16 Cross-cutting Investment and Finance Issues

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This chapter should be cited as:

Gupta S., J. Harnisch, D.C. Barua, L. Chingambo, P. Frankel, R.J. Garrido Vázquez, L. Gómez-Echeverri, E. Haites, Y. Huang, R. Kopp, B. Lefèvre, H. Machado-Filho, and E. Massetti, 2014: Cross-cutting Investment and Finance Issues. In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

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Contents

Executive Summary

For the first time, an assessment report by the Intergovernmental Panel on Climate Change (IPCC) contains a chapter dedicated to investment and finance. These are the chapter's key findings:

Scientific literature on investment and finance to address climate change is still very limited and knowledge gaps are substantial; there are no agreed definitions for climate investment and climate finance. Quantitative data are limited, relate to different concepts, and are incomplete. Accounting systems are highly imperfect. Estimates are available for current total climate finance, total climate finance provided to developing countries, public climate finance provided to developing countries, and climate finance under the United Nations Framework Convention on Climate Change (UNFCCC), as well as future incremental investment and incremental cost for mitigation measures. Climate finance relates both to adaptation and mitigation, while under the scope of this chapter, estimates of future investment needs are presented only for mitigation. [Section 16.1]

Total climate finance for mitigation and adaptation is estimated at 343 to 385 billion USD (2010/11/12 USD) per year using a mix of 2010, 2011, and 2012 data, almost evenly being invested in developed and developing countries (*medium confidence*). The figures reflect the total financial flow for the underlying investments, *not the incremental investment,* i.e., the portion attributed to the emission reductions. Around 95 % of reported total climate finance is for mitigation (*medium confidence*). [16.2.1.1]

The total climate finance currently flowing to developing countries is estimated to be between 39 to 120 billion USD per year using a mix of 2009, 2010, 2011, and 2012 data (2009/2010/2011/2012 USD) (*medium confidence*). This range covers public and private flows for mitigation and adaptation. Public climate finance is estimated at 35–49 billion USD (2011/2012 USD) (*medium confidence*). Most public climate finance provided to developing countries flows through bilateral and multilateral institutions, usually as concessional loans and grants. Climate finance under the UNFCCC is funding provided to developing countries by Annex II Parties. The climate finance reported by Annex II Parties averaged nearly 10 billion USD per year from 2005 to 2010 (2005–2010 USD) (*medium confidence*). Between 2010 and 2012, the 'fast-start finance' (FSF) provided by some developed countries amounted to over 10 billion USD per year (2010/2011/2012 USD) (*medium confidence*). Estimates of international private climate finance flowing to developing countries range from 10 to 72 billion USD (2009/2010 USD) per year, including foreign direct investment as equity and loans in the range of 10 to 37 billion USD (2010 USD and 2008 USD) per year over the period of 2008–2011 (*medium confidence*). [16.2.1.1]

Emission patterns that limit temperature increase from pre-industrial level to no more than 2 °C require considerably different patterns of investment. A limited number of studies have examined the investment needs to transform the economy to limit warming to 2 °C. Information is largely restricted to energy use with global total annual investment in the energy sector at about 1200 billion USD. In the results for these scenarios, which are consistent to keeping carbon dioxide equivalent (CO_2eq) concentration in the interval 430–530 ppm until 2100, annual investment in fossil-fired power plants without carbon dioxide capture and storage (CCS) would decline by 30 (median: –20 % compared to 2010) (2 to 166) billion USD during the period 2010–2029, compared to the reference scenarios (*limited evidence, medium agreement*). Investment in low-emissions generation technologies (renewable, nuclear, and electricity generation with CCS) would increase by 147 (median: +100 % compared to 2010) (31 to 360) billion USD per year during the same period (*limited evidence, medium agreement*) in combination with an increase by 336 (1 to 641) billion USD in energy-efficiency investments in the building, transport, and industry sector (*limited evidence, medium agreement*), frequently involving modernization of existing equipment. Higher energy efficiency and the shift to low-emission energy sources contribute to a reduction in the demand for fossil fuels, thus causing a decline in investment in fossil fuel extraction, transformation, and transportation. Scenarios suggest that the average annual reduction of investment in fossil fuel extraction in 2010–2029 would be 116 (–8 to 369) billion USD (*limited evidence, medium agreement*). Such 'spillover' effects could yield adverse effects on economies, especially of countries that rely heavily on exports of fossil fuels. Model results suggest that deforestation could be reduced against current deforestation trends by 50 % with an investment of 21 to 35 billion USD per year (*low confidence*). Information on investment needs in other sectors in addition to energy efficiency, e.g., to abate process or non-CO_2 emissions is virtually unavailable. [16.2.2]

Resources to address climate change need to be scaled up considerably over the next few decades both in developed and developing countries (*medium evidence, high agreement*). Increased financial support by developed countries for mitigation (and adaptation) measures in developing countries will be needed to stimulate the increased investment. Developed countries have committed to a goal of jointly mobilizing 100 billion USD per year by 2020 in the context of meaningful mitigation action and transparency on implementation. The funding could come from a variety of sources—public and private, bilateral and multilateral, including alternative sources of finance. Studies of how 100 billion USD per year could be mobilized by 2020 conclude that it is challenging but feasible. [16.2]

Public revenues can be raised by collecting carbon taxes and by auctioning carbon allowances (*high confidence*). Putting a price on greenhouse gas (GHG) emissions, through a carbon tax or emissions trading, alters the rate of return on high- and low-carbon investments. It makes low-emission technologies attract more investment and at the same time it raises a considerable amount of revenue that can be used for a variety of purposes, including climate finance. These carbon-related sources are already sizeable in some countries

[16.2.1.2]. The consideration of alternative sources of public revenue like taxes on international bunker fuels has the potential to generate significant funds but is still in its infancy. Reducing fossil fuel subsidies would lower emissions and release public funds for other purposes [16.2.3].

Within appropriate enabling environments, the private sector, along with the public sector, can play an important role in financing mitigation (*medium evidence, high agreement*). Its contribution is estimated at 267 billion USD per year in 2010 and 2011 (2010/2011 USD) and at 224 billion USD (2011/2012 USD) per year in 2011 and 2012 on average, which represents around 74 % and 62 % of overall climate finance, respectively (*limited evidence, medium agreement*) [16.2.1]. In a range of countries, a large share of private sector climate investment relies on low-interest and long-term loans as well as risk guarantees provided by public sector institutions to cover the incremental costs and risks of many mitigation investments. In many countries, therefore, the role of the public sector is crucial in helping these private investments happen. The quality of a country's enabling environment—including the effectiveness of its institutions, regulations and guidelines regarding the private sector, security of property rights, credibility of policies and other factors—has a substantial impact on whether private firms invest in new technologies and infrastructures. Those same broader factors will probably have a big impact on whether and where investment occurs in response to mitigation policies [16.3]. By the end of 2012, the 20 largest emitting developed and developing countries with lower risk country grades for private sector investments covered 70 % of global energy-related CO_2 emissions (*low confidence*). This makes them attractive for international private sector investment in low-carbon technologies. In many other countries, including most least developed countries, low-carbon investment will often have to rely mainly on domestic sources or international public finance [16.4.2].

A main barrier to the deployment of low-carbon technologies is a low risk-adjusted rate of return on investment vis-à-vis high-carbon alternatives often resulting in higher cost of capital (*medium evidence, high agreement*). This is true in both developed and developing countries. Dedicated financial instruments to address these barriers exist and include inter alia credit insurance to decrease risk, renewable energy premiums to increase return, and concessional finance to decrease the cost of capital. Governments can also alter the relative rates of return of low-carbon investments in different ways and help to provide an enabling environment. [16.3, 16.4]

Appropriate governance and institutional arrangements at the national, regional, and international level need to be in place for efficient, effective, and sustainable financing of mitigation measures (*high confidence*). They are essential to ensure that financing to mitigate and adapt to climate change responds to national needs and priorities and that national and international activities are linked and do not contradict each other. An enabling environment at the national level ensures efficient implementation of funds and risk reduction using international resources, national funds, as well as national development and financial institutions. [16.5]

Important synergies and tradeoffs between financing mitigation and adaptation exist (*medium confidence*). Available estimates show that adaptation projects get only a minor fraction of international climate finance. Current analyses do not provide conclusive results on the most efficient temporal distribution of funding on adaptation vis-à-vis mitigation. While the uncertainties about specific pathways and relationships remain, and although there are different considerations on its optimal balance, there is a general agreement that funding for both mitigation and adaptation is needed. Moreover, there is an increasing interest in promoting integrated financing approaches, addressing both adaptation and mitigation activities in different sectors and at different levels. [16.6]

Increasing access to modern energy services for meeting basic cooking and lighting needs could yield substantial improvements in human welfare at relatively low cost (*medium confidence*). Shifting the large populations that rely on traditional solid fuels (such as unprocessed biomass, charcoal, and coal) to modern energy systems and expanding electricity supply for basic human needs could yield substantial improvements in human welfare for a relatively low cost; 72–95 billion USD per year until 2030 to achieve nearly universal access. [16.8]

16.1 Introduction

This is the first time an assessment report by the Intergovernmental Panel on Climate Change (IPCC) contains a chapter dedicated to investment and finance to address climate change. This reflects the growing awareness of the relevance of these issues for the design of efficient and effective climate policies.

The assessment of this topic is complicated by the absence of agreed definitions, sparse data from disparate sources, and limited peer-reviewed literature. Equity, burden sharing, and gender considerations related to climate change are discussed in other chapters, inter alia Sections 3.3 and 4.6.2. This chapter does not include a separate discussion of these considerations in relation to climate finance.

There is no agreed definition of climate finance (Haites, 2011; Stadelmann et al., 2011b; Buchner et al., 2011; Forstater and Rank, 2012). The term 'climate finance' is applied both to the financial resources devoted to addressing climate change globally and to financial flows to developing countries to assist them in addressing climate change. The literature includes multiple concepts within each of these broad categories (Box 1.1). The specific mitigation and adaptation measures whose costs qualify as 'climate finance' also are not agreed. The mea-

Box 16.1 | Different concepts, different numbers

Different concepts of climate finance are found in the literature. The corresponding values differ significantly.

Financial resources devoted to addressing climate change globally:

Total climate finance includes all financial flows whose expected effect is to reduce net GHG emissions and/or to enhance resilience to the impacts of climate variability and the projected climate change. This covers private and public funds, domestic and international flows, expenditures for mitigation and 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. The estimate by Buchner et al. (2012, 2013b) of current climate finance of 343 to 385 billion USD (2010/2011/2012 USD) per year using a mix of 2010, 2011, and 2012 data, corresponds roughly to this concept.

The *incremental investment* is the extra capital required for the initial investment for a mitigation or adaptation project in comparison to a reference project. For example, the investment in wind turbines less the investment that would have been required for the coal or natural gas-generating unit displaced. Since the value depends on the unknown investment in a hypothetical alternative, the incremental investment is uncertain. Incremental investment for mitigation and adaptation measures is not regularly estimated and reported, but estimates are available from models. It can be positive or negative. Many agriculture and reducing emissions from deforestation and forest degradation (REDD+) mitigation options that involve ongoing expenditures for labour and other operating costs rather than investments are excluded.

The *incremental costs* reflect the cost of capital of the incremental investment and the change of operating and maintenance costs for a mitigation or adaptation project in comparison to a reference project. It can be calculated as the difference of the net present values of the two projects. Many mitigation measures—such as energy efficiency, renewables, and nuclear—have a higher capital cost and lower operating costs than the measures displaced. Frequently the incremental costs are lower than the incremental investment. Values depend on the incremental investment as well as projected operating costs, including fossil fuel prices, and the discount rate. Models can estimate the incremental costs of energy supply and demand but data are not immediately available and aggregate estimates cannot be provided. Estimates are available for single-mitigation options (see, e.g., Chapter 7).

The *macroeconomic costs of mitigation policy* are the reductions of aggregate consumption or gross domestic product induced by the reallocation of investments and expenditures induced by climate policy. These costs do not account for the benefit of reducing anthropogenic climate change and should thus be assessed against the economic benefit of avoided climate change impacts. Models have traditionally provided estimates of the macroeconomic costs of climate policy (see Chapter 6).

Financial flows to developing countries to assist them in addressing climate change:

The *total climate finance flowing to developing countries* is the amount of the total climate finance invested in developing countries that comes from developed countries. This covers private and public funds for mitigation and adaptation. Estimates from a few studies suggest the current flow is between 39 and 120 billion USD per year (2009–2012 USD).

Public climate finance provided to developing countries is the finance provided by developed countries' governments and bilateral institutions as well as multilateral institutions for mitigation and adaptation activities in developing countries. Most of the funds provided are concessional loans and grants. Estimates suggest that public climate finance flows to developing countries were at 35 to 49 billion USD per year in 2011 and 2012 (2011/2012 USD).

Private climate finance flowing to developing countries is finance and investment by private actors in/from developed countries for activities in developing countries whose expected effect is to reduce net GHG emissions and/or to enhance resilience to the impacts of climate variability and the projected climate change.

Under the *United Nations Framework Convention on Climate Change (UNFCCC), climate finance* is not well-defined. Annex II Parties provide and mobilize funding for climate related activities in developing countries. Most of the funds provided are concessional loans and grants. The climate finance provided to developing countries reported by Annex II Parties averaged nearly 10 billion USD per year from 2005 to 2010 (2005–2010 USD). In addition, some developed countries promised FSF amounting to over 10 billion USD per year between 2010 and 2012 (2010/2011/2012 USD).

