Financing technology in a post-2012 international climate change agreement:

Leveraging private investment for climate change mitigation technologies

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*Murdoch University*
*Western Australia*

Andrew Higham

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Declaration

I declare that this dissertation is my own account of my own research. It contains as its main content work which has not been previously submitted for a degree at any university.

Andrew Higham
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Abstract

The Bali Action Plan (UNFCCC, 2007a) acknowledges the central roles of finance and technology in the successful implementation of the United Nations Framework Convention on Climate Change (‘the Convention’). They form two of the four building blocks for a post-2012 international climate change agreement. For developing countries, the conclusion of negotiations for an acceptable and successful agreement hinges upon the provision of financial and technology support from developed countries, commensurate with the identified needs, in accordance with the polluter pays principle and the principle of common but differentiated responsibilities and respective capabilities, and reflecting the full agreed incremental costs of meeting the objectives of the Convention.

This dissertation presents research undertaken in support of these negotiations and the design of new financing and technology development and transfer policies to underpin the mitigation and adaptation efforts of the post-2012 agreement, as mandated by decision 3/CP.13 of the Conference of the Parties. The research contained within this dissertation draws and builds upon the reports of the Expert Group on Technology Transfer (UNFCCC, 2008a; 2009a;b) which were prepared in response to the mandate of the Conference of the Parties.

Financing for technology will need to be scaled up by an order of magnitude, across all technologies and in all nations (UNFCCC, 2009b). In the order of USD 1 trillion in investment, both public and private, needs to be mobilized each year (IEA, 2008a). Using estimates of the incremental costs for developing countries, the cost for Annex II Parties is estimated at an additional USD 262–670 billion per year for mitigation technologies and USD 33–163 billion per year to adapt to climate change (see UNFCCC, 2009a, pp 31–33).

A wide range of financing options and technology development and transfer policies are available, some with greater potential than others to mobilise the necessary financial resources. Effectiveness varies across policy instruments. Combining policy options so as to exploit synergies, and matching of policy responses to local and national circumstances can be significant determinants of a successful regime.

This dissertation attempts to assess and compare the possible public and private financing needs, based on the policy concept of ‘leveraging the private sector’, which is commonly touted within the negotiations by many national governments as an essential policy objective for finance and technology. Available options are described and proposals are analysed according to their effectiveness.

Scenarios of public and private financing for technology development and transfer are developed based on the average leveraging ratios achieved by a wide range of policies and programmes at the national, regional and international level. Policies under consideration both at the international and national levels are included where estimates of their leveraging potential can be made. The assessment is made for each stage of the technology innovation cycle (research and development, demonstration, deployment, diffusion) and estimates are made of the amounts of public financing required.

The results of this dissertation point to the significant role that public finance will play in achieving the objectives of the Convention. Scenarios that involve a significant increase in the leveraging effect of public policies and investment programmes on the private sector will still require substantial public investment, in the order of USD 30–160 billion per annum. It is estimated that, under this scenario, the private sector share of total investment would be increased from the cur-
rent levels of approximately 60 per cent to 75–80 per cent. The results also suggest that the financial mechanism of the Convention needs to take a more prominent role in coordinating the overall delivery of financing and to help optimize the potential for private sector financing. Integrated design of public policies and investment programmes will be important and a wide range of innovative financing instruments and types of finance will need to be deployed in a targeted way to address qualitative and quantitative gaps in the existing financial arrangements.
1 Introduction

The concept of ‘leveraging’ is a common feature of the design and operation of public policy in many policy domains. One indicator of the performance of public policy that is often used is the level of private sector leveraging that is achieved. Throughout this dissertation leveraging is defined as the ratio of public investment to private investment directly stimulated from the public intervention\(^1\).

Within the context of the negotiations for a post-2012 agreement under the United Nations Framework Convention on Climate Change (UNFCCC)\(^2\), the concept is particularly important given the radical shifts in investment that are necessary to avert dangerous climate change (International Energy Agency (IEA), 2008a). Given the scale of investment required and the fact that the private sector is the primary owner and determinant of the flow of technology and hence emissions reduction and adaptation outcomes, the interaction between public and private investment is crucial. Scarce public resources must be used to leverage private sector activities and investments if there is any hope of meeting the ultimate objective of the Convention\(^3\).

During the negotiation process under the Ad-hoc Working Group on Long Term Cooperative Action under the Convention (AWG-LCA) in 2008 and 2009, some Parties went as far as to suggest that new financing under the Convention is not necessary and that almost all of the shifts in investment that are required could result from removing barriers to and providing incentives for the private sector (UNEP-SEFI, 2002; UNFCCC, 2008b). By the time Parties reached Copenhagen in December 2009, the text they were presented with had no less than 17 separate provisions with specific references to the need to leverage private sector investment (UNFCCC, 2009c).

However, there has been limited quantitative policy research focused on leveraging within the international climate change policy context (OECD, 2009a). While estimates of current and future financing needs have been made (UNFCCC, 2009a;b), information on the effectiveness of different types of public policies and investment programmes in leveraging private finance have not yet been synthesised. Also estimates have not been made of the minimum amount of public financing that would be required to mobilise the desired total flow of financing from both public and private sources. This dissertation examines the concept of ‘leveraging’ and attempts to address these questions and provide initial estimates of the share of public and private financing that will be needed.

The dissertation builds upon the scarce literature that has been published on the leveraging effects of climate change policies, particularly:

- Doornbosch and Knight (2008) who provide analysis of public financing, but do not assess private sector leveraging ratios;
- the work undertaken through the Sustainable Energy Finance Initiative (Basel Agency for Sustainable Energy (2006), New Energy Finance (NEF) and United Nations Environment Programme (UNEP) (2008), Vivid Economics, 2009) which assesses current practices in public financial instruments for climate change and makes recommendations on how to enhance those practices;

\(^1\) The leveraging ratios are expressed as x:y, where x is the public investment made and is always kept constant at 1, and y is the private investment that is the direct result of the public investment made.

\(^2\) Here within known as ‘the Convention’ or the UNFCCC

\(^3\) Article 2 of the Convention.
• the Stern Review on the Economics of Climate Change (Stern, et al., 2006) and work of London School of Economics (Romani, 2009) which examines a wide range of policy issues that need to be taken into account when using public funds to leverage private investment in developing countries; and
• evaluations of the effectiveness of specific international and national policy instruments that have an objective of leveraging private sector investment for climate change technologies, where such evaluations have been conducted (see citations in Chapter 7).

The scope of this dissertation does not include technologies for adaptation to climate change. It is restricted to mitigation technologies, with particular attention to stationary energy generation, transport, industrial and domestic energy efficiency, noting that significant financing differences that exist between various technologies and sectors need to be taken into account. It is recognised that the potential to leverage private sector investment in technologies for adaptation is far more limited than for mitigation technologies, and the results of this research should therefore not be applied to adaptation.

In assessing how public policies and investments could leverage private sector investment for climate change technologies this dissertation uses estimates of existing and required levels of finance that have been prepared by the UNFCCC (2007b; 2008a; 2009a;b). These estimates target a stabilization of greenhouse gas emissions of 500–550 parts per million carbon dioxide equivalents (ppm CO\textsubscript{2}-e). Information on the investment needs for stabilising at 450ppm CO\textsubscript{2}-e is limited\textsuperscript{4} and estimates of financing needs below 450ppm CO\textsubscript{2}-e are almost non-existent.

The estimated additional investment required to meet the UNFCCC mitigation scenario of 500–550 ppm CO\textsubscript{2}-e is USD 262–670 billion per annum by 2030, of which at least USD 92–302.5 billion\textsuperscript{5} will be needed in non-Annex I countries, representing 68 per cent of the respective reduction in emissions (UNFCCC, 2009b). Though large in absolute terms, these figures for additional required investments are small when expressed as a percentage of future global GDP (0.3–1 per cent) or total global investment (1–3 per cent) that would need to be devoted to climate change in 2030 (UNFCCC, 2007a).

While the UNFCCC recognises that a significant share of the required financing will need to be met by the public sector, it does not make estimates of what the ratio of public and private investment might be\textsuperscript{6}. The lack of information on the public cost of action has significantly hampered the negotiations under the Convention. The Copenhagen Accord (UNFCCC, 2009d) commits to the provision of USD 100 billion per annum from 2020 from an unspecified mix of public and private sources. Furthermore, while the concept of leveraging is used extensively within the negotiating text (UNFCCC, 2009e), the specific relationship between public and private finance and how public finance will leverage private finance is not defined. These uncertainties prevent agreement on how to raise the necessary levels of public finance and how to deploy those resources to give some certainty that the requisite level of private finance is mobilised.

This dissertation aims to help fill this gap in information by attempting to estimate the ratio of public and private finance, based on the assessment of leveraging effects of existing and proposed

\textsuperscript{4} The OECD (2008a) has estimated that to meet a 450ppm CO\textsubscript{2}-e stabilisation target it would cost 2.5 per cent of global GDP equivalent to total additional annual investments of USD 1.21 trillion.

\textsuperscript{5} See Table 5, below.

\textsuperscript{6} However, it does estimate the current proportion of public financing to be approximately 40 per cent (see UNFCCC, 2009a, pg. 60)
public policies. It also explores some of the policy issues that should be taken into account when using public finance to leverage private sector investment.

The methodology used in undertaking the research for this dissertation is presented in Chapter 2.

Chapter 3 introduces the concept of leveraging private sector investment and examines the rationale for increasing the private sector share of financing for technology.

Chapter 4 reviews the concept of the technology innovation cycle and how stages of technological maturity can be used to classify public and private financing needs and to identify policies that are most suited to different technologies. Different types of finance are also available and are usually tailored to specific investment situations, which in turn can be relevant to understanding the concept of leveraging the private sector. The need to address gaps in the availability of different types of finance is addressed in Chapter 6.

The dissertation is focused on public policies and investment programmes that result in measurable private investment in climate change mitigation technologies. Public policies that have a more diffuse impact on private investment, such as the enhancement of the enabling environment that creates suitable investment conditions, are not calculated within the analysis of leveraging contained within this dissertation. However, because these conditions are fundamentally important to any successful policy that aims to mobilise private sector investment, by way of context setting, the role of the enabling environment is addressed in Chapter 5.

In Chapter 6, the financing gap for climate change is defined, based on the assessments undertake for the UNFCCC (2009b). The financing gap is assessed both in quantitative and qualitative terms. The gap is defined in monetary terms by stage of technology consistent with the approach explained in Chapter 4, and it is also assessed qualitatively by outlining key policy challenges that need to be addressed to mobilize the required quantitative flow of finance. The Chapter explains how this information provides an analytical basis for the remainder of the dissertation.

Chapter 7 reviews the leveraging ratios of a wide range of policies by stage of technological maturity, in order to arrive at an average range of the leveraging effects of policies that are in practice or are proposed within the negotiation process under the Convention.

Chapter 8 presents a summary of the leveraging ratios by stage of technological maturity and Chapter 9 applies these average leveraging ratios, in order to estimate the total average share of public and private finance that will be required in a post-2012 international climate change agreement, based on a set of pre-defined scenarios. This in turn leads to conclusions about the types of financing instruments and policies that will be required.

Finally, Chapter 10 brings together a summary of conclusions that result from this research and some preliminary findings relevant to the post-2012 climate change negotiations are presented.
2 Overview of methodological approach

The methodological approach taken in this dissertation is outlined in the Figure 1. The aim of the research is to investigate the public and private shares of investment that might be required for technologies that reduce greenhouse gas emissions by at least half of 2000 levels by 2050.

Figure 1  Methodological approach of the dissertation

As illustrated in Figure 1, the methodology involved the following steps.

In step 1, the financing gap between current financing and finance needed to deploy the mitigation technologies required to meet a 500-550 ppm CO₂-e stabilization level is determined by stage of technological maturity based on the work of the Expert Group on Technology Transfer (EGTT) (UNFCCC, 2008a; 2009a; b). In each subsequent step in the methodology financing and leveraging potential of public policies and investment programmes are classified by the stage of technology as defined by UNFCCC (2008a; 2009a).

In step 2, the concept of leveraging is defined, limitations of the concept are explored and it is placed within the context of the need for an enabling environment to support private sector investment in technology development and transfer. The leveraging performance of existing public policies and sources of finance is assessed based on programme evaluations, or the claims that are made by the source of finance or the organisation responsible for implementing the measure.

In step 3, average leveraging ratios for each stage of technological maturity are determined based on the review of leveraging ratios for individual measures in step 2.
In step 4, because of the uncertainty associated with the level of public financing that Parties will commit to through the post-2012 international climate change agreement, the implications of restricted public financing is assessed. Limits of public financing of USD 50 billion and USD 100 billion annually are imposed in the scenarios. Then the level of private sector leverage required to meet the financing gap in step 1 is determined, which informs an assessment of what types of measures will be needed in light of the Copenhagen Accord (UNFCCC, 2009d) in which there was agreement to mobilize USD 100 billion per annum, including private financial sources. The types of policies and investment programmes considered include those being proposed by Parties to the Convention as part of the post-2012 international climate change agreement.

Finally, conclusions are presented on the use of leveraging as a policy objective and evaluation tool, and based on the analysis in the steps above, on the type of public policy and financing arrangements that should form part of a post-2012 agreement.
3 The rationale for public leveraging of private investment

3.1 What is leveraging?

As defined in Chapter 1, leveraging refers to public policy interventions which aim to stimulate private sector investment and is expressed as a ratio of public investment to private investment. In order to measure the leveraging effect of public policies, a causal relationship needs to be established between the public policy and the ensuing private investment. This will be specific to each public policy.

While the use of the concept of leveraging in the private sector goes well beyond the scope of this dissertation, it is important to recognise that the use of the term in public and private sector circles differs significantly. In the private sector, leverage\(^7\) often refers to the harnessing of ‘other people’s money’ to grow a company and increase its productive capacity\(^8\). There are many variations of the concept of leveraging used in the private sector, but perhaps the most commonly used form in micro-economics is the debt to equity ratio (Miller, 1991). In macro-economics leveraging usually refers to the ratio of debt to gross domestic product (Bivens, 2004). In the wake of the financial crisis and recession of 2007–2010, the leveraging ratio of national governments, financial institutions and large multinational corporations has become an increasingly important measure of performance with the World Bank proposing defined mandatory limits on leveraging (D’Hulster, 2009).

In practice, government policy makers and private sector investors are all trying to leverage each other’s resources to maximise the effectiveness and success of their policies and investments. However, the private and public sectors have different objectives in leveraging each other’s resources. For private sector investors a primary objective of leveraging is risk management and maximising the growth potential of a business (D’Hulster, 2009).

Most venture capital firms seek to leverage their investments by investing jointly with other private equity investors (a consortium or syndication approach). This consortium of investors is referred to as an investment group, and usually consists of one lead investor and a few follower investors. This team approach to investing allows these private equity investors to spread the risk of their investments. Private equity investors also find it beneficial to utilize various government financial incentives to leverage their risk and cost of investment. They accomplish this by utilizing government business incentive programmes to leverage their own private equity in a portfolio company (NEF and UNEP Sustainable Energy Finance Initiative (UNEP-SEFI), 2008, D’Hulster, 2009).

From a public sector perspective, the policy objective of leveraging is more orientated toward shifting investment patterns, or focusing private investment toward the achievement of public goods (Romani, 2009; OECD, 2004; Cervantes, 1999).

\(^7\) The term ‘gearing’ is also used in the private sector as an alternative work for ‘leverage’.

\(^8\) Often with negative connotations, such as in the 1914 book of essays by Louis Brandeis titled ‘Other peoples money and how the bankers use it’ (Brandeis, 1914) which criticised the powerful role of investment banks and conglomerates in manipulating markets, preventing competition while impacting on worker’s rights. Similarly, in the wake of the credit crisis, heavily leveraged banks and other firms have been criticised for their reckless use of debt and squandering the savings of millions of citizens.
3.2 Key issues in measuring the leveraging effect of public policy interventions

There is a wide range of different public policy interventions which have the objective of leveraging private sector finance. It can be useful to distinguish between these forms of intervention, as they may create different leveraging effects on the private sector.

Individual projects, such as those funded through public financial institutions such as public venture capital funds may have isolated leveraging effects contained to the project itself but do not necessarily lead to any wider impacts on the behaviour of the private sector and hence do not leverage discernable additional private investment.

Public investment programmes may result in the leveraging of private investment in a set of individual projects which mobilises a critical mass of investment sufficient to create new markets for technologies which then triggers further private sector investment. These programmes may also result in knowledge spill-overs (Audretsch, 1995; Audretsch, et al., 2005; Acs, et al., 2005) into other firms or sectors of the economy not originally part of the programme, and in doing so a form of secondary leveraging is achieved. If a critical mass of investment is achieved there may be technology learning (Nakicenovic, 1997; McDonald and Schrattenholzer, 1999; OECD, 2000; IEA, 2008a) or demonstration effects (US SBA, 1994; Branscomb and Auerswald, 2002; Auerswald and Branscomb, 2003; Murphy and Edwards, 2003; Williams, 2004; Auerswald, et al., 2005; Grubb, 2005) which lower the risks for other investors or reduces the cost of further investments. Alternatively, the public investment programme may also involve other complementary interventions, such as the removal of barriers to investment aimed at improving the overall effectiveness of the public investment. An example could be investment facilitation to fast track approvals or to reduce trade related barriers to investment. Again the complementary support provided may also stimulate second order effects that mobilise additional private sector investment.

A third category of public intervention includes broader government policies that aim to alter the underlying conditions for private investment and thereby shift investment patterns (OECD, 2009b). An example may be a national energy policy, or a renewable energy strategy. These broader policies may involve a combination of programmes of investment, regulatory reforms, capacity building, investments in tertiary education, investment facilitation and the creation of greater investor awareness, which all work together to leverage private sector investment. In these cases there will be primary and secondary leveraging effects as described above for individual projects and public investment programmes, but there may also be tertiary effects, which could include greater total capacity to integrate a technology within a national economy, enhancements to the national system of innovation, increased endogenous technological capability, and other potentially more significant yet less tangible system changes that nonetheless will alter investment patterns and leverage private sector investment.

These different forms of public intervention suggest that leveraging effects, particularly of programmes and policies, can cascade as the direct leveraging creates secondary and tertiary responses from the private sector. In this way policies might be considered to catalyse change, however, the indirect responses are almost always impossible to measure directly and attribute to a particular policy (Technopolis, 2001). This cascading effect is illustrated in Figure 2.
This multilayered or integrated approach is commonly referred to within the context of the climate change Convention. In fact, the act of using public financing to leverage private sector investment is just one component of the catalytic role of the Convention. Within the Bali Action Plan (UNFCCC, 2007b, paragraph 1(vii)), Parties decided to identify “ways to strengthen the catalytic role of the Convention in encouraging multilateral bodies, the public and private sectors and civil society, building on synergies among activities and processes, as a means to support mitigation in a coherent and integrated manner”.

