report of the 5th Assessment Report an e.g. in Smith et al. (2011).

Without climate policy investments in the power sector are mainly directed towards fossil fuels, especially in non-OECD countries that rely on low-cost coal power plants to supply an ever growing demand of electricity. At global level, fossil fuel-based power generation requires average annual investments equal to USD 133 (63 to 159) billion in 2010-2029 and USD 487 (253 to 584) billion in 2010-2049 (mean and range across available estimates);[11] the bulk of investments (roughly 80%) goes to non-OECD countries: USD 110 (93 to 125) billion in 2010-2029 and USD 440 (431 to 446) billion in 2010-2049.

There is greater uncertainty on the future of renewable and nuclear power without climate policy. Model results crucially rely on assumptions about subsidies and on the possibility of nuclear phase-out in some countries. Global investments in renewable power generation are expected to increase over time from an average USD 93 (21 to 180) billion per year in 2010-2029 to USD 340 (296 to 476) billion over 2010-2049. Nuclear power generation is projected to attract an average USD 39 (7 to 88) billion annually in 2010-2029 and 147 (11 to 287) billion per year in 2010-2049.

In models the introduction of an emission reduction target abruptly changes the direction of investments. Table 16.2 and 16.3 report the specific climate target used in each study.[12] The tables cover a moderate mitigation goal (stabilization of GHGs concentration at 550 ppm CO_2-eq in 2100 / 3.7 W/m^2) and a stringent target that is roughly equivalent to the 2°C warming target in 2100 (450 to 460 ppm CO_2-eq in 2100 / 2.8W/m^2 / 2.6W/m^2). Although the policy targets are not identical, they are close enough to allow a broad comparison of results. Greater disparity exists among estimated emission reductions over 2010-2029 and 2010-2049 because there are differences in reference scenarios' emissions and because models choose different optimal emission trajectories among the many compatible with the long-term climate goal. Models that took part to the modeling comparison exercises AME and LIMITS use the same policy framework and therefore provide highly comparable data. For this reason the Tables present only aggregate indicators (median across all models for the AME and average for the LIMITS study).

The analysis of investment scenarios compatible with a 2°C warming target in 2100 and collected in table 16.2 and 16.3, reveal that climate policy is expected to induce a remarkable reallocation of investments in the power sector from fossil fuels to nuclear and renewable power generation. Investments in fossil fuels decline from 47% (39 to 60%) of total power plant investments to 22% (9 to 38%) in 2010-2029; from 45% (34 to 58%) of total to 13% (3 to 26%) in 2010-2049. This means

[11] It is important to stress that the mean value is reported because is the most synthetic indicator of available estimates and not as an expected value. It is not possible to attribute any probability distribution to models' outcomes. Therefore policy makers face pure uncertainty in face of future investment needs. Uncertainty is different from risk because the probability distribution function of risky outcomes is known or can be estimated. The range is presented to provide information on the degree of uncertainty in the literature.

[12] Also in this case the mean and median are used as synthetic indicators having no predictive power.

that global investments in fossil fuel power generation decline by USD 58 (1.5 to 173) billion per year in 2010-2029 and by USD 211 (76 to 517) billion annually in 2010-2049.

Investments are redirected towards renewables, nuclear and fossil fuels with CCS. Renewable power generation attracts an additional average annual investment of USD 134 (-3.8 to +332) billion in 2010-2029 and of USD 405 (-27 to 1048) billion per year in 2010-2049; nuclear power attracts additional USD 31 (1.4 to 117) billion per year in 2010-2029 and 154 (2 to 390) billion per year in 2010-2049; power plants with carbon capture and sequestration (CCS) have only marginal importance in 2010-2029 while attracting USD 195 (27 to 574) billion per year in 2010-2049.

Non-OECD countries absorb the greatest share of incremental investments in power generation technologies in the reference scenarios as well as in the policy scenarios. An estimated 73% (57 to 90%) of global incremental investments in the power sector goes to non-OECD countries in 2010-2049 while 79% (70 to 90%) of global investments in fossil power plants with CCS goes to non-OECD countries, indicating the importance of reducing the emissions from cheap coal power generation.

The limited evidence available suggests that climate policy will reduce investment needs for electricity transmission and distribution by USD 52 (16 to 80) billion per year in 2010-2029 and by USD 62 (-165 to +88) billion per year in 2010-2049.

Most studies surveyed in table 16.2 and 16.3 suggest that climate policy will induce higher investments in power generation. Low or zero-emission power generation technologies are generally more expensive than traditional ones. This increases the cost of electricity and induces a reduction of electricity demand with respect to the reference scenario (see Chapter 6). However, in most models the contraction of electricity demand is not sufficient to compensate for the increase in average investment cost. This causes investment in the power sector to increase.

The implications of the relative balance between supply-side and demand-side mitigation actions is evident when comparing the GEA-Supply (SN) and the GEA-Efficiency (SE) scenarios (Riahi et al., 2012). In the supply-side scenario all the effort goes to de-carbonize energy supply. The higher cost of carbon-free power generation technologies induces a sharp increase in investment needs. In the GEA-efficiency scenario significant effort instead goes towards reducing energy demand, including some lifestyle changes. Investments in energy efficiency are higher than in the reference scenario but investments in the power sector are typically lower. The two studies available with sectoral detail (McKinsey, 2009; IEA, 2011) project annual incremental investments until 2030 for energy efficiency improvements of USD 215 (175 to 254) billion for the building sector, USD 267 (150-384) billion for the transport sector, USD 104 (77 to 131) billion for the industry sector in scenarios commensurate with a 2°C target. Also including the global and non-sectoral data from the GEA (2012) assessment resulting total incremental energy efficiency investments are estimated to USD 457 (200 to 715) billion per year until 2030, with OECD and non-OECD countries sharing incremental investment needs roughly equally.

While models tend to agree on the relative importance of investments in fossil and non-fossil power generation, they provide divergent scenarios of overall incremental investment needs and of the mix of low- or zero-emission power generation technologies. This is mainly explained by different assumptions about (1) the structure of the energy system and the cost of reducing the energy intensity of the economy versus reducing the carbon intensity of energy, (2) investment costs of alternative technologies in the present and in the future, (3) technological or political constraints, and (4) reference scenarios (e.g. population, economic growth, exogenous technological progress). Such differences suggest different patterns towards the long-term policy goal as reflected in the different timings of emission reductions and technology adoptions. It is thus not clear from model results whether a rapid and massive deployment of low-carbon technologies to avoid lock-in effects should be favoured over time-phased action supported by an expected cost decrease of future technological innovation *(low evidence, medium agreement).* However, market-driven technological innovation is not unrelated to market size and its expected dynamics.

Limits to the deployment of some key technology options would increase investment needs: see GA scenarios SN, EN (limited nuclear) and GW scenario SB, EB (limited bioenergy with CCS) (Riahi et al., 2012); a large set of investment scenarios with technological and policy constraints is presented by McCollum et al. (2013).

Higher energy efficiency, technological innovation in transport, transformations in the power sector all contribute to drastically reducing demand for fossil fuels, thus causing a sharp decline in upstream and downstream investments in fossil fuel supply. Scenarios are hard to compare because not all models provide data on all fossil fuels. Average annual investment reductions in 2010-2029 are in the order of an estimaed USD 100 to 300 billion; the contraction is sharper in 2010-2049, in the order of USD 600 to 1,000 billion per year. This implies that investment in the fossil fuels extraction sector are roughly halved from 2010-2049. Some scenarios show that due to dedreasing investments in fuel extraction overall investments in energy supply would decrease in a 2°C target scenario (Carraro et al., 2012; Riahi et al., 2012; McCollum et al., 2013).

According to a range of models the main effect of climate policy would be to dramatically change the allocation of baseline energy investments rather than increase overall demand. Models with a separate consideration of energy efficiency measures foresee the need for significant incremental investment in energy efficiency in the building, transport and industry sector in addition to the reallocation of investment from high-carbon to low-carbon power supply.

There is wide agreement among model results on the necessity to ramp-up investments in R&D in order to increase end-use energy efficiency and to develop low- or zero-emission generation energy carriers and energy transformation technologies. There is very little information on how much investment in R&D is needed. The estimates reported in table 16.2 and 16.3 are only loosely comparable because the studies do not share homogenous assumptions. Additional needs in R&D range from USD 4.5-78 billion per year during 2010-2029 and up to 130 billion/year in 2010-2049. Because new carbon-free alternatives must be developed, investments in R&D are higher in case of nuclear phase-out and other technological constraints (Bosetti et al., 2011).

Table 16.2. Investments energy supply, energy demand and forestry, 2010-2029 (2010 USD billion/year)

					Energy Supply																											Energy Demand				
								Power sector																				Extraction Fossil Fuels								
									Power plants																											
Author	Scenario name	Climate target (2100)	Emissions in 2050 (Gt CO2-eq)	Region	R&D	Total Energy	Other energy	Total Power	Total Plants	Renewables	Wind	Solar	Hydro	Biomass	Geothermal	Other ren.	Nuclear	Total CCS	Biomass CCS	Coal CCS	Gas CCS	Total Fossil	Coal	Gas	Oil	Transmission and distribution	Biofuels	Tot. Extraction	Oil	Gas	Coal	Total Demand	Buildings	Transport	Industry	Forestry
Average annual investment in 2010-2029 (USD billion) - Reference scenario																																				
IEA / GEE	CPS		40.7	World		1,632		680	364	180	68	44	44	20.3	1.8	1.8	41	3.1	0.0	2.8	0.3	142	97	42	3.7	316	11.0	941	66	418	458					
			27.0	nOECD		1,044		406	200	88	28	16	35	7.6	1.0	0.1	20	0.9	0.0	0.9	0.0	93	64	26	2.6	205	4.7	634	51	256	326					
GEA	R		70.2	World		855	43.2	405	164	93							7.1	0.0	0.0	0.0	0.0	63				241	18	389								
CFM	R		45.2	World	9.7	401			255	21							88	0.0	0.0		0.0	146	104	29	13			146	146							
			30.6	nOECD	1.8	215			126	7.1							17	0.0	0.0		0.0	102	71	20	11			89	89							
AME	R		46.4	World					381	92	20	0.9	55	3.8	2.8		33	0.0	0.0	0.0	0.0	159	130	21	2.0											
			33.3	nOECD					268	66	13	0.5	41	3.3	2.0		19	0.0	0.0	0.0	0.0	121	98	14	2.0											
LIMITS	R		54.1	World	6.5	981	5.9	469	261	78	34	5.7		1.4		38	27	0.0	0.0	0.0	0.0	156	96	60		208	4.9	501	369	103	29					
			39.0	nOECD	1.3	691	5.8	323	183	45	16	2.2		0.8		26	13	0.0	0.0	0.0	0.0	125	75	49		140	1.8	361	277	62	21					
Incremental average annual investment (policy scenario - reference scenario) in 2010-2029 (USD billion) - Policy scenarios																																				
IEA/GEE	NPS		35.7	World		-130	0.0	-5.3	31	61	19	19	14	6.9	1.1	0.9	3.9	5.5	0.0	5.2	0.3	-34	-28	-5.6	-0.3	-37	3.6	-128	-21	-42	-65	203	71	103	28	
			23.3	nOECD		-104	0.0	-6.8	20	41	10	14	11	5.2	0.8	0.0	3.7	1.8	0.0	1.8	0.0	-25	-20	-4.1	-0.3	-27	1.4	-99	-16	-33	-51	124	45	61	18	
	450	450 ppm	24.8	World		-196	0.0	107	186	186	61	66	36	17	3.6	1.7	33.0	43.1	0.0	33	10	-33	-29	-2.3	-1.7	-78	29	-333	-30	-127	-176	715	254	384	77	
			16.2	nOECD		-199	0.0	46	105	118	34	39	29	13	2.5	0.1	18.7	17.8	0.0	15	3.1	-32	-26	-5.0	-1.2	-59	7.0	-252	-23	-93	-136	371	133	192	46	
GEA	S	+2°C	40.4	World		163	30	217	253	190							65	13				-14				-36	42	-125				135				
	E		45.1	World		-285	-19	-83	-3.2	-3.8							1.6	1.4				-2.4				-80	3.1	-186				249				
	SN		37.7	World		304	44	340	368	332							31	18				-13				-29	57	-138				151				
	EN		42.5	World		-277	-18	-76	3.2	1.3							1.6	1.9				-1.5				-79	3.6	-187				252				
	SB		35.9	World		305	31	366	391	312							80	16				-16				-25	36	-129				151				
	EB		39.6	World		-255	-16	-51	25	18							8.0	3.5				-4.3				-76	6.5	-194				260				
CFM	560	560 ppm	35.0	World	3.1	-54			-36	2.7							32	16	16.0		0.0	-87	-88	0.3	0.7				-18							
			23.6	nOECD	0.7	-44			-34	0.8							9.1	4.5	4.5		0.0	-49	-49	-0.1	0.6				-9.1							
	460	460 ppm	26.0	World	4.5	-22			17	5.5							60	117	102		16	-166	-152	-14	0.8				-38							
			16.2	nOECD	1.3	-29			-1.2	2.1							23	84	72		12	-111	-102	-10	1.2				-28							
AME	3.7	3.7 W/m^2	37.0	World					91	67	50	1.6	11.3	7.4	0.7		35	12	0.0	8.5	0.0	-111	-109	-0.1	-0.2											
			27.0	nOECD					44	40	30	0.8	10.5	4.9	-0.5		28	7.8	0.0	7.0	0.0	-79	-78	2.4	-0.2											
	2.6	2.6 W/m^2	28.0	World					198	169	94	10	19.1	5.9	1.0		22	73	5	15	11	-173	-159	1.0	-1.2											
			19.8	nOECD					87	90	31	8.6	18.6	3.3	0.2		21	56	3.9	13.5	8.2	-132	-112	5.3	-1.2											
LIMITS	LS4	2.8 W/m^2	31.4	World	78	-69	10	97	118	90	35	16		2.5		37	80	49				-102	-87	-15		-20		-177	-155	-0.4						
			21.8	nOECD	39	-52	9.7	66	81	65	21	11		2.3		31	58	35				-77	-67	-9.6		-16		-128	-106	-4.7						
McKinsey	S2020	550 ppm	46.2	World					56	112	64	34.7		0.7	3.8	9.3	58	0.6	0.1	0.4	0.1	-115							5.9			299	109	83	91	16
			31.9	nOECD					29	51	26	13.9		0.6	1.6	8.1	20	0.2	0.0	0.2	0.0	-42							3.4			189	55	55	64	15
	S2015	450 ppm	37.3	World					136	176	96	62		0.9	5.4	11.7	67	6.3	0.2	5.7	0.4	-113							8.3			488	175	150	131	31
			25.7	nOECD					73	87	46	28.2		0.9	2.1	10.1	23	4.4	0.1	4.2	0.1	-41							4.9			301	88	90	94	29
UNFCCC	450	450 ppm		World	50				-66													-66											57	98	40	23
	450			Dev. C.					-4													-36											16	39	22	23