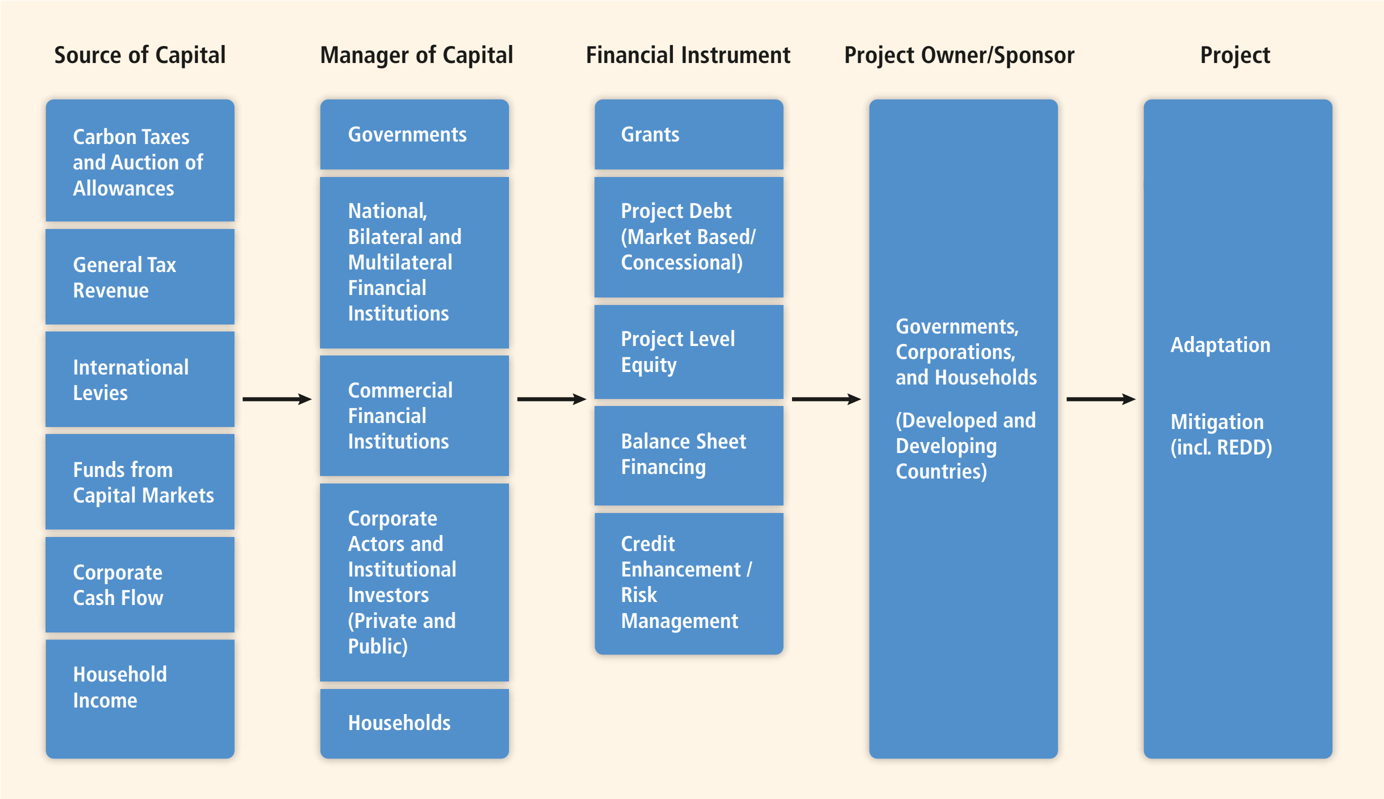

Figure 16.1 | Overview of climate finance flows. Note: Capital should be understood to include all relevant financial flows. The size of the boxes is not related to the magnitude of the financial flow.

sures included vary across studies and often are determined by the data available[1].

The rest of the chapter is structured as follows: Section 16.2 reviews estimates of current climate finance corresponding to the different concepts in Box 1, projections of global incremental investment and incremental costs for energy-related mitigation measures to 2030, and options for raising public funds for climate finance. Enabling factors that influence the ability to efficiently generate and implement climate finance are discussed in Section 16.3. Section 16.4 considers opportunities and key drivers for low-carbon investments. Institutional arrangements for mitigation finance are addressed in Section 16.5. Synergies and tradeoffs between financing mitigation and adaptation are discussed in Section 16.6. The chapter concludes with sections devoted to financing mitigation activities in developed (Section 16.7) and developing countries (Section 16.8) and a review of important gaps of knowledge (Section 16.9).

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

16.2.1 Current financial flows and sources

Figure 16.1 provides an overview of climate finance and the terms used in this chapter. The term 'capital' is used because most climate finance involves an investment, but it should be understood to include all relevant financial flows[2]. One or more capital managers mobilize the required capital and invest it in an adaptation or mitigation project. Project owners or sponsors—governments, corporations, or households—implement a project using their own and other sources of capital. However, projects often obtain capital from multiple capital managers (Buchner et al., 2011, 2012; Jürgens et al., 2012). An instrument defines the financial agreement between a project owner/sponsor and a manager of capital. A project that obtains capital from sev-

[1] Most of the financial flow data in this chapter originate from 2010, 2011, and 2012 and were published in USD. The exchange rates used by each source to convert other currencies to USD are not specified in the published sources. In these cases, the published USD figure has been maintained and the base year is similar to the year the commitment/investment/flow was announced/reported. If no base year is indicated, as for most monetary values in Section 16.2.2, the base year is 2010.

[2] Terms that cover both capital and operating costs, such as 'financial resources' or 'funds' are cumbersome (sources/managers of financial resources) or potentially confusing ('funds' can also be institutions).

eral managers would use multiple instruments. The size of the boxes is not related to the magnitude of the financial flow.

Data on current climate finance, summarized below, indicate that most capital deployed is private—private corporations and households. That is not surprising since they dominate the economy in most countries.

Domestically, government funds are disbursed directly as financial incentives or tax credits, or through national financial institutions. Climate finance under the UNFCCC currently is provided mainly by the national governments of Annex II Parties. Climate finance from the budgets of these government flows through bilateral institutions being a national public entity, such as Japan International Cooperation Agency (JICA), Agence Française de Développement (AFD), Kreditanstalt für Wiederaufbau (KfW), or through multilateral institutions having several countries as shareholders, such as the World Bank, regional development banks, and multilateral climate funds.

There is no internationally agreed definition of mitigation and adaptation projects; for example, whether a high-efficiency gas-fired generating unit is a mitigation project or which capacity building activities help to address climate change. The relevant projects, and hence the scale of climate finance, depend upon the definition of mitigation and adaptation projects adopted. In practice, the definition varies across studies and is often determined by the data available.

16.2.1.1 Estimates of current climate finance

This section reviews estimates of current global total climate finance, total climate finance flowing to developing countries, public climate finance provided to developing countries and climate finance under the UNFCCC.

There is no comprehensive system for tracking climate finance (Clapp et al., 2012; Tirpak et al., 2012), therefore, estimates must be compiled from disparate sources of variable quality and timeliness, sources that use different assumptions and methodologies and have gaps and may occasionally duplicate coverage. Available data typically relate to commitments rather than disbursements, so the amount reported may not equal the amount received by the project owner during a given year. Changes in exchange rates further complicate the picture. For these and other reasons, estimates of current climate finance exhibit considerable uncertainties.

Global total climate finance is estimated at 343 to 385 billion USD per year for 2010/11 (2010/11 USD) and 356 to 363 billion USD per year for 2011/12 (2011/12 USD), with mitigation accounting for approximately 95 % of this amount (350 billion USD and 337 billion USD, respectively) (Buchner et al., 2012, 2013b). This estimate 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[3]. The figures reflect new commitments by capital managers using a mix of 2010/11 and 2011/12 data, respectively. Private finance dominates the total, but its share declined from 74 % (267 billion USD) on average in 2010 and 2011 to 62 % (224 billion USD) on average in 2011 and 2012 (2010/2011 USD and 2011/2012 USD) (Buchner et al., 2012, 2013b). Investment in renewable generation technologies dominates the mitigation investment (Frankfurt School-UNEP Centre and BNEF, 2012).

Reasonably robust estimates of *total climate finance for individual countries* are available for only a few cases, for instance, for Germany (Jürgens et al., 2012). However, some institutions report on their financing commitments for climate and environment. Data from 19 development banks indicate that commitments of mitigation finance increased from 51 billion USD in 2011 to 65 billion USD in 2012 with commitments of adaptation finance rising from 6 to 14 billion USD over the same period (2011/2012 USD). Concessional funding provided by public development banks plays an important role in financing domestic climate projects, e.g., in Brazil, China, and Germany.

A growing number of developed and developing countries, including Bangladesh, Colombia, Indonesia, Nepal, Samoa, Tanzania, Uganda, and the United States as well as the European Commission, calculates the share of their annual budget devoted to climate change mitigation and adaptation often using a methodology known as a Climate Public Expenditure and Institutional Review (UNDP, 2013a). Country estimates range from 3–15 % of the national budget.

A few estimates of *total climate finance flowing to developing countries* are available. Clapp et al. (2012) estimate the total at 70–120 billion USD per year based on 2009–2010 data (2009/2010 USD). Data from Buchner et al. (2013a) suggest a net flow to developing countries of the order of 40 to 60 billion USD for 2010 and 2011 (2010/2011 USD).[4] For 2011 and 2012, North-South flows are estimated at 39 to 62 billion USD (2011/2012 USD) (Buchner et al., 2013b). Clapp et al. (2012) estimate the private investment at 37–72 billion USD (2009/2010 USD) per year based on 2009–2010 data and Stadelmann

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3 Methodology used by Buchner et al. (2012, 2013b): Finance flows are limited to 'climate-specific finance', capital flows targeting low-carbon, and climate-resilient development with direct or indirect mitigation or adaptation objectives/outcomes. The focus is on current financial flows (upfront capital investment costs and grants expressed as commitments, so risk management instruments are excluded). Data are for total rather than incremental investment because incremental investment requires assumptions on the baseline on a project-by-project basis. The data are for 'gross' investment, the full value of the investment, and reflect commitments because disbursement data is not widely available. The data are a mix of 2010 and 2011 data, and 2011 and 2012 data, respectively.

4 Buchner et al. (2013) estimate that developed countries mobilized 213 to 255 billion USD climate finance per year during 2010 and 2011 while 160 to 208 billion USD climate finance had been committed to climate change projects in developed countries. Developing countries mobilized 120 to 141 billion USD climate finance per year during 2010 and 2011 and 162 to 202 billion USD had been committed to climate change projects in developing countries. Those figures suggest a net flow to developing countries of the order of 40 to 60 billion USD per year (2010/2011 USD).

et al. (2013) estimate foreign direct investment as equity and loans in the range of 10 to 37 billion USD per year based on 2008–2011 data (2010 USD and 2008 USD).

The investment in registered **Clean Development Mechanism (CDM)** projects is estimated at over 400 billion USD over the period 2004 to 2012 (2004–2012 USD) (UNEP Risø, 2013). Of that amount almost 80 billion USD was for projects registered during 2011 and 195 billion USD for projects registered during 2012 (2011 USD and 2012 USD). The majority of the investment in CDM projects is private. Renewable energy projects account for over 70 % of the total investment. The share of CDM renewable energy projects with some foreign investment has grown over time, representing almost 25 billion USD in 2011 (2011 USD) (Kirkman et al., 2013).[5]

Since 1999 almost 100 **carbon funds** with a capitalization of 14.2 billion USD have been established (Alberola and Stephan, 2010).[6] Carbon funds are investment vehicles that raise capital to purchase carbon credits (52 %) and/or invest in emission reduction projects (23 %). A fund may have only private investors (48 %), only public investors (29 %) or a mix of both (23 %) (Alberola and Stephan, 2010). Investment may be restricted to a specific region or project type (e. g., REDD+). Financial data, especially for private funds, is often confidential so the amount of finance provided to developing countries via carbon funds is not available. Scaling up data from 29 funds on the amount invested in projects suggests a maximum cumulative investment of 18 billion USD (1999–2009 USD) (Kirkman et al., 2013).

Public climate finance provided to developing countries was estimated at 35 to 49 billion USD per year in 2011 and 2012 (2011/2012 USD) (Buchner et al., 2013b).[7] These public funds flow mainly through bilateral and multilateral institutions[8]. Most of the climate finance is implemented by development banks, frequently involving the blending of government resources with their own funds. There are two main reporting systems for public support in place that are not fully comparable due to differences in respective methodologies.

The Organisation for Economic Co-operation and Development (OECD) Development Assistance Committee (DAC) reports the amount of official development assistance (ODA) committed bilaterally for projects that have climate change mitigation or adaptation as a 'principal' or 'significant' objective by its 23 member countries and the European Commission. The DAC defines ODA as those flows to countries on the DAC List of ODA Recipients and to multilateral institutions provided by official agencies or by their executive agencies. Resources must be used to promote the economic development and welfare of developing countries as a main objective and they must be concessional in character, meaning as grants or as concessional loans including a grant element of at least 25 %, calculated at a rate of discount of 10 %. The amount is the total funding committed to each project, not the share of the project costs attributable to climate change (OECD, 2013a). Researchers have questioned the accuracy of the project classification (Michaelowa and Michaelowa, 2011; Junghans and Harmeling, 2013). Bilateral commitments averaged 20 billion USD per year in 2010 and 2011 (2010/2011 USD) (OECD, 2013a) and were implemented by bilateral development banks or other bilateral agencies, provided to national government directly or to dedicated multilateral climate funds (Buchner et al., 2012, 2013b).

Seven multilateral development banks (MDBs)[9] reported climate finance commitments of about 24.1 and 26.8 billion USD in 2011 and 2012, respectively (2011/2012 USD). The reporting is activity-based allowing counting entire projects but also project components. Recipient countries include developing countries and 13 European Union (EU) member states. It covers grant, loan, guarantee, equity, and performance-based instruments, not requiring a specific grant element. The volume covers MDBs' own resources as well as external resources managed by the MDBs that are also reported to OECD DAC (such as contributions to the Global Environment Facility (GEF), Climate Investment Funds (CIFs), and Carbon Funds) (AfDB et al., 2012a; b, 2013).

Under the UNFCCC, climate finance is not well-defined. Annex II Parties committed to provide new and additional financial resources to cover the "agreed full incremental costs" of agreed mitigation measures implemented by developing countries (Article 4.3), 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 (Article 4.3) (UNFCCC, 1992). None of these terms are operationally defined (Machado-Filho, 2011). These commitments are reaffirmed by the Kyoto Protocol (UNFCCC, 1998, Art. 11). The Conference of Parties (COP) has agreed that funds provided to developing country Parties may come from a wide variety of sources, public, and private, bilateral and multilateral, including alternative sources (UNFCCC, 2010, para. 99).

Annex II Parties report the financial resources they provide to developing countries through bilateral and multilateral channels for climate

5 CDM projects sell emission reduction credits, Certified Emission Reductions (CERs), to developed country buyers, which provide a return to developed country investors.

6 United Nations Environment Program (UNDP) estimates that in addition up to 6000 private equity funds have been established for the purpose of funding climate change-related activities (UNDP, 2011).