Leveraging, particularly within the broader context illustrated in Figure 2 above, involves important non-financial factors that relate to capacity and learning and institutional and policy reforms that must accompany investments in technology. These might be considered the factors that create an enabling environment for public leveraging of private investment and considered in more detail in Chapter 5 of this dissertation.

The Carbon Trust, a public corporation with the objective of catalysing a low carbon economy in the United Kingdom (UK), consistently tracks the leveraging performance of its investments. The estimates of its leveraging performance are subject to regular audits by the UK National Audit Office (NAO, 2007). In order to demonstrate the cascading effect of leverage presented in Figure 2 and to provide a concrete example of how leveraging ratios are used in practice, Figure 3 pre-
sents the Carbon Trust’s projected leveraging impact on the private sector, where they measure both the direct (primary) and indirect (secondary) leveraging that result from their programmes.

**Figure 3**  
Carbon Trust’s 2007 forecast of its overall leveraging effect illustrating the first and second order effects on private sector investment.

The climate change Convention by its Article 11 establishes a financial mechanism of the Convention. The COP has assigned the operation of the financial mechanism to the Global Environment Facility (GEF). While reviews of the GEF have identified weaknesses in regard to its effectiveness in primary and secondary leveraging (GEF, 2003a), it has been considered effective in achieving tertiary leveraging effects, even though these effects have not be quantified:

GEF partners have brought a wealth of value to GEF projects in the form of technical expertise, management capacity, equipment and technology, and other in-kind contributions. GEF partners have included NGOs, government agencies, regional and national institutions…and private sector entities [and this evaluation] found evidence of GEF projects that led to government commitment and resources (staff and budget) to continue activities and support replication in multiple localities. (GEF, 2005a, pg. 35)

However, the GEF has made some progress in monitoring the replication effect of its projects in terms of greenhouse gas emission reductions. In 2004, the GEF Evaluation Office undertook a study which estimated that after an initial GEF project had been completed, the learning from the project enabled similar projects to be catalyzed within the host countries. It estimated for 104 completed projects with an investment of USD 605 million resulting in emission reductions of 430 million tonnes of CO₂-e an additional 1270 tonnes of emission reductions were achieved due to this replication effect (GEF, 2004a, pg. 30).

There remain significant methodological concerns regarding the use of leveraging as a measure of performance. The need for greater rigour in the measurement of leveraging has been a recurring theme in reviews of the GEF since the first overall review in 1998 which recommended:
The GEF should adopt a rigorous definition of “leveraging” that includes only funding that is additional to existing funding patterns and that is expected to create global environmental benefits. It should apply this definition in the Quarterly Operational Report and other relevant GEF documents. Implementing Agencies should apply this more rigorous definition in their own databases and reports on cofinancing of GEF projects. (GEF, 1998, pg. 14)

Most programme performance evaluations lack precision in the way the temporal dimensions are considered or reported. The leveraging effects of many programmes, particularly those in the early stages of technological maturity may take time to gestate. With project-based initiatives, the leveraging (of the first order) is more easily measured, however the longer term impacts take time to occur and are difficult to measure. Programmatic initiatives, particularly those that actively facilitate change through capacity building, may take longer to demonstrate a leveraging effect, and may indeed create more persistent change and shifts in private investment patterns. Similarly, short-term leveraging performance in some programmes may not result in lasting change or the emissions savings may be counteracted by rebound effects which are commonly found in energy efficiency programmes (Jalas and Plepys, 2001).

Double counting and attribution errors are also prevalent when accounting for leveraging effects of policies and programmes. Causality is difficult to attribute because there are many potential influences on private sector investment, and proving that a public policy intervention caused a quantified increase in private investment can often be difficult, if not impossible (Technopolis, 2001). This can lead to double counting, especially where a technology, project or firm receives multiple forms of financial support or assistance from the public sector (for example between state and federal government agencies). Good reporting systems and programme evaluations take this into account but many are not transparent in how they do so. As the OECD (2009, pg. 16) has noted, “there are no agreed quantitative metrics for policies and programmes enacted by Annex II parties to incentivise private sector participation in developing country mitigation.” The UNFCCC needs to established adequate accounting standards for handling private sector financing within its reporting procedures to address the many potential inaccuracies in the data that are currently available.

There may also be displacement issues that need to be taken into account when evaluating the leveraging effect of public policies. Some businesses may benefit at the expense of others, the leveraged investments may crowd out investments that may have occurred without public support or they may favour bigger firms causing small businesses to fail to establishing themselves. Another form of displacement effect occurs when the benefits of the policy intervention ‘leaks’ outside of the jurisdiction in which it was applied, in which case the benefit may not be captured in the assessed leveraging ratio (Bingham, 2005; PACEC, 2009). As Pilat, et al., (2009) explain in relation to the displacement effect in R&D:

Traditional policies and instruments for stimulating research and innovation are under pressure to adapt to the global context for innovation. For example, the globalisation of R&D implies that the leverage effect of public instruments may become less effective if national firms can readily shift R&D or expand it in offshore markets with greater growth potential. Another possible implication is the need for greater coherence in policy making across government ministries and departments to increase the leverage of existing mechanisms.

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9 This problem is not unique to evaluations of leveraging effects. The problem of attribution is commonplace in evaluations of public policies and programmes (Hardy and Zdan, 1997; Parmenter, 2007).
Leveraging ratios should not substitute for other important measures of policy and programme performance. There is a wide range of measures of efficiency and effectiveness that should be taken into account when evaluating policies and programmes (Technopolis, 2001; Cozzens and Melker, 1997). A comprehensive review of leveraging objectives of housing programmes in the United States conducted for the House of Representatives Committee on Financial Services (US House of Representatives, 2007) found that a focus on leveraging may actually lead to less efficient outcomes if it is allowed to distract attention from the quality of programme delivery. The qualitative outcomes from programmes may be less tangible; however, they may also represent the most important measures of success.

As Bingham concludes in his 2005 review of the use and abuse of leveraging in US Federal economic and technology development programmes:

> the use of leveraging ratios for making awards and conducting evaluations should be viewed with caution because they fail to reflect many important program goals. In spite of the fact that there are limitations to the use of leveraging and leverage ratios, one thing should be kept in mind. As an economic development strategy and evaluative tool, leveraging ratios are relatively new. Thus they really have not had time to develop. (Bingham, 2005, pg. 462)

Another risk associated with mechanisms that aim to maximise leveraging of the private sector is that they may lead to private sector entities dominating the selection of investments which may not lead to optimal long-term outcomes. Decision makers may give a lower priority to longer term technology or policy objectives in order to gain a short-term success in mobilising the private sector to address acute public policy problems. For example, building local capacity and support for maintenance of an installed technology may become a lesser priority, or technologies that may be more expensive or complex but which have greater local potential may be forgone. This has been a common complaint of least developed countries during reviews of the GEF (UNFCCC, 2006). As the overall review of the GEF concluded in 1998:

> The strong emphasis placed by GEF on leveraging is legitimate, given the relatively small size of the fund and the fact that it is one of the few quantitative measures available for judging GEF success. The [evaluation] team believes, however, that there is a danger in placing too much emphasis on leveraging of financial resources by GEF projects as a measure of success. An overemphasis on total financial resources mobilized may distort programming decisions by tilting them in the direction of projects that have the largest amount of cofinancing. (GEF, 1998, pg. 13)

A case in point involves small-scale renewable energy systems. The International Finance Corporation (IFC) in partnership with the GEF established the Renewable Energy and Efficiency Fund (REEF) in 2000 aiming to catalyze private sector investment by targeting both larger and smaller investment deals. According to a GEF review in 2004:

> a GEF cofinancing facility of about US$23 million was intended for the smaller enterprise deals (less than 7 megawatts), as these are often more complex, yield lower absolute return, and are therefore less attractive to investors. Instead, however, the investors pursued a strategy of building a conventional investment portfolio with larger, more commercial, grid-connected renewable energy projects before turning to smaller projects. This strategy failed when such potentially profitable projects did not materialize. As a result, IFC had to close down REEF in 2002. (GEF, 2004b, pg. 14)
Leveraging requirements can also decrease access to finance for (some) developing countries and can lead to substitution between funding sources. This later concern was identified as a major problem in both the House of Representatives Committee on Financial Services Housing Review mentioned above (US House of Representatives, 2007) and the review of the Australian Cooperative Research Centres Programme in Australia (Commonwealth of Australia, 2008).

In regard to the issue of access to finance, the Bali Action Plan (UNFCCC, 2007b, paragraph 1 (e)(i)) emphasises the need for “improved access to adequate, predictable and sustainable financial resources”. Developing countries, particularly small island developing states and least developed countries have consistently complained that existing financing arrangements for climate change do not allow for direct access to finance. Indeed, the protracted negotiations on the establishment of the Kyoto Protocol Adaptation Fund have centred on the level of direct access that should be provided, with developed countries concerned for the efficient and transparent use of such funds.

Mechanisms that aim to leverage the private sector in a formidable way are less likely to involve direct access and grant-based financing. As will be shown in Chapter 7, the most effective mechanisms for mobilising the private sector investment either involve the well designed provision of temporary incentives direct to the private sector, or are regulatory in nature and require investments from private sector entities in a completely new technology or practice. In most cases direct country access to funding is not a feature of these mechanisms. The exception may be policy-based approaches such as the Korean proposal for crediting Nationally Appropriate Mitigation Actions, or sectoral ‘no-lose’ target crediting mechanisms such as those proposed by Japan and others (Ward, et al., 2008).

While leveraging the private sector may increase the total amount of finance for mitigation and adaptation, the benefits are likely to accrue to a small number of developing countries with larger markets, stronger administrative systems and domestic financing capabilities. Least developed countries and those with smaller economies are unlikely to benefit, as has been the case with the Clean Development Mechanism (CDM) (Bakker, et al., 2007; Ellis, et al., 2007). Capacity building is crucial, and Official Development Assistance (ODA) and grant-based funding (particularly those with efficient application and acquittal requirements) will remain important for many developing countries to support early stage technologies and urgent response actions particularly where other financing options are not available and where private sector partners are unwilling to participate.

Finally, mechanisms that are effective in leveraging the private sector may not necessarily address the issue of scale. Some mechanisms (such as public venture capital funds) can be scaled up through larger public investments or by expanding the reach of programmes and the level of emissions reductions that they achieve. However, others options (such as prizes for technology breakthroughs) are less scaleable. In terms of existing initiatives, the CDM is one mechanism that is on the way to achieving effectiveness in leveraging private sector investment at a scale that is commensurate with total investment needs (UNFCCC, 2009b).

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11 http://unfccc.int/files/meetings/ad_hoc_working_groups/lca/text/plain/non-paper_from_korea.txt, last accessed 04/2010
3.3 The rationale for increasing the share of private sector financing

The concept of leveraging in public policy may have been borrowed from the world of finance. However, it is ultimately a concept borrowed from physics — a lever gives mechanical advantage and is used to amplify a small quantity of force into a larger quantity of force. For finance it implies amplification of earnings by application of inputs such as debt, and in public policy it implies an amplification of total investment stimulated by the scarce yet effective allocation of public resources.

In public policy, the use of the concept of leveraging may also stem from the influence of economic rationalism and managerialism in the public service (Pusey, 1991; OECD, 1995), and is most certainly a response to greater scrutiny on public investment programmes and demands for better management information about the goals and progress of those programmes, in particular the cost-benefit of public investments schemes (see for example Carnegie Commission on Science, Technology, and Government, 1992).

However, the concept also has other political associations within the context of the debate on financing for climate change under the UNFCCC. Here the concept stems from three crucial provisions of the Convention, Article 4, paragraphs 3 and 5, and Article 12, paragraph 5 shown in the box below, which have been the subject of divergent interpretation since the Convention entered into force in 1994 (UNFCCC, 1994).

Article 4, paragraph 3 states that:

“The developed country Parties and other developed Parties included in Annex II shall provide new and additional financial resources to meet the agreed full costs incurred by developing country Parties in complying with their obligations under Article 12, paragraph 1. They shall also provide such financial resources, including for the transfer of technology, needed by the developing country Parties to meet the agreed full incremental costs of implementing measures that are covered by paragraph 1 of this Article and that are agreed between a developing country Party and the international entity or entities referred to in Article 11, in accordance with that Article. The implementation of these commitments shall take into account the need for adequacy and predictability in the flow of funds and the importance of appropriate burden sharing among the developed country Parties.”

Article 4, paragraph 5, states that:

“The developed country Parties and other developed Parties included in Annex II shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention. In this process, the developed country Parties shall support the development and enhancement of endogenous capacities and technologies of developing country Parties. Other Parties and organizations in a position to do so may also assist in facilitating the transfer of such technologies.”

Article 12, paragraph, 5 states that:

“The developed country Parties may also provide and developing country Parties avail themselves of, financial resources related to the implementation of the Convention through bilateral, regional and other multilateral channels.”
Annex II\(^{12}\) Parties have held the position that private finance and not public finance should dominate financial flows under the Convention and that private sector funds mobilised directly through public policies and measures under the Convention (such as the CDM) should be recognised as contributions to Article 4, paragraph 3 and 5 of the Convention (see for example European Commission\(^{13}\), 2009). They have also argued that a range of different types of finance should be recognised, including concessional loans and risk reduction instruments on the basis that they are a form of financial transfer because they contain a subsidy component and they mobilise greater investment in developing countries than would otherwise occur through the use of grant-based finance.

On the other hand, non-Annex I Parties have argued that the provisions of the Convention clearly refer to public sources of finance and that private sources should complement but not substitute for public financing (UNFCCC, 2008b). They point out the existing commitments of Annex II Parties to finance the incremental costs of mitigation and the full costs of adaptation in developing countries, in accordance with Article 4, paragraphs 3 and 4. They have also argued that the primary type of finance that should be recognised are grants rather than concessional forms of finance.\(^{14}\) For non-Annex I Parties the issue is the need for Annex II Parties to provide compensation for historical emissions that impose costs through the need to adapt to climate change and the lack of opportunity to develop using low cost fuels as was the case for industrialized countries.

Despite this ongoing battle within the negotiation process, the decisions of the COP and guidance provided to the financial mechanism of the Convention has consistently include references to both the need to account for private sector financing that has resulted from the public policies of Annex II Parties, as well as the need to report under the Convention on the leveraging that results from Annex II Parties’ public policies and investment programmes, and those of the funds of the Convention. For example, decisions of the COP (UNFCCC, 1996b; 1997c) including the memorandum of understanding with the GEF as the interim operating entity of the financial mechanism of the Convention, as well as more recent COP decisions providing guidance to the GEF (UNFCCC, 2008d) call on it to actively increase and report on its leveraging of other sources of finance, including the private sector.

Furthermore, in relation to reporting on private finance through Annex I national communications the UNFCCC Guidelines on Reporting and Review (UNFCCC, 2000a, paragraph 54) states that:

> Parties shall, when reporting details of measures related to the promotion, facilitation and financing of the transfer of, or access to, environmentally-sound technologies, clearly distinguish between activities undertaken by the public sector and those undertaken by the private sector. As the ability of Parties to collect information on private sector activities is limited, Parties may indicate, where feasible, in what way they have encouraged private sector activities, and how these activities help meet the commitments of Parties under Article 4.3, 4.4 and 4.5 of the Convention.

\(^{12}\) Annex II Parties under the UNFCCC are those (developed country) Parties who are obliged under Article 4, paragraph 3 to provide finances to developing countries to enable the implementation of the Convention.

\(^{13}\) The EU position leading up to Copenhagen was that up to 80 per cent of the incremental costs of financing mitigation and adaptation in developing countries could be financed by the private sector and by the carbon markets. The remainder would be provided through a range of bilateral and multilateral public sources.

Indeed, COP decision 3/CP.13 agreed “to encourage Parties to scale up and/or develop innovative public/private financing mechanisms and instruments that increase access to developing country project and business developers that play a role in the transfer, development and/or deployment of ESTs [environmentally sound technologies], focusing in particular on...increasing the potential of public funds to leverage private sector capital” (UNFCCC, 2007b, paragraph 17 (e)).

In relation to the types of finance that are provided for under the Convention (i.e. concessional or grant-based finance), Article 11\textsuperscript{15} is categorical. It states that its purpose is the “provision of financial resources on a grant or concessional basis, including for the transfer of technology”.

Leveraging is a key performance indicator of the GEF (UNFCCC, 1998; Nichols and Martinot, 2000). According to the GEF, the purpose of its engagement of the private sector is to attain enhanced levels of global environmental benefit, in light of the following points:

• “private investment flows are far more important than official development assistance to the same countries;
• privatization of state-owned electric utilities, which accelerated in the 1990s, suggests the need to work more with the private sector in the energy sector;
• private sector actors can transfer state-of-the-art technology for energy efficiency and other environmentally desirable objectives;
• project sustainability and replication are often dependent on conditions that are conducive for further private sector investments; and
• GEF support in this area offers prospects for further mainstreaming of similar efforts by the implementing agencies.” (GEF, 2003a, paragraph 14)

Public financing is prone to a vast array of pressures and competing priorities and there are opportunity costs that arise from any particular funding choice. Public financing for climate change mitigation technologies may divert resources from other public good outcomes.

Furthermore, the ultimate policy objective is to successful shift current investment patterns so that the activities of all actors in society from the household-scale through to large trans-national corporations result in levels of greenhouse gas emissions that do not build-up in the atmosphere and contribute to climate change. In order to achieve this in the most cost-effective way, public policies and investments are required which either mandate changes in private sector investment patterns or provide sufficient incentives that make those changes economically feasible, while also removing barriers to clean technologies and investment patterns (UNEP-SEFI, 2002; Stern, et al., 2006; UNFCCC, 2008a, 2009a; b; Doornbosch and Knight, 2008; Romani, 2009).

While Parties to the Convention continue to debate the role of public and private finance, the gap in financing between what Annex II Parties are obliged to provide in accordance with the Convention (either public or private) and what have actually been delivered remains large, as will be explained in detail in Chapter 6. The financial mechanism of the Convention has attracted less than two per cent of the total financing required to meeting the objectives of the Convention (UNFCCC, 2009a), and given the required scale of financing, the efforts of the GEF to leverage private sector finance are unlikely to fill the overall gap in financing needs.

\textsuperscript{15} Paragraph 1, Article 11, United Nations Framework Convention on Climate Change.
4 The technology innovation cycle, types of finance and public leveraging of private investment

4.1 The technology innovation cycle and leveraging

Public policies aimed at accelerating technology development and transfer\(^{16}\) target different stages in the cycle of technology innovation (Gross and Foxon, 2003). The leveraging effect of public policies and investments tend to change depending on which stage of the innovation cycle is being targeted (see figure 5 in UNFCCC, 2009b).