Table 16.3. Investments energy supply, 2010-2049 (2010 USD billion/year)

Author	Scenario name	Climate target (2100)	Emissions in 2050 (Gt CO2-eq)	Region	R&D	Energy Supply																										Total Demand
								Power sector																				Extraction Fossil Fuels				
									Power plants																							
						Total Energy	Other energy	Total Power	Total Plants	Renewables	Wind	Solar	Hydro	Biomass	Geothermal	Other ren.	Nuclear	Total CCS	Biomass CCS	Coal CCS	Gas CCS	Total Fossil Fuels	Coal	Gas	Oil	Transmission and distribution	Biofuels	Tot. Extraction	Oil	Gas	Coal	
Average annual investment in 2010-2049 (USD billion) - Reference scenario																																
GEA	R		96.2	World		3,581	198	1,617	739	476							11	0	0	0	0	253				878	76	1,690				
CFM	R		59.8	World	38	4,461			1,166	296	76	0	219				287	0	0	0	0	584	437	105	42			3,295	3,295			
	R		42.1	nOECD	29	2,608			671	173	26	0	147				67	0	0	0	0	431	314	80	36			1,937	1,937			
AME	R		59.7	World					1,429	339	104	15	155	20	10		146	0	0	0	0	560	480	70	4.0							
	R		45.6	nOECD					1,029	232	58	13	116	17	7.6		107	0	0	0	0	446	379	51	4.0							
LIMITS	R		62.9	World	24	4,003	38	1,703	946	248	138	23		9.1		79	146	0	0	0	0	552	338	213		756	8.8	2,253	1,728	410	115	
	R		46.6	nOECD	5.6	2,806	34	1,189	671	181	80	16		6.8		50	87	0	0	0	0	442	271	171		518	3.5	1,579	1,222	271	86	
Incremental average annual investment (policy scenario - reference scenario) in 2010-2049 (USD billion) - Policy scenarios																																
GEA	S	+2°C	28.3	World		606	146	867	883	593							321	72	0	26	45	-103	92	58		-16	208	-615				650
	E		28.2	World		-1,075	-65	-218	-48	-27							35	27				-83				-170	45	-837				1,281
	SN		27.6	World		941	200	1,135	1,085	1,048							31	90				-85				50	235	-629				708
	EN		26.9	World		-1,072	-60	-218	-52	-12							2	34	0	14	20	-76	115	62		-165	51	-846				1,278
	SB		24.5	World		989	136	1,368	1,280	929							390	73				-111				88	103	-618				718
	EB		23.3	World		-967	-57	-88	55	21							74	44				-84				-143	49	-871				1,340
CFM	560	560 ppm	46.9	World	13	-676			-12	23							106	225	213		12	-367	-349	-17	-0.6				-664			
			33.2	nOECD	9.5	-311			-42	14							54	142	132		11	-253	-239	-13	-0.6				-268			
	460	460 ppm	35.5	World	130	-1,191			232	31							143	574	411		163	-517	-433	-73	-11				-1,423			
			24.0	nOECD	73	-620			132	21							84	404	272		132	-378	-310	-58	-9.5				-752			
AME	3.7	3.7 W/m^2	25.4	World					481	276	187	53	22	22	6.0		153	189	30	87	25	-395	-389	-23	-1.2							
			18.9	nOECD					298	190	139	46	19	17	0.6		100	145	25	65	21	-310	-305	-15	-1.2							
	2.6	2.6 W/m^2	13.7	World					1,080	603	272	99	52	19	5.8		100	411	138	72	121	-491	-444	-36	-2.2							
			10.1	nOECD					764	404	132	80	47	15	1.8		82	307	108	56	98	-393	-344	-23	-2.2							
LIMITS	LS4	2.8 W/m^2	23.5	World	107	-312	45	749	826	458	165	154		17.4		122	290	425	148	156	121	-347	-258	-89	0.0	-77	68	-1,098	-988	-28	-82	
			17.1	nOECD	18	-97	38	713	745	393	108	109		16.7		94	225	391	114	127	97	-272	-204	-68	0.0	-101	50	-459	-631	-24	-63	

Notes for Tables 16.2 and 16.3. **Scenarios.** R denotes the reference scenario for all models. Policy scenarios: **IEA/GEE** (IEA, 2011): Constant Policies Scenario (CPS), New Policy Scenario (NPS) and 450 Scenario (450). CPS Investment in CCS is also included under Coal & Gas (retrofitting); World investment in biofuels includes international bunkers; investment in solar PV in buildings is attributed to power plants in supply-side investment. **GEA** (IIASA-GEA, Global Energy Assessment (Riahi et al., 2012)):emissions include non-CO_2 gases and are measured in CO_2-eq. The GEA-Supply (SU) and GEA-Efficiency (E) are scenarios without technological constraints and advanced transportation. SN and EN are obtained with the same assumptions of the SU and E scenarios with in addition a constraint on nuclear power. SB and EB are obtained by imposing a constraint on bioenergy with carbon capture and storage. **CFM** (Carraro et al., 2012): two universal taxes on all GHG emissions that lead to concentrations equal to 560 and 460 ppm CO_2-eq in 2100 (t560 and t460). R&D investments in end-use. **AME** (Asia Modeling Exercise - (Calvin et al., 2012)), median of a subset of models. The 3.7 / m^2 and the 2.6 w / m^2 roughly correspond to concentration targets of 550 and 450 ppm CO_2-eq in 2100. Median value available for each scenario. Medians are also used to report investments in technological aggregates. For this reason investments in the aggregated are not equal to the sum of their components. **LIMITS** (Low Climate Impact Scenarios and Implications of Required Tight Emission Control Strategies - (McCollum et al., 2013)): LS4 scenario imposes the 2.8 W/m2 in 2100, without constraints. Emission level reported for 2030 includes only CO_2. R&D investments in end-use and energy supply. **McKinsey** (data obtained from Climate Desk; methods explained in (McKinsey, 2009)). S2015 and S2020 assume full potential, 100% success rate, negative lever of costs, beginning of policy in 2015 and 2020, respectively. The S2015 scenario has emission reductions in 2030 compatible with a long-term 450 ppm CO_2-eq target. The S2020 scenario has emission reductions in 2030 compatible with a long-term 550 ppm CO_2-eq target. Industry includes energy efficiency measures and process changes. Industry includes cement (USD 7 billion/year in 2010-2029 in the S2015 scenario), iron and steel (USD 31 billion), chemicals (USA 21 billion), other industry (USD 24 billion), waste (USD 11 billion). **UNFCCC** (2008a): investments in 2030 rather than average per year from 2010 to 2029. **Regions**: W (World), S (non-OECD), Developing Countries (Dev. C.). All concentration targets in 2100 in ppm CO_2-eq.

The global fossil fuel energy sector is the single largest emitter of greenhouse gases and has properly drawn the attention of the research community whose major modeling efforts are summarized in table 16.2 and 16.3. However, land-use is the second largest source of greenhouse gas emissions and within land use, tropical deforestation is by far the largest source (see AR5 WGI). Given the scale of land use emissions, efforts to stabilize global contractions will require investments in land use change as well as in the energy sector.

Kindermann et al. (2008) use three global forestry and land use models to examine the costs of reduced emissions through avoided deforestation over the 25 year period from 2005-2030.[13] The models' results suggest substantial emission reductions can be achieved. The models estimate that 1.6 to 4.3 Gt of CO_2 per year could be reduced for USD 20 t of CO_2 with the greatest reductions coming from Africa followed by Central and South America and Southeast Asia.

Kindermann et al. (2008) use the models to estimate the costs needed to reduce emissions from deforestation by between 10% and 50% of the baseline. To do so they assume tropical countries would project baseline rates of deforestation and then finance forest preservation activities using funds provided (sources unidentified), leading to substantially reduced rates of deforestation. The results suggest that deforestation could be reduced by 10% (0.3–0.6 Gt CO_2 per year) over the 25-year period for an investment of USD 0.4 billion to USD 1.7 billion per year in forest preservation activities, and a 50% reduction (1.5–2.7 Gt CO_2 per year) could be achieved for an investment of USD 17.2 billion to USD 28.0 billion per year. This is a figure comparable to what has been found by UNFCCC (2008a) and McCollum et al.(2013), listed in table 16.2.

16.2.2.2 Investment gap in energy related sectors

Current carbon-intensive investment patterns as reflected in table 16.1 need to be changed signifcantly to become compatible with emission pathways commensurate with a 2°C objective. Current levels of climate investment of USD 343 to 385 billion per year comprise investment in renewable energy and energy efficiency which occured in a phase of exceptionally high energy sector investments driven by the high growth in emerging countries. They have not resulted in an absolute reduction of fossil fuel investment and do not constitute incremental investment. Climate investments in developed countries at the same time have not been exclusively focussed on the most cost-effective technologies.

The level of mitigation investment, by itself, provides little indication of the likelihood of reaching a specified stabilisation pathway due to the complex reallocation of investment required throughout the energy-related sectors. If accompanied by additional indicators like the carbon intensity of average new investments more robust conclusions can be drawn on the viability of certain stabilsation pathways.

Findings from model studies vary in respect to the relevance of a re-allocation of investment within the energy supply sector from high to low-carbon, (including from fossil up-stream activities to low-carbon power plants) vis-à-vis a reallocation of investments from energy supply to energy efficiency. Model estimates of global total annual incremental investments for energy-related activities until 2030 range from a decline by USD -30 billion per year to substantial inceases by more than USD +500 billion per year, if energy efficiency is included. These differences result partly from different model assumptions and partly from the different ways in which models cover other parts of the economy. In principle, an assessment of changes of investment and resulting needs under different climate policy scenarios should consider all sectors and not be isolated to the energy-related ones. National policy decisions can be usefully supported by national data rather than aggregated data with netting of changes across several countries.

[13] The models used are the Dynamic Integrated Model of Forestry and Alternative Land Use (DIMA) (Roktiyanskiy et al., 2007), the Generalized Comprehensive Mitigation Assessment Process Model (GCOMAP) (Sathaye et al., 2006) and the Global Timber Model (GTM) (Sohngen and Mendelsohn, 2003).

16.2.2.3 Overall incremental costs

Incremental costs can be calculated for an individual project, for a program, for a sector, a country an entire region. From an economic perspective one could define incremental cost as a country-level compensation-based measure of lost social welfare, or easily as a measure of lost gross domestic product (GDP) or consumption. The full incremental cost for a given country could be calculated as the difference between GDP in the absence of UNFCCC commitments and GDP when the country is undertaking actions to meet those commitments. The compensation-based measure of full incremental cost is instructive in the sense that it provides a country-level perspective on the macro aggregate cost of mitigation actions (estimates provided in chapter 6), but it does not provide information on the micro economic investments that must be made and costs incurred to meet the mitigation commitments. This distinction is important if the operationalization of the international climate finance commitments will be through institutions designed to provide micro-level investment and cost support rather than macro-level compensation payments.

For three studies listed in Tables 16.2 and 16.3 it is possible to assess incremental economy-wide costs of emission reductions compatible with the 2°C at global level. Cumulative global incremental cost in CFM, AME and LIMITS are respectively equal to USD 7.3, 5.9 and 7.4 trillion in 2010-2029 (i.e. USD 395, 295 and 370 billion per year on average) and to USD 74, 50 and 68 trillion in 2010-2049 (i.e. USD 1.85, 1.25 and 1.7 trillion per year on average).[14] Positive and negative changes are netted across countries. To inform country level decisions country specific data are useful. Investment needs are thus only a fraction of incremental costs. This difference is largely due to reduced growth of carbon constrained economies in many models.

Again, it should be noted, that adaptation costs and economic losses from future climate change are not considered in the estimates of 16.2.2. A discussion of respective financing and investment needs for adaptation can be found in the Working Group II Report of the 5th Assessment Report an e.g. in Smith et al. (2011).

FAQ 16.1. How much investment and finance is currently directed to projects that contribute to mitigate climate change and how much extra flows will be required in the future to stay below the 2°C limit?

Current mitigation finance is estimated at USD 350 billion (2010/11 USD) per year using a mix of 2010 and 2011 data. This total includes a mix of instruments and a variety of sources and intermediaries. It covers full investment in mitigation measures, such as renewable energy generation technologies, that also produce other goods or services. Of the total, developing countries raised USD 120-141 billion of which 34-41% were public funds. Developed countries raised USD 213-255 billion including 17-23% public sources. Flows committed to developed countries amounted to USD 160- 208 billion and USD 162-202 billion to developing countries.

Climate policy is expected to induce a remarkable reallocation of investments in the power sector from fossil fuels to renewable power generation, nuclear and fossil fuels with CCS in all scenarios compatible with a 2°C objective in 2100. Investments in fossil fuels would decline on average by more than 50% in 2010-2029; by more than 70% over the period 2010-2049. Renewable power generation would attract an additional average annual investment of USD 134 billion over 2010-2029 and of USD 405 billion per year in 2010-2049; nuclear power would absorb additional USD 31

[14] Only three models report incremental costs in terms of GDP in AME. In 2010-2029 costs are equal to USD 1 trillion if measured as the area under the marginal abatement cost curve (USD 17.5 trillion in 2010-2049), and 1 trillion if measured as consumption loss (USD 16.5 trillion in 2010-2049). Not all models report data on GDP loss. In LIMITS WITCH, REMIND and MESSAGE report data on incremental cost in terms of GDP. GCAM reports the area under the MAC curve, which is equal to USD 0.8 and 16.2 trillion, respectively in 2010-2029 and in 2010-2049 respectively.

billion per year in 2010-2029 and 154 billion per year in 2010-2049; power plants with carbon capture and sequestration (CCS) would have marginal importance in 2010-2029 while attract USD 195 billion per year in 2010-2049. Moreover, substantial incremental investments for energy efficiency are expected in the climate policy scenarios. In the building sector annual average incremental investments of USD 215 billion would flow until 2030, USD 267 billion in the transport sector, and USD 104 billion in the industry sector. Investments in transmission and distribution would decline by -20 to -80 USD billion per year in 2010-2029. Model results suggest that deforestation can be reduced against current deforestation trends by 10% with an investment of USD 0.4 to 1.7 billion per year and by 50% reduction with an investment of USD 17 to 28 billion per year.