7 Buchner et al. (2013b) count climate finance provided by bilateral finance institutions, multilateral finance institutions, government bodies, and climate funds as public flows. The difference between lower- and upper-bound results when taking the ownership structure of multilateral institutions into account and excluding all bilateral flows marked as having climate as 'significant' objective.

8 Ryan et al. (2012) estimate the annual average finance provided to developing countries for energy efficiency at 18.9 billion USD in 2010 from bilateral financial institutions and 4.9 billion USD from multilateral financial institutions over the period 2008–2011.

9 African Development Bank (AfDB), the Asian Development Bank (ADB), the European Bank for Reconstruction and Development (EBRD), the European Investment Bank (EIB), the Inter-American Development Bank (IDB), the World Bank (WB) and the International Finance Corporation (IFC).

change action to increase transparency about public flows of climate finance vis-à-vis expectations and needs. The latest summary of the Annex II reports on their provided climate finance indicates that they provided a total of 58.4 billion USD for the period 2005 through 2010, an average of nearly 10 billion USD per year (2005–2010 USD) (UNFCCC, 2011a).[10] Most of the funds provided are concessional loans and grants. In addition, a range of developed countries promised FSF of about 10 billion USD per year from 2010 to 2012 (2010/2011/2012 USD) (see Section 16.2.1.3).[11]

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 (GCF) becomes operational. Annex II Party contributions to the Trust Fund of the GEF, the Special Climate Change Fund (SCCF) and the Least Developed Countries Fund (LDCF) amounted to about 3.3 billion USD for 2005 through 2010, an average of less than 0.6 billion USD per year (2005–2010 USD) (UNFCCC, 2011a). Most of the funds are used for mitigation. The Adaptation Fund derives most of its funds from the sale of its share of the CERs issued for CDM projects[12].

16.2.1.2 Current sources of climate finance

Climate finance comes from the sources of capital shown in Figure 16.1 including capital markets, carbon markets, and government budgets. Most government funding comes from general revenue but some governments also raise revenue from sources—carbon taxes and auctioned GHG-emission allowances—that have mitigation benefits. Most corporate funding comes from corporate cash flow including corporate borrowing, often called balance-sheet finance (Frankfurt School-UNEP Centre, 2013).[13] Household funding comes from household income from wages, investments, and other sources. Governments, corporations, and households can all access capital markets to mobilize additional funds.

This section summarizes estimates of the revenue currently generated by carbon taxes and auctioned GHG-emission allowances. Fuel taxes, fossil fuel royalties, and electricity charges can be converted to CO_2eq charges but they are excluded here because they are usually implemented for different policy goals.

Carbon taxes generate about 7 billion USD in revenue annually mainly in European countries (2010/2011 USD).[14] Denmark, Finland, Germany, Ireland, Italy, Netherlands, Norway, Slovenia, Sweden, Switzerland, and the United Kingdom—generated about 6.8 billion USD in 2010 (2010 USD) and 7.3 billion USD (2011 USD) in 2011. India[15], Australia, and Japan introduced carbon taxes in July 2010, July 2012, and October 2012, respectively. In some countries, part or all of the revenue is dedicated to environmental purposes or reducing other taxes; none is earmarked for international climate finance.

Auctioned allowances, fixed price compliance options, and the international sale of surplus Assigned Amount Units (AAUs) generate about 2 billion USD per year for national governments (2010/2011 USD). Among the 30 countries participating in the EU emissions trading scheme, Austria, Germany, Hungary, Ireland, the Netherlands, Norway, and the United Kingdom auctioned some emission allowances during the second (2008–2012) phase (European Commission, 2012). Buchner et al. (2011, 2012) estimate auction revenue at 1.4 and 1.6 billion USD for 2010 and 2011 (2010/2011 USD). Germany has so far earmarked a portion of its auction revenue for international climate finance (Germany Federal Ministry for the Environment Nature Conservation and Nuclear Safety, 2012). New Zealand collected 1.25 and 1.42 million USD for 2010 (6 months) and 2011, respectively, from its fixed price compliance option of 10.8 USD per tonne of CO_2 (15 NZD) (New Zealand Ministry for the Environment, 2012).

Several eastern European countries (Estonia, Czech Republic, Poland, and Russia) sell surplus AAUs to generate 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).[16] Revenue rose from 276 million USD in 2008 (2008 USD) to 2 billion USD in 2009 (2009 USD) and then declined to less than 1.1 billion USD in 2010 (2010 USD) (Kossoy and Ambrosi, 2010; Linacre et al., 2011; Tuerk et al., 2013). Buchner at al. (2011, 2012) estimate the revenue at 580 and 240 million USD for 2010 and 2011, respectively (2010 and 2011 USD).

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10 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. The information is compiled by the UNFCCC Secretariat from Annex II national communications. The figures represent 'as committed' or 'as spent' currency over the 6 years. The procedures used by different countries and the Secretariat to convert currencies into USD are not known.

11 Although COP took note of the ´fast start finance' (FSF) commitment in paragraph 95 of Decision 1/CP.16 (UNFCCC, 2010) and the funds committed have been reported annually to the UNFCCC, the FSF is not formally climate finance under the UNFCCC.

12 Currently the only international levy is the 2 % of the CERs issued for most CDM projects provided to the Adaptation Fund. The Fund sells the CERs and uses the proceeds for adaptation projects in developing countries. Sale of CERs generated revenue of over 90 million USD for FY 2010 (2010/2011 USD) and over 50 million USD for FY 2011 (World Bank, 2012a). In December 2012 Parties agreed to extend the share of proceeds levy to the issuance of emission reduction unit (ERUs) and the first international transfers of AAUs (UNFCCC, 2012a, para. 21).

13 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.

14 Revenue from taxes explicitly named carbon taxes in the OECD database of environmentally related taxes, available at http://www2.oecd.org/ecoinst/queries/index.htm.

15 In India, the carbon tax is on coal only.

16 The Green Investment Schemes are a source of climate finance for these countries.

16.2.1.3 Recent developments

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

The **financial crisis** in late 2008 reduced investment in renewable energy (Hamilton and Justice, 2009). In late 2008 and early 2009, investment in renewable generation fell disproportionately more 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 (Frankfurt School-UNEP Centre and BNEF, 2012).

In response to the financial crisis, Group of Twenty Finance Ministers (G20) governments implemented **economic stimulus packages** amounting to 2.6 trillion USD. Of that amount, 180 to 242 billion USD was low-carbon funding (2008 and 2009 USD) (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 sector deficits scaled down green spending when the economy started recovering (Eyraud et al., 2011).

At the UNFCCC in Copenhagen in 2009, developed countries committed to provide new and additional resources approaching 30 billion USD of **FSF** to support mitigation and adaptation action in developing countries during 2010–2012 (UNFCCC, 2009a). The sum of the announced commitments exceeds 33 billion USD (UNFCCC, 2011b, 2012b; c, 2013a)[17]. Japan, United States, United Kingdom, Norway, and Germany being the five biggest donors have reported commitments amounting to 27 billion USD (2010/2011/2012 USD). Nakooda et al. (2013) finds that around 45 % have been provided as grants and around 47 % in the form of loans, guarantees, and insurance. Approximately 61 % of the funds had been committed for mitigation, 10 % for REDD+, ,18 % for adaptation, 9 % for multiple objectives and for 2 % of the funding the purpose is unknown. The funders reported commitments to recipient country governments via bilateral channels (33 %), multilateral climate funds (20 %), recipient countries companies (12 %), and multilateral institutions (9 %). Data on actual disbursements is not available to date because of the multi-year time lag between commitment and disbursement.

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'. Criteria have been proposed that indicate, when applied to the pledges, that proportions ranging from virtually none to almost all are new and additional (Brown et al., 2010; Stadelmann et al., 2010, 2011b). For Germany, Japan, the United Kingdom, and the United States annual FSF contributions were significantly higher than the 2009 expenditure related to climate activities in developing countries (Nakooda et al., 2013).

16.2.2 Future low-carbon investment

As noted in Chapter 6, the stabilization of GHG concentrations 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 will require significant shifts in global investment in the energy, land use, transportation, and infrastructure sector. The future investment flows summarized in this section are based on several large-scale analyses conducted over the past few years. For the most part these analyses explore scenarios to achieve specified temperature or concentration goals. Hence, 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.

Figure 16.2 presents estimates of baseline, i.e., current 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 global total annual investment at about USD_{2010} 1200 billion and very strong roles for investments in fossil fuel extraction, transmission and distribution (T&D), and electricity generation.

16.2.2.1 Investment needs

While a large number of studies and many modelling comparison exercises have assessed technological transformation pathways and the macroeconomic costs of transforming the global economy, only a handful of studies estimate the associated investment needs. Section 16.2.2.2 summarizes available estimates of investment needs under climate policy between 2010–2029 and 2030–2049, for the world as a whole and for non-OECD and OECD countries. Models and scenarios differ so the focus is on incremental investment, i.e., the differences in the estimated investment between the reference and mitigation scenarios.[18] It must also be noted that the model estimates crucially rely on assumptions about the future costs of technologies and of subsidies, on the possibility of nuclear phaseout in some countries, and on the mitigation policies already included in the reference scenarios.

Without climate policy, investments in the power sector would mainly be directed towards fossil fuels, especially in non-OECD countries that rely on low-cost coal power plants to supply their growing

[17] The information is compiled by the UNFCCC Secretariat from national reports on FSF. The figures represent 'as committed' currency over the three years. The procedures used by different countries and the Secretariat to convert currencies into USD are not known.

[18] Adaptation costs and economic losses from future climate change are not considered in any of these estimates.

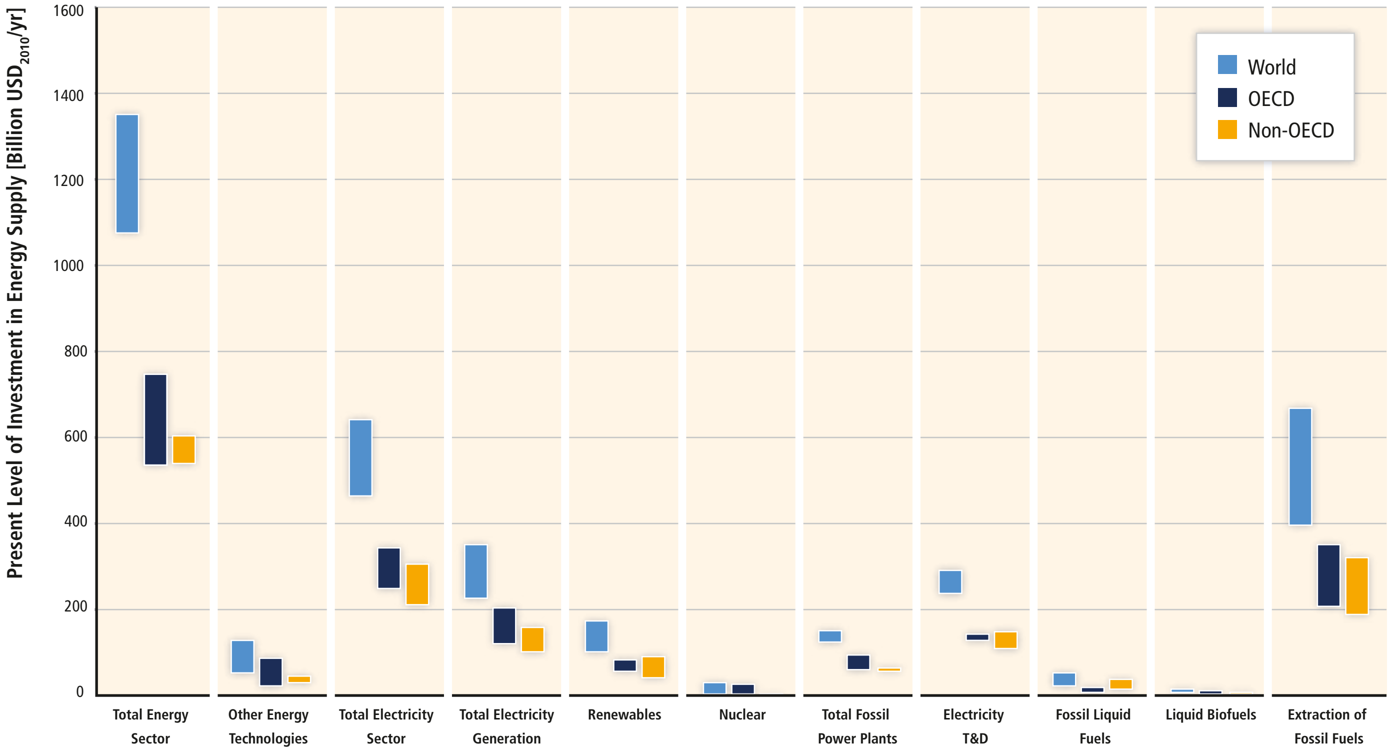

Figure 16.2 | Present level of investment in energy supply. Note: The bars indicate the minimum and maximum level of investments found in the literature. Ranges result from different sources of market information and differing definitions of the investment components to be included. Source: From McCollum et al. (2013) based on data from IEA World Energy Outlook 2011 (IEA, 2011) and GEA (Riahi et al., 2012).

demand for electricity. At the global level, fossil fuel-based power generation would require an average annual investment of 182 (95 to 234) billion USD in 2010–2029 and 287 (158 to 364) billion USD in 2030–2049;[19] the bulk of investments (roughly 80 %) goes to non-OECD countries.[20] There is greater uncertainty in models about the future of renewable and nuclear power without climate policy. Modelled global investment in renewable power generation is expected to increase over time from 123 (31 to 180) billion USD per year in 2010–2029 to 233 (131 to 336) billion USD over 2030–2049. Nuclear power generation would attract 55 (11 to 131) billion USD annually in 2010–2029 and 90 (0 to 155) billion USD per year in 2030–2049.

The **introduction of an emission reduction target** in the models abruptly changes the investment pattern. Figures 16.3 and 16.4 report the investment change for major power generation technologies, fossil fuel extraction, and for end-use energy efficiency, for emission scenarios compatible with a long-term target of keeping mean global temperature increase below 2 °C in 2100.[21] Although the policy targets are not identical, they are close enough to allow a broad comparison of results. The dispersion across estimated emission reductions over 2010–2029 and 2010–2049 is mainly due to differences in reference scenario emissions and because models choose different optimal emission trajectories among the many compatible with the long-term climate goal.