The literature exploring the process of technology innovation is diverse and the pattern of innovation has been characterised in many different ways. Schumpeter (1911, 1934) was perhaps the first to make the distinction between the elements of technology cycle — invention, innovation and diffusion — in his study of the cycle of businesses. The concept was essentially linear, and it was further developed and refined by students of Schumpeter and many others from many different disciplines throughout the 20\(^{th}\) Century. Contemporary innovation theory has challenged the linear model as a poor representation of innovation in practice, arguing that process of innovation is dynamic and often chaotic (e.g. Kline, 1985). However, while many commentators note that in practice linear progressions in technological maturity are rare, a satisfying model for non-linear technology innovation has not emerged and for convenience most adopt a linear characterisation of technological maturity.

Figure 4, prepared for the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report Working Group III Report (Metz, et al., 2006) adapted from Foxon (2003), illustrates some of the dynamics in the development of technologies, including the respective roles of the public and private sectors. The diagram illustrates a linear sequence yet also attempts to show that technology development learning flows both ways and in a cyclical and dynamic fashion.

\[\text{Figure 4} \quad \text{Technology development cycle and the main driving forces.}\]


\(^{16}\) The phrase ‘technology development and transfer’ is used throughout this dissertation as a substitute for the longer phrase ‘research, development, demonstration, deployment, diffusion and transfer of technologies’ which addresses each stage of the technology innovation cycle.
The technology development cycle depicted in Figure 4 is basically a linear sequence from basic research and development (R&D) to the widespread diffusion of a commercially mature technology throughout society. However, there is no agreement on the best way to define such sequential “phases” of innovation. Figure 5 illustrates the various terminology that are commonly used in the literature.

**Figure 5** Overview of different concepts of technological maturity and phases of technology development and innovation used in the literature.

<table>
<thead>
<tr>
<th>Level of technological maturity</th>
<th>Invention</th>
<th>Innovation</th>
<th>Diffusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research</td>
<td>Demonstration</td>
<td>Economically feasible under specific conditions</td>
<td>Mature market</td>
</tr>
<tr>
<td>Research and Development</td>
<td>Demonstration</td>
<td>Up-scaling</td>
<td>Commercialisation</td>
</tr>
<tr>
<td>Basic R&amp;D</td>
<td>Technology R&amp;D</td>
<td>Market Demonstration</td>
<td>Commercialisation</td>
</tr>
<tr>
<td>Basic research</td>
<td>Applied research and design</td>
<td>Applied market and policy research</td>
<td>Efficiency research</td>
</tr>
<tr>
<td>Learning by research</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research and Development</td>
<td>Demonstration</td>
<td>Deployment</td>
<td>Diffusion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Commercially mature</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Technology transfer</td>
<td></td>
</tr>
</tbody>
</table>

Source: UNFCCC (2008a) adapted from Arrow (1962a; 1962b); Schumpeter (1939); Schmookler (1966); Hayami and Ruttan (1985); Grubb (2005); Arthur (2006); IPCC (2005); Sandén and Azar (2005).

In this dissertation, the categories that are used are ‘research and development’ (R&D), ‘demonstration’, ‘deployment’, and ‘diffusion’.

To categorise technologies by their stage of technological maturity as the basis for undertaking the analysis of financing of technology in different stages of maturity, a typology of technological maturity needs to be established that is based on the barriers that technologies experience and that corresponds with the risks faced by the private sector in making investments in technology (UNEP-SEFI, 2002; UNFCCC, 2008a). This is convenient because it provides a conceptual link between technology maturity, barriers to finance and deployment, the main types of finance and financial support that technologies may require, the types of public policies and investment strategies that can be applied to stimulate innovation and the extent to which these policies and investments are able to leverage private sector investment.
The typology of technology maturity and the relationship between each stage and the factors listed above are shown in Table 2.

Table 2 Types of barriers, main types of finance, types of policies and leveraging potential by stage of technological maturity

<table>
<thead>
<tr>
<th>Stage of technological maturity</th>
<th>Types of barriers</th>
<th>Main types of finance</th>
<th>Types of policies</th>
<th>Leveraging potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;D</td>
<td>Proof of concept, technical, scale, cost, economic, social, institutional</td>
<td>Grant-based finance, fiscal incentives, equity (seed capital)</td>
<td>Joint R&amp;D programmes, tax incentives, grant programmes</td>
<td>Low</td>
</tr>
<tr>
<td>Demonstration</td>
<td>Scale, cost, economic, social, institutional</td>
<td>Grant-based finance, fiscal incentives, equity (seed capital and venture capital)</td>
<td>Tax incentives, grant programmes</td>
<td>Low</td>
</tr>
<tr>
<td>Deployment</td>
<td>Cost of the technology exceeds that of the incumbent technology by more than the marginal or incremental cost of the emission reductions</td>
<td>Cost, economic, social, institutional, market transaction costs</td>
<td>Grant-based finance, fiscal incentives, equity (venture capital, private equity)</td>
<td>Production subsidies, feed-in tariffs, deployment targets, tax credits, public venture capital funds, removal of perverse subsidies</td>
</tr>
<tr>
<td>Diffusion</td>
<td>Cost of the technology exceeds that of the incumbent technology by less than the marginal or incremental cost of the emission reductions</td>
<td>Economic, social, institutional, market transaction costs</td>
<td>Fiscal incentives, private equity, debt</td>
<td>Technology standards, emission trading schemes, green loan programmes, green bonds, removal of perverse subsidies</td>
</tr>
</tbody>
</table>

Source: adapted from UNEP-SEFI (2002); UNEP (2008a), UNFCCC (2008a,b), IEA policy database (2010).

The dissertation follows the same approach that was adopted by the UNFCCC (2009a) in its analysis of current and future financing needs and in its use of the technology innovation cycle. The UNFCCC used the following diagram (Figure 6), adapted from Stern et al., (2006) to illustrate the way learning and experience curves and costs interact with incumbent, commercial technologies. This diagram is also useful in regard to understanding the relative leveraging effects of public policies and investments at each stage of the technology innovation cycle.
Figure 6  Technology learning curves and how the costs of new technologies and the time that it takes for new technologies to become competitive can be reduced through a combination of accelerated R&D programmes, technology demonstration programmes, deployment support measures, carbon prices and diffusion support measures.


The leveraging potential of public policies and investments that target technologies across the innovation cycle also tend to follow a typical pattern consistent with trends in the incremental costs illustrated in Figure 6, where the shaded portion of the graph indicates the marginal or incremental costs of climate change mitigation technologies. Figure 6 illustrates how public interventions can reduce the cost of technologies, but it also illustrates how these policies can increase the potential to leverage private sector investment in technologies at the various stages of maturity. At the R&D, demonstration and deployment stages the risks for the private sector are great, and public policies find it difficult to leverage private investment. The average leveraging ratios achieved for each stage of technological maturity are reviewed in detail in Chapter 7, however the general trend is illustrated in Figure 7.\[17\]

\[17\] The diagram represents the overall relationships, however, there are exceptions to the rule. In practice there is a range of leveraging ratios achieved at each stage of the technology innovation cycle, which is presented in detail in Chapter 7. For example, in some cases leveraging ratios in the medium range have been found for research and development and demonstration technologies, and leveraging ratios in the high range have been found for technologies in the deployment stage.
Figure 7. *Theoretical relationship between the proportion of private sector investment required, the leveraging ratios that can be achieved by public policies and investments and the stages of technological maturity.*

Source: Author’s Diagram based on UNFCCC (2009b) and NEF and UNEP-SEFI (2008). Note: Low is estimated as a range from 1:0.5–1:3; Medium is estimated as a range from 1:3–1:1:10; High is estimated as a range from 1:10–1:100.

### 4.2 Types of finance and leveraging

To maximise the leveraging potential of public policies and investment programmes, it is essential that the types of finance offered match the various needs of the private sector. It is useful to focus on major gaps or bottlenecks that prevent the flow of private financing. Financing needs can vary significantly over time, by technology and by country, and public policies need to be responsive to these changing circumstances.

There are many different types of financing that can be applied to a climate change technology project or programme, however, in general there are three main types of finance: equity, mezzanine and debt finance (Rogers, 2009). Public policy and investment programmes can stimulate and directly make available different types of finance to target gaps in the availability of finance for particular technologies with the aim of leveraging greater private sector investment.

Figure 8 illustrates the characteristics of each type of finance.
Figure 8  Characteristics of the major types of finance

Public financing mechanisms can be tailored to address each type of finance. Measures that aim to support early stage technology development tend to be equity-based financial instruments, mezzanine financing is particularly suited to assist in the commercialisation of technologies, and debt financing instruments are often applied to low risk technologies and are suited to deployment and diffusion of technologies (Coogan, et al., 2007). An example of the later is the World Bank’s Climate Change Bond which was first issued in November 2008 and after four issues of bonds the instrument has raised approximately USD 1 billion for investment in climate change mitigation projects in developing countries (World Bank, 2010a). These types of initiatives are particularly important in the context of the state of the financial markets in the period 2007–2010 and the need to ensure the growth in climate change investments.

Firms often acquire much more complex financing arrangements than this general typology of finance suggests. The European Union (EU) FUNDATEC project undertook an extensive survey of technology developers in 2007 to determine what sources of finance are most commonly used (Coogan, et al., 2007). Technology developers in Europe, Asia and the United States were surveyed. The frequency with which technology developers identified different financial sources is presented in Figure 9. The horizontal axis shows the number of responses within the survey to the use of particular types of finance.
A company will typically attempt to finance its operations with a maximum of debt financing because this will allow the company to minimise the cost of finance, and to maximise its ongoing control of the company and the amount of revenue that it will retain for future development of the company. However, debt financing may be difficult to obtain due to the inherent risks involved in new technologies or new companies (NEF and UNEP-SEFI, 2008).

As Figure 9 shows, companies in the early stages of development are heavily dependent upon government grants, seed capital (from public and private investors) and the own personal funds of the technology developer. As a company takes its technology closer to commercialisation, venture capital and private equity financing becomes more common, and then in the commercial stage, debt financing tends to dominate.
5 The enabling environment: a prerequisite for public leveraging of private investment

At its very basic level, effective action on any challenging national policy issue, such as climate change, requires a stable political environment, the rule of law, suitable national policies and regulations, and the human capacities within that nation to undertake the necessary tasks. Equally important is the international context, such as the presence of fair trading policies, supportive international monetary and aid policy, and access to institutions and support to take action.

It is widely agreed that the appropriate enabling environment and market conditions will dramatically improve the effectiveness of an intervention and that there is a need for targeted measures that improve the enabling conditions for investments in climate technology (IPCC, 2000). Any public policy that attempts to leverage greater private sector investment will be hamstrung without concomitant public investments in the enabling environment.

Therefore, the financial aspects of technology development and transfer which are the focus of this dissertation must be considered within this broader context of the barriers to financing technologies in developing countries. While this dissertation does not directly address the question of enabling environments, it is clear that it must be a key component of any strategy to increase public sector leveraging of private sector investment. The UNFCCC defines enabling environments as, “fair trade policies, removal of technical, legal and administrative barriers to technology transfer, sound economic policy, regulatory frameworks and transparency, all of which create an environment conducive to private and public sector technology transfer” (UNFCCC, 2003, pg. 7).

For many developing countries, even with suitable national policy frameworks, the domestic private sector is not sufficiently developed and there is a reliance on foreign investment and expertise to advance essential national development interests, including the implementation of climate change policies. The ability of a country to attract private capital and to benefit from the foreign investment that is made is crucial for national economic development. An understanding of the international patterns of private financing is instructive for understanding how enabling environments are crucial pre-requisite for public policies that aim to leverage private sector investment to address climate change.

Figure 10 presents the overall structure of global private sector financial flows.

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Broadly, private finance can be classified into two categories: domestic capital and foreign capital flows. Domestic capital may come from three principal sources: private investors, public capital markets and commercial banks. The capacity of these capital providers/markets, to some degree, is determined by the level of economic development of the country (Carmody and Ritchie, 2007). The ability to raise funds for clean energy on public capital markets in developing countries, for example, depends on the existence of such a market in the country.

Private investment in clean energy assets that originates in another country would be categorized as Foreign Direct Investment (FDI). FDI represented 22 per cent of current global investments by private corporations in 2007 (United Nations Commission on Trade and Development (UNCTAD), 2008). As illustrated in Figure 10, in general the flow of FDI between developed countries is much greater than flows of FDI to developed countries. However, while this general trend holds true, closer observation at a regional-scale shows significant differences in the level of foreign investment by country. The World Bank’s World Development Report consistently shows that FDI tends to flow to those countries where relatively strong enabling conditions for investment exist (World Bank, 2010b, pg. 295). For this reason, public policy mechanisms that attempt to leverage private sector investment must be accompanied and preferably preceded with investments in the legislative, policy and institutional arrangements that support investment (OECD, 2009b). If this is not possible, then the potential to leverage private finance will be diminished and the need for public financing will be greater.

A key enabling environment issue affecting the ability of public policies and investment programmes to leverage private sector investment is the extent of public subsidies directed towards existing greenhouse gas emission intensive technologies and fuels. UNEP (2008b, pg. 11) estimates that fossil fuel subsidies could be in the order of USD 300 billion per annum, although country by country analysis has not been conducted. When this figure is compared with the USD 262–670 billion per annum of additional finance needed for mitigation (see Chapter 6, below), it is clear that even partial elimination of perverse subsidies could go a long way to addressing the financing gap, particularly if those subsidies can be redirected to low emission technologies. Indeed, the Group of 20 (G20) declared in 2009 to make significant progress on the elimination of perverse subsidies in the context of climate change (G20, 2009).
The performance of the CDM also demonstrates that public financing mechanisms are not effective in leveraging private sector investment unless a suitable investment climate is present. In 2006, Jung undertook a cluster analysis of countries based on their investment climate and found a significant correlation with the geographical distribution of CDM projects. CDM projects tend to be concentrated in a few countries with attractive investment conditions, and the number of projects declines significantly for countries that do not possess the necessary institutional and legal systems or where perceived political or economic risks are high. Interest rate risks can be a significant barrier to investment. Schneider et al., (2008) demonstrate that these correlations continue to persist (Table 3).

**Table 3 Correlation between investment attractiveness and number of CDM projects**

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of CDM projects (a)</th>
<th>Composite indicator of investment attractiveness (b)</th>
<th>Point Carbon investment ranking (c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>596</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>China</td>
<td>397</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Brazil</td>
<td>221</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Mexico</td>
<td>152</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Malaysia</td>
<td>42</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>Chile</td>
<td>31</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Thailand</td>
<td>28</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Korea</td>
<td>28</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>Indonesia</td>
<td>21</td>
<td>57</td>
<td>11</td>
</tr>
<tr>
<td>South Africa</td>
<td>17</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Peru</td>
<td>16</td>
<td>26</td>
<td>7</td>
</tr>
<tr>
<td>Argentina</td>
<td>13</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>Vietnam</td>
<td>10</td>
<td>22</td>
<td>13</td>
</tr>
<tr>
<td>Morocco</td>
<td>5</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Egypt</td>
<td>5</td>
<td>35</td>
<td>15</td>
</tr>
</tbody>
</table>

(a) Pueyo Velasco (2007)  
(b) Oleschak and Springer (2007)  
(c) Point Carbon (2007)

Source: Schneider et al., (2007).

There is a trend toward the preparation and implementation of national low emission development strategies in developing countries that address both the underlying conditions necessary to leverage private sector investment (the enabling environment) and also the gaps in the availability of public financing linked with a commitment from developed countries to provide the necessary financial support. The remainder of this dissertation focuses on the leveraging potential of individual public policies and investment programmes, however, the need for this integrated approach must be underlined, as it provides a more effective means of addressing the financing gap identified in Chapter 6 below.
6 The financing gap

Estimates of the financing gap that needs to be addressed to shift the world towards a low greenhouse gas emissions economy have been prepared by UNFCCC (2007a; 2008a; 2009a;b), synthesising a wide range of estimates in the literature. There is undoubtedly a large gap that exists across all technologies, all stages of technological maturity and all regions of the world, as illustrated in Figure 11. In this figure the financing gap is the ‘additional’ finance that is required. The term ‘low’ on the horizontal axis refers to the low end of the estimate range and the term ‘high’ on the horizontal axis refers to the high end of the estimate range.

Figure 11 Summary of the financing gap by stage of technological maturity (incremental costs as defined in Figure 6, above)

Source: UNFCCC (2009b).

The assessment of the financing gap is based on estimates of financing currently available and financing needs to stabilize greenhouse gas concentrations in the atmosphere at 500–550 ppm CO₂-e. The estimates of financing needs also assume that all of the operational costs that are saved by introducing clean technologies (such as the fuel costs saved by switching from oil or coal to solar or wind technologies) are captured. Operational saving may be captured over the life of an investment, however, the up-front investment costs can present a more significant challenge for public policies and investment programmes seeking to leverage private sector investment.

As UNFCCC (2009b) explains:

In terms of additional capital costs, the IEA in its Energy Technology Perspectives reports investment needs in the diffusion phase of up to USD 1,100 billion annually, as an average over the years 2010–2050. For diffusion in developing countries, USD 660 per year would be required based on an investment share of 60 per cent for developing countries and 40 per cent for developed countries, as estimated by the IEA (2008a, pg. 240).
Furthermore, the IEA estimates that USD 100–200 billion per year is required globally in early deployment costs, 60 per cent of which would be required in developing countries. Indeed analysis for the OECD by IEA staff shows the potential for costs to increase to 5600 billion annually should significant technology development prospects fail or if key policy mechanisms are ineffective (Doornbosch et al., 2008). Figure 12 presents the same data used by the UNFCCC in Figure 11, based on up front investment costs rather than incremental costs. As a comparison between figures 11 and 12 shows, the major difference is in the diffusion stage. Within this stage it is the investment costs associated with the transport sector, and particularly advanced vehicles, which dominate. These vehicles are much more fuel efficient, and over their lifetimes the increased up front capital costs are compensated with reduced running costs (IEA, 2008a).

Figure 12 Summary of the financing gap by stage of technological maturity (up front investment costs)

![Estimated Annual Investment Needs for Climate Change Mitigation Technologies](image)

Source: Author’s estimates based on UNFCCC (2009b) and IEA (2008a)

Unless otherwise stated, throughout this dissertation the figures used for the analysis of leveraging ratios are the incremental costs. While the investment cost reflects the initial hurdle for financing mitigation technologies, the public financing mechanisms assessed in this dissertation are designed so that businesses can structure their financing to take account of the higher up front capital costs of mitigation technologies with lower operational costs. The types of finance used for this purpose are discussed in section 4.2 of this dissertation. Each technology, project and business situation is unique in regard to the mix of capital and operating costs, revenues, equity and debt. This necessitates a mix of the types of finance and the use of innovative concessional financing tools by public policy and public investment programmes. It is also a reason for the need for a portfolio of public policy and public financing mechanisms which are tailored to address specific situations or needs.
Section 6.1 below discusses a more detailed breakdown of the estimates of the current level of financing for climate change mitigation technologies, and section 6.2 presents detailed information on the future financing needs.