16.2.3 Raising public funding for climate finance

This section reviews possible sources of public funds for climate finance analyzed by the UNFCCC, the High-level Advisory Group on Climate Change Financing (AGF), the G20 finance ministers and other studies (UNFCCC, 2007; AGF, 2010; G20, 2010). Only sources that also yield mitigation benefits are discussed here. They are grouped into the following categories:

1. Sources that contribute to developed countries national budgets, dependent on national decisions;
2. Sources that contribute to national budgets, dependent on international agreements; and
3. Funds collected internationally pursuant to an international agreement

Each category is discussed in turn. The estimates in this section are projected amounts generated in 2020 expressed in 2010 USD unless otherwise indicated. The estimates are summarized in table 16.4.

Table 16.4. Summary of Potential Sources of Public Funds for Climate Finance in 2020

Source	Projected amount generated in 2020 (2010 USD billion/year)
Sources that contribute to developed country national budgets, dependent on national decisions	
Domestic carbon taxes	AGF: 300; G20: 250
Phase out of fossil fuel subsidies	AGF and G20: 40-60
Higher fossil fuel royalties	No estimate
Wires charge on electricity generation	AGF: 5
Sources that contribute to national budgets, dependent on international agreements	
Border carbon cost levelling	Grubb 2011: 5*
Carbon exports optimization tax	AGF: 9-31
Funds collected internationally pursuant to an international agreement	
Extension of the "share of proceeds"	AGF: 1-3
Auctioning a portion of AAUs	AGF: 5-12
Carbon pricing for international aviation	UNFCCC: 10-25**; AGF: 6; G20: 13
Carbon pricing for international shipping	UNFCCC: 10-15**; AGF: 22-25; G20: 26

Note: AGF, G20 and UNFCCC refer to estimates from AGF (2010), G20 (2011) and UNFCCC (2007) respectively.* = Date not specified; ** = 2006 USD
Source: Compiled from AGF (2010); G20 (2010); UNFCCC (2007); Grubb (2011)

Sources that contribute to developed country national budgets, dependent on national decisions

The AGF and G20 reports estimate the revenue that could be generated by developed countries in 2020 from the following sources:

- *A domestic carbon tax or sale of allowances for a domestic emissions trading scheme*. With a carbon price of USD 20-25 per tonne of CO_2 equivalent, the AGF estimates that Annex II countries could raise about USD 300 billion. The G20 report estimates the potential revenue generated by these countries at USD 250 billion.
- *Phase out of fossil fuel subsidies*. Fossil fuel subsidies in Annex II countries currently amount to USD 40-60 billion per year. Some or all of the subsidies could be phased out. This will directly increase government budget and indirectly improve the competitiveness of clean technologies as traditional energy sources are no longer subsidized.
- *Higher fossil fuel royalties*. Potential revenues were not estimated. Only 5 Annex II countries collect royalties from fossil fuel production.
- *A "wires charge" on electricity generated or CO_2 emissions due to electricity generation*. A charge of USD 1 per tonne of CO_2 on emissions due to electricity generation would raise about USD 5 billion per year (AGF, 2010) in Annex II countries. A country may be reluctant to implement such a charge if it has a carbon tax or emissions trading scheme that also covers emissions by electricity generators.

The AGF and G20 reports assume that most of the revenue raised from these sources would be retained for domestic purposes. Of the USD 290 to 360 billion per year generated by Annex II countries, only USD 35 to 40 billion is assumed to be used to meet their commitment to fund the climate change finance needs of developing countries.

Sources that contribute to national budgets, dependent on international agreements[15]

When developed countries implement policies to limit greenhouse gas emissions they attempt to minimize production shifts to countries that do not have such policies. Such production shifts undermine both the emissions reduction goal ("carbon leakage") and economic activity. The mitigation policy can be designed to minimize these effects; for example, by giving free allowances to vulnerable firms subject to an emissions trading scheme. Policy designs that reduce leakage have a cost; distributing free allowances reduces the revenue from auctioned allowances. Border levies on GHG-intensive imports discourage carbon leakage due to the mitigation policy and so permit adoption of more efficient domestic policies.

Many developing countries oppose unilateral imposition of border levies on imports, but two options for internationally negotiated border levies have been proposed that could benefit both developing and developed countries:

- *Border carbon cost levelling* (Grubb, 2011). Developed countries with a carbon tax or emissions trading scheme would collect an internationally agreed levy on imports of GHG-intensive products from countries without such a policy.[16] Participating developed countries would impose the same levies on the same products regardless of their origin. The levy for a product would be based on the emissions associated with best available production technology, so it would not protect inefficient industries. The levy revenue would be transferred to an international fund.
- *A carbon exports optimization tax*. The AGF evaluated an export fee levied by developing countries on exports of GHG-intensive products to developed countries with a carbon tax or emissions trading scheme (Müller and Sharma, 2005). This serves the same purpose as the

[15] The UNFCCC, AGF and G20 reports also consider a financial transaction tax, which would fall into this category. It is not discussed here because it is not a mitigation measure.

[16] Developing countries would not impose the border levies, so their imports are not affected.

developed country border levies but is administratively more complex. Such a tax could raise USD 9 to 31 billion per year. The revenue would be retained by the exporting country.

Developed countries would be able to implement more efficient domestic policies due to the reduced risk of leakage. In particular, they could auction more allowances thus generating more domestic revenue even though all of the revenue from border levies goes to developing countries. Developing countries benefit from the additional revenue to finance climate change action in their countries. Such a system of border levies would best be implemented through an international agreement, but currently it is not under serious consideration.

Funds collected internationally pursuant to an international agreement

Funds also can be raised internationally pursuant to an international agreement. The share of proceeds, the two per cent share of CERs issued for most CDM projects, which is the main source of funds for the Adaptation Fund, is the best example of such a source. To date over USD 170 million has been raised through the sale of 10.4 million CERs. Specific proposals to generate additional funds from international market mechanisms include (see also UNFCCC (2008b)):

- *Extension of share of proceeds*. Applying the share of proceeds to ERUs and international trades of AAUs and possibly raising the rate to 5% could generate USD 1-3 billion per year based on projected offset use by Annex I countries in 2020. In 2012 countries agreed to extend the 2% share of proceeds to ERUs and the first international trade of AAUs. In the Doha amendment to the Kyoto Protocol, it was decided that for the second commitment period, the Adaptation Fund shall be further augmented through a 2% share of the proceeds levied on the first international transfers of assigned amount units (AAUs) and the issuance of emissions reduction units (ERUs) for joint implementation projects immediately upon the conversion to ERUs of AAUs or removal units (RMUs) (UNFCCC, 2012b para 21). The financial flows to be mobilized during the second commitment period of the Kyoto Protocol resulting from this decision are yet to be assessed.
- *Auction a share of the AAUs*. Norway proposed that a share of the AAUs corresponding to future commitments of Annex I Parties be auctioned internationally. The AGF estimated that auctioning 2 to 5 % of AAUs could generate USD 5 to 12 billion per year in 2020.

Funds to finance climate change actions in developing countries could also be generated through international regulation of emissions from international aviation and shipping. The high and rising CO_2 emissions from these sources could be regulated by an emissions levy or an emissions trading scheme with auctioned allowances which could generate revenue for climate change actions in developing countries.

- *Regulation of international aviation emissions by the International Civil Aviation Organization (ICAO)*. Estimates of the potential annual revenue in 2020 range from USD 6 billion (AGF, 2010) to USD 13 billion (G20, 2010) to USD 10 to 25 billion (UNFCCC, 2007). Some of the revenue, of the order of 40%, would need to be used to compensate for adverse economic impacts on developing countries.
- *Regulation of international shipping emissions by the International Maritime Organization (IMO)*. Estimates of the potential annual revenue in 2020 range from USD 10 to 15 billion (UNFCCC, 2007) to USD 22 to 25 billion (AGF, 2010) to USD 26 billion (G20, 2010). Some of the revenue, of the order of 30 to 40%, would need to be used to compensate for adverse economic impacts on developing countries.

Most developing countries oppose regulation of international aviation and shipping emissions by ICAO and IMO because the regulations adopted by those organizations apply to all countries. They argue that developed countries should bear the burden of reducing these emissions in accordance with the principle of common but differentiated responsibility. It is not clear that the principle of common but differentiated responsibilities applies to airlines and shipping companies or to emissions beyond national borders. Nevertheless, it can be addressed through compensation to developing countries. Each developing country would receive compensation equal to, for example, its share of global trade multiplied by the revenue collected. That would leave net revenue equal to the revenue collected multiplied by the developed country share of global trade.

Revenue from regulation of international aviation and shipping emissions could flow to national governments rather than to ICAO and IMO. The European Union passed legislation that includes the emissions of all flights arriving at or departing from an EU airport in the EU ETS effective 1 January 2012. Implementation for flights to and from non-EU destinations has been deferred for one year. Most allowances are distributed free to airlines. The governments of EU member states collect revenue from the auctioned allowances.

An alternative to the regulation of international aviation emissions is a levy on the price of international passenger tickets. Such charges have been introduced by several countries to raise fund to fight HIV/Aids and other pandemics. Müller and Hepburn (2006) suggest an average levy of € 5 per passenger per flight and estimate that it would raise about € 10 billion (USD 13 billion) annually. An air transport levy is more likely to be implemented by national governments than by ICAO so the revenue would flow through national budgets.

Global modeling results

Using IAMs it is possible to estimate the potential maximum size of carbon revenues when all emissions are taxed or all permits are auctioned. This exercise relies on long-term modeling and is based upon a scenario in which all world regions commit to reduce GHG emissions using an efficient allocation of abatement effort, i.e. globally equal marginal abatement costs. Therefore it should be used to gain insights rather than exact forecasts.

From the analysis of scenarios generated by the AME and LIMITS projects (Calvin et al., 2012; McCollum et al., 2013) it is possible to derive the following messages:

- Carbon revenues are potentially large, in the order of USD 200 billion in China, the EU and the USA in 2030. At the global level they could top USD 1,600 billion in 2030.
- Carbon revenues may peak in the mid-term and decline in the long-term, as contracting emissions (the tax base) more than offset the increase in the carbon price (Carraro et al., 2012). Regions in which marginal abatement costs are lower reduce the tax base at a faster pace and thus see carbon revenues falling faster. Fast growing regions may see growing carbon revenues.
- Scenarios and/or regions in which absorption of emissions – e.g. by means of bioenergy with CCS – plays an important role in the mitigation portfolio may exhibit net negative emissions. This implies that net carbon revenues become negative; therefore, governments must finance net negative emissions using either the general fiscal budget or international donors (Carraro et al., 2012).

16.3 Enabling environments

The following section intends to highlight the relevance of enabling environments in targeting low-carbon investments. The concept of enabling environments has evolved to describe government policies that focus on creating and maintaining an overall macroeconomic environment (UNCTAD, 1998).[17] There are many broad interpretations of enabling environments, as the concept is not clearly defined. According to Bolger (2000), an 'enabling environment' represents the wider context

[17] For enabling environments for technology transfer see McKenzie Hedger et al. (2000).

within which development processes take place, i.e. the role of societal norms, rules, regulations and systems. This environment may either be enabling or constraining.

Stadelmann and Michaelowa (2011) examine the low carbon business enabling environment and define it as "the overall environment including policies, regulations and institutions that drive the business sector to invest in and apply low-carbon technologies and services." According to this definition, it includes three main components: 1) the core business environment, which is not climate-specific but relevant for all type of businesses e.g. customs, tax regime, labour market and ease of starting, operating, and closing a business; 2) the broader investment climate, including education, financial markets and infrastructure, which is partially low-carbon related e.g. via climate change education or investments in electricity grids; and 3) targeted policies that drive the business sector to invest in and apply low-carbon technologies and services.

Eyraud et al. (2011) conducted an empirical investigation of the macroeconomic drivers of 'green investment', which they define as the "investment necessary to reduce greenhouse gas and air pollutant emissions, without significantly reducing the production and consumption of non-energy goods". (Eyraud et al., 2011, p. 5) They are presented here according to the components outlined above (Stadelmann and Michaelowa, 2011) and complemented by other sources where indicated.

Core business environment (relevant for all businesses):

- The production and business costs such as unit labour costs, wages, cost of starting a business, and corporate income tax.
- Economic growth and income level boost demand for energy and investment in the energy sector.
- Population growth can have an impact on energy demand and land-use beyond formal markets, especially in developing countries.

Broader investment climate (partly low-carbon relevant):

- Interest rates/Access to capital. 'Green investment' is particularly responsive to interest rate movements, as these investments tend to be particularly capital intensive and reliant on external financing.
- The cost of fossil energy sources. High fossil energy prices lower the relative cost of the electricity produced from carbon mitigation activities such as renewable energy. This effect is reinforced when carbon emissions are taxed.
- Technological progress and innovation. Investment in new technologies is highly dependent upon technical advances and the level of human capital; hence education policies, R&D and human capacities play an important role in facilitating innovation.
- Institutional capacity across sectors and at various levels: legal institutions and rule of law have to be in place to ensure predictability and stability (Brinkerhoff, 2004).
- Geophysical conditions refer to the availability of natural resources, such as volume of water, or the number of hours of sunshine or wind in a given time frame.

Targeted policies:

- The fiscal environment: Government climate and renewable energy policies can play an important role in creating an environment conducive to investment in climate mitigation activities. Taxation, public revenue and debt policies promulgated by governments change the incentive structure and affect markets in which a mitigation technology is expected to compete. Feed-in-tariffs and carbon pricing mechanisms yield particularly significant results in the study. However, outdated fiscal instruments and fiscal policy that does not change along with technologies and goals can incentivize undesired behaviours or technologies.

- Climate change related capacity building: According to Stadelmann and Michaelowa (2011), capacity building and enabling environments are two separate but interrelated concepts. While capacity building targets knowledge and skills gaps in order to plan and implement low-carbon business activities, improving the enabling environment involves regulatory reforms and institutions. Capacity building can also be seen as a subcomponent of creating an enabling environment (UNFCCC, 2009), as it aims to improve it by overcoming market and human and institutional capacity barriers. Support for capacity building can be a substitute for income transfers, increasing the probability that the recipient country will succeed in implementing the mitigation policies, which may then result in less funding (Urpelainen, 2010).
- Reliability and predictability: Stable, predictable and long-term government commitment contributes to the effectiveness and efficiency of climate policy because it reduces uncertainty about expected investment returns. On the other hand, fluctuating, variable, and unpredictable regulations can undermine marketplace efficiency by introducing policy uncertainty (Blyth et al., 2007; Brunner et al., 2012).

In their econometric examination, Eyraud et al. (2011) found that lowering the cost of capital is particularly effective in boosting investment in low-carbon activities. Hence, macroeconomic factors that are good for private investment as a whole are also the most important determinants of climate investment. Put differently, the obstacles impeding private investment in general, also hamper investment in low-carbon technologies.