The results of an analysis of investment estimates in Figures 16.3 and 16.4 show that climate policy is expected to induce a major reallocation of investments in the power sector. Investments in fossil-fired power plants (without CCS) were equal to about 137 billion USD per year in 2010. Investment would decline by 30 (2 to 166) billion USD per year (about –20 % for the median) during the period 2010–2029, compared to the reference scenarios. Investment in low-emissions generation technologies (renewable, nuclear, and electricity generation with CCS) would increase by 147 (31 to 360) billion USD per year (about 100 % for the median) during the same period.

Based on a limited number of studies (McKinsey, 2009; IEA, 2011; Riahi et al., 2012), annual incremental investments until 2030 in energy-efficiency investments in the building, transport, and industry sector increase by 336 (1 to 641) billion USD. The only three studies with sectoral detail in end-use technologies show an increase of investments of 153 (57 to 228) billion USD for the building sector, 198 (98 to 344) billion USD for the transport sector, 80 (40 to 131) billion USD for the

19 The mean should not be considered as an expected value. It is not possible to attribute any probability distribution to models' outcomes. Therefore policymakers face pure uncertainty in face of future investment needs. The range is presented to provide information on the degree of uncertainty in the literature.

20 See captions of Figures 16.3 and 16.4 for a list of the studies surveyed.

21 Also in this case, the mean and median are used as synthetic indicators having no predictive power.

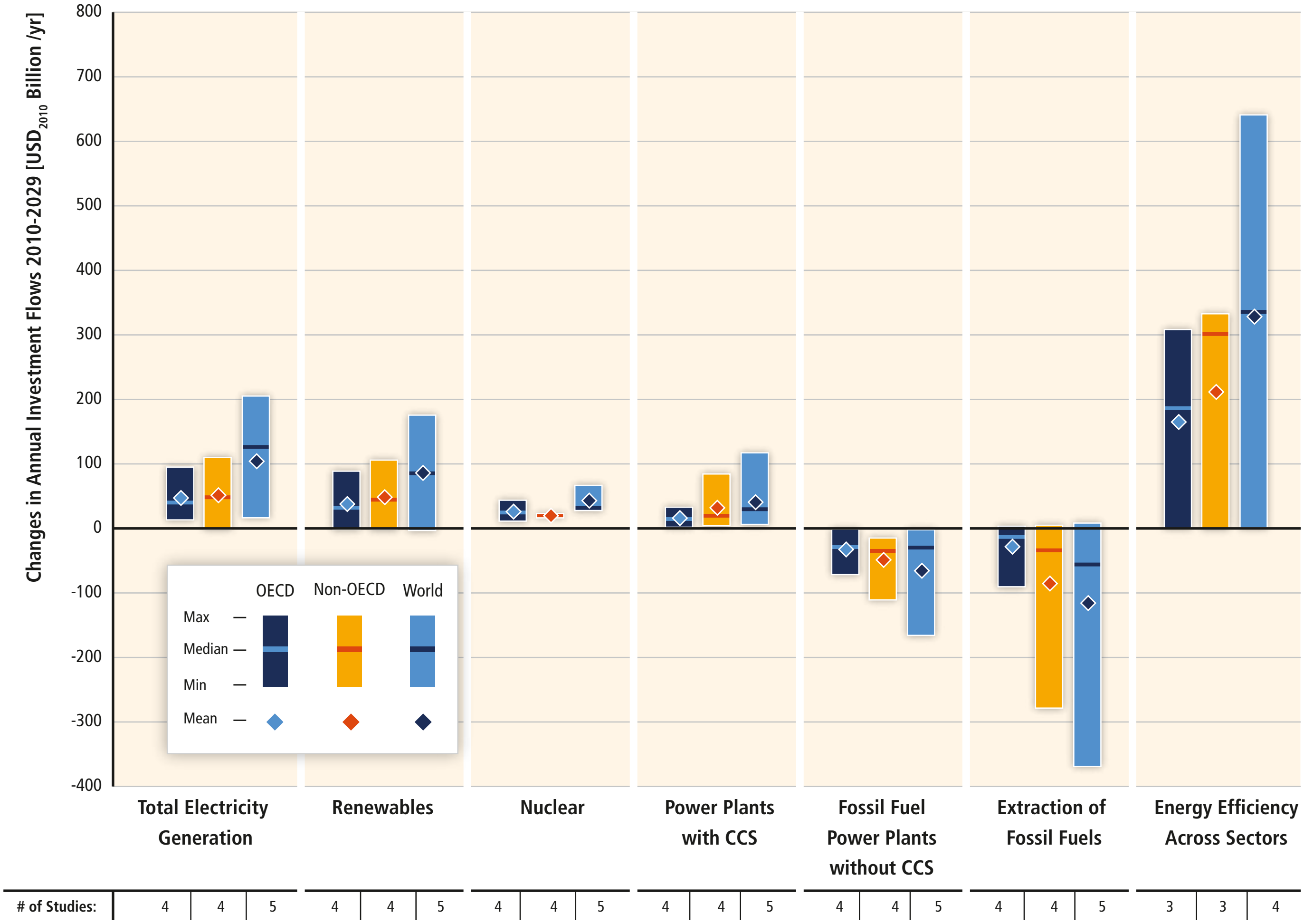

Figure 16.3 | Change of average annual investment in mitigation scenarios (2010–2029). Investment changes are calculated by a limited number of model studies and model comparisons for mitigation scenarios that stabilize concentrations within the range of 430–530 ppm CO_2eq by 2100 compared to respective average baseline investments. Note: The vertical bars indicate the range between minimum and maximum estimate of investment changes; the horizontal bar indicates the median of model results. Proximity to this median value does not imply higher likelihood because of the different degree of aggregation of model results, low number of studies available, and different assumptions in the different studies considered. The numbers in the bottom row show the total number of studies available in the literature. Sources: UNFCCC (2008). IEA (2011): 450 Scenario (450) relative to the Constant Policies Scenario (CPS). The CPS investment in CCS is also included under Coal and Gas (retrofitting); World investment in biofuels includes international bunkers; investment in solar photovoltaic (PV) in buildings is attributed to power plants in supply-side investment. Riahi et al. (2012): the Global Energy Assessment Mix scenario (GEA-Mix) relative to the GEA reference scenario. Carraro et al. (2012): 460 ppm CO_2eq in 2100 (t460) relative to reference scenario. McCollum et al. (2013): the Low Climate Impact Scenarios and Implications of Required Tight Emission Control Strategies (LIMITS), RefPol-450 scenario (2.8 W/m^2 in 2100) relative to the reference scenarios, mean of six models. McKinsey (2009): data obtained from Climate Desk, S2015 scenario with full technological potential, 100 % success rate, negative lever of costs, beginning of policy in 2015 | Regions: OECD, non-OECD, and World.

industry sector. Incremental investments in end-use technologies are particularly hard to estimate and the number of studies is limited (Riahi et al., 2012). Results should therefore be taken with caution.

While models tend to agree on the relative importance of investments in fossil and non-fossil power generation, they differ with respect to the mix of low-emission power generation technologies and the overall incremental investment. This is mainly due to different reference scenarios (e.g., population, economic growth, exogenous technological progress), and assumptions about (1) the structure of the energy system and the costs of reducing the energy intensity of the economy versus reducing the carbon intensity of energy, (2) the investment costs of alternative technologies over time, and (3) technological or political constraints on technologies. Limits to the deployment of some key technology options or the presence of policy constraints (e.g., delayed action, limited geographical participation) would increase investment needs (Riahi et al., 2012; McCollum et al., 2013).

Higher energy efficiency, technological innovation in transport, and the shift to low-emission generation technologies—all contribute to a drastic reduction in the demand for fossil fuels, thus causing a sharp decline in investment in fossil fuel extraction, transformation, and transportation. Scenarios from a limited number of models suggest that average annual investment reduction in 2010–2029 would be equal to 56 (–8 to 369) billion USD. The contraction would be sharper in 2030–2049, in the order of 451 (332 to 1385) billion USD per year.

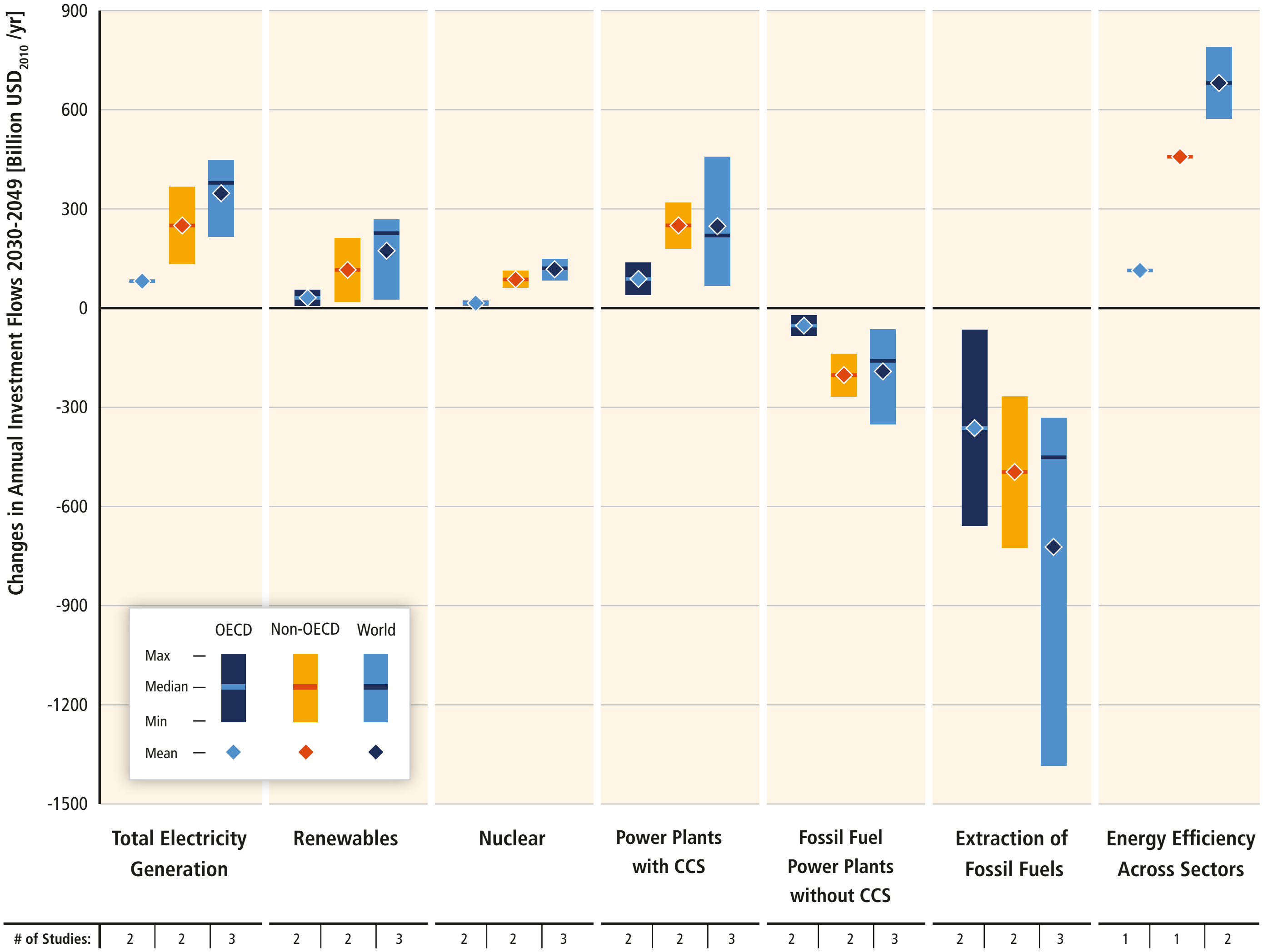

Figure 16.4 | Change of average annual investment in mitigation scenarios (2030–2049). Investment changes are calculated by a limited number of model studies and model comparisons for mitigation scenarios that stabilize concentrations within the range of 430–530 ppm CO_2eq by 2100 compared to respective average baseline investments. Note: The vertical bars indicate the range between minimum and maximum estimate of investment changes; the horizontal bar indicates the median of model results. Proximity to this median value does not imply higher likelihood because of the different degree of aggregation of model results, low number of studies available, and different assumptions in the different studies considered. The numbers in the bottom row show the total number of studies available in the literature. Sources: Riahi et al. (2012): the Global Energy Assessment Mix scenario (GEA-Mix) relative to the GEA reference scenario. Carraro et al. (2012): 460 ppm CO_2eq in 2100 (t460) relative to reference scenario. McCollum et al. (2013): the Low Climate Impact Scenarios and Implications of Required Tight Emission Control Strategies (LIMITS), RefPol-450 scenario (2.8 W/m^2 in 2100) relative to the reference scenarios, mean of six models. Regions: OECD, non-OECD, and World.

All models that provide data on investments for fossil fuel extraction show that overall investments in energy supply would decrease against the baseline trends in scenarios consistent with the 2 °C limit (IEA, 2011; Carraro et al., 2012; Riahi et al., 2012; McCollum et al., 2013).

According to a range of models, climate policy would thus substantially change the allocation of baseline energy investments rather than increase overall demand for energy investment.

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 research and development (R&D) to increase end-use energy efficiency and to improve low-emission generation energy carriers and energy transformation technologies. Estimates of the additional funding needed for energy-related R&D range from 4.5 to 78 billion USD per year during 2010–2029 (UNFCCC, 2007; Carraro et al., 2012; McCollum et al., 2013) and from 115 to 126 billion USD per year in 2030–2049 (Carraro et al., 2012; Marangoni and Tavoni, 2013; McCollum et al., 2013). Because of the need for new low-carbon alternatives, investments in R&D are higher in case of nuclear phaseout and other technological constraints (Bosetti et al., 2011).

Land-use is the second largest source of GHG emissions and within land use, tropical deforestation is by far the largest source (see Chapters 5 and 11). Efforts to stabilize atmospheric concentrations of GHGs will require investments in land use change (LUC) 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.[22] The models' results suggest substantial emission reductions can be achieved. The models estimate that 1.6 to 4.3 $GtCO_2$ per year could be reduced for 20 USD tCO_2 with the greatest reductions coming from Africa followed by Central and South America and Southeast Asia. They also use the models to estimate the costs to reduce deforestation by between 10 % and 50 % of the baseline. Deforestation could be reduced by 10 % (0.3–0.6 $GtCO_2$ per year) over the 25-year period for an investment of 0.5 to 2.1 billion USD per year in forest preservation activities, and a 50 % reduction (1.5–2.7 $GtCO_2$ per year) could be achieved for an investment of 21.2 to 34.9 billion USD per year. This is comparable to what has been found by UNFCCC (2008) and McCollum et al. (2013).