6.1 Current financing for climate change mitigation technologies

It is useful to obtain a picture of the current state of financing for climate change technologies in order to understand the scale of the financing challenge and to study the effectiveness of various instruments currently being employed to leverage additional finance from the private sector.

Financing for climate change mitigation technologies is dominated by private sources of finance, but those private investments are heavily dependent upon public investments that cover the marginal (or additional) costs of mitigation technologies and the policy frameworks that provide the necessary incentives and market conditions that enable investment (UNFCCC, 2009a; NEF and UNEP-SEFI, 2008).

Table 4 shows current investment in mitigation technologies by source of finance and by stage of technological maturity.

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

<table>
<thead>
<tr>
<th>Source</th>
<th>R&amp;D (total spending)</th>
<th>Demonstration (total spending)</th>
<th>Deployment (additional cost of climate technologies)</th>
<th>Diffusion (additional cost of climate technologies)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Global</td>
<td>Global</td>
<td>Global</td>
<td>Developing countries</td>
<td>Global</td>
</tr>
<tr>
<td>Public</td>
<td>6^a</td>
<td>Partially included with R&amp;D</td>
<td>33^c</td>
<td>NA</td>
<td>19.5–27.0^f</td>
</tr>
<tr>
<td></td>
<td>At least 9.8^b</td>
<td></td>
<td>45^d</td>
<td>NA</td>
<td>12–22^h</td>
</tr>
<tr>
<td>Private</td>
<td>13^a</td>
<td>Partially included with R&amp;D</td>
<td>NA</td>
<td>NA</td>
<td>31.5–49</td>
</tr>
<tr>
<td>Total</td>
<td>15.8–70</td>
<td>Partially included with R&amp;D</td>
<td>30–45</td>
<td>NA</td>
<td>31.5–49</td>
</tr>
</tbody>
</table>

Source: UNFCCC (2009a); Abbreviations: NA = not available, R&D = research and development.

^a Based on 2 per cent share of global R&D of USD 1,000 billion in 2006.

^b IEA (2008c).


^e UNFCCC (2007a).

^f This estimate is the sum of financing for mitigation technologies provided by the clean development mechanism (CDM), joint implementation, bilateral official development assistance (ODA), multilateral development banks (MDBs), export credit agencies (ECAs) and by the Global Environment Facility (GEF), plus the New Energy Finance estimate of investment in carbon funds for the purchase of emissions permits in compliance and voluntary markets in 2007. It is assumed that most GEF, bilateral ODA, MDB and ECA financing is additional; however, this is not always the case.

^g Signifies all items included in the global amount except the investment in carbon funds for the purchase of emissions permits.

^h UNEP and NEF (2008). Based on NEF data. Estimates of the additional portion of the private investment for energy efficiency and low carbon investments in the energy sector. Additional investment is the premium in excess of the investment required for conventional technologies that provide comparable services. Based on data for the GEF and the CDM the additional portion of the investment is 15 per cent of the total investment.

^i IEA (2008a). This figure includes some unspecified investments at the demonstration stage.
The majority of the current financing (approximately 94 per cent) for climate change mitigation technologies occurs outside of the Convention (see UNFCCC, 2009a, Table 5). This has implications for the ability of an international climate change agreement to increase the leveraging of private sector investment because the influence of the Convention on these non-Convention sources of finance is very limited.

Nonetheless, the UNFCCC will at least have a tacit or indirect impact on domestic decisions of national governments and the policies and financing mechanisms outside of the Convention, and in general, these non-Convention institutions are also motivated and committed to increasing the level of financing and in particular to increase the extent of private sector financing for climate change.

The Bali Action Plan (UNFCCC, 2007b, paragraph 1 (b)(ii)) envisaged that under the Convention actions of national governments would be measurable, reportable and verifiable, and that through this mechanism of accountability to the COP, some influence may be gained on the policies and financing mechanisms of national governments and entities such as the international financial institutions.

### 6.2 Estimates of financing needs for climate change mitigation technologies

Many reports and studies have provide estimates of the financing needed for individual technologies and groups of technologies. Most studies do not provide detailed information on incremental investment for the full spectrum of technologies for mitigation and adaptation. Estimates of the additional financing needed to achieve the projected implementation of specified mitigation technologies can be derived from models and mitigation cost curves. These estimates are shown grouped by stage of technological maturity in Table 5. The additional finance needs are estimated to be between USD 262–670 billion annually, averaged from 2010–2050. Consequently the total level of investment (i.e., including current investment) required annually is USD 332–835 billion annually.

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19 See references in Table 5, below.
Table 5  Financing for Mitigation Technologies by Stage of Technological Maturity  
(billions of United States dollars per year)

<table>
<thead>
<tr>
<th></th>
<th>R&amp;D (total spending)</th>
<th>Demonstration (total spending)</th>
<th>Deployment (additional cost of climate technologies)</th>
<th>Diffusion (additional cost of climate technologies)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Global</td>
<td>Global</td>
<td>Global</td>
<td>Developing countries</td>
<td></td>
</tr>
<tr>
<td><strong>Current total</strong></td>
<td>15.8–70</td>
<td>NA</td>
<td>30–45</td>
<td>NA</td>
<td>77.3–164</td>
</tr>
<tr>
<td><strong>Additional financing needed</strong></td>
<td></td>
<td>50\textsuperscript{a}</td>
<td>57–94\textsuperscript{c}</td>
<td>250–440\textsuperscript{b}</td>
<td>262–670</td>
</tr>
<tr>
<td></td>
<td>20–100\textsuperscript{b}</td>
<td>25–35\textsuperscript{d}</td>
<td>27–36\textsuperscript{d}</td>
<td>200–210\textsuperscript{d}</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10\textsuperscript{e}</td>
<td>10–38.5\textsuperscript{e}</td>
<td>150–264\textsuperscript{b}</td>
<td>82–180\textsuperscript{e}</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>25.8–170</td>
<td>At least 27–36</td>
<td>55–139</td>
<td>At least 10–38.5</td>
<td>339.3–834</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: based on UNFCCC (2009b); Abbreviations: NA = not available, R&D = research and development.  

*Note:* The “Current Total” row is taken from table 4 of this dissertation.  


\textsuperscript{b} Doornbosch, et al., (2008, pg.5).  

\textsuperscript{c} UNFCCC (2007a, pg. 7). Public finance only.  

\textsuperscript{d} Calculated from demonstration costs estimated in: International Energy Agency (2008a, Chapter 3).  

\textsuperscript{e} UNFCCC (2007a, pg. 90).  

\textsuperscript{f} UNFCCC (2007a, pg. 6).  

\textsuperscript{g} The level of investment required in developing countries is calculated using the same investment share as estimated by the UNFCCC secretariat, which is 40.9 per cent in developing countries and 59.1 per cent in developed countries (UNFCCC, 2007a, pg. 214, annex V, table 4).  

\textsuperscript{h} McKinsey (2009, pg. 8 and pg. 17).  

Estimates of financing needs are derived from models of the economy which attempt to simulate how greenhouse gas emissions may respond to pre-defined scenarios for economic development and the deployment of technologies that would reduce emissions from a business as usual scenario (Rosenberg, 1982; IEA, 2008b; UNFCCC, 2009a). The models make assumptions regarding the costs and rate of deployment of low emission technologies. They also assume that certain least cost climate change policies are introduced in developed and developing countries and that the costs of introducing new technologies respond to assumed learning curves, where costs decline as the technology becomes more commonly deployed. The main model used to arrive at cost estimates in this dissertation the Energy Technology Perspectives Model and the World Energy Model (IEA, 2008a; 2008b) of the IEA, which have been supplemented to incorporate emissions reductions options in non-energy sectors of the economy (industry, agriculture and forestry) by the UNFCCC (2007a; 2009a). Detailed information on the assumptions in these models and the methodological approach in estimating investment needs is contained in UNFCCC (2007a). The same definitions and assumptions used in the UNFCCC study are applied in this dissertation.

An important policy assumption contained within the IEA modelling is that a global emissions trading scheme is introduced by 2020 and that the largest emitting developing countries participate in this scheme. The IEA also assumes that a large share of the abatement task is delivered through energy efficiency, which has a negative cost. Underlying assumptions have important consequences for studying the public and private shares of investment costs.
There is potential for costs to be underestimated. For example, if a global emissions trading scheme is not introduced the overall costs of abatement will increase because the policies and measures needed are likely to deliver a higher total cost of abatement. Furthermore, if all energy efficiency investments are not realised because non-financial barriers prevent their adoption, the overall investment costs will increase because more expensive abatement options will be needed. It is also necessary to take into account the risks of policy failure and slower than expected reductions in the costs of key technologies which will also increase total abatement costs.

On the other hand, there is good reason to expect that the modelling results overestimate the costs of addressing climate change. The models used are not well suited to simulating the economic benefits that accrue from investments in climate change technologies and as such they tend to focus on the up front investment costs that are required. However, these up front cost will be reduced over time by the benefits that accrue, such as the growth in markets, energy security or job creation benefits, that is to the extent that they can be made additional (Barker, et al., 2006; 2009). Furthermore, difficult to model or intangible benefits such as the reduced costs and impacts of adaptation to climate change or the reductions in air pollution and health costs and impacts that result from investments in climate change technologies are not included in the IEA models. So in this regard the IEA estimates will tend to inflate the costs associated with addressing climate change.

Ex-post evaluations of economic models and their projections of costs to address environmental issues have found that they have over-estimated investment needs. For example, the actual costs of addressing ozone layer depletion under the Montreal Protocol were found to be only 13 per cent of forecast costs, and the actual costs of addressing sulphur dioxide in the US were found to be just 6 per cent of the forecast costs (McKinsey and Co, 2008). A study of the costs of environmental regulations in the European Union (Oosterhuis, 2006) found that a majority of ex-ante economic evaluations over-estimated costs by at least a factor of two. This suggests that estimates of investment needs for climate change may also be inflated. Of course only time will tell.

As mentioned above, cost of abatement curves can also be used to study the costs of abatement opportunities and the relative costs of various technologies. It is not possible to compare modelled investment needs with cost of abatement studies because the metrics used are not consistent, however, they do provide a different and useful perspective on overall relative technology and abatement costs.

The data from cost of abatement curves (e.g. Vattenfall, 2007; UNFCCC, 2008c) show how the public and private cost ratio of different technologies and abatement opportunities can differ substantially. For example, hydrofluorocarbon (HFC) projects have investment ratios an order of magnitude less than renewable energy projects. Similarly, energy efficiency projects have low leverage ratios because the investment costs are relatively small compared to the carbon financing that can be attracted. Capoor and Ambrosi (2007; 2008) reviewed the World Bank portfolio of carbon investments and found that leveraging ratios for HFC projects are in the order of 1:2, energy efficiency is in the order of 1:2–5 and renewable energy projects can leverage in the order of 1:8–11. Similar leveraging ratio estimates have been prepared in a comprehensive review of CDM projects by Seres and Haites (2008).

These differences illustrate how in general, emissions trading schemes that are designed to be able to maximise investment in low cost abatement opportunities such as energy efficiency throughout the economy, are likely to have lower leverage ratios yet achieve better overall performance, whereas renewable energy standards are likely to have higher investment ratios but results in lower overall levels of abatement.
It is important to bear these issues in mind when examining the leveraging effect of policies. As argued in Chapter 5, detailed accounting rules and procedures are needed if leveraging ratios are to be used for comparing the effectiveness of specific policies. However, a careful aggregate analysis of leveraging as a measure of the public and private shares of investment needs is useful for decision makers. Such an approach can help to base decisions concerning the financial burden Annex II nations should accept and can help inform decisions on the extent to which new ‘off budget’ revenue raising mechanisms will be needed, such as the auctioning of Assigned Amount Units or various levies and auctioning mechanisms proposed by Parties.

6.3 Institutional and policy gaps in global financing for climate change

There are two fundamental over-riding factors that influence the financing of climate change technologies. Together these factors form the basis of a functioning global carbon market that can stimulate a flow of finance from the private sector to meet the incremental costs of low emission technologies.

The first is the creation of a global carbon price to internalise the cost of carbon emissions such that they increase to the full the social cost of carbon over time (Stern, et al., 2006). The IEA (2008a) estimate that carbon prices will need to be in the order of USD 180 in 2030 to be on a trajectory to achieve a halving of global emissions by 2050.

The second and directly related factor requires binding emissions reductions targets by developed countries and measurable, reportable and verifiable actions that limit emissions in developing countries. These targets are vital for creating the demand for the investments in technologies and abatement options. Emissions reductions should be consistent with the science of climate change to avoid large social, economic and environmental costs of adaptation to climate change.

However, the creation of a global carbon market will be insufficient to address the challenge of financing the shift to a low greenhouse gas emission economy. As explained by the Stern Review (Stern, et al., 2006) government intervention is required both to:

- accelerate technology development and transfer in order to lower the cost of mitigation and to achieve the emission reductions that will be necessary in the long-term (Stern, et al., 2006, Part III); and
- address market failures and remove barriers to low emission technologies and investments (Stern, et al., 2006, Part IV).

Work undertaken within the London School of Economics (Romani, 2009, pg. 6) addressed a key related question: “How scarce public funds can be used efficiently and innovatively to leverage private sector flows for mitigation and adaptation in developing countries whilst carbon markets are in the early stages of development”. The suggest four key dimensions to addressing this question:

1. Public financial instruments to raise finances;
2. Public financial mechanism that mobilise finance and create markets;
3. Increasing the flow, scale and quality of proposals for financing policies, programmes and projects; and
4. Overall design of the global financial architecture for climate finance.

20 Recognising the principle of common but differentiated responsibilities and capabilities, Article 3, paragraph (1) of the Convention.
Sections 6.3.1–6.3.4 below considers each of the areas listed above as identified by Romani et al., (2009). Then the key gaps in financing for each stage of the technology innovation cycle are summarised in section 6.3.5.

6.3.1 Public financing instruments to raise finances

There are two primary ways that international institutions and national governments can raise financing for climate change. The first involves governments raising finance through taxes\(^{21}\). The second involves raising finance through debt. UNFCCC (2009b, pg. 97) has focused on the former, as shown in Table 6.

### Table 6. Options for raising revenue to finance technology development and transfer activities under the Convention (billions of United States dollars)

<table>
<thead>
<tr>
<th>Proposal</th>
<th>Source of funding</th>
<th>Purpose</th>
<th>Notes</th>
<th>Nominal annual level of funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing the scale of existing mechanisms</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>European Union</td>
<td>Continue 2 per cent levy on SoP from CDM</td>
<td>A</td>
<td>Ranging from low to high demand in 2020</td>
<td>0.2–0.68</td>
</tr>
<tr>
<td>Bangladesh, Pakistan</td>
<td>3–5 per cent levy on SoP from CDM</td>
<td>A</td>
<td>Ranging from low to high demand in 2020</td>
<td>0.3–1.7</td>
</tr>
<tr>
<td>Many Parties</td>
<td>CDM and other crediting mechanism</td>
<td>M</td>
<td>In 2020</td>
<td>10–34</td>
</tr>
<tr>
<td>Defined budgetary contributions from developed countries</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group of 77 and China</td>
<td>0.5–1 per cent of GNP of Annex I Parties(^{a})</td>
<td>A, M</td>
<td>Calculated for 2007 GDP</td>
<td>201–402</td>
</tr>
<tr>
<td>Contributions raised through market-based mechanisms and taxation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>Contributions based on GDP, GHG and population and possibly auctioning permits in developed countries</td>
<td>A, M</td>
<td>Initial phase</td>
<td>10</td>
</tr>
<tr>
<td>Norway, Switzerland</td>
<td>2 per cent auctioning of AAUs and GHG</td>
<td>A</td>
<td>Annually</td>
<td>15–25</td>
</tr>
<tr>
<td></td>
<td>2 USD per t CO(_2) with a basic tax exemption of 1.5 t CO(_2) eq per inhabitant</td>
<td>A</td>
<td>Annually</td>
<td>18.4</td>
</tr>
<tr>
<td>Republic of Korea, Colombia, LDCs</td>
<td>Crediting NAMAs</td>
<td>M</td>
<td></td>
<td>Uncertain</td>
</tr>
<tr>
<td></td>
<td>2 per cent levy on SoP from joint implementation and emissions trading</td>
<td>A</td>
<td>Annually, after 2012</td>
<td>0.03–2.25</td>
</tr>
<tr>
<td>LDCs</td>
<td>Levy on international air travel (IATAL)</td>
<td>A, M</td>
<td>Annually</td>
<td>4–10</td>
</tr>
<tr>
<td>LDCs, Tuvalu</td>
<td>Levy on bunker fuels (IMERS)</td>
<td>A, M</td>
<td>Annually</td>
<td>4–15</td>
</tr>
<tr>
<td></td>
<td>Auction of allowances for international aviation and marine emissions</td>
<td>A, M</td>
<td>Annually</td>
<td>28</td>
</tr>
</tbody>
</table>

Sources: UNFCCC (2009b) after UNFCCC (2007a; 2008d; 2008f) and Müller (2008).

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

\(^{a}\) Owing to a lack of information on GNP, potential funding was calculated using GDP.

\(^{21}\) In the case of international institutions such as the UNFCCC, it has been suggested that Parties could agree to raise finances through assessed contributions from national governments, which would ultimately flow from governments taxes and levies.
Table 6 shows that only the proposal of the Group of 77 and China is capable of raising sufficient funds to address the financing needs for climate change as reported in section 6.2, above. The negotiations on finance under the Convention leading up to COP 15 in Copenhagen clearly demonstrated the unwillingness of developed countries to accept a model for raising finance predominantly based on public finance. Instead they propose arrangements that rely mostly on private finance (UNFCCC, 2008b). Developed countries are willing to accept some proportion of public financing being raised based on a formula that would define the burden sharing arrangement (as is currently the case with the replenishment of the GEF), but this would be only on the basis of a ‘pledge and review’ arrangement, rather than the mandatory approach proposed by the Group of 77 and China. Such an arrangement is unlikely to lead to a stable and predictable flow of finance.

As the International Monitory Fund (IMF, 2010, pg. 5) notes the “traditional approach to raising new development finance — a succession of donor conferences and pledging sessions — has a checkered history. Concrete pledges tend to have short horizons, while delivery on longer-term commitments tends to fall well short of what was promised.”

These concerns and limitations have led many to pursue public financing instruments that are based on debt as an alternative to those that require flows of revenue from national governments.