FAQ 16.2. How can the required climate investment and finance best be mobilized?

There is a need for both public and private sources, domestic and international. The public sector has the potential to raise revenues by collecting carbon taxes, by auctioning carbon allowances or selling assigned amount units (AAUs). These carbon-related sources of funding are already sizable in some countries and have the potential to generate very large financial flows under ambitious stabilization targets. A contraction of fossil fuel subsidies could be an additional source of funding. At the same time, the public sector has a major role promoting an enabling environment for mitigation technologies, especially in reducing political uncertainty.

The private sector is already a key source for low carbon projects in industrialised and developing countries and will continue to do so. Its contribution is estimated at USD 250-285 billion in 2010/2011 that represents around 75% of overall mitigation finance (2010/2011 USD). Currently, major challenges for low-carbon investments, are especially lower returns on investment, higher investment costs, higher perceived risks and small project size compared to fossil fuel alternatives.

Policy and financial instruments ensuring a stable cash-flow, enhanced provision of equity, reduction of the cost of investment capital and risk-mitigation are crucial to scale up private low-carbon investments. Appropriate governance arrangements at the national, regional and international level are an essential pre-requisite for efficient, effective and sustainable financing of mitigation measures. To this end institutions need to respond to national needs and priorities.

16.4 Financing low-carbon investments, opportunities and key drivers

Financing mitigation projects is, in principle, similar to any other investment. This section highlights the specifics and first lessons learned. Its objective is to provide an overview of relevant factors that attract private capital for low-carbon investments. As an introduction, the investor types and the key investment criteria are introduced. Afterwards, challenges that hamper investors will be assessed, such as investment risks and access to capital. Finally, selected financial instruments used in low-carbon transactions are presented and evaluated.

16.4.1 Investors and investment decisions

The demand for financing of low carbon investments is heterogeneous. In order to choose the most effective financial instrument, it is crucial to understand the basic investment logic as well as the investor's role, and potentially the availability of financial intermediaries.[18] Box 16.1 characterises some of the major types of investors.

Box 16.1. Types of investors relevant for investment and finance in low-carbon activities

Households' asset finance is sourced domestically, and stems from income and savings. They borrow to invest in climate mitigation projects and low-carbon technology companies. In 2011 households provided around USD 32.3 billion for low-carbon finance; 75% of households' contributions were in developed countries and 25% were in developing countries (Buchner et al., 2012).

Energy corporate actors, or strategic investors, are dedicated entities with the ability to design, commission, and operate and maintain emissions reduction projects. These include power and gas utilities, independent power producers, energy companies, contractors that engineer, procure and construct (EPC) projects, and independent developers of projects. Strategic investors provided USD 97.4 – 109.7 billion in 2011 for low-carbon finance (Buchner et al., 2012). Investing in low-carbon projects is their business model and source for generating income.

Non-energy corporate actors deploy emissions reduction assets to reduce their energy bills, meet voluntary commitments or comply with emission trading schemes. These include technology companies and companies with large real estate and facilities portfolios. The estimate of contributions from non-energy corporate actors includes a very large share, more than USD 51 billion, of small-scale renewable energy such as solar PV and solar water heating & cooling. Altogether, non-energy corporate actors provided between USD 65 – 74.1 billion in 2011 for low-carbon investment (Buchner et al., 2012).

Institutional investors comprise a broad range of investor types from fund managers to pension funds including both, asset owners and asset managers. With overall USD 71 trillion in assets under management, they can have long-time horizon investments diversified across asset classes with varying risk return profiles and investment tenors, sectors and geographies (Inderst et al., 2012). The ability of asset managers to invest in climate finance depends on investment strategy, restrictions agreed upon with their clients as well as the regulatory framework. Life insurance and pension funds are especially constrained by the latter (Glemarec, 2011).

Governments are major investors and financiers in low-carbon activities in many countries. In 2010/2011, the public sector provided USD 97.2-99.3 billion (2010 USD) of public funding for climate finance (Buchner et al., 2012). Governments have an interest in reducing emissions in order to meet international agreements and self-imposed targets. Therefore they either invest directly, especially in activities with large externalities such as R&DD or infrastructure, or provide funding to mobilize private sector investments. For the latter they assume their regulatory and fiscal function (UNEP, 2005) and partly channel funds through public financial institutions.

[18] For the different types of financing typically used, i.e. required, in the different stages of renewable technologies, such as R&D, commercialization, manufacturing and sales see Mitchell et al. (2011).

Development intermediaries include multilateral, bilateral, sub-regional and national finance institutions, as well as UN agencies and national cooperation agencies. From the total of public climate finance in 2010/2011, development finance institutions channelled USD 76.8 billion (2010 USD) (Buchner et al., 2012). By working closely with recipient governments on national strategies and policy frameworks conducive to investment, these entities help develop demand for climate finance (AGF, 2010)

Risk and return are crucial decision factors in any investment finance decision, including in low-carbon activities. The higher the (perceived) risks are, the higher the expectations on return will be. The risk-return profile acceptable for an investor/lender depends on the type of capital. Like banks, debt financiers, have a strong interest in seeing that their loans are paid back and hence provide funds to less risky, proven technologies and established companies (Hamilton, 2010). It is estimated that in 2009 they required an average internal rate of return (IRR) of round 300-700 basis points above the LIBOR for RE projects in industrialised countries (see table 16.5). Early venture capitalists are situated on the other side of the financing continuum. They typically invest in new companies and technologies, and are thereby willing to take higher risks while expecting much higher returns. These investors may require an internal rate of return (IRR) of 50% or higher because of the high chances that individual projects will fail. Private equity companies that invest in more established companies and technologies may still require an IRR of about 35% (Justice, 2009). However, these typical IRR have to be considered with care since they may vary according to the prevailing basis interest rates (i.e. the current LIBOR rate), perceived risks of the investment category and the availability of alternative investment opportunities. Many renewable energy projects, especially in developing countries where additional risk margins are added, are struggling to reach returns of this level to satisfy the expectations of financiers of equity and debt (see section 16.4.2).

Table 16.5. Sources of capital, typical deployment and internal rate of return for renewable energies

	Source of capital					
	Venture capital	Private equity	Infrastructure funds	Pension funds	Bank mezzanine debt	Bank senior debt
Deployment	Equity investments in start ups New technology Prototypes	Equity investments prior to initial public offering Demonstrator technologies	Equity investments in private companies Proven technology	Equity investments in private companies and projects Proven technology	Loans for emerging technology New and poorly capitalised companies and projects	Loans for Proven technology Established and well capitalised companies and projects
IRR	> 50 %	35%	15%	15 %	LIBOR + 700 bps	LIBOR + 300 bps

Note: Rough estimate of market expectations for industrialised countries in 2009
Source: Justice (2009)

Equity and debt are basically the two major sources of finance. Both come at a certain cost, which is very sensitive to risk, i.e. risk premium or risk margin. The higher the perceived risk, the higher the cost of capital and required return needing to be generated to cover the costs (i.e. higher risk results in a higher discount rate for cash flow) (Romani, 2009). For RE projects, higher costs of capital will increase start-up costs which are generally front loaded and higher per unit of capacity than for fossil fuel based projects even if financing conditions are identical (Brunnschweiler, 2010). Lenders require a higher equity share if a project is perceived as risky. A typical project finance structure in an industrialised country consists of 10-30% equity, whereas in developing countries this share tends to be higher (UNEP, 2007). However, equity tends to be scarce in many developing countries (see 16.4.2.2).

Project finance is usually the preferred financing approach for infrastructure or energy projects worth more than EUR 15 million (UNEP, 2005). In this non-recourse structure, debt and equity are paid back exclusively from the cash flows generated by the project, as opposed to balance sheet financing, where all **'on-balance sheet'** assets can be used as collateral. In 2010/2011, USD 52.7 to 62.1 billion of project-level market rate debt went towards emission reduction. Project-level equity was estimated at USD 20 to 23.5 billion. However, the largest share of climate finance (USD 203.1 to 224.8 billion) consisted of balance sheet financing (2010 USD) (Buchner et al., 2012).

The type of finance required depends on the type of activity, its development phase and its application. Renewable energy generation and transmission ranges from solar home systems for households to large scale hydropower plants and international grid infrastructure. Criteria to characterize the financing demand are primarily **risk profile,** but also **tenor** (i.e. loan duration) and **size**. The total financing demand can be split into tranches with varying risk profiles (e.g. debt vs. equity) and varying tenors that match the characteristics of existing financing instruments.

16.4.2 Challenges for low-carbon investment

Challenges should be defined as anything that substantially reduces the probability of adoption and implementation of low-carbon technologies. Many factors pertaining to the general investment environment can have an enabling character or can act as a challenge (see 16.3) but there are also low-carbon specific factors and, if they remain, may keep the market penetration of these technologies to low percentages (Gillingham and Sweeney, 2011). The latter will be assessed in this subsection.

Challenges vary significantly within the different investment categories and are dependent upon the investor. Nonetheless, most low-carbon activities share some common financial challenges. The majority of measures in energy efficiency, RE infrastructure or technology development require high initial capital investments. Therefore, amortization periods are long, and these investments are particularly sensitive to increases in the cost of capital (Eyraud et al., 2011). However, long-term finance is often lacking, especially in a developing country context (World Bank, 2011a). Additionally, since RE or energy efficiency projects are often smaller relative to conventional energy projects, transaction costs for investors are high. Investors may also be reluctant to invest in low-carbon activities due to the high perceived risks; financiers tend to penalize new or poorly understood processes. This also has important consequences for the willingness of insurance companies to underwrite RE projects, which in turn induces investors to reject projects. It has been estimated that if commercial insurance was available for some RE-specific technological and operational risk, private sector investment in the sector could grow by a factor of four or more (UNEP, 2004).

Investment in low-carbon activities can be grouped broadly in four thematic categories: i) energy efficiency, ii) energy generation and transmission infrastructure, iii) technology development, and iv) land use. All categories attract public as well as private, project and corporate finance. Although individual activities within each group may differ, each group is typically faced with some additional typical financial challenges. Energy efficiency measures, for instance, often face misaligned incentives between the asset owner, user and lender. It is more complex for energy efficiency projects to structure and share the underlying risks. Finally, energy savings are intangible as collateral (Justice, 2009; Ryan et al., 2012; Venugopal and Srivastava, 2012). Energy generation and transmission projects are, in turn, often unable to access project finance especially for smaller projects (Venugopal and Srivastava, 2012). Funding early-stage companies and technologies is traditionally a domain for private equity and venture capitalists. Yet the return offered by projects in mitigation technology lies mostly below the internal hurdle rates of the typical venture capitalist

(Hamilton, 2010). Unlike the other categories, REDD+ activities are predominantly publicly financed for now. The main reason why the private sector has avoided REDD+ is the uncertainty and unpredictability of demand for verified emission reductions (The Prince's Charities, 2012).

16.4.2.1 Investment risks

Investments in low-carbon activities face partly the same risks as other investments in the same countries analogous to the core and broader investment climate. These risks can be broadly grouped into political risks (e.g. political instability, expropriation, transfer risk, breach of contract, etc.) and macroeconomic risks (e.g. currency risk, financial risks, etc.). In some developing countries, political and macroeconomic risks represent a high barrier to investment (Ward et al., 2009; World Bank, 2011b; Venugopal and Srivastava, 2012).

However, there are also types of risks characteristic for low carbon investments especially those attempting to place into service newer technologies that are unproven at commercial scale**. Low-carbon policy risks** are one type of these risks that concern the predictability, longevity and reliability of policy, e.g. low-carbon regulations might change or not be enforced (Ward et al., 2009; Venugopal and Srivastava, 2012). Private capital will flow to those countries, or markets, where regulatory frameworks and policies provide confidence to investors over the time horizon of their investment(Carmody and Ritchie, 2007).

Mitigation activities also face **specific technology and operational risk**. For relatively new technologies, these are related to performance of the technology (i.e. initial production and long-term performance), delay in the construction, and the risk of not being able to access affordable capital (see paragraph on access to capital below). Some low carbon activities also tend to depend on an expected future development, e.g. steep learning curves for certain technologies. On the operational side, the range of risks include the credit quality of the counterparties, off-take agreements, especially in a scenario where the mitigation technology has a higher cost of production, supply chain scalability, unreliable support infrastructure and maintenance costs (Jamison, 2010; Venugopal and Srivastava, 2012).

Moreover, risks tend to be overestimated due to imperfect information in RE markets that are undergoing a technological and structural transition (Sonntag-O'Brien and Usher, 2006) and also because a longer time frame calculated in risk assessment that increases uncertainty. A lack of quantitative analytical methodologies for risk management adds to the perceived level of risk.

16.4.2.2 Cost of capital / Access to capital

In many countries, there are imperfections in the capital market restricting the access to affordable long-term capital (Maclean et al., 2008). This is particularly the case in many developing countries where local banks are not able to lend for 15-25 years due to their own balance sheet constraints (Hamilton, 2010), like the mismatch in the maturity of assets and liabilities. In addition, appropriate financing mechanisms for end-users' uptake are lacking in many developing countries (Derrick, 1998).

Attracting sufficient equity, is often critical for low-carbon activities, especially for RE projects in developing countries (Glemarec, 2011).The equity base of a company is used to attract (leverage) mezzanine or debt finance especially in project finance investments. Since equity is last in the risk order and can be recovered only by means of sale of shares of the asset or its liquidation, return expectations are significantly higher than for debt or mezzanine finance. Often, equity is also the key limiting factor in the expansion of a low –carbon activity, e.g. through growth of a company, expansion into new markets, research and development or multiplication of a project approach (UNEP, 2005).

Private investors are reluctant to deploy capital (at affordable rates) because of their lack of experience with alternative technologies, and with new classes of project developers, business models, and markets (De Jager et al., 2011). Moreover, developers of RE projects often have limited performance track records making it difficult for investors to assess the risk of the project which therefore tends to be perceived as high (Sonntag-O'Brien and Usher, 2006).

16.4.2.3 Cash flows

Except for a minority of philanthropic investors private sector investors will allocate their capital to the asset/corporation which offers the highest economic return based on a given risk profile. Therefore, low carbon investment opportunities, compete with other investment opportunities. RE projects usually entail higher investment costs and lower operating costs than fossil fuel plants. Hence a higher level of financing must be amortized (Sonntag-O'Brien and Usher, 2006). In addition, high perceived risks increase investors' hurdle rates of return.