Investment needs in other sectors commonly relate to energy-efficiency measures included above. Information on global or regional investment needs to abate process emissions or non-CO_2 emissions in sectors like the waste, petroleum, gas, cement, or the chemical industry is virtually unavailable. For instance, McKinsey (2009) does not provide information that could be separated from energy-efficiency measures in the sectors. An indicative estimate for the waste sector can be derived from Pfaff-Simoneit (2012) suggesting investment needs of approximately 10–20 billon USD per year if access to a modern waste management system were to be provided for an additional 100 million people per year.

16.2.2.2 Incremental costs

Incremental costs can be calculated for an individual project, a programme, a sector, a country, or the world as a whole. The incremental costs reflect the incremental investment and the change of operating and maintenance costs for a mitigation or adaptation project in comparison to a reference project. It can be calculated as the difference of the net present values of the two projects. Estimates of the incremental costs of mitigation measures for key sectors or the entire economy have been prepared for over 20 developing countries (Olbrisch et al., 2011). When estimates of both the incremental costs and the incremental investment are available, the former is generally lower because of the annualization of incremental investments for the calculation of incremental costs.

From an economic perspective, macroeconomic incremental costs can be defined as the lost gross domestic product (GDP). This measure provides an aggregate cost of the mitigation actions (estimates provided in Chapter 6), but it does not provide information on the specific micro-economic investments that must be made and costs incurred to meet the mitigation commitments. This distinction is important if international climate finance commitments will be implemented through institutions designed to provide financial support for specific investments and costs rather than macro-level compensation.

Other than on the project-level, investment needs are thus frequently only a fraction of incremental costs on the level of the macro-economy. This difference is largely due to reduced growth of carbon-constrained economies in many models. Adaptation costs and economic losses from future climate change, which are not considered in these estimates, should be lower for climate policy scenarios than in the reference scenario.

16.2.3 Raising public funding by developed countries for climate finance in developing countries

Comparison of the model estimates of future mitigation investment (Section 16.2.2) with the current level of global total climate finance (Section 16.2.1.1) indicates that global climate finance needs to be scaled up. Increased financial support by developed countries for mitigation (and adaptation) in developing countries will be needed to stimulate the increased investment. This section reviews possible sources of additional funds that could be implemented by developed country governments to finance mitigation in developing countries.

In December 2009, developed countries committed to a goal of mobilizing jointly 100 billion USD a year by 2020 to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation. This funding will come from a wide variety of sources, public and private, bilateral and multilateral, including alternative sources of finance (UNFCCC, 2009a).[23] This goal has been recognized by the COP (UNFCCC, 2010, para. 98). This recognition does not change the commitments of Annex II Parties specified in Article 4 of the Convention to provide financial resources for climate-related costs incurred by developing countries.

Studies by the High-level Advisory Group on Climate Change Financing (AGF) (AGF, 2010) and the World Bank Group et al. (2011) at the request of G20 finance ministers have analyzed options for mobilizing 100 billion USD per year by 2020. The AGF concluded that it is challenging but feasible to reach the goal of mobilizing 100 billion USD

[22] 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).

[23] There is currently no definition of which 'climate' activities count toward the 100 billion USD, what 'mobilizing' means, or even which countries are covered by this commitment (Caruso and Ellis, 2013).

Table 16.1 | Summary of potential sources of public funds for climate finance in 2020.

Option	Projected amount generated in 2020 (billion USD_{2010}/year)	Share assumed to be dedicated to international climate finance
1) Options that contribute to developed country national budgets, dependent on national decisions		
Domestic auctioned allowances	AGF: 125–250[b]; G20: 250	AGF: 2–10 %; G20: 10 %
Domestic carbon tax[c]	AGF: 250	AGF: 4 %
Phase out of fossil fuel subsidies	AGF: 8; G20: 40–60	AGF: 100 %; G20: 15–25 %
Higher fossil fuel royalties	AGF: 10	AGF: 100 %
Wires charge on electricity generation	AGF: 5	AGF: 100 %
2) Options that contribute to national budgets, dependent on international agreements		
Border carbon cost levelling	Grubb 2011: 5*	
Financial transactions tax	AGF: 2–27	AGF: 25–50 %
3) Funds collected internationally pursuant to an international agreement		
Extension of the 'share of proceeds'	AGF: 38–50	AGF: 2–10 %
Auctioning a portion of AAUs	AGF: 125–250 [b]	AGF: 2–10 %
Carbon pricing for international aviation***,[a]	UNFCCC: 10–25**; AGF: 6; G20: 13	AGF: 25–50 %; G20: 33–50 %
Carbon pricing for international shipping***,[a]	UNFCCC: 10–15**; AGF: 16–19; G20: 26	AGF: 25–50 %; G20: 33–50 %

Notes: AGF, G20, and UNFCCC refer to estimates from AGF (2010), World Bank Group et al. (2011) and UNFCCC (2007), respectively.* = Date not specified; ** = 2006 USD; *** Could fall into category 2 depending upon the method of implementation; [a] The AGF and G20 estimates for international aviation and international shipping assume that a substantial fraction (30 to 50 %) of the global revenue is allocated to developing countries. [b] The AGF combines auctioned AAUs and auctioned domestic allowances, here half of the total is included in each category; [c] The AGF estimates revenue of 10 billion USD per 1 USD tax per tonne of CO_2, that is equivalent to potential revenue of 250 billion USD and a 4 % share for international climate finance as reported here. Sources: Compiled from AGF (2010), World Bank Group et al. (2011), UNFCCC (2007), and Grubb (2011).

annually for climate actions in developing countries. Both reports conclude that a mix of sources is likely to be required to reach the goal.

Both reports estimate the revenue that could be mobilized in 2020 by various options to finance climate action in developing countries in the context of a carbon price of 25 USD per tonne of CO_2eq in Annex II countries. The feasibility of the options was not assessed. For some options, only a fraction of the revenue was assumed to be available for international climate finance. Their estimates of the international climate finance that could be generated by each option, together with other estimates, where available, are summarized in Table 16.1. Only options to mobilize public funds and that yield mitigation benefits are included in the table; options for increased borrowing by multilateral institutions and mobilizing more private finance are excluded.

Virtually all of the options put a price on GHG emissions thus providing a mitigation benefit in addition to generating revenue. The options are grouped into the following categories (Haites and Mwape, 2013):

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

Funds mobilized by options in the first two categories flow into national budgets, so the amount allocated for international climate finance depends on national decisions. In contrast, funds mobilized by options in the third category go directly to an international fund.

The AGF and G20 reports assume for many options that only small fraction of the total revenue mobilized is dedicated to international climate finance. Hence, these options would mobilize revenue to meet the international climate finance goal and at the same time mobilize substantial revenue for domestic use by Annex II governments. The domestic share of the revenue could be used by Annex II treasuries to reduce deficits and debt, or to reduce existing distortionary taxes and so help stimulate economic growth.

Global modelling estimates

Using integrated models, it is possible to estimate the potential carbon revenues when all emissions are taxed or all permits are auctioned. These estimates reflect 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 revenue forecasts.

From the analysis of scenarios already presented in this chapter (Carraro et al., 2012; 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 up to 200 billion USD each in China, the European Union and the United States in 2030. At the global level, they could top 1600 billion USD in 2030.

Carbon revenues may peak in the mid-term and decline in the long-term, as decreasing emissions (the tax base) more than offset the increase in the carbon price (Carraro et al., 2012). In regions with lower marginal abatement costs, the tax base shrinks faster so carbon revenues fall faster. Fast-growing regions may see growing carbon revenues for several decades more.

Scenarios and/or regions in which absorption of emissions—e.g., by means of bioenergy with CCS—plays an important role may exhibit net negative emissions. This implies net reduction of carbon revenues so governments must finance net negative emissions using either the general budget or international funding (Carraro et al., 2012).

16.3 Enabling environments

This section highlights the importance of a supportive enabling environment in facilitating low-carbon investments. The concept of enabling environment is not clearly defined, so it has many different interpretations. One is government policies that focus on "creating and maintaining an overall macroeconomic environment" (UNCTAD, 1998).[24] Another (Bolger, 2000), interprets an 'enabling environment' as the wider context within which development processes take place, i.e., the role of societal norms, rules, regulations, and systems. This environment may either be supportive (enabling) or constraining.

According to Stadelmann and Michaelowa (2011), capacity building and enabling environment are separate but interrelated concepts. Capacity building targets knowledge and skills gaps, while the enabling environment for low-carbon business activities is "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, the enabling environment has three main components: (1) the core business environment, which is relevant for all types of businesses, e.g., tax regime, labour market, and ease of starting and operating 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 encourage the business sector to invest in low-carbon technologies.

Capacity building can also be seen as a subcomponent of an enabling environment (UNFCCC, 2009b) as it aims to improve the enabling environment by overcoming market, human, and institutional capacity barriers. Support for capacity building can increase the probability that the recipient country will succeed in implementing mitigation policies, and hence may reduce the total funding needed (Urpelainen, 2010).

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

Reliability and predictability are important elements of an enabling environment. While stable and predictable government policies reduce uncertainty about expected return on investment, frequent and unpredictable changes to policies can undermine market efficiency (Blyth et al., 2007; Brunner et al., 2012). Predictability and stability require well-established legal institutions and rule of law. Institutional capacity across sectors and at various levels is also important (Brinkerhoff, 2004).

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, macro-economic factors and policy regulatory frameworks that are good for private investment as a whole are also important determinants of climate investment. Put differently, obstacles that impede private investment also hamper investment in low-carbon technologies. More elements related to the drivers of low-carbon investments, which are part of enabling environments, are found in the next sub-section.

16.4 Financing low-carbon investments, opportunities, and key drivers

Financing mitigation projects is, in principle, similar to financing any other investment. This section provides an overview of factors that attract private capital for low-carbon investments. First, different categories of capital managers and their key investment criteria are introduced. Next, challenges that hamper investors, such as investment risks and access to capital, are assessed. Finally, selected financial instruments used in low-carbon transactions are presented and discussed.

16.4.1 Capital managers and investment decisions

Mitigation measures often are financed through investments by several different capital managers (see Figure 16.1). It is crucial to understand the basic investment logic and the preferred financial instruments of each type of capital manager.[25] Box 16.2 characterizes some of the major types of capital managers.

Risk and return are crucial decision factors in any investment finance decision, including low-carbon activities. The higher the perceived risk,

[25] 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).

Box 16.2 | Types of capital managers relevant for investment and finance in low-carbon activities

Governments commit to mitigation measures to comply with international agreements and self-imposed targets. Their role as capital managers is limited to mitigation measures where they invest directly. In 2011 and 2012, the public sector provided on average 135 billion USD per year (2011/2012 USD) of public funding for climate finance, thereof 12 billion USD provided directly by government bodies[1] (Buchner et al., 2013b).

Public financial institutions include national, bilateral, multilateral, and regional finance institutions, as well as UN agencies and national cooperation agencies. These institutions invested 121 billion USD in mitigation and adaptation measures in 2012 (2012 USD), more than 50 % was provided as concessional loans (Buchner et al., 2013b).

Commercial financial institutions, such as banks, pension funds, life insurance companies, and other funds, manage over 71 trillion USD in assets. 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 institutional investors to invest in mitigation measures depends on their 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). Their contribution was estimated at 22 billion USD in 2012 (2012 USD) (Buchner et al., 2013b).

Energy corporations including power and gas utilities, independent power producers, energy companies, and independent project developers can design, commission, and operate renewable energy projects. They provided approximately 102 billion USD (2012 USD) for climate finance in 2012 (Buchner et al., 2013b).

Non-energy corporations invest in mitigation measures to reduce their energy bills, meet voluntary commitments or comply with emission trading schemes. Altogether, they provided around 66 billion USD in 2012 for low-carbon investment (2012 USD) (Buchner et al., 2013b).

Households' investments are funded by income and savings supplemented by loans. In 2012, households provided around 33 billion USD for climate finance projects; 83 % of households' contributions were in developed countries, especially in Germany, Japan, and Italy (Buchner et al., 2013b).

[1] This estimate excludes financing by public financial institutions and by dedicated climate fund, the latter providing approximately 1.6 billion USD (2012 USD) in 2012 (Buchner et al., 2013b).

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).

Equity and debt are basically the two basic types of finance. Both come at a certain cost, which is very sensitive to risk, i. e., risk premium or risk margin. The type of finance required depends on the type of activity, its development phase, and its application.

Project finance is usually the preferred financing approach for infrastructure or energy projects worth more than 21.4 million USD (UNEP, 2005). In this financing structure, debt and equity are paid back exclusively from the cash flows generated by the project and there is no recourse to the balance sheet (also call non-recourse finance); as opposed to balance-sheet financing, where all '*on-balance sheet*' assets can be used as collateral. In 2012, around 70 billion USD of project-level market rate debt went towards emission reduction (70 % provided by the public sector). Project-level equity was estimated at approximately 11 billion USD. However, the largest share of mitigation , 198 billion USD, consisted of balance-sheet financing (2012 USD) (Buchner et al., 2013b).

Risk profile, tenor (i. e., loan duration) and **size** are the primary criteria to characterize the financing demand. 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. For renewable energy projects, higher cost 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 industrialized 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 Section 16.4.2.2).

16.4.2 Challenges for low-carbon investment

Factors that reduce the relative attractiveness of implementing a low-carbon technology shall be considered as a challenge. Many factors pertaining to the general investment environment can have an enabling character or can act as a challenge (see Section 16.3). However, there are also low-carbon specific factors—especially in absence of a clear price signal for carbon emissions—that, 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, dependent upon the investor and the type of activity. For instance, each group is 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. In addition, energy savings are intangible as collateral (Hamilton and Justice, 2009; Ryan et al., 2012; Venugopal and Srivastava, 2012).

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 macro-economic risks (e.g., currency risk, financial risks, etc.). In some developing countries, political and macro-economic risks represent a high barrier to investment (Ward et al., 2009; World Bank, 2011a; Venugopal and Srivastava, 2012).