Romani et al., (2009) focus on bonds as the debt-based tool of choice to raise capital for climate change. A bond is essentially a loan that a government takes out with the purchaser of the bond. The bond is secured against the capital assets of the nation state. As Romani, et al., (2009) describe there are many different bond structures and designs that respond to the purpose for which they are to be used, as well as the political context in which they are created. Large-scale issuance of bonds can create large financial and political risks for governments which requires them to take a direct stake in the investments being made. Therefore bonds tend to create a direct incentive for governments to ensure that the regulatory framework is in place to ensure the bond mechanism achieves an optimal outcome. If bonds are structured so that their issuance is directly related to the returns from investments made in previous issuances, then the impact on government budgets can be minimised.

One of the major problems with using green bonds as a primary means of raising finance is the reliance on concessional financing that it creates. The debt must be serviced and this either comes from government budgets or from the returns on investment from the bonds. To ensure that public debt is being used wisely the projects, programmes or policies for which bonds are being used to finance must be heavily scrutinised. Developing countries on the other hand reject any strong oversight on the actions that they take to mitigate and adapt to the impacts of climate change. From a developing country perspective, developed countries are legally obliged to provide direct and untied transfers of finance as a form of compensation for historical emissions and to enable developing countries to make the transition to a low emission economy (see Müller, 2009).

The IMF (2010) has proposed a fund structure based on so called ‘green bonds’ which would be capable of providing a steady flow of both grants to developing countries (particularly for adaptation) and a mix of different concessional financial instruments based on the special drawing rights of developed country nations held by the IMF. This proposal would see a mix of USD 40 billion in loans and USD 60 billion in subsidies to developing countries. However, the structure of this arrangement would see developing countries take an equity stake in the fund, and would most

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22 See also the review of finding commitments made by the European Union (Pallemaerts and Armstrong, 2009) which shows that it is far from meeting its pledge in 2001 to provide USD 369 million as part of the Bonn declaration (UNFCCC, 2001).
likely require them to dominate the governance of such a fund, which would be unacceptable to developing countries who have insisted in balanced regional representation in any governance arrangement for climate financing (see G77 and China, 2008).

6.3.2 Public financing mechanisms: The need for public venture capital
NEF and UNEP-SEFI (2008) have identified two important gaps in the early stages of venture capital financing as technologies move from the R&D to the demonstration stage, and beyond to reach the deployment stage. Venture capital and private equity financing are crucial during these stages due to the high risks still inherent in the technologies and the businesses that are bringing them to the market.

The gaps in venture capital financing are illustrated in Figure 13 and are quantified in Figure 14. These estimates are based on total investment costs as per IEA (2008a) rather than the incremental costs provided by UNFCCC (2009b). Note that in these global figures, regional distribution of venture capital and private equity finance is heavily biased to the United States, which possesses the most mature venture capital and private equity markets. Outside of the US there is very little early stage venture capital financing, and in developing countries, this type of financing is almost entirely absent.

*Figure 13 Gaps in early stage venture capital financing for climate change mitigation technologies.*

![Diagram of venture capital stages]

Source: Adapted from NEF and UNEP-SEFI (2008).
Figure 14  Volumes of venture capital and private equity financing illustrating the growth in later stage venture capital and private equity and the very limited availability of early stage finance for climate change mitigation technologies.

As shown in Figure 14, the level of early stage venture capital has not grown significantly since 2001. Analysis by UNEP has demonstrated the need for public sector venture capital financing tools to fill these gaps due to the reluctance of private sector to bear the significant risks associated with early stage financing (NEF and UNEP-SEFI, 2008).

Figure 15 estimates the increase in venture capital and private equity financing that is necessary to finance the technologies in the demonstration and deployment stages to meet a 500–550ppm CO₂-e stabilisation as presented in Figure 12. In this figure, the vast majority of early stage venture capital is the public investment needed to stimulate later stage private investments, suggesting that a global public venture capital fund capitalised with USD 28.6–34.8 billion is required to help leverage subsequent venture capital and private equity investments to bring new technologies into deployment.
Figure 15  Increase in types of venture capital and private equity investments to investment in new technologies required for a 500–550ppm CO₂-e stabilisation (billions of United States dollars per year).

Author’s estimate based on IEA (2008a) and: NEF and UNEP-SEFI (2008). Note that the low scenario refers to the low end of the estimated range and the high scenario refers to the high end of the estimated range in figure 12.

6.3.3 Increasing the flow, scale and quality of proposals

According to the Institutional Investors Group on Climate Change (IIGCC, 2006; 2009; 2010) and Vivid Economics (2009), investment by large institutional investors is hampered by a lack of high quality propositions from fund managers and other parties and a lack of an overall policy framework that can underpin investment in low emission technologies.

There is also a lack of information about the potential for investment and the potential returns involved. NEF database using 2007 data shows the gap between funds available and actual investment (Figure 16). Ideally the reverse should be the case with the availability of investment opportunities exceeding funds available and hence driving investors to find new financing for climate change mitigation technologies.
The World Resources Institute (WRI, 2008) propose the establishment of an International Project Development Facility, which could undertake market analysis, programme and large-scale project feasibility and early scoping and development work, and could help structure suitable financial packages drawing upon available (and new) public financing mechanisms to reveal to the market the potential for investment on commercially attractive terms.

In 2009, Australia recognised the need to address the gap between funds available and bankable projects in its proposal for a Leveraging Service within the negotiations under the Convention. In its submission of 9 June 2009 (Government of Australia, 2009) to the second reading speech of the AWG-LCA Chair’s negotiating text, it inserted the following text, which was supported by other Annex I Parties:

A new technology leveraging service which could form part of a broader facilitation platform should be created to provide an interactive facilitation service for actions identified through low emission development strategies and/or TNA/NAMA/NAPA processes. This service is to be provided to developing countries and would, on a voluntary basis, assess potential actions, assist in the development of rigorous projects proposals and assist in matching with the most appropriate form of investment support, particularly with a view to leveraging private sector funding. This service would work closely with relevant international financing institutions, multilateral development banks and the private sector.

This proposal was later incorporated into the proposed Technology Mechanism that was close to agreement in Copenhagen and was featured in paragraph 11 of the Copenhagen Accord (UNFCCC, 2009d).

Hamilton (2009) argues that support arrangements, similar to those that have been used to create bankable projects in developing countries, need to be applied to create ‘investment grade’ poli-
cies, particularly as Parties move to implement the system of nationally appropriate mitigation actions and large-scale national adaptation plans envisaged in the negotiating text.

### 6.3.4 Global financial architecture: Role of the financial mechanism of the Convention

In response to the growing concerns about climate change there has been a proliferation of financial schemes established to support investment in climate change technologies, particularly since 2005\(^{23}\). Most of these new sources of finance have been established outside of the Convention. Figure 17 illustrates the institutional ‘landscape’ of climate change financing mechanisms both inside and outside of the UNFCCC. Within this general structure there are many other financing instruments. For example, there are hundreds of public financing mechanisms at national and subnational-scales and dozens of financing instruments that have been implemented by regional development banks (UNEP, 2008a; UNFCCC, 2008a).

**Figure 17**  Global institutional landscape for financing climate change technologies

The institutions in which public financing mechanisms are located can have an important bearing on the leveraging effects that are achieved by those mechanisms. This is often because the institutions have different financing instruments at their disposal or because the mandate with which they operate differs. For example, the Bretton Woods Institutions (International Monetary Fund and the World Bank Group) have a wide range of financial tools at their disposal, many of which have been designed to leverage private sector investment. On the other hand, funds established under the Convention are often only mandated to provide grant-based financing, which may not be designed to mobilise private sector investment in achieving the desired mitigation or adaptation outcomes.

The proliferation of financing mechanisms outside of the Convention could be interpreted as an encouraging sign in that it creates competition between institutions which may stimulate innovation as each entity finds a suitable role within the financing landscape. However, such proliferation can result in duplication and lack of overall efficiency. It is also a sign that there is a lack of leadership on the issue of financing as each institution is vying for power to take the commanding role. The Convention is the pre-eminent expression of global efforts to address climate change and surely it should embody sufficient financial and political power to provide the leadership and direction for financing, maximise efficiency and shape the financing landscape so that it delivers in a manner consistent with the objectives of the Convention (Müller and Winkler, 2009).

However, the GEF as the only source of finance for mitigation directly under the authority of the Convention is one of the smallest sources of finance within the existing financial landscape.

Strengthening the role of the Convention in the institutional architecture for financing climate change technologies may not necessarily mean that all mechanisms for delivering finance for emissions reduction projects would reside within the Convention. If this were the case it would essential require the creation of a new financing institution under the Convention with similar capability as the Bretton Woods institutions (UNFCCC, 2009a;b). It should be possible to harness the existing institutions to deliver the objectives of the Convention. However, to do so requires a financing mechanism under the Convention that has both the authority and the means to do so. In terms of the means, adequate financial leverage under the Convention is critical. It would be necessary for the Convention to possess sufficient financial resources to leverage shifts in global financial institutions on the scale necessary.

The financial mechanism of the Convention could function as a large fund of funds. Under the guidance of the COP, the mechanism would define the desired global strategic outcomes, the activities to be supported and how to hold to account the recipient financial institutions, and make the allocation of funds conditional upon reforms in these institutions\textsuperscript{24} that further contribute toward the financing of climate change technologies.

China has proposed a new financial architecture under the Convention, which is presented in Figure 18. The proposed finance Board would have take the strategic role in the coordination of financing instruments and institutions towards the overall efficient delivery of financing for climate change.

\textsuperscript{24} For example, funds allocated to the World Bank could be made conditional that the Bank moves to phase out financing for high emission technologies.
As Müller (2010) argues, the Copenhagen Accord (UNFCCC, 2009d) when read in conjunction with the AWG-LCA text on the institutional arrangements for finance (UNFCCC, 2009f) can be interpreted to conclude that the Copenhagen Green Climate Fund will be established as an operating entity of the financial mechanism of the Convention. The Fund would be governed by a Finance Board under the Convention, and it would oversee the distribution of funds through various financial windows, potentially existing funds under the Convention or outside of the Convention.

When read in its proper context from the perspective of the AWG-LCA texts and negotiations, the Copenhagen Accord not only resolves the question of the quantity of finance (albeit without clarity of the public and private shares) but it also clarifies that a Convention Fund governed by a new institution of the Convention under the guidance of the COP will be established, and given its size and potential institutional power, it may go some way to restoring the role of the Convention’s financial mechanism in steering the overall financial architecture for climate change.

6.3.5 Key gaps by stage of technological maturity

6.3.5.1 Research and development: lack of support for developing countries

The UNFCCC report on financing options for technology development and transfer (2009b) concluded that “[a]lthough R&D is becoming more international, there is no international funding mechanism and there is limited coordination for such activities”.

Grubb (2005) recommends an internationally coordinated approach to R&D in the energy sector and in particular a Global Research and Development Fund to support technologies whose high development cost cannot readily be borne by public funds in a single country.

Many other authors have recommended substantial increases in publicly funded R&D. For example, Stern et al., (2006) recommend a doubling of government R&D funding to drive down technology costs and to support new breakthrough technologies that can substantially reduce greenhouse gas emissions across the economy.

At COP 14 in Poznan, an in-session workshop was held on “cooperation on research and development of current, new and innovative technology, including win-win solutions”. At that work-
shop the Chair of the EGTT stated that possible options for cooperation being explored by the EGTT include global pooling of R&D funds, coordinating existing R&D programmes, and increasing public investment and incentives for greater private investment in R&D. The workshop emphasized that “the accelerated development of key technologies could reduce the cost of stabilizing the concentration of greenhouse gas (GHG) emissions in the atmosphere by hundreds of billions of dollars globally.” (UNFCCC, 2008e)

Cooperative approaches identified in the workshop included joint programmes, technology centres, demonstration projects and research infrastructure investments. The importance of building endogenous R&D capacity in developing countries and the current gaps in financing for R&D in developing countries was identified as a significant issue of concern.

Cooperative R&D is one of outstanding issues within the technology development and transfer negotiations under the AWG-LCA, with the text currently heavily bracketed (UNFCCC, 2009e) and with the USA prosecuting a position that would prevent funds from the Convention going to R&D in developing countries.

6.3.5.2 The demonstration stage and the ‘valley of death’

At the demonstration stage developers experience a phenomenon known as the ‘valley of death’ where there is a gap in both public and private sources of finance (Figure 19). This metaphor is extensively used by researchers and policy makers to describe the gap in available financing for companies and technologies that are in their early development stages, where R&D funding becomes less available but the risks are still too great for private investors to contemplate, or the sum of money needed is minimal and not within the funding windows of larger funding mechanisms (US SBA, 1994; Branscomb and Auerswald, 2002; Auerswald and Branscomb, 2003; Murphy and Edwards, 2003; Wessner, 2005; Williams, 2004; Auerswald, et al., 2005).

![Figure 19 Valley of Death showing the typical financing sources and stages of technology development](image)

Figure 19 Valley of Death showing the typical financing sources and stages of technology development


Grubb (2005) recommends a specific global fund to support technology demonstrations. Many Parties to the Convention (EU, Japan, Australia, US, China) have also proposed international measures targeting the demonstration of technologies in developing countries (UNFCCC, 2008b).
Japan supports global technology road maps that would be supported by national programmes to
demonstrate technologies at scale. Japan has established a USD 10 billion ‘Cool Earth’ initiative
to demonstrate a wide range of new technologies in developing countries (METI, 2008). The EU
proposes a series of ‘technology orientated agreements’ with a focus on technologies with large
mitigation potential currently in the demonstration stage (UNFCCC, 2008b).

6.3.5.3 Deployment of technologies in developing countries
The International Energy Agency and the UNFCCC have estimated that an additional 10 to 120
billion per annum in early deployment support for technologies in developing countries will be
necessary as part of an overall financing strategy to meet a 500–550 ppm CO₂-e stabilisation
(IEA, 2008b; UNFCCC, 2009b).

Under the Convention these are additional or incremental costs that are to be financed by devel-
oped countries (Annex II Parties). However, the types of mechanisms that can most efficiently
drive the early deployment of technologies are national market-based mechanisms which subsi-
dise these more expensive technologies and make then attractive relative to the cost of incumbent
technologies that are more emissions intensive. Project-based approaches such as the CDM have
not been designed to support early stage technologies, and project-based mechanisms such as the
GEF would need to be scaled up to such a extent as to be unwieldy. For these reasons, a policy-
based approach is more desirable.

A policy-based approach would support developing countries to financing national policies such
as renewable energy targets through policy instruments such as feed-in tariffs or renewable en-
ergy obligations for electricity generators. With technical assistance from developed countries,
the national government would develop strategies for implementing national policies to drive
early deployment of climate change technologies. A financial mechanism under the Convention
would provide the appropriate financing package to support the implementation of the policy.
This may involve a combination of financing instruments, including direct grants, concessional
loans, carbon crediting and other forms of support. The financing may be made conditional upon
other national policy reforms that if not addressed would affect the overall performance of the
policy.

Another option for early deployment of technology may be to allow for a portion of a developed
country’s renewable energy obligations to be fulfilled from new renewable energy projects in de-
veloping countries. This would have the benefit of reducing the overall cost of renewable energy
obligations in developed countries (IEA, 2005) and would provide additional source of financing
for early deployment of technologies in developing countries.

6.3.5.4 Technology diffusion: Energy efficiency technologies and measures
In most economic modelling of investments in climate change technologies, energy efficiency
takes a dominant share of emissions reductions. For example the World Energy Outlook (IEA,
2008a) estimates that close to half of the emissions reductions to meet a 500–550ppm CO₂-e sta-
bilisation scenario is met by energy efficiency, especially in the transport and buildings sectors.
Such investments in energy efficiency are projected by the IEA to result in cumulative fuel sav-
ings of USD 7 trillion by 2030 (IEA, 2008a).

Despite the importance of energy efficiency, there are very few mechanisms that actively support
energy efficiency technologies. Analysis in UNFCCC (2008a) concludes that the transport sector
and commercial and residential buildings sectors are the least well covered sectors, and that the
CDM has been spectacularly ineffective in supporting energy efficiency.
WRI (2008) recommends a large-scale concessional loan-based instrument to support energy efficiency investments in developing countries. The IFC has successfully demonstrated this approach in China and Russia. The IFC investment in China involved issuing USD 126 million in loans which resulted in USD 1.78 billion in private sector investment into energy efficiency measures (leveraging 1:10). Because energy efficiency measures result in lower costs due to fuel savings they are suited to loan-based instruments where large-scale efficiency reforms can finance the repayment of loans.
7 Leveraging ratios of existing and proposed measures to finance climate change mitigation technologies

This chapter reviews the levering ratios of a wide range of policies by stage of technological maturity, in order to arrive at an average range of the levering effects of policies that are in practice or are proposed within the negotiation process under the Convention.

Existing public incremental financing for climate change mitigation technologies is estimated at about USD 55.5–82.0 billion per annum with approximately 4–5 dollars of private finance leveraged on average for every 1 dollar invested by governments through the various financial sources and vehicles both inside and outside the Convention (UNFCCC, 2009b). As shown in Chapter 6, this is substantially less than the total level of investment that is required.

Unless leveraging ratios are improved, the required level of public finance to address climate change mitigation will be at least 67.4–213.6 billion per annum. Importantly, leverage ratios tend to increase as technologies become more mature (see Figure 20), but to meet climate change targets less mature technologies which are higher risk investments, with lower private sector leveraging potential, must be deployed early. This suggests that the public sector contributions must be higher or the public policy measures in the earlier stages of technology deployment need to be much more effective in leveraging the private sector.

Figure 20 Stylistic representation of the proportions of public and private financing necessary at each stage of technological maturity.

Available evidence shows that existing funds under the Convention are relatively weak in their ability to leverage private sector investment. For example, the financial mechanism of the Convention currently achieves relatively low levels of private sector leveraging. In 2004, a review of a sample of GEF projects (GEF, 2004b) revealed that about 10 per cent of GEF projects involved meaningful engagement with the private sector. It was estimated that for every USD 1 of public
money invested from specialised funds, USD 0.67 of private money was leveraged. In GEF’s 2001 annual report it confirmed that for USD 4.2 billion it was able to leverage USD 2.3 billion of private investment averaged over the period 1991–2001 for all of its programme areas (GEF, 2001). However, more recent data suggests a significant improvement in GEF leveraging, perhaps reflecting a concerted effort by the GEF to address this issue in recent years. From September 2008 to June 2009 mitigation projects with a total allocation of USD 233 million from the GEF Trust Fund will leverage just over USD 500 million in private finance (a ratio of about 1:2) (personal communication D. Zevgolis, GEF programme officer, 10 April, 2010). Currently the GEF invests just USD 0.22 billion per annum in technology development and transfer for climate change (UNFCCC, 2009b).