Given current prices of fossil fuels, many mitigation technologies are not economically profitable for investors unless there are specific support schemes in place (Mitchell et al., 2011). Investments in RE projects that combine equity and debt finance in the absence of any support frequently offer IRRs below the expectations of most investors (see 16.4.1). Thus, RE projects are still most attractive in policy-driven markets where subsidies, tax incentives or other targeted policies can partially compensate for the marginal competitiveness of renewable energies with conventional power generation (Justice, 2009) and improve cash flows.

16.4.2.4 Market and project sizes

Renewable energy projects are usually smaller in size than fossil fuel based or nuclear plants. Since the pre-investment costs vary disproportionally with the project size, they have a much higher impact on the transaction cost for smaller projects than for larger ones (Ward et al., 2009). These costs include feasibility and due diligence work, legal and engineering fees, consultants and permitting costs. Hamilton (2010) finds that small RE projects above the micro-finance scale in developing countries seeking less than USD 10 million of debt are generally not attractive to an international commercial bank. Due to the higher transaction costs small RE projects might also generate lower gross returns, even if the rate of return lies within the market standards (Sonntag-O'Brien and Usher, 2006).

There is basically no secondary market to raise debt for RE projects. Hence, institutional investors, whose major asset class is bonds, lack opportunities to invest since RE infrastructure projects either do not issue bonds at all or the issuance size is too small (Justice, 2009; Kaminker and Stewart, 2012). In order to reach investment grade the minimum issuance size tends to be about GBP 300 million (Veys, 2010). Most RE projects are in the range of EUR 50 – 500 million, with few in the upper end (Justice, 2009). In 2011, clean energy bonds amounted to only 0.183% of the global bond market (Kaminker and Stewart, 2012).

16.4.2.5 Tenor-risk combination

Financing low carbon infrastructure in economies lacking a significant track record in low carbon technologies requires long-term financing but still faces significant risks. Capital markets tend to prefer a combination of long tenor with low risk and are willing to finance high risk only in the short-term. Due to higher political and macroeconomic instability in developing countries, investors are particularly reluctant to invest in projects with such a long investment horizon. Even though pension funds and insurance companies are long -term investors, concerns about quality and reliability of cash flow projections, credit ratings of off-takers for power purchase agreements, short-term performance pressures, and financial market regulations often prevent them from investing in long-term low carbon assets (Kaminker and Stewart, 2012). Industrial firms are also facing constraints with extended payback periods, since they are typically operating with a short-term horizon that requires to have a rapid positive return on investment (Della Croce et al., 2011).

16.4.2.6 Human resources and institutional capacity

Investments are often necessary to ensure availability of the technical capacity required to design, construct, operate and maintain technologies and systems used in mitigation projects. The lack of technical capacity and training systems is a significant barrier in harnessing available renewable energy sources in, for example, many developing economies (Ölz and Beerepoot, 2010). In cases where the proprietary ownership of low-carbon technology is in the hands of private sector companies, and where the diffusion of technologies also typically occurs through markets in which companies are key actors, there is a need to focus on the capacity of these actors to develop, implement and deploy carbon mitigation and renewable energy technologies (Wilkins, 2002). Therefore, the importance of increasing technical and business capability as a part of capacity building at firm, intermediary, and regulatory levels is critical (Lall, 2002; Figueiredo, 2003).

16.4.3 Instruments

There are numerous policy instruments and financial instruments that have an influence on the quantity and quality of investments in low-carbon activities. While policy instruments to incentivize mitigation activities are assessed in depth in chapter 13, 14 and 15, this subsection focuses on three types of instruments with the following purposes: reducing risk, reducing the cost of capital and providing access to capital, as well as enhancing cash-flows. There is a growing literature on how the public sector can use these instruments to mobilize additional private finance for low-carbon activities. There are certainly other instruments such as Public-Private-Partnerships that have proven capable of tackling the outlined challenges by sharing risks and costs among the public and the private sector (Glemarec, 2011). Moreover, it must be acknowledged that the existence of an ambitious overarching domestic or global carbon pricing, through a carbon tax or ETS, would make some of the assessed instruments redundant, especially those addressing low-carbon policy and technology risks (Venugopal and Srivastava, 2012).

16.4.3.1 Mitigating investment risks

Risk mitigation can play an essential part in helping to ensure that a successful project financing structure is achieved by transferring risk away from borrowers, lenders and equity investors. Various instruments provided by private insurers and by means of public mechanisms can help to partially or fully reduce the exposure of investors to risks of political risk, exchange rate fluctuations, business interruption, shortfalls in output, delays or damage during fabrication, construction, and operation of a product, project, and company (Marsh, 2006).

- **Credit enhancements** / guarantees are intended to reduce the risks in the event the loan becomes a non performing asset, and thereby facilitate and expand loan making, reduce interest rates, and improve loan terms while leaving it to lenders to evaluate the creditworthiness and conditions of the investment. Credit enhancement approaches usually cover part of the loan and can take the shape of e.g. commercial credit insurances and government guarantees (Stadelmann, Castro, et al., 2011) [TSU NOTE: Format of citation style will be corrected by TSU].
- **Trade credit insurance** can be provided not only commercially by insurance companies, but also by, or on behalf of governments to manufacturers, exporters or their financiers. It usually provides partial protection against certain commercial risks (e.g. counterparty default) and political risks (e.g. war and terrorism, expropriation, currency transfer or conversion limitations) and other risks like non-honouring of sovereign financial obligations or breach of contract by sovereign actors (MIGA, 2012; OPIC, 2012).
- **Production and savings guarantees** are typically provided to their clients by energy service companies (ESCO) and large EPC contractors. Only proven practices and technologies are eligible to receive these guarantees, covering both technical risk (from customer payment default due to non-performance attributable to the ESCO or EPC contractor), and

comprehensive risk (defaults due to technical and financial creditworthiness of the customer) (IDB, 2011).

- **Local currency finance:** Currency fluctuations can be particularly risky for a project or company if a major investment is made in foreign currency and revenues are in local currency. Development finance institutions can provide loans denominated in local currency or provide risk management swaps which allow clients to hedge existing or new foreign currency denominated liabilities back into local currency; and the use of structured funds like the TCX (2013) (IFC, 2013).

There is a wide portfolio of proven commercial and government supported risk mitigation products which can be instrumental in efficiently expanding low carbon investment. For exporters of manufactures goods and some ministries of finance, their allocation and application requires a substantial level of expertise, experience and resources available in specialised insurance companies, export credit agencies, selected commercial and development banks. The expansion of the use of risk mitigation instruments to support low-carbon investment has a large potential especially on a uniform international level (e.g. World Bank MIGA) where potential issues relating to trade distortion and moral-hazard could be treated consistently. The retail delivery of risk mitigation products for low carbon investments still entails challenges.

In investment grade countries, risk-mitigation instruments and access to long-term finance can be provided at reasonably low cost and have the potential to mobilise substantial additional private sector mitigation investments. In other countries low carbon investment would have to rely mainly on domestic sources and international grant finance (Harnisch and Enting, 2013). Some innovative partial credit guarantees by blending MDB resources and grant finance have been implemented to promote small scale solar projects in India (Hervé-Mignucci et al., 2013).

16.4.3.2 Reducing cost of capital /Facilitating access to capital

In many situations emission mitigation measures imply additional or incremental investments. Independent of the specific role of equity or debt finance in these individual investments, and irrespective of potential future reductions of operating and maintenance costs the level of these investments can be a severe barrier to the investment decisions of different investors (as outlined in section 16.4.2).

Soft loans are repayable funds provided at terms preferable to those prevailing on the market including, for example lower interest rates, longer tenor, longer grace period and reduced level of collateralisation. Providers of soft loans are typically development banks on behalf of governments. The conditions of the loans can usually be changed quickly according to market conditions. In international cooperation soft loans to public sector entities of varying degree and type of concessionality have been established as main financing instruments by bilateral and multilateral development banks because of their reduced interest rate, long tenor and grace periods (Maclean et al., 2008; Birckenbach, 2010; UNEP, 2010, 2011, 2012b). In 2011, bilateral finance institutions, for instance, disbursed 73 % of their mitigation finance as concessional loans and 6% on a grant basis (UNEP, 2012b). They are also the most widely used financial instrument of national finance institutions who provided 86.6% of their climate funding in 2010/2011 through soft loans (Buchner et al., 2012).

Grants are non-repayable funds disbursed to a recipient by one party (grant makers), often a government department, agency, development bank, foundation or trust. Grants can play an important role in reducing up-front capital investment costs and meeting viability gaps for projects that are more expensive than business as usual (Buchner et al., 2012).

Rebates provide immediate price reductions at the moment of sale. Rebates can be structured to decline over time, encouraging early adopters and reflecting anticipated technology cost reductions

(De Jager and Rathmann, 2008).Rebates are typically administered by retailers of respective products in cooperation with a government agency.

Tax deductions or tax credits for specific types of investments can have a similar effect as soft loans by reducing the net annual payments for the amortisation of a capital investment. They can be useful in enticing profitable enterprises to enter the market for renewable energies to reduce their tax liabilities. However, they require a broader embedding in a country's tax system and a base in the tax code. Additionally, the specific level cannot be easily adapted to changed market conditions and will depend on the specific tax burden of the taxed entity (Wohlgemuth and Madlener, 2000).

Equity plays a critical role in financing a project and it is potentially attractive for governments to provide equity to companies or projects in order to support desirable activities. At the same time, state aid issues, limited expertise of the public sector in allocating capital in risky operations, and management of companies and problems arising from the identity of owner and regulator are frequently brought forward as reasons against a broad public engagement as equity investor.

In support of emission mitigation activities a number of approaches have been successfully demonstrated. Key categories and respective examples (Harnisch and Enting, 2013) with sometimes stronger and sometimes weaker interfaces for government interventions include

- Different types of government encouragement of direct equity investments in sustainable companies (publically listed companies) and projects by individual private investors (e.g. citizen wind farms, privately owned solar plants)
- Different types of encouragement of equity engagements by insurance companies and public and private pension funds (e.g. infrastructure projects or publically listed companies)
- Facilitating support of actively and passively managed sustainable investment funds for public and private equity of companies and projects (e.g. various Sustainability Funds, Carbon Efficient Index, Brazil Index Fund)
- Direct equity engagements by governments, sovereign wealth funds (e.g. Norwegian Government Pension Fund, Abu Dhabi Investment Authority) or development banks (e.g. CDC, IFC, DEG, FMO, Proparco)
- Expansion of the equity base of public and private banks with a strong role in providing mitigation finance (see recent capital increases e.g. for World Bank Group and European Investment Bank)
- Public participation in fund of fund equity engagements by governments (e.g. ADB Clean Energy Venture Capital Initiative, EU GEEREF)
- Government participation in junior tranches of structured funds to leverage private investrnent (e.g. GCPF or Green Growth Fund)
- Favourable tax treatment of leasing arrangements for sustainable products e.g. energy efficiency in which capital intensive investments are kept of the balance sheet of the operator, thus reducing his equity requirements

Because of the challenges discussed above some public sector investors have decided to limit their equity investment to minority stakes, and apply clear investment criteria, avoid crowding-out of private investors and to use defined exit strategies (IFC, 2009).

16.4.3.3 Enhancing cash-flow

Third party guaranteed renewable energy premiums for individual power purchase agreements or nationally agreed **feed-in tariffs** (FITs) provide a secure long-term cash-flow to operators of renewable energy systems —based on technology, system size, and project location. The long duration and guaranteed off-take for electricity output, and grid access can help to secure both debt and equity financing for a project. The result is that a FIT can lower the risk for project developers, lenders, and investors and, consequently lower the cost of capital and required rate of return on these projects (Cory et al., 2009). The cost of a FIT program is often recovered by utilities through rates or supported through public benefit funds. FITs for renewable energy have been implemented in a broad range of industrialised and developing countries (Fulton et al., 2010). The level of the FiT for a specific technology, region and time determines the effectiveness and efficiency of the program but is difficult to establish up-front and adapt to as the market evolves.

CO_2 Offset-Mechanisms can also provide additional cash-flow via the sales of credits to support the economics of a mitigation investment. Unlike renewable energy premiums, however, there is uncertainty about the future level of this cash-flow. This has made many financiers hesitant to provide debt finance for respective projects. Some MDBs, like the ADB have a provision to buy credits upfront contributing to investment capital and reducing uncertainty on the future cash-flows from the sale of carbon credits (ADB, 2011, 2012).

16.5 Institutional arrangements for mitigation finance

Effective governance of climate change at the international, regional, and national levels is an essential pre-requisite for an efficient and effective system of finance for mitigation. Institutions are essential for ensuring that action on climate change responds to national needs and priorities in an efficient and effective way.[19] This is particularly relevant in the area of mitigation financing where the magnitude and the diversity of needs and the complexity and diverse nature of financing instruments make the role of institutions and their existence crucial.

Through institutions knowledge is accumulated, codified and passed on in a way that is easily transferable and used to build capacities, share knowledge, transfer technologies, help develop markets, and build enabling environments for investments to be made. Without proper institutions, some actions and investments may remain simply as stand-alone projects with no lasting effects, or a one-off capital equipment supply rather than a transaction with a transfer of skills, know-how, full knowledge of the technology, and a contribution to a broader system of innovation and technological change (Ockwell et al., 2008).

16.5.1 International Level

16.5.1.1 Global arrangements

Global arrangements for climate change mitigation finance are essential for several reasons. Most commonly cited is the fact that because the earth's climate is a public good, investing within borders is often not seen as beneficial to a particular country unless doing so becomes a collective effort (Pfeiffer and Nowak, 2006). The UNFCCC, among others, was established to address this dilemma and turn the global effort on climate change into a collective action that would be seen by all as beneficial to the whole (Burleson, 2007). Trusted institutions are needed to channel the funding in an orderly process; and to help developing countries tap these resources in an effective and orderly manner. This will not be easy for many countries. In addition to the pledges under the UNFCCC for "fast-start" funding between 2010 and 2012 and up to USD 100 billion annually by 2020 (see 16.2.1) there has been an expansion in the number of public and private funds. UNDP estimates that over the last decade some 50 international public funds, 45 carbon markets, in addition to 6,000 private

[19] The term "institution" in this context is defined narrowly to mean an established organization dedicated to facilitate, manage, or promote mitigation finance, as opposed to the broader meaning of the term commonly used in the study of the social sciences and used to mean a structure or mechanism of social order and cooperation governing the behavior of individuals in society, e.g. the institutions of marriage, or religion.

equity funds (set up largely independent of international climate policy) have been established for the purpose of funding climate-change-related activities (UNDP, 2011).