There are also types of risks characteristic for low-carbon investments: **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; Frisari et al., 2013). 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 Section 16.4.2.2). Some low-carbon activities also tend to depend on an expected future development, e.g., steep learning curves for certain technologies. Operational risks include the credit quality of the counterparties, off-take agreements, especially in a scenario where the mitigation technology has a higher costs of production, supply chain scalability, unreliable support infrastructure, and maintenance costs (Jamison, 2010; Venugopal and Srivastava, 2012).

Moreover, risks may be overestimated due to limited information in markets that are undergoing a technological and structural transition (Sonntag-O'Brien and Usher, 2006) and the longer time frame used to assess the risk increases uncertainty. A lack of quantitative analytical methodologies for risk management may add to the perceived risk.

Return on investment: The basic challenge is to find a financing package that provides the debt and equity investors with a reasonable return on their investment given the perceived risks. 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 around 3 to 7% above the London Interbank Offered Rate (LIBOR) reference interest rate, for renewable energy projects in industrialized countries. Venture capitalists, angel investors, and some foundations (through so-called programme-related investments) are situated on the other side of the financing continuum. They typically invest in new companies and technologies, and are willing to take higher risks while expecting commensurately larger returns. These investors may require an 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% (Hamilton and Justice, 2009). However, these typical IRRs 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.

Cost of capital and 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), e.g., to match the maturity of assets and liabilities.

Attracting sufficient equity is often critical for low-carbon activities, especially for renewable energy 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, R&D, or multiplication of a project approach (UNEP, 2005).

Market and project size: Since the pre-investment costs vary disproportionally with the project size, smaller low-carbon projects incur much higher transaction costs than larger ones of conventional energy projects (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 low-carbon projects in developing countries seeking less than 10 million USD of debt are generally not attractive to an international commercial bank. Due to the higher transaction costs, small 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 low-carbon projects. Hence, institutional investors, whose major asset class is bonds, lack opportunities to invest in low-carbon energy projects because they do not issue bonds or the issuance size is too small (Hamilton and Justice, 2009; Kaminker and Stewart, 2012). The minimum issuance size for investment grade bonds tends to be about 460 million USD, so few projects can achieve this standard (Veys, 2010). Many renewable energy projects need investment in the range of 70–700 million USD, with only a few big ones towards the upper end (Hamilton and Justice, 2009). In 2011, clean energy bonds amounted to only about 0.2 % of the global bond market (Kaminker and Stewart, 2012).

Tenor-risk combination: 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 macro-economic instability in developing countries, investors are particularly reluctant to invest in projects with such a long investment horizon. Although 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 inhibit them from investing in long-term low-carbon assets (Kaminker and Stewart, 2012). Industrial firms also face constraints with extended payback periods, since they typically operate with a short-term horizon that requires rapid positive returns on investment (Della Croce et al., 2011). A significant positive consideration, however, is that low-carbon projects like waste heat, geothermal, wind, and solar have zero or negligible fuel price volatility risk.

Human resources and institutional capacity: The lack of technical and business capabilities at the firm, financial intermediary and regulatory level are significant barriers to harness low-carbon technologies, especially in many developing economies (Ölz and Beerepoot, 2010). In countries where private sector actors do not only own the low-carbon technology but are also predominately responsible for the diffusion of technologies in the market, capacity building efforts need to focus on these actors' ability to develop, fund, and deploy the respective technologies (Lall, 2002; Figueiredo, 2003; Mitchell et al., 2011).

16.4.3 Financial instruments

Policy instruments to incentivize mitigation activities are assessed in depth in Chapters 13, 14, and 15. Evidently a missing price signal for carbon emissions is a major obstacle for low-carbon investments. But not only in absence of such a price signal, other important measures can be applied to reduce critical barriers for low-carbon investment. Basic financial instruments are illustrated in Figure 16.1 and introduced in Section 16.4.1. This subsection focuses on three types of financial instruments with the following purposes: reducing risk, reducing the cost of capital, and providing access to capital, as well as enhancing cash-flows. Figure 16.5 illustrates in a simplified manner how these instruments can enhance market competitiveness of low-carbon projects. There is a growing literature on how the public sector can use these instruments to mobilize additional private finance, and can help to improve the risk-return profile of investments for low-carbon activities.

16.4.3.1 Reducing 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

Figure 16.5 | Instruments to enhance market competitiveness of low-carbon projects.

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).

There is a wide portfolio of proven commercial- and government-supported risk mitigation products that can be instrumental in efficiently expanding low-carbon investment. Their allocation and application requires a substantial level of expertise, experience, and resources available in specialized insurance companies, export credit agencies, and selected commercial and development banks. Examples of such products are highlighted below. They signal the potential for expanded use of risk mitigation instruments to support low-carbon investment (Frisari et al., 2013).

Credit enhancements/guarantees, such as commercial credit insurance and government guarantees, usually cover part of the loan and reduce the loss incurred by a lender if the borrower is unable to repay a loan. The lender must still evaluate the creditworthiness and conditions of the loan, but these instruments can reduce the interest rate and improve the terms, thereby expanding the available credit or reducing the costs (Stadelmann et al., 2011a).

Trade credit insurance 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). Such insurance is provided by commercial insurance companies and by governments to their manufacturers, exporters, or financiers.

Production and savings guarantees are typically provided to their clients by energy service companies (ESCOs) and large energy performance contracting (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 can be used if currency fluctuations are particularly risky for a project or company because a major investment is made in foreign currency and revenues are in local currency. Loans in local currency or risk management swaps to hedge foreign currency liability back into respective local currency can be provided by development finance institutions (IFC, 2013; TCX, 2013a). Structured funds like the Currency Exchange Fund (TCX) are dedicated to hedge these cross-border currency and interest rate mismatches (TCX, 2013b).

By the end of 2012, the 20 largest emitting developed and developing countries with lower risk country grades for private sector investments were producing 70 % of global energy-related CO_2 emissions (Harnisch and Enting, 2013). In investment-grade countries, risk mitigation instruments and access to long-term finance can be provided at reasonably low costs, and have the potential to mobilize substantial additional private sector mitigation investments. In other countries, low-carbon investment would have to rely mainly on domestic sources or international public finance.

16.4.3.2 Reducing cost of and facilitating access to capital

In many situations, 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).

Concessional or 'soft' loans are repayable funds provided at terms more favourable than those prevailing on the market including lower interest rates, longer tenor, longer grace period, and reduced level of collateral. Providers of concessional loans are typically development banks on behalf of governments. In international cooperation, concessional loans of varying degree and type have been established as main financing instruments to support public sector entities and local banks by bilateral and multilateral development banks (Maclean et al., 2008; Birckenbach, 2010; UNEP, 2010, 2011, 2012). In 2011, bilateral finance institutions, for instance, disbursed 73 % of their mitigation finance as concessional loans (UNEP, 2012). National finance institutions provided around 87 % of their climate funding in 2010/2011 via soft loans (Buchner et al., 2012).

Grants are non-repayable funds provided to a recipient for a specific purpose by a government, public financial institution or charity. 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 for purchase of an eligible product. 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 increase the after-tax cash flow for a specific investment. Hence, they can have a similar effect as soft loans by reducing the net annual payments for the amortization 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 to be embedded 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 to support desirable activities. At the same time, limited expertise of the public sector in allocating capital in risky operations and in management of companies, and problems arising from the relationships of owners and regulators, are frequently cited as reasons against a broad public engagement as equity investor. In support of emission mitigation activities, a number of approaches have been successfully demonstrated. 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 to avoid crowding-out of private investors and to use defined exit strategies (IFC, 2009).

16.4.3.3 Enhancing cash flow

Nationally agreed **feed-in tariffs** (FITs) or **third-party guaranteed renewable energy premiums** for individual power purchase agreements provide a secure long-term cash-flow to operators of renewable energy systems—based on technology, system size, and project location. Debt and equity for a project can hence be secured due to the long duration, the guaranteed off-take of the electricity generated, and the grid access. Consequently, FITs do not only increase and stabilize the return, but also reduce the risks for developers, lenders, and investors. As a result, the cost of capital and required rate of return can be reduced as well (Cory et al., 2009; Kubert and Sinclair, 2011). The FITs for renewable energy have been implemented in a broad range of industrialized 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 programme, but it is difficult to establish the appropriate level up front and to adapt it as the market evolves and the technology matures.

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 payment stream. This has made many financiers hesitant to provide debt finance for these 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; Asian Development Bank, 2012).

16.5 Institutional arrangements for mitigation financing

Institutions are essential to channel climate finance to mitigation and adaptation measures (Stadelmann, 2013) and to ensure that the actions funded respond to national needs and priorities in an efficient and effective way.[26] 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 effective climate investments. 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 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 and implement the funding in an orderly and efficient process.

Funds that are part of the financial mechanism of the UNFCCC are subject to guidance from the COP. Until recently, these included only the GEF Trust Fund, the SCCF and the LDCF, all of which are administered by the GEF (see Section 16.2.1.1) (UNFCCC, 2013b). In 2010, the COP decided to establish the GCF to be designated as a new operating entity of the Financial Mechanism (UNFCCC, 2010). The GCF, that is currently being operationalized, is expected to become the main global fund to support climate action in developing countries, but it has not yet been capitalized. In addition, the Adaptation Fund has been established under the Kyoto Protocol.

The UNFCCC recognizes that funding for mitigation may come from a variety of sources and through a variety of channels beyond the financial mechanism, such as multilateral and bilateral institutions engaged in official development assistance. There has been an expansion in the number of public and private climate funds in the last decade. The UNDP estimates that over the last decade some 50 international public funds, 45 carbon market funds, in addition to 6000 private equity funds (set up largely independent of international climate policy) have been established for the purpose of funding climate change-related activities (UNDP, 2011). Some of these, such as CIFs are multi-donor funds administered by the World Bank but with their own governance and

[26] 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 behaviour of individuals in society, e.g., the institutions of marriage or religion.

organizational structure. The CIFs were designed as an interim measure to demonstrate how scaled-up support can be provided and include a sunset clause linked to progress on the financial architecture under UNFCCC. They consist of two trust funds: the Clean Technology Fund (CTF), which promotes scaled-up financing for demonstration, deployment, and transfer of low-carbon technologies with significant potential for long-term GHG emissions savings, and the Strategic Climate Fund (SCF), under which are three separate initiatives for piloting transformational, scaled-up action on climate change (World Bank, 2011b; c). The pledges and contributions to the CIFs are recorded as ODA, and therefore constitute a multi-bilateral arrangement (World Bank, 2010).

The CDM and carbon funds are directly linked to emission. Prior to the decline of certificate prices, they played a central role in attracting climate investments. The CDM is one of three trading mechanisms created by the Kyoto Protocol that a developed country can use to help meet its national commitment. The CDM allows a developed country to use credits issued for emission reductions in developing countries. The other two mechanisms—Joint Implementation (JI) and International Emissions Trading (IET)—involve only developed countries with national commitments. The CDM is the largest of the mechanisms (UNFCCC, 2013c). Some of the carbon funds have been established by multilateral financial institutions. The World Bank established the first fund, the Prototype Carbon Fund, in 1999, and has since created several additional funds (World Bank, 2013).

There are several institutions promoting mitigation finance by private actors, which frequently combine financial power of up to several trillions. However, their scope of work differs considerably. Some of the major private sector institutions include inter alia the World Business Council on Sustainable Development (WBCSD) (WBCSD, 2013), the Climate Markets and Investment Association (CMIA) (CMIA, 2013), and the Global Investor Coalition on Climate Change (Global Investor Coalition on Climate Change, 2013).

Regional arrangements play an important role in fostering regional cooperation and stimulating action and funding. These regional institutions include the regional multilateral development banks and the regional economic commissions of the United Nations on the multilateral side.27 They are increasingly engaging in the promotion of mitigation and adaptation activities in their respective regions and establishing and helping to manage regional financing arrangements (Sharan, 2008). In the Asia and Pacific region, examples of regional financial arrangements to promote funding for mitigation activities include ADB´s Clean Energy Financing Partnership Facility, the Asia Pacific Carbon Fund, and the Future Carbon Fund. Other regional development banks have been equally active (Asian Development Bank, 2013a; b; c).

[27] 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), European Bank for Reconstruction, and Development (EBRD).

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

Bilateral cooperation arrangements are widely used by donor countries to provide funding to partner country governments and their implementing organizations. They frequently involve development banks and agencies with a proven track record in international cooperation. The three principal means to channel climate change funding bilaterally are (1) bilateral programmes for funding international cooperation in the energy, water, transport, or forestry, (2) dedicated funding windows established to target climate change funding open to a wider range of implementing institutions, and (3) new funds implemented by bilateral development institutions with their own governance structure. The OECD has established a framework for the implementation and reporting modalities that can be applied to all climate-relevant ODA and partially for other official flows (see OECD, (2013b) for agreed principles on statistics, effectiveness, evaluation, and the like). Officially supported export credits provided by export credit agencies on behalf of national governments are also covered by a respective OECD arrangement (OECD, 2013c).

Triangular cooperation arrangements are defined by the OECD as those involving a traditional donor, most likely a member of DAC, an emerging donor in the south (providers of South-South Cooperation), and the beneficiary countries or recipients of development aid (Fordelone, 2011). Although they have grown in number in recent years, triangular arrangements, and particularly those for climate change financing, are 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 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 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 programmes and activities that contribute to mitigation do not appear in the literature as institutions dedicated to support climate finance.

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. Institutional arrangements and mechanisms that are successful in mobilizing and leveraging private capital tend to be more cost-effective in climate change mitigation, but some projects with low private investments (e.g., projects reducing industrial GHGs or projects owned by state-owned enterprises) are also among the most cost-effective (Stadelmann, 2013). The institutions and public finance mechanisms are diverse, but all aim to help commercial financial institutions to do this job effectively and efficiently. Many of the institutions support specialized public finance mechanisms such as 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). National development banks play an important role in financing domestic climate projects in many countries especially by providing concessional funding (Smallridge et al., 2012; Höhne et al., 2012; IDFC, 2013).

Many developing countries, other than the larger ones, are trying to cope with the multiplicity of sources, agents and channels offering climate finance (Glemarec, 2011). These efforts take two forms.

One form is coordination of national efforts to address climate change by relevant government institutions. Very few developing countries have an institution fully dedicated to climate finance (Gomez-Echeverri, 2010). Rather, climate finance decisions involve multiple ministries and agencies often coordinated by the ministry of the environment. Involvement of ministries of foreign affairs and ministries of finance is becoming more common due to their engagement in international negotiations and the promise of increased resources under UNFCCC.