The CDM has been a more effective tool for leveraging private investment, with leverage ratios in the order of 1:6–10 (derived from Haites, 2007; OECD, 2009b). But even if the CDM was scaled up as has been proposed by many Parties to the UNFCCC, the financing gap would remain large. The UNFCCC estimates that an expanded CDM and other crediting measures could provide an additional 10–34 billion per annum by 2020 (UNFCCC, 2008c).

Outside of the Convention, the World Bank claims a leverage ratio of 1:6 and the IFC claims to achieve the greatest levels of private sector leveraging of 1:5–11 (GEF, 2004b; World Bank, 2007). Reviews of these programmes suggest that these organizations are more successful in leveraging private sector investment because as banks they possess the financial instruments that are attractive to the private sector, they manage risks within the boundaries that private sector investors are willing to accept and they have decision making systems that are more consistent with decision making in the private sector (GEF, 2004b).

UNEP (2008a) reviewed 43 relatively new and innovative public financial mechanisms (PFM) operating at the national and sub-national-scale. Their analysis included an assessment of the leveraging effects of these instruments and concluding that “an assessment of experience with a number of different models of PFMs shows that typical leverage ratios range from 3 to 15:1”. The public financial mechanisms reviewed by UNEP (2008a) are presented along with existing commercial financing mechanisms according to the stage of technological maturity that they address in Figure 21. Gaps in financing, which were discussed in Chapter 6, are also identified in Figure 21.

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25 Often public funding from other sources was leveraged. GEF public sector leveraging is estimated at 1:4–6
26 In 2007, USD 46 billion was invested through the CDM. Therefore total CDM investment would be USD 56–80 billion per year (UNFCCC, 2008c).
27 That is to say that for every one dollar of public money invested 3–15 are leveraged from the private sector.
Differences in leveraging ratios also reflect the stage of technological maturity that each programme addresses. The GEF is often working in the deployment stage, where private sector risk is higher; whereas the World Bank and IFC are focused on technologies in the diffusion stage. Similarly the majority of CDM projects are also focused on the later stages of technological maturity, where private finance is more available (UNFCCC, 2008a; 2009a; b).

Sections 7.1–7.4 below review the leveraging ratios of various public policies and investment programmes that have been used within each stage of the technology cycle. Information on the effectiveness of policies and investment programmes in other sectors is also used where this information provides useful insights for the potential leveraging ratios of equivalent policies and investment programmes for climate change mitigation technologies.

7.1 Research and Development

Public policies and sources of finance that support R&D investments are predominantly focused at the national-scale, with international measures characterised by coordination and information sharing efforts, such as the IEA Implementing Agreements, the International Partnership for the Hydrogen Economy, and the Methane to Markets initiative.

At the national level, financing for public R&D tends to involve competitive grant-based programmes aimed at public institutions such as universities, which are structured to deliver on strategic priorities determined by the respective national governments. In some cases these public programmes are disconnected from private R&D efforts occurring on often similar technologies in corporations. However, the public sector also usually provides direct grant-based support to private R&D activities.

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Another approach to mobilising private sector investment is through joint/collaborative research centres and programmes where industry and public partnerships combine resources and research activities are blended toward achieving shared research outcomes. Intellectual property agreements within these public/private partnerships are used to share the benefits of research outcomes. These joint approaches have proved relatively successful where public research objectives are aligned with clear and immediate private benefits and tend to occur in areas of applied research rather than basic research areas. In situations where research is focused on public good outcomes the opportunities for partnerships diminish and the potential for private sector leveraging from public R&D expenditure is significantly reduced.

According to Australia’s recent review of its Cooperative Research Centres (CRC) programme, total public investment of AUD 9.7 billion leveraged AUD 2.3 billion of private sector investment (a leverage ratio of 1:0.24). Despite the relatively low levels of private sector research that the CRC programme leverages, the intensity of leveraging requirements are considered a major barrier to public good research and has resulted in gaming of research programmes and significant substitution of resources from different governments (state and federal) and government agencies (Commonwealth of Australia, 2008). Similarly, Feldman and Kelley (2001) have reviewed the effectiveness of the US Advanced Technology Program (a public-private partnership programme) in leveraging private sector R&D through a survey of participants, however, leveraging ratios for the programme were not established (Feldman and Kelley, 2001).

According to the European Commission Research Division every Euro invested by the Commission in public R&D leverages an additional Euro in private investment (EU Directorate General Research, 2007). However, the extent to which private sector investment in R&D is leveraged in climate change technologies is less well known.

A commonly used mechanism for stimulating private sector R&D is the provision of taxation incentives which involve foregoing public taxation revenue rather than the direct use of public funds to stimulate investment. There are many types of tax incentives offered by governments, including exemptions such as real estate tax abatements, deductions, credits, preferential calculations, or reduced rates that can lower the company’s total tax burden (IEA World Energy Outlook Policy Database31, Kline and Benioff, 2008). This type of instrument stimulates whole of economy investment in R&D to provide a broad base of investment. It can only be used by established firms that have income streams (and therefore taxation debts) that can be offset with taxation credits. It is difficult to estimate the leveraging effect of tax incentives, because companies may have intended to undertake the research without the tax incentive. However if it is assumed that the majority result in new R&D activities and if it is assumed that tax incentives have 100 per cent tax deductibility, then the value of the tax deductions should equate to the value of the research undertaken resulting in a 1 to 1 leveraging ratio. In the US Federal R&D tax credit claims reached an estimated USD 5.5 billion in 2003, in additional to the tax credits programmes offered by 32 US States (National Science Board, 2008).

Analysis of private R&D performance in the United States and Japan highlights the importance of effective connections between academic research undertaken in universities with private firms (Branstetter and Hyeog Ug, 2004). These connections tend to maximise the spill over effects of public research and in return increase the quality and quantity of effective private R&D activities. Both the quality of advanced education and research and the relationships between academia and

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31 Available at http://www.iea.org/Textbase/pm/?mode=weo, last accessed 04/2010.
private firms are important to maximise leverage on private sector research activity and knowledge building. However, it has not been possible to quantify the effect.

In the context of the Convention, China has proposed that additional resources for R&D could be made available either through a defined new revenue stream or through defined contributions from developed countries (UNFCCC, 2008c). This new funding would be pooled into a climate change R&D fund and used to leverage additional new R&D investment by both the public and private sector. While estimates of the leveraging potential of this proposal have not been made, it may be possible to draw upon previous experience with this type of approach as used in the agricultural sector with the creation of the Consultative Group on International Agricultural Research (CGIAR) in 1971.

An extensive review of CGIAR by the World Bank (Lele, 2004) concluded that CGIAR has been very effective, and that for every one dollar invested, 9 dollars in additional food production within the developing world has resulted. However, the same review found pressure to increase leveraging of finance within CGIAR resulted in diminished public good research outcomes and “a drift in the research programme [which] undermined the traditional excellence of CGIAR science” (Lele, 2004, pg. 94). Nonetheless, based on the CGIAR experience it may be possible to expect leveraging from a global R&D fund in the order of 1:5–10 (see also Raitzer, 2003). While this approach would boost R&D efforts in global priority technology areas, addressing the need for R&D in developing countries will require additional support measures.

Responding to the gap in R&D in developing countries, India (UNFCCC, 2008f) has proposed the establishment of a network of climate technology development and diffusion centres aimed at addressing the diverse range of technology, business and regulatory barriers to the development and diffusion of a specific technology, involving technology developers, companies, regulators and policy makers. The activities of this network would include product development, development of appropriate business models and policy and market research/analysis to support regulatory and policy development.

In July 2008 the Carbon Trust (Carbon Trust, 2008) published a detailed proposal which reflects the Indian proposition and has been designed so that it can be scaled up. Table 7 presents the main components of the Carbon Trust proposal, including the potential leveraging effects that could be achieved, based on the experience of the Carbon Trust. Their full-scale proposal is used for the estimates in Table 7.
<table>
<thead>
<tr>
<th>Activity type</th>
<th>Estimated required funding per project (USD)</th>
<th>Type of support/funding mechanism</th>
<th>Typical length of project</th>
<th>Estimated number of projects initiated per Centre per year</th>
<th>Indicative required funding per year (USD million)</th>
<th>Leverage ratio</th>
<th>Resultant private investment (USD million)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Applied research and development</strong></td>
<td>0.1–1 million</td>
<td>Grant (co-funding)</td>
<td>2–5 years</td>
<td>10–20</td>
<td>10</td>
<td>Direct industry co-funding (1:1 leverage potential)</td>
<td>10</td>
</tr>
<tr>
<td><strong>Technology accelerators</strong></td>
<td>2–10 million</td>
<td>Grant (co-funding)</td>
<td>2–5 years</td>
<td>1–5</td>
<td>40</td>
<td>Direct industry co-funding (1:2 leverage potential). Catalyzed market, leading to significant commercial investment (1:10 leverage potential).</td>
<td>80 400</td>
</tr>
<tr>
<td><strong>Business incubator services</strong></td>
<td>50–100 thousand</td>
<td>Grant, advisory services and/or investment</td>
<td>6–12 months</td>
<td>5–25</td>
<td>2.5</td>
<td>Subsequent fundraising by supported companies as a result of incubation services (1:10 leverage potential).</td>
<td>25</td>
</tr>
<tr>
<td><strong>Enterprise creation</strong></td>
<td>10 million</td>
<td>Investment</td>
<td>3–7 years</td>
<td>1–2</td>
<td>10</td>
<td>Direct industry co-investment (1:5 leverage potential).</td>
<td>50</td>
</tr>
<tr>
<td><strong>Early stage funding for low carbon ventures</strong></td>
<td>3 million (for first round funding only)</td>
<td>Investment or loan</td>
<td>3–7 years</td>
<td>2–10</td>
<td>30</td>
<td>Co-investment by private sector funds (1:10 leverage potential). Further catalyzed market for low carbon investment through demonstrated success.</td>
<td>300</td>
</tr>
<tr>
<td><strong>Energy efficiency measures</strong></td>
<td>10–100 thousand</td>
<td>Advisory services and/or loans</td>
<td>12–24 months, repeatable</td>
<td>100–1,000 pa</td>
<td>50</td>
<td>Stimulate investment by organisation receiving support (1:5).</td>
<td>250</td>
</tr>
<tr>
<td><strong>Skills/capacity building</strong></td>
<td>50 thousand –1 million</td>
<td>Grant and/or advisory services/training</td>
<td>6–24 months</td>
<td>2–5</td>
<td>5</td>
<td>Leverage of partner company resources. Catalyzed markets by freeing supply chain capacity constraints (leveraging potential unknown).</td>
<td>unknown</td>
</tr>
<tr>
<td><strong>National policy and market insights</strong></td>
<td>100–500 thousand</td>
<td>In-house and commissioned strategy work</td>
<td>3–12 months</td>
<td>2–5</td>
<td>2.5</td>
<td>Catalyzed markets by enabling development of regulatory regimes which incentivise and de-risk low carbon private sector investment (leveraging potential unknown).</td>
<td>unknown</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>150</td>
</tr>
</tbody>
</table>
International prizes for R&D breakthroughs or advanced purchasing commitments by developed countries are two similar mechanisms that have been proposed (Newell and Wilson, 2005; World Bank, 2008a).

They are similar in that they provide a future financial incentive to motivate innovators to develop solutions to climate change. Advanced purchasing commitments have been applied in the health sector for the development of vaccines. The idea is that a government or philanthropic organisation agrees to subsidise the purchase of a technology which currently does not exist. In the case of the health sector, the technology in question was a vaccine for pneumococcal disease\(^{32}\) (see Kremer, et al., 2005).

There is some debate on the effect that advanced purchasing commitments generate in terms of R&D investment (World Bank, 2008b). In the context of the health sector, and on the more pessimistic side of the range, Finkelstein (2004) estimates that every 1 dollar incentive for advanced purchasing leverages six cents of additional R&D expenditure, with much greater leveraging occurring in the commercialization of drug therapies. It is thought that while advanced purchasing commitments do have a pull effect on investment, it is in the later stages of technology development rather than in the early R&D stages where the stimulus is greatest.

Another important limitation with advanced purchasing commitments is that they require very clear contractual arrangements on the purchasing, and this requires a wide range of potential legal and other issues to be predicted without knowledge of what specific issues may emerge.

Prizes may be more suited to climate change technologies and they avoid this later issue of predefining the purchase commitment. They may also be more suited to stimulating research, as the awarding of an international prize is something more familiar than an advanced purchasing commitment and more relevant to the work of researchers. Research by Nalebuff and Stiglitz (1983) shows how prize-based mechanisms tend to induce less risk averse behaviour and foster more radical innovations than other motivational factors. Evidence would suggest that research activity stimulated from a prize would be more than the level at which the prize was set, but it is not possible to estimate the leverage that could result. For the purposes of this dissertation it is assumed that leveraging in the order of 1:1–2 would be achieved.

Table 8 summarises the types of measures that being employed or proposed to leverage investment from the private sector into R&D. The figure provides information the potential to scale up, and the applicability of each approach to different private sector entities and to enhancing financing in developing countries.

<table>
<thead>
<tr>
<th>Policy approach</th>
<th>Typical leveraging ratios</th>
<th>Research Stage</th>
<th>Potential to Scale up</th>
<th>Benefits</th>
<th>Disbenefits</th>
<th>Applicability to Developing Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grants - Direct</td>
<td>1:0–0.5</td>
<td>Basic research; proof of concept</td>
<td>Large</td>
<td>Can be effective in supporting start up firms and researchers that cannot attract private investment due to risk profiles</td>
<td>Unless carefully design grant programmes do not tend to encourage collaboration between institutions and the private sector</td>
<td>Yes</td>
</tr>
<tr>
<td>Leveraged Grants</td>
<td>1:3–4</td>
<td>Applied research, deployment</td>
<td>Moderate</td>
<td>Achieves greater leverage than direct grants</td>
<td>May be difficult to secure private sector involvement in some technology areas; may skew research away from public good to private research objectives</td>
<td>Limited</td>
</tr>
<tr>
<td>Joint Public/Private Research Centres</td>
<td>1:0.2–1</td>
<td>Applied research</td>
<td>Moderate</td>
<td>Provides a model for shared intellectual property</td>
<td>May skew research away from public good to private research objectives</td>
<td>Yes</td>
</tr>
<tr>
<td>Network of Innovation Centres</td>
<td>1:7–8</td>
<td>All Stages</td>
<td>Large</td>
<td>Integrated approach allows for synergies to be harnessed across different mechanisms. Builds endogenous capacity and local technology adaptations</td>
<td>As a regional and integrated approach would require care to build upon existing activity within each region</td>
<td>Yes</td>
</tr>
<tr>
<td>Incubators</td>
<td>1:1–20</td>
<td>Development</td>
<td>Moderate</td>
<td>Increases business capability and accelerates technology development and learning</td>
<td>As this is a business by business approach it may be difficult to scaled-up significantly</td>
<td>Yes</td>
</tr>
<tr>
<td>Tax incentives</td>
<td>1:1</td>
<td>Applied research</td>
<td>Large</td>
<td>Support large firms that have existing income streams</td>
<td>Small start up firms do not have revenue streams and can't take advantage of tax benefits</td>
<td>Limited</td>
</tr>
<tr>
<td>Advanced Purchasing Commitments</td>
<td>1:1–2</td>
<td>Applied research; Development</td>
<td>Limited</td>
<td>Particularly well suited to technologies will disparate yet active private sector research</td>
<td>Difficult to predict advanced purchasing contracts</td>
<td>Limited</td>
</tr>
<tr>
<td>Inducement Prizes</td>
<td>1:1–2</td>
<td>Applied research</td>
<td>Limited</td>
<td>Suited to stimulating more radical innovations</td>
<td>Tends to have a narrow focus on a single breakthrough technology</td>
<td>Limited</td>
</tr>
</tbody>
</table>
7.2 Demonstration

During the demonstration (and deployment) stage of a technology’s development, the main policy challenge is to create an effective relationship between the public and private sector and to ensure that socially vital technologies and emissions reduction activities are available in time and fit for purpose.

In recent years, the US National Renewable Energy Laboratory (NREL), the US Department of Energy and many other agencies that support technology development in the US have taken more strategic and direct involvement in technology support in the demonstration phase (NREL, 2006).

Technology incubation involves an intensive approach to supporting early stage technology developers to leveraging private sector investment (infoDev, 2009). Incubators help in the commercialization of technologies and coach technology developers in understanding the requirements of financiers and create bankable business plans. The services provided by the incubators include physical infrastructure, training, marketing, technical support, access to financing, legal support and networking.

According to the US Department of Energy its investment in 2002 of USD 2.5 million in technology incubators resulting in USD 173 million in private capital raised; a leveraging ratio of 1:69 (Figure 22). The success of this programme demonstrates the potential effectiveness of incubator programmes, which are being extensively adopted by national governments throughout the world.

Figure 22 NREL Energy Technology Incubator Programme Performance, 2002–2006

Achieved Results*

A DOE/NREL investment of about $2.5M, in a select group of the nation’s top incubators, has catalyzed:

- 69 Graduate companies *(c)
- 102 Technologies commercialized *(c)
- 2378 employees (Jobs!!) in the companies
- $173 million in capital raised by companies *(c)
- $254 million in revenues *(c)
- $10.8 million in state money *(c)
- $21.6 million in other leveraged funds *(c)
- 104 Clean Energy company clients now in incubators

*(c) = cumulative results 2002-2006


In the United Kingdom, the Carbon Trust established an incubator programme for low emissions technologies in 2004. As of the 2008, the Trust had invested GBP 3.8 million in 70 low carbon start up businesses, which has resulted in GBP 65 million in private sector investment (leveraging 1:17) (UNEP-SEFI, 2008).
For technology-based start-up firms equity financing is essential. Because of the high perceived risk of investing in a start-up firm they have fewer options for obtaining finance. Here technology incubators play a significant role. The incubators help firms to prepare their business plans, a major ingredient in getting finance. Firms also get help from the incubators with legal assistance for drafting license agreements and intellectual property protection.

The majority of technology incubators are affiliated with some kind of public or private research institution, such as a university, technology park and organizations with R&D capabilities. Often government support is key to the success of such incubators.

Figure 23 presents the number of incubators in various energy technologies globally, excluding China, in 2007. Some incubators support more than one technology.

*Figure 23  Clean Energy Incubators by Sector, 2007*

Source: UNEP and NEF (2008); Abbreviations: Eff = Efficiency.

Technology incubation programmes are most common in the United States and Europe as shown in Figure 24.
Source: UNEP and NEF (2008). The vertical access indicates the number of incubators identified by country.

In the US, the Small Business Innovative Research Program provided approximately USD 1.8 billion in 2007 in grants to American small businesses for early-stage R&D projects. Approximately 50 per cent of small businesses receiving grants through the programme have reached the fully commercial stage, 23 per cent remained under development, 16 per cent were in the commercialization phase and the remainder had failed (Humanitis, 2007). According to Charles Wessner, who has recently conducted an extensive evaluation of the programme (Wessner, 2008), its success has lead to its adoption in many other countries including Finland, Sweden, Russia, Netherlands, India, Japan, Korea and Taiwan.