Within the Framework Convention, the funding for mitigation in developing countries has come principally through the Financial Mechanism of the Convention. Until recently, the GEF was the only operating entity of the Financial Mechanism of the Framework Convention that operates the regular Trust Fund, the Special Climate Change Fund (SCCF) and the Least Developed Country Fund (LDCF). The Sixteenth Session of the Conference of the Parties held in Cancun, Mexico established the Green Climate Fund and through this decision, has become a new and additional operating entity for the Financial Mechanism under the Convention (UNFCCC, 2011b). The GCF is expected to become the main global financial mechanism to support climate action in developing countries. Under the Kyoto Protocol, instruments that generate additional funding and incentives for mitigation are available and include the clean development mechanism (CDM), joint implementation (JI) and emissions trading (ST).

The UNFCCC also encourages other multilateral organizations, regional international financial institutions and others to provide funding to developing countries for mitigation. The increasing demands for mitigation activities have led to the establishment of several funding instruments managed by multilateral banks and institutions. Some of these, such as Climate Investment Funds are multi-donor funds administered by the World Bank but with their own governance and organizational structure. The Climate Investment Funds have two trust funds: a Clean Technology Fund (CTF) which promotes scaled-up financing for demonstration, deployment and transfer of low-carbon technologies with significant potential for long-term greenhouse gas emissions savings and the Strategic Climate Fund (SCF) under which are three separate initiatives for piloting transformational, scaled-up action on climate change; Scaling Up Renewable Energy in Low Income Countries Program (SREP), the Forest Investment Program (FIP), and the Pilot Program for Climate Resilience (PPCR) (World Bank, 2011c; d). The pledges and contributions to the CIFs are recorded as ODA and, therefore, constitute a multi-bilateral arrangement (World Bank, 2010).

16.5.1.2 Regional arrangements

Regional institutions play an important role in fostering regional cooperation and stimulating action and funding for mitigation activities. These institutions include the regional multilateral development banks and the regional economic commissions of the United Nations on the multilateral side.[20] While their mission is to promote, and in the case of the regional development banks, to finance development activities in general, they are increasingly engaging in the promotion of mitigation activities in their respective regions, and establishing and helping manage regional financing arrangements for mitigation (Sharan, 2008). A good example of the initiatives taken by a regional institution is the series of regional financial arrangements established to promote funding for mitigation activities in the Asia and Pacific, the Clean Energy Financing Partnership Facility (CEFPF), the Asia Pacific Carbon Fund (APCF), and the Future Carbon Fund (FCF). Other regional development banks, such as the African Development Bank with their African Carbon Support Program and the Inter American Development Bank have been equally active.

Other regional groupings such as the Economic Community for West African States (ECOWAS), the Association of Southeast Asian Nations (ASEAN), the Secretariat for Central American Economic Integration, Mercosur, Corporación Andina de Fomento, and the Andean Pact to name just a few, have been actively promoting sub-regional integration of energy systems and cooperation in climate change activities in developing countries for some years. In the developed world, one of the best

[20] Economic Commission for Latin America, Inter American Development Bank (IDB), Economic Commission for Africa (ECA), African Development Bank (AfDB), Economic Commission for Asia and the Pacific (ESCAP), Asian Development Bank (ADB), Economic Commission for Europe (ECE).

examples of these regional political groupings is the European Union which has been extremely active in the area of climate change and in supporting activities in developing countries.

16.5.1.3 Bilateral and triangular arrangements

Apart from providing funding to global or regional funds, donor countries use three principal means to channel climate change funding: a) through their own existing bilateral programs for funding international cooperation in the energy, water, transport or forestry, b) through dedicated funding windows established to target climate change funding open to a wider range of implementing institutions and c) via new bilateral funds with their own implementation structure. Often governments rely on development agencies and financing arms, with their proven track record in international cooperation, to channel the funds.

The role of bilateral delivery channels in climate change finance for mitigation has grown rapidly over the last decade and as a result, they constitute the major source of public international climate finance. The OECD has been collecting data on climate-change-mitigation-related ODA since 1998 [21] and since 2010 it has also added comprehensive data on adaptation. According to its own statistics, the OECD reports that in 2010, its 24 Development Assistance Committee (DAC) members provided USD 22.9 billion of climate change-related aid to developing countries. This represents some 15% of its total ODA and of this, two-thirds was provided for mitigation activities as per OECD DAC reports (OECD, 2011). The figures reported are based on members' reports and warrant harmonisation as standard definitions and methodologies are not used. Nevertheless, the figures indicate the growing trend in bilateral attention to climate-change-related activities over a decade or more (Corfee-Morlot et al., 2009).

As in other fields of multilateral and bilateral development cooperation, there are discussions about aid effectiveness. Concerns exists specifically in mitigation-related ODA about a diversion of funds from development aid in sectors such as health and education, and about the additionality of expanded funding for mitigation and adaptation (Michaelowa and Michaelowa, 2005).

Although they have grown in number in recent years, triangular arrangements, and particularly those for climate change financing, are relatively new and constitute a relatively recent mode of development cooperation (ECOSOC, 2008). These arrangements have attracted a number of countries particularly for technology cooperation across sectors or specified industries. The OECD defines triangular cooperation arrangements as those involving a traditional donor, most likely a member of DAC, an emerging donor in the south (providers of South-South Cooperation and which include an increasing number of countries) to implement development cooperation programs/projects, and the beneficiary countries or recipients of development aid (Fordelone, 2011).

The rise of triangular arrangements has been driven by the growing role of middle-income countries and their increasing presence in providing development co-operation in addition to receiving it and by the desire to experiment with other types of cooperation where the experience of developing countries can be brought to bear.

16.5.2 National and sub-national arrangements

The landscape of institutional arrangements for action on climate change across countries is diverse. In many countries, actions on climate change are not clearly defined as such. Consequently, many of the national arrangements that exist to promote programs, activities, and action which clearly

[21] Since 1998, the OCED/DAC has monitored aid targeting the objectives of the Rio Conventions through a reporting system that tracks aid according to whether aid is targeting the conventions as a principle objective or not. These are the so called "Rio Markers" which exist for biodiversity, desertification, climate change mitigations, and since 2010, for adaptation. There are many methodological challenges and reliability of these indicators, as there is no agreed definition as to what is "climate finance".

contribute to mitigation do not appear in the literature as institutions dedicated to support finance for mitigation.

In many countries, particularly in developed countries and in a few larger developing countries, finance for mitigation comes mainly from the private sector, often with public support through regulatory and policy frameworks and/or specialized finance mechanisms. The most effective institutional arrangements and mechanisms - both public and private - in this regard, are therefore those that are successful in mobilizing and leveraging private capital for mitigation activities. The institutions and the types of public finance mechanisms that exist across countries are diverse, but all have the common feature of aiming to help commercial financial institutions to do this job effectively and efficiently. Many institutions exist for the purpose of supporting specialized public finance mechanisms such as financial institutions that provide dedicated credit lines, guarantees to share the risks of investments and debt financing of projects, microfinance or incentive funds and schemes to mobilize R&D and technical assistance funds to build capacities across the sectors including the private and commercial sectors (Maclean et al., 2008).

In many developing countries, other than the larger ones, there is an on-going attempt to cope with the multiplicity of sources, agents and channels offering financial resources for mitigation activities (Glemarec, 2011). These efforts exist at two levels. At one level, there are the government institutions engaged in the coordination of national efforts to address climate change. According to a survey undertaken at the end of 2010 by the United Nations Development Programme(Gomez-Echeverri, 2010), very few developing countries have institutions that are fully dedicated to addressing climate change or the financing of mitigation activities. In many countries, the ministry of the environment has the designated role of coordinating and in some cases helping in the implementation of climate change activities. In some countries, ministries of foreign affairs are also involved in finance issues through their engagement in international negotiations. Ministries of finance are also becoming increasingly involved with the arrival of large multilateral funding and the promise of increased UNFCCC resources.

Some developing countries are beginning to establish specialized national implementing entities designed specifically to mainstream climate change activities in overall development strategies. These institutions are responsible for blending internationally available funding for climate change activities through national climate funds that in turn also include domestic as well as private sector resources (Flynn, 2011). See table 16.6 for examples of national funding entities. One feature common to all of them is the desire to tap global and other finance, including national, and to allocate resources for activities that are fully mainstreamed into the national needs and priorities. They are also expected to play a role in response to the increasing demand for “direct access” to climate finance rather than through bilateral or multilateral mechanism. This modality is already accepted in the Adaptation Fund and will most likely grow in importance with the funding of the GCF.

Table 16.6. Selected examples of national funding entities

Name and country	Description	Source of Funds and Operations	Governance
Amazon Fund, Brazil	Established to combat deforestation and promote sustainable development in the Amazon	Designed to attract national and private investment in Amazon rainforest projects as well as donations and earnings from non-reimbursable investments made. Norway is largest donor to date.	Managed by BNDES, the national development bank of Brazil which has the responsibility to raise funds, facilitate and monitor and support projects. The Amazon Fund operates as a private Fund. It has two decision-making bodies: The Amazon Fund Guidance Committee composed of federal and state governments and civil society provides overall guidance. The Amazon Fund Technical

			Committee, composed of six scientific experts appointed by the Ministry of the Environment for 3 year terms, is responsible for issuing the certificates of carbon emissions reductions, carbon emissions by hectare and amount of hectares of deforestation avoided.
Bangladesh Climate Change Resilience Fund (BCCRF)	Established to provide support for the implementation of Bangladesh's Climate Change Strategy and Action Plan 2009-2018 and particularly vulnerable communities	Designed to attract funds from UNFCCC finance mechanisms, and direct donor support (UK, EU, Sweden, Denmark and USAID have pledged)	Managed by a board composed of Ministers of environment, finance, agriculture, Foreign Affairs and Women and Children Affairs and disaster management, as well as donors and CSO
China CDM Fund (CDMF)	Established jointly by Ministries of Finance, Foreign Affairs, Science and Technology and National Development and Reform Commission (NDRC) as an innovative finance mechanism to support the National Climate Change Programme, demonstrate new and sustainable climate finance mechanisms, and promote international cooperation	Funded by revenues generated from CDM projects in China (which accounts for the majority of the funding), operating revenue from activities such as wealth management, and grants and other cooperation grants from domestic and international institutions	Governed by the Board of the China CDM Fund that comprise representatives of 7 line ministries, and managed and operated by a management center affiliated with the Ministry of Finance.
Indonesia Climate Change Trust Fund (ICCTF)	Established jointly by the National Development Planning Agency and Ministry of Finance to pool and coordinate funds from various sources to finance Indonesia's climate change policies and programs including implementation of National Action Plan for Reducing GHG emissions aimed at reducing GHG emissions unilaterally by 26% and up to 41% with international support by the year 2020.	Currently funded by grants from development partners but designed for direct access to international climate funding and to attract private funding in the future.	UNDP is an interim Trustee operating under a Steering Committee headed by the National Development Planning Agency and also includes donors and other line ministries. ICCTF is currently in transition to become a fully nationally managed climate trust fund. This transition is expected to be completed in 2014
Guyana REDD Investment Fund (GRIF)	Established to finance activities under the Low Carbon Development Strategy of Guyana and to create an innovative climate finance mechanism.	Designed to attract donor support. Norway is largest donor to date and operating under a performance-based funding modality, based on an independent verification of Guyana's deforestation and forest degradation rates and progress on REDD+ enabling activities.	A Steering Committee chaired by the Government of Guyana and composed of members of government and financial contributors, is the decision-making and oversight body of the Fund. The IDA of the World Bank Group acts as Trustee, and the partner entities provide operational services. The World Bank, IDB and UN agencies are currently the partner entities.

Source: Gomez-Echeverri (2010), UNDP and World Bank (2012), Amazon Fund (2012), BCCRF (2012), CDMF (2012), ICCTF (2012), World Bank (2012b)

In many countries, sub-national arrangements are increasingly becoming an effective vehicle for advancing energy and climate change goals. These arrangements and the institutions that support them are being established to advance regional collaboration in areas of common interest and to benefit from greater efficiency and effectiveness through actions with greater geographical coverage (Setzer, 2009). For example, because of their population densities and economic activities, cities are major contributors to global GHG emissions, and as such they are major potential contributors to worldwide mitigation efforts (Corfee-Morlot et al., 2009). In recent years, there has been an increase in the number of networks and initiatives specifically dedicated to enhance the role of cities in the fight against climate change. As a result, these initiatives are potentially big contributors to mitigation efforts. Because of the lack of clear processes linking these initiatives to national and international climate change policy, their impact in broader policy frameworks is less certain (UN-Habitat, 2011).

16.5.3 Performance of institutions

The increasingly crowded and complex institutional landscape for climate mitigation finance is evidence of the growing interest of public and private sources to enter the field of climate change finance and mitigation activities in developing countries. Some see this as welcome news given the immense amount of resources required to meet the challenges of stabilizing the GHG emissions at acceptable levels. This increase in funding is undoubtedly stimulating attention and action on climate change and activities designed to reduce the impacts of climate change as well as enhance international cooperation, particularly in the cases of multi-donor funds created by the World Bank and other institutions. As climate change negotiations advance within the framework of the Durban Platform[22], and as countries continue to submit their Nationally Appropriate Mitigation Actions (NAMAs), scaled up financing will be the key to success, and such additional funding is being seen in a positive light.

But there are also concerns being raised about the growing number of institutions. Some main concern include, the fear of diverting attention and resources from development ODA (additionality doubts), and from national priorities if not fully mainstreamed into development strategies and needs, problems caused by proliferation of funding entities with their own governance needs and demands placed upon fund recipients straining scare national resources, the difficulty of achieving policy coherence and coordination so as not to work at cross purposes, fears of lack of transparency, concerns about fragmentation and duplication of efforts, and lastly, concerns that the number of established funds may undermine the authority of the financial mechanism of the UNFCCC - GEF and GCF (Poerter et al., 2008). For the effective use of climate funds the operation of related institutions must be streamlined and the capacity in developing countries to cope with an increasing number of these institutions must be developed further.

16.6 Synergies and trade-offs between financing mitigation and adaptation

Climate policy rests on the pillars of mitigation and adaptation to climate change. The objective of this section is to introduce a conceptual framework linking adaptation and mitigation in terms of financing and investment. Estimates of investments needed for mitigation are provided in 16.2.2, and for adaptation investments in the sectoral chapters of WG II. Firstly, this section addresses the interactions of financing adaptation and mitigation in terms of their specific effectiveness and trade-offs, as well as their competition for funding over time. Secondly, it discusses examples of integrated financing approaches.

16.6.1 Optimal balance between mitigation and adaptation and time dimension

As previously mentioned in the framing chapters that drew attention to the interactions between mitigation and adaptation to climate change, it is very likely that adaptation to climate change should be viewed as a complement to mitigation policies, not a substitute.