The second form is the establishment of specialized national funding entities designed specifically to mainstream climate change activities in overall development strategies. These institutions blend international climate funding with domestic public funds and private sector resources (Flynn, 2011). Table 16.2 lists examples of national funding entities. A common feature is the desire to allocate resources for activities that are fully mainstreamed to the national needs and priorities. To do this, the national funding entities seek to tap the numerous international sources of climate finance and supplement them with domestic resources. They are also expected to develop the governance and capacity requirements for 'direct access' to funds from the Adaptation Fund and the GCF.[28]

[28] Direct access means that an accredited institution in the recipient country may receive funds directly to implement a project. Currently, most international funding institutions insist that projects be implemented by a multilateral development bank or UN agency.

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, but 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). One possible opportunity for enhancing this linkage is through the new National Appropriate Mitigation Actions (NAMAs) being submitted by developing countries within the context of UNFCCC. The NAMA process agreed to at Bali provides an opportunity to incorporate sectoral policies with relevance to their cities (Li, 2011).

16.5.3 Performance in a complex institutional landscape

The institutional landscape for climate finance is becoming increasingly complex as interest of actors to enter the field of climate change finance and mitigation activities in developing countries increases. As in other international cooperation, there are discussions about effectiveness of climate finance (see OECD (2008) for politically agreed principles on aid effectiveness). Concerns have been raised about diverting attention and resources from development aid, i.e., ODA, such as health and education, the additionality of expanded funding for mitigation and adaptation (Michaelowa and Michaelowa, 2011), the difficulty of defining and measuring comparable results and achieving coherence with national priorities and development strategies, the lack of transparency, the fragmentation and duplication of efforts, and that the number of established funds may undermine the authority of the operating entities of the financial mechanism of the UNFCCC (Poerter et al., 2008). The proliferation of climate funds (HBF and ODI, 2013) and funding channels with their own governance procedures can create a substantial bureaucratic burden for recipients (Greene, 2004). Compounding these problems is the fragmentation of governance architectures that prevail in most developing countries (Biermann et al., 2009). Climate finance may be more effective if the operation of related institutions is streamlined and the capacity in developing countries to cope with the increasing number of these institutions is developed further. Evidence on the effectiveness of institutions to mainstream climate change mitigation and adaptation activities is currently lacking.

Table 16.2 | A sample of national funding entities in developing countries. Sources: Adapted from Gomez-Echeverri (2010), updated based on UNDP and World Bank (2012), Amazon Fund (2012), BCCRF (2012), CDMF (2012), ICCTF (2012), World Bank (2012b), UNDP (2013b).

Name, country, establishment	Description	Source of fund and operations	Governance
Amazon Fund, Brazil (2010)	Established to combat deforestation and promote sustainable development in the Amazon. Focus: adaptation and mitigation	Designed to attract national and private investment for Amazon rainforest projects as well as donations and earnings from non-reimbursable investments made	Managed by the Brazilian Development Bank (BNDES), a Guidance Committee composed of federal and state governments and civil society, and a Technical Committee
Bangladesh Climate Change Resilience Fund (BCCRF) (2010)	Established to provide support for the implementation of Bangladesh's Climate Change Strategy and Action Plan 2009–2018 and particularly vulnerable communities. Focus: adaptation and mitigation	Designed to attract funds from UNFCCC finance mechanisms, and direct donor support	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 civil society organizations
China CDM Fund (CDMF) (2007)	Established jointly by Ministries of Finance, Foreign Affairs, Science and Technology, and National Development and Reform Commission (NDRC). Focus: mitigation	Funded by revenues generated from CDM projects in China, as well as grants from domestic and international institutions	Governed by the Board of the China CDM Fund that comprises representatives of seven line ministries, and managed and operated by a management centre affiliated with the Ministry of Finance
Indonesia Climate Change Trust Fund (ICCTF) (2010)	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 programmes	Currently funded by grants from development partners but designed for direct access to international climate funding and to attract private funding	The UNDP is an interim Trustee operating under a Steering Committee headed by the National Development Planning Agency that also includes donors and other line ministries
Guyana REDD Investment Fund (GRIF) (2010)	Established to finance activities under the Low Carbon Development Strategy of Guyana and to create an innovative climate finance mechanism. Focus: mitigation and adaptation	Designed to attract donor support. Operates 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 with members of government and financial contributors chaired by the Government of Guyana, is the decision making and oversight body. The International Development Association (IDA) of the World Bank Group acts as Trustee and the partner entities provide operational services
Ethiopia Climate Resilient Green Economy Facility (2012)	Established to support country's vision of attaining a middle-income economy with low-carbon growth by 2020. Focus: mitigation and adaptation	Designed to mobilize, access, and blend both local and international public and private resources to support Ethiopia's Climate Resilience Green Economy Strategy	Governed by a Ministerial Steering Committee chaired by Ministry of Finance and Economic Development with an advisory body composed of development partners, multilateral organizations, national non-governmental organizations (NGOs), civil society, private sector, and academia

16.6 Synergies and tradeoffs between financing mitigation and adaptation

This section introduces a conceptual framework linking adaptation and mitigation in terms of financing and investment. Estimates of investments needed for mitigation are provided in Section 16.2.2, and for adaptation investments in the sectoral chapters of the Working Group II report. First, this section addresses the interactions of financing adaptation and mitigation in terms of their specific effectiveness and tradeoffs, as well as their competition for funding over time. Second, it discusses examples of integrated financing approaches.

16.6.1 Optimal balance between mitigation and adaptation and time dimension

Both mitigation and adaptation measures are necessary to effectively avoid harmful climate impacts. However, an assessment on whether, where, and which types of adaptation and mitigation measures and policies are substitutes or complements requires theoretical analysis and empirical evidence (Section 13.3.3). Investing in mitigation may reduce the need to invest in adaptation, and vice versa. Several authors have recognized that optimal mitigation and adaptation strategies should be jointly determined (Schelling, 1992; Kane and Shogren, 2000; Dellink et al., 2009; Bosello et al., 2010), including from the perspective of a global decision maker. The optimal balance of mitigation and adaptation depends on their relative costs, for any given profile of climate change impacts. To avoid inefficiencies, the socially discounted rate of return on resources invested in mitigation and adaptation should be equal. Therefore, mitigation and adaptation compete to attract investments. From the perspective of simple economic models, a reduction in the costs of mitigation should lead to more mitigation and less adaptation, and, according to this view, they are substitutes (Ingham et al., 2005).

From the perspective of development and climate studies (Tol, 2007; Ayers and Huq, 2009), climate change in most cases will impact the economy by reducing its production potential (part of the residual damage), and the level of impacts will depend on its efficiency, diversity, and vulnerability, as well as on how institutions are able to adapt.

On the other hand, policies to address mitigation and/or adaptation could promote the transfer of technologies and financial resources, and strengthen institutions and markets, which could lead to the enhancement of a country's productive capacity (Halsnæs and Verhagen, 2007).

Combined mitigation and adaptation strategies taking into account cost-effectiveness may involve economic tradeoffs. The optimal balance, including allocation of resources, should be determined taking into account possible co-benefits, which may be difficult to assess. Many actions that integrate mitigation and adaptation have enough co-benefits to make obvious sense of their immediate implementation (see Working Group II report), in spite of the fact that in many cases, assessment of their effective combination, cost-effectiveness, and tradeoffs requires improved information, improved capacities for analysis and action, and further policymaking (Wilbanks and Sathaye, 2007). Modelling of any direct interaction between adaptation and mitigation in terms of their specific effectiveness and tradeoffs would also be desirable (Wang and McCarl, 2011).

An analysis on the time composition (timing of mitigation and adaptation) of the optimal climate change strategy is also important to assess how to best allocate climate change funds. Emerging frameworks for assessing the tradeoffs between adaptation and mitigation include those from the point of view of risks and costs. 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 is because climate and economic systems have inertia and delaying action increases the costs of achieving a given temperature target. These studies suggest that the competition between mitigation and adaptation funds extends over time.

By arguing "uncertainty on the location of damages reduces the benefits of 'targeted' proactive adaptation with regard to mitigation and reactive adaptation", some 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. Other authors propose a framework that could integrate into an optimization model not only mitigation and adaptation, but also climate change residual damages. In the light of the uncertain impacts of climate change, prioritizing mitigation measures is justified, on the basis of a precautionary approach. Adaptation actions "should be optimally designed, consistently with mitigation, as a residual strategy addressing the damage not accommodated by mitigation" (Bosello et al., 2010).

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 reduction of damages and is preferred when damage stocks are small. Contrary to Bosello et al. (2010), they advocate that, instead of taking adaptation as a 'residual' strategy, well-planned adaptation is an economically effective complement to mitigation since the beginning and should occur in parallel. Thus, adaptation investment should be considered as an important current policy option due to the near-term nature of given benefits.

Moreover, the optimal balance of adaptation and mitigation measures and investments should be determined in function of the magnitude of climate change; "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). While the uncertainties about specific pathways remain, and although there are different considerations on their optimal balance, there is a general agreement that funding for both mitigation and adaptation is needed.

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 interest in promoting integrated financing approaches, addressing both adaptation and mitigation activities in different sectors and at different levels. Although the GCF will have thematic funding windows for adaptation and mitigation, an integrated approach will be used to allow for cross-cutting projects and programmes (UNFCCC, 2011c, para 37).

The theoretical literature reviewed in Section 16.1.1 provides only general guidance on financing mitigation and adaptation measures. Analysis of specific adaptation and mitigation options in different sectors reveals that adaptation and mitigation can positively and negatively influence the effectiveness of each other (see also Working Group II report). Particular opportunities for synergies exist in some sectors (Klein et al., 2007), including agriculture (Niggli et al., 2009), forestry (Ravindranath, 2007; Isenberg and Potvin, 2010), and buildings and urban infrastructure (Satterthwaite, 2007).

Mitigation activities have global benefits while most adaptation activities benefit a smaller geographical area or population. Funding sources with a regional, national or sub-national perspective, therefore, will increasingly favour adaptation over mitigation measures (Dowlatabadi, 2007; Wilbanks and Sathaye, 2007). Thus the sources of climate finance available may yield a mix of mitigation and adaptation measures quite different from the global optimal mix. Additional studies "to understand the complex way in which local adaptation aggregates to the global level" are needed (Patt et al., 2009). Although the optimal mix cannot be determined precisely, the availability of international climate finance for both mitigation and adaptation is necessary to counteract such tendencies.

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, and may play an important 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, programmes, and projects of the bank (ADB, 2003).

The 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, 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 GHG 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 Section 14.3.2 for additional information on regional examples of cooperation schemes identifying synergies between 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 wastewater 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 mobilize these synergies within existing development cooperation programmes.

Another point of debate regarding synergies and tradeoffs between financing mitigation and adaptation relates to the conceptual framework that suggests allocating responsibility for international financing of adaptation based on the historical contribution of countries to climate change in terms of GHG emissions and their capacity to pay for the costs of adaptation at international level (Dellink et al., 2009). The provision of international climate finance, of course, raises other issues of equity and burden sharing, which are beyond the scope of this chapter.

16.7 Financing developed countries' mitigation activities

This and the next section consider the manner in which developed and developing countries may choose to finance the incremental investments and operating costs associated with GHG 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.

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 also determine the distribution of the burdens posed by the financing needs, i.e., if it will be financed by households and firms through higher prices, taxes, or both.

In 2011 and 2012, on average, 177 billion USD of global climate finances were invested in developed countries (49 % of the global total climate finance) of which the vast majority (81 %) originated in the same country as the investment was undertaken (2011/2012 USD) (Buchner et al., 2013b). Due to the financial crisis investment in renewable energy in developed countries dropped 14 % in 2009 (Frankfurt School-UNEP Centre and BNEF, 2012), but saw a rapid recovery due to the green stimulus packages (IEA, 2009; REN21, 2010). The eight development banks of OECD countries that are members of the International Development Finance Club (IDFC) allocated 28 billion USD (2011 USD) and 33 billion USD (2012 USD) 'green'[29] finance to domestic projects in 2011 and 2012, respectively (Höhne et al., 2012; IDFC, 2013). Public climate finance was also directed to developing countries at a range of 35–49 billion USD per year for 2011 and 2012 (2011/2012 USD) (Buchner et al., 2013b).

Without climate policy, an estimated 96 (70–126) billion USD per year of investment in fossil power generation will occur in developed countries from 2010–2029; from 2030 to 2049, this figure increases to 131 (86–215) billion USD per year. In a climate policy scenario compatible with a 2 °C warming limit in 2100, OECD countries are expected to reduce investments in fossil power generation by 57 % (–2 to –89 %) during 2010–2029, but investments will drop by 90 % (–80 to –98 %) during 2030–2049. Investment in renewable power generation instead will increase by 86 % (58 to 116 %) during 2010–2029 and by 200 % (77 to 270 %) during 2030–2049 (based on IEA (2011), Carraro et al. (2012), Calvin et al. (2012) and McCollum et al. (2013), used in Section 16.2.2).

To date, public sourcing for climate finance originates primarily from general tax revenues. However, under ambitious stabilization targets, financial sources that yield mitigation benefits have the potential to generate high revenues that could be used for climate finance. Carbon taxes and the auctioning of emissions allowances carry the highest potential, a phaseout of fossil fuel subsidies, and a levy or emission trading scheme for international aviation and shipping emissions are

29 'Green' finance as reported by IDFC includes projects with other environmental benefits. Approximately 93 % (80 %) of the 'green' finance by IDFC in 2011 (2012) was climate finance (Höhne et al., 2012; IDFC, 2013).

estimated to generate considerable revenues as well (UNFCCC, 2007; AGF, 2010; World Bank Group et al., 2011).

Most developed countries offer a reasonably attractive core and broader enabling environment for climate investments. Developed countries, as do many emerging economies, combine substantial energy-related GHG emission reduction potential with low country risks. At the end of 2012, 29 out of 36 assessed developed countries fell into the group of lower risk country grade, producing 39 % of global fuel-related CO_2 emissions (Harnisch and Enting, 2013). Private finance can thus be the main source of low-carbon investment in these countries, however private actors are 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. 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 to provide dedicated credit lines, guarantees to share the risks of investments, debt financing of projects, microfinance or incentive funds, and schemes to mobilize R&D and technical assistance funds for building capacities across the sectors. 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).