The evaluation of SBIR in the health sector sub-programme examined the private leverage generated from the public investments since 1992 (Wessner, 2008). The study found that for the original USD 551 million invested over the period (until 2001), approximately 50 per cent of businesses had made it to market and cumulative sales revenue of businesses increased from USD 821 million in 2002 to USD 1.95 billion in 2007. Therefore the leverage ratio over 13 years is 1:3.5.

Also in the US, the Small Business Investment Company (SBIC) programme was created in 1958 to help small businesses meet long-term capital not available through commercial banks. Small companies often require equity financing in the critical USD 250,000 to USD 5 million range, not usually obtainable from private venture capital firms. SBICs help to bridge this capital gap. In 2000, there were approximately 404 SBICs with over USD 16 billion under management nationwide. In 2000, approximately USD 5.5 billion was invested in 3,060 small businesses and, for 2001, nearly USD 6 billion in SBIC investments is expected to be made (National Research Council, 2000).

Other programmes attempt to facilitate investment by matching investors with technology developers who are in the very early stages of technology development. In Australia, the COMET programme has been able to assist the firms it supports to get third party funds from groups such as

business angels, thereby resulting in AUD 6 being invested for every AUD 1 expended on the programme by the Australian Government (Cutler & Company, 2008).

The amended EU Emission Trading Directive foresees that Member States should use at least 50 per cent of their auctioning revenues to finance the climate change actions domestically and internationally, including the environmentally safe capture and geological storage of CO₂. In addition, up to 300 million allowances in the new entrants reserve of the revised EU Emissions Trading Scheme (ETS) will be made available for the construction and operation of up to 12 commercial demonstration projects for the environmentally safe capture and geological storage of CO₂ and innovative renewable energy technologies in the EU. At an assumed forward price of 25 euros per allowance, the set aside could generate EUR 7.5 billion in financing for demonstration technologies until 2020.

UNEP recently reviewed 43 clean energy public finance mechanisms, compared and drew lessons from them, and considered if and how they could be scaled up at an international level (UNEP, 2008a). These measures are categorised by stage of technological maturity and according to their leveraging ratios in Table 9. As this Table highlights, very few mechanisms are functioning at the demonstration stage.

Table 9  
Public Finance Mechanisms Classified by Stage of Technological Maturity, Leveraging Potential and Scalability (low = 1:0.5–2; medium = 1:2–5; high = 1:5–20)

<table>
<thead>
<tr>
<th>Public Finance Mechanism Type</th>
<th>Stage of Technology</th>
<th>Levering Potential</th>
<th>Scalability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credit line for Senior Debt</td>
<td>Diffusion</td>
<td>Low-Medium</td>
<td>High</td>
</tr>
<tr>
<td>Guarantee</td>
<td>Diffusion</td>
<td>Medium-High</td>
<td>High</td>
</tr>
<tr>
<td>Project loan facility</td>
<td>Diffusion</td>
<td>Low-Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Project Development Grants</td>
<td>Diffusion</td>
<td>Medium-High</td>
<td>Medium</td>
</tr>
<tr>
<td>Credit line for Subordinate Debt</td>
<td>Deployment-Diffusion</td>
<td>Medium-High</td>
<td>High</td>
</tr>
<tr>
<td>Grants for Technical Assistance</td>
<td>Deployment-Diffusion</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Soft Loan Programmes</td>
<td>Deployment-Diffusion</td>
<td>Low-Medium</td>
<td>High</td>
</tr>
<tr>
<td>Carbon Finance</td>
<td>Deployment-Diffusion</td>
<td>Medium-High</td>
<td>Medium</td>
</tr>
<tr>
<td>Loan Softening programmes</td>
<td>Deployment-Diffusion</td>
<td>Medium-High</td>
<td>Medium</td>
</tr>
<tr>
<td>Equity Fund</td>
<td>Deployment</td>
<td>Medium-High</td>
<td>High</td>
</tr>
<tr>
<td>Venture Capital</td>
<td>Demonstration-Deployment</td>
<td>Medium-High</td>
<td>High</td>
</tr>
<tr>
<td>Inducement Prizes</td>
<td>R&amp;D-Demonstration</td>
<td>Medium-High</td>
<td>Low-Medium</td>
</tr>
</tbody>
</table>

Source: UNEP (2008a) and personal communication E. Usher, Manager UNEP-SEFI, 1 December 2008.

Table 10 summarises the types of measures that national governments are currently employing or may be considering to leverage investment from the private sector into companies with technologies that are in the demonstration stage. The table provides information on the potential to scale up, the applicability of each approach to different private sector entities and their applicability to enhancing financing in developing countries.
<table>
<thead>
<tr>
<th>Policy approach</th>
<th>Typical leveraging ratios</th>
<th>Potential to Scale up</th>
<th>Benefits</th>
<th>Disbenefits</th>
<th>Applicability to Developing Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grants</td>
<td>1:5–10</td>
<td>Low-Medium</td>
<td>Provides flexibility, doesn’t need to be repaid</td>
<td>May be difficult to access, particularly for developing country firms</td>
<td>Yes</td>
</tr>
<tr>
<td>Public Private Partnerships</td>
<td>1:1–2</td>
<td>Low-Medium</td>
<td>Allows for risk sharing; Can be used to finance large and difficult long-term projects (e.g. infrastructure)</td>
<td>Tends to favour large established firms</td>
<td>Yes</td>
</tr>
<tr>
<td>Public Procurement</td>
<td>1:0.5–1</td>
<td>Low-Medium</td>
<td>In total, public procurement is large-scale and long-term and can provide significant market stimulus</td>
<td>Tends to favour large established firms; Often project-scale; May not match with public procurement objectives of value for money</td>
<td>Limited</td>
</tr>
<tr>
<td>Early-stage Public Venture Capital</td>
<td>1:10–20</td>
<td>High</td>
<td>Equity stake in business can lead to higher business performance; addresses a clear financing gap</td>
<td>Requires companies to relinquish control, may demand high returns on investment</td>
<td>Highly dependent upon enabling environment</td>
</tr>
<tr>
<td>Inducement Prizes</td>
<td>1:10–20</td>
<td>Medium</td>
<td>Can harness competitive forces to drive innovation; spill over benefits can be significant; complementary to other financing options</td>
<td>Tends to focus on specific technologies and applications</td>
<td>Yes</td>
</tr>
</tbody>
</table>
7.3 Deployment

The IEA (2008a) estimates that up to USD 200 billion per annum is needed globally in early public financing support for the early deployment of energy technologies, including up to 120 billion per annum in developing countries.

The challenge for financing technology deployment in developing countries at this scale should not be underestimated. Developing countries do not have the capacity to finance the incremental costs of these more costly technologies, and will rely upon financial and technology transfers from developed countries to do so. However, most mechanisms for technology transfer currently support mature technologies rather than advanced technologies (UNFCCC, 2008a). The GEF has previously attempted small-scale efforts at early deployment of technologies in developing countries but with mixed success (GEF, 2004a).

Existing financial mechanisms provide support at the project-scale and programmatic approaches which aggregate projects and scale up the flow of financing are just beginning to be used. Sectoral and policy-based approaches to financing which provide direct budgetary support for the national policies that are required to deploy advanced technologies at sufficient scale currently do not exist (UNFCCC, 2008c).

Sectoral and policy-based approaches are discussed in section 7.4 below, as they are (like the CDM) more directly relevant for technologies in the diffusion stage. Importantly, these approaches will rely upon the accreditation of national policies and measures (Ward, et al., 2008). Many of the options for national policies that support the early deployment of technologies in developing countries have been implemented in developed countries and the experience in using these policies is discussed below.

One of the most commonly used public policy tools for the support of technologies in the deployment stage are subsidies, which cover the cost premium for these technologies. Subsidies for the deployment of climate change mitigation technologies are usually provided in the forms summarised in Table 11, below.

Table 11 Types and examples of subsidies used to support technologies in the deployment stage.

<table>
<thead>
<tr>
<th>Subsidy Type</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct production subsidies</td>
<td>Green-vehicle production subsidies; GEF financing for Solar PV manufacture in developing countries</td>
</tr>
<tr>
<td>Direct deployment subsidies</td>
<td>GEF projects; bilateral and multilateral aid programmes</td>
</tr>
<tr>
<td>Tax Incentives</td>
<td>Import excise exceptions; investment tax credits (e.g. income tax deductibility for investment in reforestation projects); Production tax credits (e.g. tax deductibility for companies producing a quantity of a given technology); Accelerated depreciation al-</td>
</tr>
<tr>
<td>Subsidy Type</td>
<td>Examples</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Low incentives (specified capital can be depreciated at a faster rate) 34</td>
<td></td>
</tr>
<tr>
<td>Recycling tax revenue</td>
<td>UK Climate Change Levy</td>
</tr>
<tr>
<td>Feed-in tariffs</td>
<td>German and Spanish feed-in tariff for domestic solar thermal power</td>
</tr>
<tr>
<td>Portfolio standards for energy generation</td>
<td>Mandatory Renewable Energy Targets and renewable obligations (Australia, EU)</td>
</tr>
<tr>
<td>Certificate schemes for energy efficiency</td>
<td>UK White Certificate Scheme</td>
</tr>
</tbody>
</table>

Source: IEA World Energy Outlook Policy Database 35

Direct production subsidies can be structured to leverage additional private sector investment if they are made contingent upon co-investment from private firms. For example, the AUD 1.3 billion Australia green car subsidy will be paid to the Australian car manufacturing industry over a 10 year period as competitive grants that require at least AUD 3 private sector investment for every AUD 1 public subsidy (Minister for Innovation, 10 November 2008). The grants will be conditional upon meeting agreed low emission targets for vehicle performance.

Alternatively, subsidies can be linked to regulatory changes that, when coupled, drive private sector investment. Emissions trading schemes have tended to function in this way because emissions permits have been allocated for free to some industries (which is a form of subsidy because the permits have a monetary value and can be sold) or direct compensation is paid to polluters (especially those that are emissions intensive and trade exposed) to cover the increased costs that result from the emissions trading scheme. It is not possible to determine the level of internal investment that has resulted from the EU ETS and therefore the leverage ratio that has been achieved. The extent to which the long market in the EU ETS in 2006 resulted from abatement by liable parties or over-allocation of permits is heavily debated and analysis is only beginning to emerge (Ellerman and Buchner, 2008). Nonetheless, the leveraging ratio is likely to be less than other policies and measures because emissions trading schemes tend to stimulate low cost abatement options with low investment costs and relatively high proportions of public carbon financing.

Subsidy programmes have also been commonly used to stimulate investments in energy efficiency both by industry and households. Evaluations of energy efficiency incentive programmes have found that 40–85 per cent of programme recipients would have acted in the absence of the programme (Farla and Blok, 1998). Care must be taken when designing subsidy programmes to maximize efficiency requiring more discriminating methods for distributing subsidies. In the case of energy efficiency, standards and regulations are a more preferable policy instrument because they are much more efficient in leveraging private investment, whereas subsidies tend to socialise the cost of investment while privatizing the benefits (Newell, 2008).

Figure 25 presents the effect of direct subsidies on solar photovoltaic (PV) power in Japan and wind power in Denmark in terms of the market value of installed capacity in the case of PV, and company revenue in the case of wind (Carbon Trust, 2007). While this is a different measure of the leverage effect of a public investment, it does indicate the benefit of broad-scale subsidy pro-

34 Accelerated depreciation allowances tend to specify the technologies that are covered in the scheme and are not responsive to new technology developments. They have proved to be difficult to scale up to address a wider range of technologies.

grammes in supporting technologies which are at a competitive disadvantage to conventional power generation.

Figure 25  Effect of direct subsidies on solar photovoltaic (PV) power in Japan and wind power in Denmark

![Diagram showing the effect of direct subsidies on solar photovoltaic (PV) power in Japan and wind power in Denmark.](image)


A recent study by Navigant Consulting (2008) estimates that extending the federal investment tax credit for renewable energy for eight years (valued at USD 15.7 billion in forgone taxation revenue) would increase domestic investment in the solar industry by USD 232 billion by 2016, resulting in energy new solar energy to power seven million homes and to create directly or indirectly 440,000 jobs. The resulting leveraging ratio of the federal investment tax credits is 1:14 over several years.

Fiscal measures can be used to recycle taxation revenue and increase advanced technology deployment rates. The UK Climate Change Levy and companion Climate Change Agreements is one example. The Levy is a tax on the use of energy in industry, commerce and the public sector. The revenue raised is recycled to business through three streams:

1. Offsetting cuts of 0.3 per cent in employers’ National Insurance contributions;
2. Additional support for energy efficiency (technical support plus a 100 per cent first year capital allowance for certain energy saving investments, which is expected to be worth up to GBP 70 million a year); and
3. Programmes to stimulate the uptake of renewable sources of energy (GBP 50 million a year).

The objective has been no net gain for the public finances and no increase in the tax burden on industry as a whole (although it may not be cost-neutral at the individual firm level).


Under the companion Climate Change Agreements, energy-intensive industries receive a rebate of up to 80 per cent of the Levy if they agree to a programme of energy savings, negotiated sector by sector. A review by Wordsworth and Grubb (2003) was unable to determine the level of private sector investment that resulted from this measure, however, they conclude that the measure is cost-effective and would result in substantial private sector investment.

Pricing policies such as feed-in tariffs allow for ease of entry into the marketplace, particularly for smaller companies and investments that wish to target the incremental costs of alternative energy sources, making them particularly suited to developing countries, where power markets are often small and dispersed (Sawin, 2004). Data on the leveraging ratios of feed-in tariffs has not been located in the course of researching this dissertation. If carefully targeted and designed to pay the marginal cost of abatement it would be reasonable to assume that feed-in tariffs leverage private investment at a similar scale as other initiatives such as the CDM which pays investors the marginal cost of abatement. Therefore for the purpose of this study it is assumed that feed-in tariffs leverage in the order of 1:6–10.

On the other hand, quota-based systems such as the Australian renewable energy target, which regulate for a certain quantity of abatement or installed capacity tend to be higher in cost and leverage less private investment, although the cost is passed on to the consumer directly rather than being paid with state taxation revenues. They may also cap the level of investment in climate change technologies if they are set lower than the market is willing to provide given consumer demand for such products. Again data on the average leveraging effect of quota-based systems could not be obtained, however, for the same reasons as feed-in tariffs, it is assumed that they leverage in the order of 1:6–10.

Public procurement can also be used for the deployment of climate change mitigation technologies. A common example is in vehicle technologies, where some governments set aside a portion of the government vehicle fleet for low emission vehicles. In addition, governments may set longer term targets for the purchase of advanced vehicles that are currently unavailable in the domestic market. Because governments have large purchasing power, vehicle manufacturers have an incentive to develop vehicles that will meet these standards in order to fill the government’s demand for low emission vehicles. A coordinated approach to public procurement on a global scale would have a large leveraging effect on some industries (such as the car industry) although it is difficult to predict, and politically and practically awkward to coordinate.

Countries without privatised energy markets effectively purchase power generation technologies directly and those governments have retained the opportunity to directly use their purchasing power to stimulate early deployment of energy technologies. For example, China and Indonesia have established purchasing policies for renewable energy technologies (wind and solar in the case of China and geothermal and hydro in the case of Indonesia) and have had reasonable success in stimulating substantial penetration of renewable energy through this approach. These approaches perhaps leverage additional private investment at a ratio of 1:1–2.

Another related option to stimulate the early deployment of climate change technologies would be to establish price guarantees (Anderson, 2006). In this approach the government would set a marginal price for particular technologies and would pay producers that marginal price for every unit of technology deployed. The price premium could be financed through taxes, a levy on electricity generation or consumption or the revenues generated through renewable energy obligations, or the auctioning of emissions permits. Assuming that the premium price approximates the marginal cost of abatement, this approach is likely to achieve leverage ratios similar to the CDM
Reverse auctions and tendering mechanisms which are also related to price guarantees (Newell, 2008) might achieve similar leveraging.

Standards and regulations are also important tools for the early deployment, but are more commonly associated with technologies that have already been deployed but have not yet become universally diffused into a society (such as the banning of incandescent light bulbs to trigger the widespread diffusion of compact fluorescent lights and other efficient lighting options).

An example of a regulatory approach to technology deployment in the energy efficiency area is the proposed Industry Mandatory Energy Efficiency (IMEE) Scheme in Australia. This proposed scheme involves a legislative requirement for businesses to undertake energy or greenhouse gas emission audits and to implement all abatement opportunities identified through the audit that have a payback period of less than three years. An economic assessment of the proposed scheme concluded:

Based on best available estimates of the magnitude and distribution of energy savings opportunities available to Australian sites, such a programme — involving mandatory assessment, investment and reporting requirements for large energy consumers (consuming 100 TJ or more of energy each year) — is likely to deliver a net economic benefit over ten years of around $710 million (in net present value (NPV) terms).

This is based on a (notional) requirement for these sites to implement energy saving projects with a payback period of 3 years or less, and the effect of a modest domestic carbon price (assumed to average around $15 per tonne CO2e) in the period 2010 to 2020. In the absence of an assumed future carbon price (the value of which is currently uncertain and will depend on a range of international and domestic policy considerations), the net economic benefit is estimated at $630 million (NPV). (Allen Consulting, 2008, pg. vi)

Programme costs would represent a total cost to Australian business of AUD 1.15 million, which is in effect is a leveraging ratio of 1:630–700 (without taking into account additional rebound effects which may significantly reduce the overall effect of such programmes). If a 50 per cent discount is assumed to account for the rebound effect the leveraging ratio would be in the order of 1:300.

Preferential treatment and fast track approval processes have also commonly been used to support socially desirable technologies. For example, governments may establish project facilitation services, or may fund crucial pre-project analysis (such as the identification of sequestration sites and infrastructure needs for carbon capture and storage) to support technologies. Estimating the leveraging effect of these more diffuse policy measures is difficult and no robust estimates have been identified within the context of this dissertation. Nonetheless, these facilitation mechanisms can be very important in attracting investment as they remove barriers and some of the prohibitive transaction costs that would otherwise prevent advanced technology deployment.

The Private Financing Advisory Network (PFAN) offers a free consulting service to project sponsors and developers to help them raise private sector finance by providing capacity building in finance knowledge and know-how transfer. PFAN functions on a small-scale but has recently secured additional resources to scale up significantly. It aims to leverage USD 500–700 million over three years with an annual budget of under USD 5 million. During the pilot phase the PFAN budget was in the order of USD 1 million (including in kind support) and it was able to leverage in the order of USD 20 million (Climate Technology Initiative, 2008).
As mentioned previously a review of a sample of GEF projects in 2003 found that the GEF was achieving relatively low private sector leveraging. Private sector leveraging totaled USD 391 million as a result of USD 3.6 billion total investment in GEF-3, and for the climate change focal area of the GEF the leveraging ratio was 1:0.62. Private leveraging was dominated by a few projects, with only about 20 projects (3 per cent of projects) involving private sector contributions (GEF, 2003a; b). However, as will be discussed in section 7.4, below, some of the GEF implementing agencies (in particular the IFC and World Bank) have the ability to use concessional financing tools and have much higher leveraging ratios, as shown in Table 12.