Several authors have recognized that optimal mitigation and adaptation strategies should be jointly determined. Investing in mitigation may reduce the need to invest in adaptation and vice versa (Schelling, 1992; Kane and Shogren, 2000; Dellink et al., 2009; Bosello et al., 2010). According to this view, in order to avoid inefficiencies the social discounted rate of return of resources invested in

[22] The Durban Platform for Enhanced Action is the negotiation track responsible for coming up with a protocol and a binding agreement to take effect in 2020.

mitigation and adaptation should be equal. Nevertheless, mitigation and adaptation generally compete to attract investments. From the perspective of simple economic models, a reduction in the cost of mitigation should lead to more mitigation and less adaptation and, according to this view, they are substitutes (Ingham et al., 2005).

In contrast, the view that adaptation and mitigation can be jointly optimally determined is presented by several authors (Tol, 2007; Ayers and Huq, 2009). From the perspective of development and climate studies, climate change in most cases will reduce the production potential of the economy, the magnitude depending on vulnerability, efficiency, and institutional capacity to adapt. Conversely, both climate change adaptation and mitigation may include policies such as financial and technology transfer, institutional strengthening and market improvements which enhance the productive capacity of the country (Halsnæs and Verhagen, 2007).

Although many actions that integrate mitigation and adaptation offer enough co-benefits to make obvious sense immediately (see WG II), in many cases effective integration of mitigation and adaptation, in order to make a significant difference in cost avoidance, requires improved information, improved capacities for analysis and action, and further policymaking (Wilbanks and Sathaye, 2007). Given the lack of modelling of any direct interaction between adaptation and mitigation in terms of their specific effectiveness and trade-offs, a more detailed analysis is desirable (Wang and McCarl, 2011).

Emerging theoretical frameworks for assessing the trade-offs between adaptation and mitigation include those from the point of view of risks and costs. Kane and Shogren (2000) provide a formal treatment of the relationship between adaptation and mitigation measures based on the endogenous risk literature. People invest resources to reduce the risk they confront or create (Ehrlich and Becker, 1972; Lewis and Nickerson, 1989). Recent studies have used integrated assessment models to numerically calculate the optimal allocation of investments between mitigation and adaptation. They confirm the analytical insights of Kane and Shogren (2000) and suggest that investments in mitigation should anticipate investments in adaptation (Lecocq and Shalizi, 2007; de Bruin et al., 2009; Bosello et al., 2010). The reason for this being that climate and economic systems have inertia and delaying action increases the cost of achieving a given temperature target. Adaptation is instead a long-term phenomenon and little investment is necessary in the first decades of this century. These studies suggest that the competition between mitigation and adaptation funds extends over time.

By arguing that uncertainty on the location of damages reduces the benefits of “targeted” proactive adaptation with regard to mitigation and reactive adaptation, other authors reinforce the idea that it is optimal to wait to invest in adaptation (Lecocq and Shalizi, 2007). For the above reasons, Carraro and Massetti (2011) suggest that the greatest share of the GCF should finance emissions reductions rather than adaptation in developing countries.

Patt et al. (2009) are more critical regarding the assessment using IAMS, claiming that current IAMS over-estimate the level of adaptation and underestimate the cost and that, while adaptation could play a more significant role in reducing the impacts of climatic change, such adaptation is likely to be more difficult and costly than current models suggest.

In addition to IAMs, there are also theoretical contributions to the issue of timing. Zehaie (2009) finds that adaptation when timed before mitigation has strategic effects; since mitigation has private costs but public benefits, when countries cooperate only on mitigation, the incentives to shift future mitigation costs are greater and it is likely that each country will exploit the possibility of passing mitigation abatement costs on to other countries.

Wang and McCarl (2011) recognizes that, in terms of an overall investment shared between mitigation and adaptation, mitigation tackles the long-run cause of climate change while adaptation tackles the short-run (De Bruin et al., 2009) reduction of damages and is preferred when damage stocks are small. Nevertheless, they advocate that adaptation is an economically effective complement to mitigation and should occur in parallel due to the interdependent nature of mitigation and adaptation. The near term nature of given benefits makes adaptation investment an important current policy option.

Moreover, the optimal balance of mitigation and adaptation actions and investments depends on the assumed magnitude of climate change. While the uncertainties about specific pathways remain undiminished, it is important to emphasize that, in the meantime, neither mitigation nor adaptation should be delayed; if mitigation can keep climate change to a moderate level, then adaptation can handle a larger share of the resulting impact vulnerabilities (Wilbanks et al., 2007).

16.6.2 Integrated financing approaches

Despite the lack of modelling of any direct interaction between adaptation and mitigation in terms of financing, there is an increasing willingness to promote integrated financing approaches, addressing both adaptation and mitigation activities in different sectors and at different levels.

The optimal balance of mitigation and adaptation actions and investments depends on the possibilities of gains and envisaged impacts between and across sectors, as well as on geographic scale: in general, the more localized the scale, the more attractive adaptation apprears.

Analysis of the details of specific adaptation and mitigation activities in different sectors reveals that adaptation and mitigation can positively and negatively influence on each other's effectiveness. Such influence must be taken into consideration as an analytical tool for considering investment and finance. Because different sectors have different realities and demands, financing approaches to each of these sectors necessarily vary.

As mentioned in Chapter 14, creating synergies between adaptation and mitigation can increase the cost-effectiveness of climate change actions. Particular opportunities for synergies exist in some sectors (Klein et al., 2007),for example, agriculture (Niggli et al., 2009), forestry (Ravindranath, 2007; Isenberg and Potvin, 2010), buildings and urban infrastructure (Satterthwaite, 2007) which are just a few integrated sectoral financing approaches. Nevertheless, there are also trade-offs between adaptation and mitigation, as mentioned in the sectoral chapters and in the WGII report.

The sectoral chapters and the report by WGII have assessed possible synergies and trade-offs between sector-specific mitigation and adaptation measures and ways of maximizing the former and avoiding the latter. There may however be significant differences across sectors in terms of the scope of such opportunities. Nevertheless, there is very limited literature at present to assess these synergies and trade-offs from the specific financing and investment point of view.

Mitigative activities have almost exclusively global externalities while most adaptation activities are limited to a smaller geographical area or population, given that the first relates to a global public good while most adaptation measures relate to regional public and private goods. Taking into account the strong regional nature of climate change impacts, a regional financing arrangement will be more responsive and relevant than a global one. Thus, while a regional financing arrangement complements global financing arrangements for mitigation, it plays a very special and even unique role in adaptation (Sharan, 2008).

Regional funding tools have made arrangements for financing adaptation activities in complement to mitigation measures: e.g. the Poverty and Environment Fund (PEF) of the Asian Development Bank promotes the mainstreaming of environmental and climate change considerations into development strategies, plans, programs and projects of the bank (ADB, 2003).

The African Development Bank (AfDB) acts as manager and coordinator of new funding for the Congo Basin forest ecosystem conservation and sustainable management (UNEP, 2008). According to the operational procedures by AfDB, in order to be eligible for financing under the Congo Basin Forest Fund (CBFF), project proposals and initiatives considered for funding should, among other things, aim at slowing the rate of deforestation, contribute to poverty alleviation, provide some contribution to climate stabilization and greenhouse gas emissions reduction, and may show environment, economic and social risk assessment in addition to appropriate mitigation measures, as well as be supported by national strategies to combat deforestation while preserving biodiversity and promoting sustainable development (AfDB, 2009). See chapter 14.4 for additional information on regional distribution of mitigation and adaptation financing.

Many ongoing bilateral and multilateral development activities address mitigation and adaptation at the same time. A recent survey by Illmann et al. (2013) discusses examples from agriculture (conversion of fallow systems into continuously cultivated area; the reuse of waste water for irrigation), forestry (reforestation with drought resistant varieties; mangrove plantations), and from the energy sector (rural electrification with renewable energy, production of charcoal briquettes from agricultural waste). The study identifies significant potential to further mobilise these synergies within existing development cooperation programs.

Another point of debate regarding synergies and trade-offs between financing mitigation and adaptation relates to the conceptual framework for allocating responsibility for international financing of adaptation based on the historical contribution of different countries to climate change, in terms of GHG emissions and their capacity to pay for the costs of adaptation internationally (Dellink et al., 2009).

16.7 Financing developed countries' mitigation activities

This and the next section consider the manner in which developed and developing may choose to finance the incremental investments and operating costs associated with greenhouse gas mitigation activities. It is fully recognized that a country's individual circumstances will in large part determine how financing is accomplished, and further, that individual national circumstances vary widely among members of the developed and developing country groups.

Given the assumption above, the manner in which developed countries finance their mitigation activities depends largely on the policies chosen to limit GHG emissions and the ownership of the sources of emissions. Policies and ownership will also determine the distribution of the burdens posed by the financing needs, i.e. if it will be financed by households and commercial activity through higher goods and services prices, or taxes, or both.

Determind by using a mix of 2010 and 2011 data, developed countries raised USD 213-255 billion per year of the total of USD 350 billion (2010/11 USD) of mitigation finance, including 17-23% public sources. Funds committed to mitigation activities in developed countries amounted to USD 160-208 billion (Buchner et al., 2013). Almost 90% was provided by the private sector (Buchner et al., 2012). Due to the financial crisis investment in renewable energy dropped 14% in 2009 (UNEP, 2012a), but saw a rapid recovery due to the green stimulus packages, that amounted up to USD 182-242 billion in G20 countries (IEA, 2009; REN21, 2010). The five OECD development banks members of IDFC provided USD 45 billion of climate finance in 2011 of which USD 29 billion was allocated to domestic projects (2011 USD) (Höhne et al., 2012).

Without climate policy, only an estimated 20% of global investment in fossil energy will flow into developed countries. In a climate policy scenario compatible with a 2°C warming target in 2100 OECD countries are expected to absorb 46% (28 - 61 %) of the additional average annual investment over 2010-2029 and 27% (14 - 33%) over 2010-2049.

To date, public sourcing for climate finance originate primarily from general tax revenues. However, under ambitions stabilization targets the financial source that yield mitigation benefits have the potential to generate high revenues which could be used for climate finance. Carbon taxes and the auctioning of emissions allowances carry the highest potential, followed by a phase out of fossil fuels and a levy or emission trading scheme for international aviation and shipping (UNFCCC, 2007; AGF, 2010; G20, 2010).

Most developed countries offer a reasonably attractive core and broader enabling environment for climate investments. Similar to some of the emerging economies, developed countries combine substantial energy related greenhouse gas emission reduction potential with investment grade rating. Out of 18 industrialised among the 30 largest emitting countries, 14 countries, covering 36% of global CO_2 emissions, had investment-grade sovereign or trade credit insurance ratings at the end of 2012 (Harnisch and Enting, 2013). Private finance is therefore the most relevant source in developed countries, however often dependent on public support through regulatory and policy frameworks and/or specialized finance mechanisms.

While macroeconomic and policy risk have been reasonably low in the past, low-carbon policy risks have affected investments in developed countries. Regarding policies and support schemes targeting low-carbon activities, the picture is diverse. In principle, risk-mitigation instruments and access to long-term finance can be provided at reasonably low cost. Suitable institutions exist to implement specialized public finance mechanisms such as financial institutions to provide dedicated credit lines, guarantees to share the risks of investments, and debt financing of projects, microfinance or incentive funds and schemes to mobilize R&D and technical assistance funds for building capacities across the sectors.

In 2012, the most widespread methods of fiscal incentives were capital subsidies, grants and rebates. They were in place in almost 90% of high income countries. 70% of the countries used public funds to target renewable energies e.g. through public investment loans and grants. Feed-in tariffs were in place in 27 high income countries at national or state level (75% of all countries analyzed) (Sawin et al., 2012).

The most effective institutional arrangements and mechanisms in both public and private spheres are those that are successful in mobilizing and leveraging private capital for mitigation activities. The institutions and types of public finance mechanisms in existence across countries are diverse but share the common aim of helping commercial financial institutions to effectively and efficiently perform this job (Maclean et al., 2008).

16.8 Financing mitigation activities in and for developing countries including for technology development, transfer and diffusion

Analogous to the previous section, this section outlines key assessment results for mitigation finance in and for developing countries, i.e. embracing domestic flows as well as financing provided by developed countries.

Of the total current financial flows, developing countries raised USD 120 to 141 billion in 2010/2011 of which 34-41% were public funds. Funds committed to developing countries amounted to USD 162 to 202 billion (Buchner et al., 2013). Climate projects in developing countries showed a higher share of on balance sheet financing and concessional funding provided by national and international development finance institutions than developed countries (Buchner et al., 2012). Domestic public development banks played an important role in this regard. The 14 non-OECD development banks members of IDFC provided USD 44 billion of domestic climate finance in 2011 (2011 USD) (Höhne et al., 2012).

According to UNFCCC (2011a), in 2005-2010 Annex I countries provided a total of USD 58.4 billion, about 10 billion per year on average, climate finance to developing countries. In 2009, developed countries committed to jointly mobilizing USD 100 billion per year by 2020 to address the needs of developing countries and to provide USD 30 billion of ‘fast start finance’ to developing countries in the period from 2010-2012 (UNFCCC, 2010, 2011b). By November 2012, reported commitments amounted to USD 28 billion (WRI, 2012). However, it is highly controversial whether these funds where "new and additional" as promised (Brown et al., 2010b; Stadelmann et al., 2010; Stadelmannnnn et al., 2011).

Multilateral institutions played an important role in delivering climate finance to developing countries. In 2010/2011, multilateral development banks provided USD 21.2 billion of climate finance (Buchner et al., 2012). These institutions are also managing a range of multi donor trust climate funds, such as the Climate Investment Funds, and the funds of the financial mechanism of the Convention (GEF, SCCF, LDCF). The Green Climate Fund is expected to become an additional important mechanism to support climate activities in developing countries globally. Regional development banks have been engaging in promoting important mitigation activities in their respective regions, and establishing and helping manage regional financing arrangements for mitigation (Sharan, 2008). Bilateral institutions are also a major source of public international climate finance with USD 11.3 billion in 2010/2011 provided by bilateral development banks (Buchner et al., 2012).

In the reference scenarios as well as in policy scenarios compatible with a 2°C warming target in 2100, non-OECD countries absorb the greatest share of incremental investments in power generation technologies. Without climate policy, investments in the power sector are mainly directed towards fossil fuels. 80% of global investment in fossil energy would flow into the fossil fuel power sector in non-OECD because many developing countries rely on low-cost coal power plants to supply an ever growing demand of electricity. In a climate policy scenario compatible with a 2°C warming target in 2100, non-OECD countries are expected to absorb the majority of additional average annual investment on renewable, namely 54% (39 - 72%) over 2010-2029 and 73% (67 - 86%) over 2010-2049.