In 2012, the most widespread fiscal incentives were capital subsidies, grants, and rebates. They were in place in almost 90 % of high-income countries. In 70 % of the countries public funds were used to support renewable energy, e.g., 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) (REN21, 2012).

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.

An estimated 51 % of the total global climate finance in 2011 and 2012, namely on average 182 billion USD per year, was invested in developing countries (2011/2012 USD). Thereof, 72 % was originating in the same country as it was invested) (Buchner et al., 2013b). The total climate finance flowing from developed to developing countries is estimated to be between 39 and 120 billion USD per year in 2011 and 2012 (2011/2012 USD). This range covers public and the more uncertain flows of private funding for mitigation and adaptation. Clapp et al. (2012) estimate the total at 70–120 billion USD per year based on 2009–2010 data. Data from Buchner et al. (2013a) suggest a net flow to developing countries for 2010 and 2011 of the order of 40 to 60 billion USD. North-South flows are estimated at 39 to 62 billion USD per year for 2011 and 2012 (2011/2012 USD) (Buchner et al., 2013b).

Public climate finance provided by developed countries to developing countries was estimated at 35 to 49 billion USD per year in 2011 and 2012 (2011/2012USD) (Buchner et al., 2013b). Multilateral and bilateral institutions played an important role in delivering climate finance to developing countries. Seven MDBs[30] reported climate finance commitments of about 24.1 and 26.8 billion USD in 2011 and 2012, respectively[31] (2011 and 2012 USD) (AfDB et al., 2012a; b, 2013). These institutions manage 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 GCF is expected to become an additional international mechanism to support climate activities in developing countries. Bilateral climate-related ODA commitments were at an average of 20 billion USD per year in 2010 and 2011 (2010/2011 USD) (OECD, 2013a)[32] and were implemented by bilateral development banks or bilateral agencies, provided to national government directly or to dedicated multilateral climate funds (Buchner et al., 2012). However, bilateral and multilateral commitments are not fully comparable due to differences between methodologies.

Climate projects in developing countries showed a higher share of 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 11 non-OECD development

30 African Development Bank (AfDB), the Asian Development Bank (ADB), the European Bank for Reconstruction and Development (EBRD), the European Investment Bank (EIB), the Inter-American Development Bank (IDB), the World Bank (WB), and the International Finance Corporation (IFC).

31 The reporting is activity-based allowing counting entire projects but also project components. Recipient countries include developing countries and 13 EU member states. It covers grant, loan, guarantee, equity, and performance-based instruments, not requiring a specific grant element. The volume covers MDBs' own resources as well as external resources managed by the MDBs that might also be reported to OECD DAC (such as contributions to the GEF, CIFs, and Carbon Funds).

32 It covers total funding committed to projects that have climate change mitigation or adaptation as a 'principal' or 'significant' objective. The ODA is defined as those flows to countries on the DAC List of ODA Recipients and to multilateral institutions provided by official agencies or by their executive agencies. Resources must be used to promote the economic development and welfare of developing countries as a main objective and they must be concessional in character (OECD, 2013a).

Box 16.3 | Least Developed Countries' investment and finance for low-carbon activities

This box highlights key issues related to investment and finance for Least Developed Countries (LDCs), however some of these issues are certainly also relevant for other developing countries.

Climate change increased the challenges LDCs are facing regarding food, water, and energy that exacerbate sustainable development. 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 geophysical 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. Of the 1.2 billion people without electricity in 2010, around 85 % live in rural areas and 87 % in Sub-Saharan Africa and Southern Asia. For cooking, the access deficit amounts to 2.8 billion people who primarily rely on solid fuels. About 78 % of that population lives in rural areas, and 96 % are geographically concentrated in Sub-Saharan Africa, Eastern Asia, Southern Asia, and South-Eastern Asia (Sustainable Energy for All, 2013) (see Section 14.3.2.1 for other estimates provided by the literature). 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.

Regarding specific mitigation finance needs, there are no robust data for LDCs. It is estimated that shifting the large populations that rely on traditional solid fuels (such as unprocessed biomass, charcoal, and coal) to modern energy systems and expanding electricity supply for basic human needs could yield substantial improvements in human welfare for a relatively low cost (72–95 billion USD per year until 2030 to achieve nearly universal access) (Pachauri et al., 2013). For instance, in Bangladesh, the costs to provide a minimum power from solar home system's energy source to off-grid areas was around 285 USD per household (World Bank, 2012c). However, the very few country studies on mitigation needs and costs 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 730 million USD in mitigation related ODA to LDCs in the year 2011. Bangladesh received the highest share with 117 million USD, followed by Uganda and Haiti with more than 70 million USD (OECD, 2012).

Most LDCs have very few CDM projects that are also an important vehicle for mitigation (UNFCCC, 2012d; UNEP Risø, 2013). To improve the 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, 2012e).

Some LDCs are starting to allocate public funds to mitigation and adaptation activities, e.g., NAPAs or national climate funds (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 Index, 23 countries are LDCs (World Bank, 2011a). Obstacles to general private business activities in turn hinder long-term private climate investments (Hamilton and Justice, 2009). 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 a challenging environment, it is difficult to implement targeted public policies and financial instruments to mobilize private mitigation finance. Moreover, the weakness of technological capabilities in LDCs presents a challenge for successful development and transfer of climate-relevant technologies (ICTSD, 2012).

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.

bank members of IDFC provided 44 billion USD of domestic 'green'[33] finance in 2011 and 2012 (2011 and 2012 USD) (Höhne et al., 2012; IDFC, 2013).

According to UNFCCC (2011a), Annex II countries provided an average of almost 10 billion USD per year of climate finance to developing countries. In 2009, developed countries committed to provide new and additional resources approaching 30 billion USD of 'FSF' to support mitigation and adaptation action in developing countries during 2010–2012. The sum of the announced commitments exceeds 33 billion USD (UNFCCC, 2011b, 2012b; c, 2013a). Data on the amount actually disbursed is not available. Some analyses question whether these funds were 'new and additional' (Brown et al., 2010; Stadelmann et al., 2010, 2011b).

There is limited robust information on the current magnitude of private flows from developed to developing countries. Clapp et al. (2012) estimate the private investment at 37–72 billion USD per year based on 2009–2010 data (2008/2009 USD) and Stadelmann et al. (2013) estimate foreign direct investment as equity and loans in the range of 10 to 37 billion USD (2010 and 2008 USD) per year based on 2008–2011 data.

In 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. About 73 % (65 % to 80 %) of global investment in fossil power plants between 2010–2029, and 78 % (76 to 80 %) between 2030–2049, would flow into in the non-OECD because many developing countries rely on low-cost coal power plants to supply an ever-growing demand of electricity in the scenarios examined (based on IEA (2011), Carraro et al. (2012), Calvin et al. (2012), and McCollum et al. (2013) used in Section 16.2.2). In a climate policy scenario compatible with a 2 °C warming limit in 2100, non-OECD countries are expected to absorb 51 % (34 % to 66 %) of incremental average annual investment in renewables over 2010–2029, and 67 % (61 % to 73 %) over 2030–2049.

In tackling climate change, developing countries face different types and magnitudes of constraints. Out of the 149 assessed developing countries, only 37 were assigned lower risk country grades. These countries, being attractive for international private sector investment in low-carbon technologies, represent 38 % of global CO_2 emissions. However, the majority of developing countries currently exhibits higher country risk grades—reflecting less attractive international investment conditions—and finds it more difficult to attract foreign private investment (Harnisch and Enting, 2013). 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). Between 2005 and 2009, developed countries provided 2.5 billion USD of ODA to support creation of general enabling environments in developing countries (2005–2009 USD) (Stadelmann and Michaelowa, 2011).

Since investment risks for low-carbon projects in developing countries are typically perceived to be higher than in developed countries, the cost of capital and the return requirements of investors are respectively higher. The IRR for general infrastructure in developing countries, for instance, is a median of 20 % 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 balance sheet constraints (Hamilton, 2010), such as 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 scarce in many developed countries, increasing the dependence on project finance. Especially in low-income countries, project sponsors frequently rely on external assistance to cover project development costs for many investments because of their high risks and non-commercial nature (World Bank, 2011d).

Many developing countries use a range of incentives for investments in renewable energies (REs), especially fiscal incentives (OECD, 2013d). Public financing instruments to stimulate RE, such as public investment, loans, or grants, were in place in 57 % of the countries analyzed and FITs were established in 39 developing countries in 2012 (REN21, 2012). Carbon pricing has not yet widely been adopted by developing countries, apart from the non-perfect carbon price incentive via the CDM. However, currently new ETS are set up, planned, or under consideration in some developing countries such as China (provinces and cities), Kazakhstan, Ukraine, Chile, Brazil, and South Korea, but it will take time until such ETS will be fully operational and provide enough investment certainty (Kossoy et al., 2013).

Regional groupings such as the ECOWAS, the ASEAN, and 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 climate action (Glemarec, 2011). Most developing countries rely on relevant ministries and agencies chaired by the ministry of the environment or finance to coordinate climate change finance (Gomez-Echeverri, 2010). Some developing countries are establishing national implementing entities and funds that mainstream climate change activities into overall development strategies. Often these institutions are designed to blend international funding with domestic and private sector resources (Flynn, 2011).

[33] 'Green' finance as reported by IDFC includes projects with other environmental benefits. Approximately 93 % (80 %) of the 'green' finance by IDFC in 2011 (2012) was climate finance (Höhne et al., 2012; IDFC, 2013).

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.

- **Common definitions and data availability**. To date there are no common definitions for central concepts related to climate finance or financial accounting rules. 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, and 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. Frequently it is not possible to distinguish exactly between adaptation and development finance, since they are closely interconnected. Another difficult assessment is on the differences between funding under the ODA and 'new and additional' funds available. Important metrics like the high-carbon investment by sub-sector and region, the carbon intensity of new investments, downward deviations from reference emission pathways, or the cost-effectiveness of global mitigation investments are not tracked systematically.

- **Model outputs and approaches**. Only very limited model results exist for additional investments and incremental costs to abate CO_2 emissions in sectors other than energy supply, e.g., via energy efficiency in industry, buildings, and transport, as well as in other sectors like forestry, agriculture, and waste, or to mitigate process and non-CO_2 emissions in the petroleum and gas, cement, and chemical industry, or from refrigeration and air conditioning. Very limited analysis has been published that takes a globally consistent perspective of incremental investments and costs at the level of nation states and regions. This perspective could enrich the scientific discussion because 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 of the need for additional R&D for low-carbon technologies and practices and on the timing of these needs (infrastructure and technology deployment roadmaps) are not available. While there is literature on mitigation technology diffusion and transfer in general, it is not clear whether specific financial requirements to this end are different from finance for other mitigation activities.

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

- **Effectiveness and efficiency of climate finance.** 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 LDCs.

- 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 its 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. Little is known on determinants for an economically efficient and effective allocation of public climate finance. 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.

- 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 is needed first.

- **Balance between mitigation and adaptation finance and investment.** The optimal balance, 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 tradeoffs. A better-informed assessment of the effective integration of mitigation and adaptation, including tradeoffs and cost avoidance estimates, is needed. Moreover, there is limited research and literature to assess synergies and tradeoffs between and across sector-specific mitigation and adaptation measures from the specific financing and investment point of view.

16.10 Frequently Asked Questions

FAQ 16.1 What is climate finance?

There is no agreed definition of climate finance. The term 'climate finance' is applied both to the financial resources devoted to addressing climate change globally and to financial flows to developing countries to assist them in addressing climate change. The literature includes multiple concepts within each of these broad categories.

There are basically three types of metrics for **financial resources devoted to addressing climate change globally.** *Total climate finance* includes all financial flows whose expected effect is to reduce net greenhouse gas emissions and/or to enhance resilience to the impacts of climate variability and the projected climate change. This covers private and public funds, domestic and international flows, expenditures for mitigation and adaptation, and 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. The *incremental investment* is the extra capital required for the initial investment to implement a mitigation or adaptation measure, for example, the investment in wind turbines less the investment that would have been required for a natural gas generating unit displaced. Since the value depends on a hypothetical alternative, the incremental investment is uncertain. The *incremental costs* reflect the cost of capital of the incremental investment and the change of operating and maintenance costs for a mitigation or adaptation project in comparison to a reference project. It can be calculated as the difference of the net present values of the two projects. Values depend on the incremental investment as well as projected operating costs, including fossil fuel prices, and the discount rate.

Financial flows to assist developing countries in addressing climate change typically cover the following three concepts. The *total climate finance* flowing to developing countries is the amount of the total climate finance invested in developing countries that comes from developed countries. This covers private and public funds for mitigation and adaptation. *Public climate finance* provided to developing countries is the finance provided by developed countries' governments and bilateral institutions as well as multilateral institutions for mitigation and adaptation activities in developing countries. *Private climate finance flowing to developing countries* is finance and investment by private actors in/from developed countries for activities in developing countries. Under the UNFCCC, c*limate finance* is not well-defined. Annex II Parties provide and mobilize funding for climate related activities in developing countries. Most of the funds provided are concessional loans and grants.

FAQ 16.2 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 climate finance was estimated at around 359 billion USD per year of which 337 billion USD per year was invested in mitigation using a mix of 2011 and 2012 data (2011/2012 USD). This covers the full investment in mitigation measures, such as renewable energy generation technologies that also produce other goods or services. Climate finance invested in developed countries amounted to 177 billion USD and in developing countries 182 billion USD (2011/2012 USD).

Climate policy is expected to induce a significant change in investment pattern in all scenarios compatible with a 2 °C limit. Based on data from a limited number of scenarios, there would need to happen a remarkable reallocation of investments in the power sector from fossil fuels to low-emissions generation technologies (renewable power generation, nuclear, and electricity generation with CCS). While annual investment in conventional *fossil-fired power plants without CCS* is estimated to decline by about 30 billion USD per year in 2010–2029 (i. e., by 20 % compared to 2010), annual investment in *low-emission generation technologies* is expected to increase by about 147 billion USD per year (i. e., by 100 % compared to 2010), over the same period.

Investment in *energy efficiency in the building, transport, and industry sector* would need to increase by several hundred billion USD per year from 2010–2029. Information on investment needs in other sectors, e. g., CO_2 to abatement processes or non-CO_2 emissions, is sparse.

Model results suggest that *deforestation* could be reduced against current deforestation trends by 50 % with an investment of 21 to 35 billion USD annually.

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