In tackling climate change, developing countries are faced with different types and magnitude of constraints.

Out of 12 developing countries among the 30 largest emitting countries, 9 countries covering 39% of global CO_2 emissions had investment grade sovereign or trade credit insurance ratings at the end of 2012 (Harnisch and Enting, 2013), making them suitable to international private sector investment.

The majority of developing countries, however, has a lower or no such rating – reflecting perceived less attractive investment conditions for foreigners – and will thus often find it difficult to attract foreign private investment. In addition, the economics of mitigation in many developing countries further suffer from subsidized fossil fuels prices. Moreover, the lack of technical capacity and training systems is a significant barrier for low carbon investment in many developing economies (Ölz and Beerepoot, 2010). Additional factors like foreign exchange risks and other non-financial barriers like enforcement of regulation increase the uncertainty of doing business in many developing countries including those with investment grade ratings. Between 2005 and 2009, developed countries provided USD 2.5 billion of ODA to support creating general enabling environments in developing countries (Brown et al., 2010b; Stadelmann et al., 2010).

Investment risks for low-carbon projects in developing countries are typically perceived higher than in developed countries, increasing the cost of capital and the return requirements of investors. In developing countries, the IRR is typically higher than in developed countries, for instance, general infrastructure IRR figure around a median of 20% in emerging economies compared to about 12% in developed countries (Ward et al., 2009). Access to affordable long-term capital is limited in many developing countries (Maclean et al., 2008), where local banks are not able to lend for 15-25 years due to their own balance sheet constraints(Hamilton, 2010), like the mismatch in the maturity of assets and liabilities. In addition, appropriate financing mechanism for end-users' up-take are also often missing (Derrick, 1998). Moreover, equity finance is also scarce in many developed countries, increasing the dependence on project finance. Especially in low income countries, project sponsors rely on external assistance to cover the project development costs (World Bank, 2011a).

Many developing countries use a range of incentives for investments in renewable energies, especially fiscal incentives. Public financing instruments to stimulate RE, such as public investment, loans or grants, were in place in 57% of the countries analyzed and feed-in tariffs were established in 39 developing countries in 2012 (Sawin et al., 2012). Carbon pricing has not yet widely been adopted by developing countries, apart from the non-perfect carbon price incentive via the CDM. Currently, new ETS are set-up or planned in some developing countries like China (cities) and South Korea, but it will take time until such ETS will be fully operational and provide enough investment certainty.

Regional groupings such as the Economic Community for West African States (ECOWAS), the Association of Southeast Asian Nations (ASEAN), the Mercosur, have been actively promoting sub-regional integration of energy systems and cooperation in climate change activities.

On the national level, there is an on-going attempt to cope with the multiplicity of sources, agents and channels offering financial resources for mitigation activities (Glemarec, 2011). Very few developing countries have institutions fully dedicated to addressing climate change or the financing of mitigation activities (Gomez-Echeverri, 2010) with typically several ministries in charge of planning and implementation. Some developing countries are beginning to establish specialized national implementing entities designed specifically to mainstream climate change activities into overall development strategies. These institutions have the responsibility of blending funding available internationally for climate change activities through national climate funds that in turn also include domestic as well as private sector resources (Flynn, 2011).

Box 16.2: LDC issues relating to investment and finance for low-carbon activities

COMMENTS ON TEXT BY TSU TO REVIEWER: Boxes highlighting further LDC-specific issues are included in other chapters of the report (see chapter sections 1.3.1, 2.1, 6.3.6.6, 7.9.1, 8.9.3, 9.3.2, 10.3.2, 11.7, 12.6.4) and a similar box may be added to the Final Draft of chapters, where there is none in the current Second Order Draft. In addition to general comments regarding quality, reviewers are encouraged to comment on the complementary of individual boxes on LDC issues as well as on their comprehensiveness, if considered as a whole.

The concerns of LDCs about food, water and energy security are deepened by the climate crisis which challenges the goals of inclusive and environmentally sustainable economic growth. Most LDCs are highly exposed to climate change effects as they are heavily reliant on climate-vulnerable sectors such as agriculture (Harmeling and Eckstein, 2012). Most of the LDCs, already overwhelmed by poverty, natural disasters, conflicts and geo-physical constraints, are now at risk of further devastating impacts of climate change. In turn they contribute very little to carbon emissions (Baumert et al., 2005; Fisher, 2013). At the same time, LDCs are faced with a lack of access to energy services and with an expected increase in energy demand due to the population and GDP growth. By investing in mitigation activities in the early and interim stages, access to clean and sustainable energy can be provided and environmentally harmful technologies can potentially be leapfrogged. Consequently, needs for finance and investment are pressing both for adaptation and mitigation in LDCs.

Regarding mitigation finance needs, there are no robust data for LDCs. The very few existing country studies are not representative of the whole group of LDCs and are not comparable. Data on international and domestic private sector activities in LDCs are also lacking, as are data on domestic public flows. With respect to North-South flows, the OECD DAC reported that developed countries provided USD 730 million (2010 USD) in mitigation related ODA to LDCs in the year 2011. Bangladesh received the highest share with USD 117 million, followed by Uganda and Haiti with more than USD 70 million (OECD, 2012).

Most LDCs have very few CDM projects which are also an important vehicle for mitigation (UNEP Risø, 2012; UNFCCC, 2012a). In order to improve the equitable regional distribution of CDM projects, the CDM Executive Board has promoted the regulatory reform of CDM standards, procedures and guidelines. Furthermore, stakeholder interaction has been enhanced and a CDM loan scheme has been established by UNFCCC to provide interest-free loans for CDM project preparation in LDCs (UNFCCC, 2012c).

Some LDCs are starting to allocate public funds to mitigation and adaptation activities, e.g. NAPAs or national climate funds (see also below) (Khan et al., 2012). However, pressing financial needs to combat poverty favour other expenditures over climate-related activities.

Most LDCs struggle to provide an enabling environment for private business activities, a very common general development issue (Stadelmann and Michaelowa, 2011). It is noteworthy that among the 30 lowest-ranking countries in the World Bank's Doing Business Index23 countries are LDCs (World Bank, 2011b). Obstacles to general private business activities in turn hinder long-term private climate investments (Justice, 2009). Moreover, the weakness of technological capabilities in LDCs presents a challenge for successful development and transfer of climate-relevant technologies (ICTSD, 2012). In a challenging general enabling environment, it is further difficult to implement targeted policies and financial instruments to mobilize private mitigation finance as effectively as in other countries.

Due to very high perceived risk in LDCs, risk premiums are very high. This is particularly problematic as low-carbon investments are very responsive to the cost of capital (Eyraud et al., 2011)

In order to develop along a low-carbon growth path, LDCs rely on international grant and concessional finance. It is especially important to ensure the predictability and sustainability of climate finance for LDCs, as these countries are inherently more vulnerable to economic shocks due to their structural weaknesses (UNCTAD, 2010).

While all donors and development institutions provide mitigation finance to LDCs, there are some dedicated institutional arrangements, such as the LDCF and the SCCF under the Convention. Some LDCs have also implemented national funding institutions, e.g. Benin, Senegal and Rwanda in the framework of the Adaptation Fund, or the Bangladesh Climate Change Resilience Fund.

While knowledge and data gaps regarding mitigation finance are generally higher in developing than in developed countries, they are even more severe in LDCs.

16.9 Gaps in knowledge and data

Scientific literature on investment and finance for low-carbon activities is still very limited and knowledge gaps are substantive. To date there are no common definitions for central concepts related to climate finance. Neither are there complete or reasonably accurate data on current climate finance and its components namely developed country sources or commitments, developing country sources or commitments, international flows, private vs. public sources.

The role of domestic and South-South flows and domestic investments in developing countries is also not adequately understood and documented.

Important metrics like the high carbon investment by sub-sector and region, the carbon intensity of average new investments, downward deviations from reference emission pathways or the cost-effectiveness of global mitigation investments are not tracked.

A comprehensive assessment of the interrelation between private and public sector actors in sharing incremental costs and risks of mitigation investments, for example via concessional loans or guarantee instruments has not been undertaken yet.

For the energy sector there is no convergence on the order of magnitude of net incremental investment costs for the sum of these sectors. Interactions of stringent climate policies with overall growth and investment of individual economies and the world economy as a whole are also not understood well yet.

Only limited model results on additional investments and incremental costs are available on a global level for sectors other than energy supply , i.e. industrial energy efficiency, buildings, transport and forestry, for key mitigation pathways and consistent with energy supply model approaches and data. Very limited analysis has been published which takes a globally consistent perspective of incremental investments and costs on the level of nation states and groups of actors. This perspective could enrich the scientific discussion as global and regional netting approaches among sectors and sub-sectors may fall short of the complexity of real political decision making processes.

A comprehensive and transparent treatment of investment and technology risks in energy models is not available. The impact of fuel price volatility on low-carbon investments is generally not considered. Reasonably robust quantitative results for the needs for additional R & D for low-carbon technologies and practices and on the timing of these needs (infrastructure and technology deployment roadmap) are not available.

The systematic function of cities needs to be analyzed in greater depth. Given the complex interrelationships between various elements of the urban system, actions in one sector influence the cost-effectiveness of other actions in the same sector, as well as those in other sectors.

Knowledge about enabling environments for effective deployment of climate finance in any country is insufficient. There is very limited empirical evidence to relate the concept of low-carbon activities to macro determinants from a cross-country perspective. More research is especially needed regarding determinants for mitigation investment in least developed countries.

There is only case-specific knowledge by practitioners on the selection and combination of instruments that are most effective at shifting (leveraging) private investment to mitigation and adaptation. There is no general understanding of what are the efficient levers to mobilize private investment and their potential in any country (since they will differ by investment and country).

The effectiveness of different public climate finance channels in driving low-carbon development is insufficiently analyzed. Estimates of the incremental cost value of public guarantees, export insurances and non-concessional loans of development banks would provide valuable insights. There is also little known on determinants for an economically efficient and effective allocation of public climate finance (it is known for development assistance but not for climate-related finance).

There is no agreement yet which institutional arrangements are more effective at which level (international national local) and for what investment in which sector. However, an understanding of the key determinants of this efficiency and of the nature of a future international climate policy agreement must come first.

Optimal balance between mitigation and adaptation finance and investment, including its time dimension is a difficult exercise given the lack of modelling of any direct interaction between adaptation and mitigation in terms of their specific effectiveness and trade-offs. A better informed assessment of the effective integration of mitigation and adaptation, including trade-offs and cost avoidance estimates is needed. Moreover, there is limited literature to assess synergies and trade-offs between and across sector-specific mitigation and adaptation measures from the specific financing and investment point of view.

Appendix

McKinsey

Our calculations based on McKinsey Climate Desk data available at https://solutions.mckinsey.com. Data exported on Sat Jan 05, 2013 (21:38:15 CET). Description of method used is available from (McKinsey, 2009).Data on investments (CAPEX),with negative costs lever.

450 ppm scenario corresponds to scenario with full potential, 100% success rate, policy starts in 2015. 550 ppm scenario same as 450 ppm scenario but policy starts in 2020.

Data is in 2005EUR. Transformed in 2010USD following the standard conversion rules for the IPCC AR5.

Price of oil 80USD/barrel. Industry includes waste. CCS includes retrofit and new build.

Transport includes air and maritime transport in global data, only road transport in regional data. Transport includes investment on biofuels.

non-OECD: includes Chile, which in reality is part of OECD.

IIASA-GEA

Chapter 17 of the Global Energy Assessment assesses technical measures, policies and related costs and benefits for meeting the following objectives (Riahi et al., 2012):

- providing almost universal access to affordable clean cooking and electricity for the poor;
- limiting air pollution and health damages from energy use;
- improving energy security throughout the world; and
- limiting climate change.

In the GEA-Supply scenario the main transformations occur in energy supply. In the GEA-efficiency scenario it is energy efficiency to play the most important role. The core GEA-efficiency scenario assumes a nuclear phase-out and corresponds to the EN scenario in Table 16.2 and 16.3. The GEA-supply scenario corresponds to the SU scenario in Table 16.2 and 16.3. The GEA-supply scenario with nuclear phase-out corresponds to the SN scenario in Table 16.2 and 16.3. The SU and E scenarios without bioenergy with carbon capture and sequestration (BECCS) correspond to the SB and EB scenarios in table 16.2 and 16.3.

AME

The Asia Modeling Exercise (AME) examined the role of Asia in climate mitigation policies (Calvin et al., 2012). 23 regional and global models used the same scenario protocol to produce comparable results. Table 16.2 and 16.3 refer to scenarios that limit radiative forcing to 3.7 and 2.6 W/m2 in 2100. Global participation from 2015 was assumed. 13 models report results for the 3.7 W/m2 target and 8 models report results for the 2.6 W/m2 target. Investments were not reported by the modeling teams. Investments have been estimated using reported supply of power generation (measured in EJ) with assumptions on the load factor, lifetime and overnight investment costs from (IEA / OECD, 2010) and from expert judgment (see Table A.1).

Table A.1. Assumptions used to derive investments form AME scenarios

Technology	Overnight cost ($/kWe)	Load factor	Lifetime
Biomass w/ CCS	3500	0.85	30
Biomass w/o CCS	2500	0.85	30
Coal w/ CCS	3200	0.85	40
Coal w/o CCS	2000	0.85	40
Gas w/ CCS	2500	0.85	30
Gas w/o CCS	750	0.85	30
Geothermal	4000	0.85	30
Hydropower	4000	0.60	80
Non-Biomass Renewables	4000	0.85	30
Nuclear	3688	0.85	60
Oil w/ CCS	2500	0.85	30
Oil w/o CCS	1000	0.85	30
Other	2000	0.85	30
Solar	1500	0.20	25
Wind	1500	0.30	25

Investments in region *n* at time *t* in technology *j* were obtained as follows:

$$I(n,t,j) = \frac{277.8}{loadfactor} \times \cos t\,(j) \times \left\{ \left[E(n,t+1,j) - E(n,t,j) \right] + \frac{E(n,t,j)}{lifetime} \right\}.$$

Investment reported in Table 16.2 and 16.3 correspond to the median value available for each scenario. Medians are also used to report investments in technological aggregates. For this reason investments in the aggregated are not equal to the sum of their components.

LIMITS

The LIMITS project (Low Climate Impact Scenarios and Implications of Required Tight Emission Control Strategies - (McCollum et al., 2013)) focuses on the 2°C target. The project compares results from five models: GCM, MESSAGE, REMIND, TIAM-ECN, WITCH. However, TIAM-ECN did not report data on investments and was not used to derive estimates included in table 16.2. and 16.3. The average of the four models that reported data is used in table 16.2. and 16.3.

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