Table 12 summarises the types of measures that governments are currently employing or may be considering to leverage investment from the private sector into the early and expanding deployment of new technologies that are near commercially viable yet still face significant barriers.

<table>
<thead>
<tr>
<th>Policy approach</th>
<th>Typical leveraging ratios</th>
<th>Potential to Scale up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct production subsidies</td>
<td>1:3</td>
<td>Small-Medium</td>
</tr>
<tr>
<td>Direct deployment subsidies</td>
<td>1:2</td>
<td>Small-Medium</td>
</tr>
<tr>
<td>Tax Credits</td>
<td>1:15</td>
<td>Medium</td>
</tr>
<tr>
<td>Feed-in tariffs</td>
<td>1:6–10</td>
<td>Large</td>
</tr>
<tr>
<td>Portfolio standards for energy generation</td>
<td>1:7–8</td>
<td>Medium</td>
</tr>
<tr>
<td>Regulatory mechanisms for energy efficiency</td>
<td>1:300</td>
<td>Large</td>
</tr>
<tr>
<td>Public procurement</td>
<td>1:1–2</td>
<td>Small</td>
</tr>
<tr>
<td>Price guarantees, reverse auctions, tenders</td>
<td>1:6–10</td>
<td>Medium</td>
</tr>
<tr>
<td>Expansion of PFAN</td>
<td>1:20–100</td>
<td>Medium</td>
</tr>
<tr>
<td>Consumer-based energy efficiency programmes</td>
<td>1:10</td>
<td>Large</td>
</tr>
<tr>
<td>GEF: UNDP/UNEP</td>
<td>1:1</td>
<td>Medium</td>
</tr>
<tr>
<td>GEF: World Bank</td>
<td>1:5–11</td>
<td>Large</td>
</tr>
<tr>
<td>Credit line for Subordinate Debt</td>
<td>1:2–20</td>
<td>Large</td>
</tr>
<tr>
<td>Grants for Technical Assistance</td>
<td>1:5–20</td>
<td>Medium</td>
</tr>
<tr>
<td>Soft Loan Programmes</td>
<td>1:0.5–5</td>
<td>Large</td>
</tr>
<tr>
<td>Carbon Finance</td>
<td>1:6–10</td>
<td>Medium</td>
</tr>
<tr>
<td>Loan Softening programmes</td>
<td>1:2–5</td>
<td>Medium</td>
</tr>
<tr>
<td>Public Equity Fund</td>
<td>1:10–20</td>
<td>Large</td>
</tr>
<tr>
<td>Public Venture Capital</td>
<td>1:10–20</td>
<td>Large</td>
</tr>
</tbody>
</table>

Source: Author’s estimates based on literature referenced in section 7.3 and UNEP (2008a).

7.4 Diffusion

While the development, demonstration and deployment of new technologies is an important part of the challenge to stabilise greenhouse gas emissions, the potential for the diffusion of existing technologies is large, the barriers to diffusion are less significant and the public costs associated with diffusion of technologies can be significantly less than for new technologies.

Indeed, many technologies in the diffusion stage can be implemented with net negative costs. The IPCC (Metz, et al., 2007) concluded that mitigation options with net negative costs have the po-

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37 Shaded instruments within this table are not described in the text above. They are either discussed in the other section of the dissertation, or they are described in UNEP (2008a). Leveraging ratios for these instruments are the author’s estimates based on the leveraging ratios of similar instruments and interviews with representatives from UNEP-SEFI.
tential to reduce annual emissions in 2030 by around six gigatonnes of CO$_2$-e, accounting for about 10 per cent of projected global emissions. According to the Japanese Ministry of Economy, Trade and Industry (METI, 2008), existing efficient technologies can contribute between 40 and 50 per cent of total emission reductions by the year 2050.

Current activities to facilitate the diffusion of technologies are dispersed, uncoordinated and without adequate medium and long-term goals. Many initiatives are voluntary which makes financing unpredictable and prevents long-term strategic planning for investment and the setting of climate protection goals within developing countries.

At the consumer level, there are now many green loan programmes in place around the world, including within the US and Australia and in many countries in the EU. The Australian Green Loan Programme\(^{38}\) combines low-interest loans of up to AUD 10000, green renovation packs as well as detailed household sustainability assessments. The programme involves AUD 300 million of public investment and will leverage approximately AUD 2 billion private investment (1:7).

The Austrian Federal Environment Fund (IEA Energy Efficiency Policy Database, 2009) provides subsidies to attract investment in renewable energy and energy efficiency. In 2003, just over EUR 60 million was invested in the diffusion of technologies resulting in private sector investments of EUR 295 million (leveraging at a ratio of 1:5).

Carbon markets are a significant source of financing for the diffusion of climate change technologies. Trends in the public and private shares of financing for carbon credits are shown in Figure 26\(^{39}\). This figure provides an estimate of the effectiveness of carbon markets in leveraging the private sector to finance the incremental costs of projects. It is not a measure of the leveraging ratio for total investment in carbon markets (which as previously mentioned is in the order of 1:6–10). In 2007, the public share of financing for the incremental costs of diffusion technologies was about one third of the private share.

**Figure 26** Public and private investment in carbon finance

![Figure 26](source: NEF database (2008).

By the end of 2008 cumulative investment through the CDM has been close to 100 billion driven by public investment in the incremental costs (carbon credits) of around 10 billion (Seres and Haites, 2008). However, the CDM does not necessarily result in any new investment; rather it

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tends to shift where the investment might have occurred, since the purchaser of CERs is often from a compliance market and the emissions reduction in the CDM project offsets its liability in a domestic emissions trading scheme. For example, investments that would have occurred in Europe through the EU ETS have instead been transferred to a developing country (although at a lower carbon cost and usually at a lower total investment cost).

In Brazil phase 1 of the PROFINA initiative (Programme of Incentives for Alternative Electricity Sources) has resulted in generation of 3,300 MW of renewable energy (from wind, biomass and small hydroelectric sources) through a system of subsidies and incentives, which draw on an Energy Development Account funded by end-use consumers through an increase on energy bills. Total investment resulting from PROFINA was USD 3.84 billion of which private investment was USD 2.9 billion with a leveraging ratio of 1:4 (IEA Renewable Energy Policy Database, 2009).

In Canada, the CAD 200 million Green Municipal Investment Fund (GMIF) is a permanent revolving fund providing financing to municipal governments or their partners to underwrite the capital costs of innovative environmental infrastructure projects. The GMIF has leveraged over CAD 1 billion in public and private investment through an outlay of CAD 118 million in loans and CAD 20 million in grants in 47 capital projects since 2000 (IEA Renewable Energy Policy Database, 2009).

The European Union’s Global Energy Efficiency and Renewable Energy Fund (GEEREF) aims to complement the resources and instruments available from the multilateral financing institutions in order to increase the risk sharing options available. The startup capital provided by European governments is EUR 100 million. Cofinancing is expected to bring the fund up to EUR 1 billion. GEEREF is an investment fund of funds aiming to enhance leveraging of private sector finance. As the fund has only recently been operationalised, its potential to leverage the private sector is unknown but for the purposes of this study it is assumed that it will be as effective as many existing public venture capital funds and will leverage in the order of 1:10 (IEA Renewable Energy Policy Database, 2009).

In regard to official development assistance, the US aid programme claims that the Global Development Alliance (GDA) programme, which was established in 2002 to partner with governments, businesses, foundations, and other non-governmental organizations, has established more than 600 alliances with over 1,700 partners, and has leveraged USD 5.8 billion in private resource commitments from USD 2.1 billion in U.S. government resources (Government of the USA, 2008). That equates to a leverage ratio of about 1:2.7.

Sectoral approaches to global reductions in greenhouse gas emissions have been identified as a key measure to be included in the post-2012 international climate change agreement. The Bali Plan of Action (UNFCCC, 2007b, paragraph 1 (b)(iv)) called for “Enhanced national/international action on mitigation of climate change, including...cooperative sectoral approaches and sector-specific actions”. Subsequently many Parties to the Convention have proposed specific sectoral approaches (UNFCCC, 2008d). Sectoral approaches were the subject of an in-session workshop of the AWG-LCA at its third session in Accra, Ghana in August 2008.

A wide range of options have been canvassed and to date there is no clear consensus on which approaches are likely to be acceptable to the majority of the Parties. However, there does seem to be some degree of support for sector no-lose targets in some sectors if adequate financial and technical support can be committed by Annex II countries.
Schmidt, et al., (2008) provide an overview of how sector no-lose targets may be implemented in key emitting sectors. They recommend a country-based approach to avoid concerns that global sectoral regulatory measures would impact on national sovereignty. They also recommend restricting sectoral approaches to sectors that have:

- a small number of entities;
- easy data collection;
- homogenous products; and
- participation in international trade.

In practice, they claim that by focusing on the electricity generation, iron and steel, aluminium, oil refining, cement, lime and pulp and paper sectors it would be possible to cover 80–90 per cent of industrial emissions through the involvement of 20 developing countries.

Essentially the no-lose target approach would involve the setting of sectoral greenhouse gas emissions intensity (i.e. emissions per unit of production) baselines and crediting (providing a flow of finance to the value of the marginal cost of abatement) for emissions reductions in developing countries below the baseline. The mechanism would potentially use the existing institutions and mechanism of the CDM.

Ward, et al., (2008) investigate the role of sector no-lose targets in scaling up finance for climate change mitigation activities in developing countries. As illustrated in Figure 27, they depict the scaling up or aggregation of activities from the existing project and emerging programmatic-based CDM to sectoral CDM, policy-based CDM and finally sectoral or whole of economy no-lose targets.

**Figure 27** Options for increasing the scaling up of the CDM

- 'Regular' CDM
- Programmatic CDM
- Sectoral CDM
- Sector no-lose targets
- Policy CDM


Programmatic approaches to the CDM involve aggregating small-scale activities that each follow exactly the same methodology and thereby allow for an unlimited number of actions to occur within one approved CDM programme. This approach is currently being trialled under the CDM, but has yet to result in large-scale emissions reductions.

Sectoral CDM involves the inclusion of an entire sector of a developing country as a single CDM project. The most likely option would be that credits would be awarded to national governments for reductions in emissions intensity below the baseline for that sector. The government would implement policies and measures to reduce emissions in the sector and would receive credits if emissions fall below the baseline. It would then distribute those credits to entities within the sector according to that entities contribution to the overall level of emissions intensity reductions.

Policy CDM would involve approving the policies of national governments that resulted in emissions reductions, potentially across several sectors. However, the COP has explicitly ruled out this approach. Paragraph 20 of decision 4/CMP.1 states “that a local/regional/national policy or
standard cannot be considered as a clean development mechanism project activity” (UNFCCC, 2005). An example of a policy that may be considered is where a government adopts a national energy efficiency target to increase national energy efficiency by a defined amount relative to a baseline. However, difficulties in measuring and verifying emissions reductions that where the direct result of a national policy may be insurmountable and for this reason there has been little progress in the development of this approach.

Sectoral no-lose targets (SNLTs) are similar to the Sectoral CDM approach discussed above. However, according to Ward, et al., (2008) “the main difference between sectoral CDM and SNLTs is that the technicalities referring to baselines, monitoring and verification, as well as the supervision and approval by the CDM Executive Board, would be maintained under a sectoral CDM, while the national sector baseline for a sector no-lose target would be negotiated at the COP level.

In terms of the levels of private investment that would result from any of these approaches, it is likely that on average the ratio between public investment (i.e. the marginal cost of abatement or the cost of the carbon credits) and private investment would remain at a similar level to the current ratio under the CDM, which is about 1:6-10. This is because the same types mitigation actions would occur with the same public/private investment ratios, only on a larger-scale. The effectiveness of this mechanism would be greater as certain barriers to investment would be removed. For example, the total administrative and other transaction cost burdens on private investors would be reduced. However, because the flow of credits under sectoral approaches is to national governments, the ability to attract private investment would become dependent upon the overall strategic approach of those governments and the incentives and other regulatory approaches used to stimulate investment in emissions reductions. The potential to scale up is ultimately a function of the demand for credits, which is fundamentally driven by the emission reduction targets set by Annex I countries. If Annex I countries do not set ambitious targets then the demand for emissions reductions in developing countries will be low, resulting in low prices for credits and lower overall abatement activity.

Table 13 summarises the types of measures that governments are currently employing or may be considering to leverage investment from the private sector for the diffusion of technologies. The instruments in the shaded part of the Table where discussed in the previous section on Deployment, but are also relevant to technologies in the diffusion stage. Measures shaded in the table are results from UNEP (2008a) and have not been discussed above.
### Table 13  Summary of existing policy approaches to leveraging private sector investment in diffusion stage technologies

<table>
<thead>
<tr>
<th>Policy approach</th>
<th>Typical leveraging ratios</th>
<th>Potential to Scale up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green loan programmes</td>
<td>1:7</td>
<td>Large</td>
</tr>
<tr>
<td>Subsidy and grant programmes</td>
<td>1:5</td>
<td>Medium</td>
</tr>
<tr>
<td>Global Energy Efficiency and Renewable Energy Fund</td>
<td>1:10</td>
<td>Medium</td>
</tr>
<tr>
<td>Canadian Green Municipal Fund</td>
<td>1:10–20</td>
<td>Large</td>
</tr>
<tr>
<td>Official Development Assistance</td>
<td>1:2–3</td>
<td>Small</td>
</tr>
<tr>
<td>CDM - Project</td>
<td>1:6-10</td>
<td>Medium</td>
</tr>
<tr>
<td>CDM - Programmatic</td>
<td>1:6-10</td>
<td>Medium</td>
</tr>
<tr>
<td>Sector no-lose targets</td>
<td>1:6-10</td>
<td>Large</td>
</tr>
<tr>
<td>Expansion of PFAN</td>
<td>1:20–100</td>
<td>Medium</td>
</tr>
<tr>
<td>Consumer-based energy efficiency programmes</td>
<td>1:10</td>
<td>Large</td>
</tr>
<tr>
<td>GEF: UNDP/UNEP</td>
<td>1:1</td>
<td>Medium</td>
</tr>
<tr>
<td>GEF: World Bank</td>
<td>1:5–11</td>
<td>Large</td>
</tr>
<tr>
<td>Credit line for Senior Debt</td>
<td>1:0.5–5</td>
<td>High</td>
</tr>
<tr>
<td>Guarantee</td>
<td>1:2–20</td>
<td>High</td>
</tr>
<tr>
<td>Credit line for Subordinate Debt</td>
<td>1:2–20</td>
<td>High</td>
</tr>
<tr>
<td>Grants for Technical Assistance</td>
<td>1:5–20</td>
<td>Medium</td>
</tr>
<tr>
<td>Loan Softening programmes</td>
<td>1:2–5</td>
<td>Medium</td>
</tr>
</tbody>
</table>

Source: Author’s estimates based on literature referenced in section 7.4 and UNEP (2008a).

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40 Shaded instruments in the table are not described in the text above. They are either discussed in the other section of the dissertation, or they are described in UNEP (2008a). Leveraging ratios for these instruments are the author’s estimates based on the leveraging ratios of similar instruments and interviews with representatives from UNEP-SEFI.
8 Summary of leveraging potential by stage of technological maturity

Section 7 reviewed a wide range of policies and measures currently being implemented or proposed for inclusion in the post-2012 climate change agreement. The ability of these initiatives to leverage investment from the private sector varies considerably. Figure 28 and Table 14 summarise the leveraging potential of all policies and measures reviewed in this dissertation according to the stage of technological maturity that they most support.

Figure 28 Summary of measures reviewed, including typical leveraging ratios by stage of technological maturity

Evidence suggests that private sector financing of climate change technologies is heavily reliant upon stimulus from the public sector, through the establishment of market conditions and enabling environments, policies and measures that remove barriers to technology, and through grants and fiscal policies that make climate change technologies financially viable (UNEP, 2008a; Doornbosch, et al., 2008).
Table 14  Summary of leveraging potential of policies and measures reviewed in this Chapter 741

<table>
<thead>
<tr>
<th>Initiative</th>
<th>Leverage</th>
<th>Initiative</th>
<th>Leverage</th>
<th>Initiative</th>
<th>Leverage</th>
<th>Initiative</th>
<th>Leverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grants - Direct</td>
<td>1:0–0.5</td>
<td>Grants</td>
<td>1:5–10</td>
<td>Direct production subsidies</td>
<td>1:3</td>
<td>Green loan programmes</td>
<td>1:7</td>
</tr>
<tr>
<td>Leveraged Grants</td>
<td>1:3–4</td>
<td>Public Private Partnerships</td>
<td>1:1–2</td>
<td>Direct deployment subsidies</td>
<td>1:2</td>
<td>Subsidy and grant programmes</td>
<td>1:5</td>
</tr>
<tr>
<td>Joint Public/Private Research Centres</td>
<td>1:0.2–1</td>
<td>Public Procurement</td>
<td>1:0.5–1</td>
<td>Tax Credits</td>
<td>1:15</td>
<td>GEERE Fund</td>
<td>1:10</td>
</tr>
<tr>
<td>Network of Innovation Centres</td>
<td>1:7–8</td>
<td>Early-stage Public Venture Capital</td>
<td>1:10–20</td>
<td>Feed-in tariffs</td>
<td>1:6–10</td>
<td>Canadian Green Municipal Fund</td>
<td>1:10–20</td>
</tr>
<tr>
<td>Tax incentives</td>
<td>1:1</td>
<td>Regulatory mechanisms for energy efficiency</td>
<td>1:300</td>
<td>CDM - Project</td>
<td>1:6–10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advanced Purchasing Commitments</td>
<td>1:1–2</td>
<td>Public procurement</td>
<td>1:1–2</td>
<td>CDM - Programmatic</td>
<td>1:6–10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inducement Prizes</td>
<td>1:1–2</td>
<td>Price guarantees, reverse auctions, tenders</td>
<td>1:6–10</td>
<td>Sector no-lose targets</td>
<td>1:6–10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expansion of PFAN</td>
<td>1:20–100</td>
<td></td>
<td></td>
<td>Expansion of PFAN</td>
<td>1:20–100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumer-based energy efficiency programmes</td>
<td>1:10</td>
<td></td>
<td></td>
<td>Consumer-based energy efficiency programmes</td>
<td>1:10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GEF: UNDP/UNEP</td>
<td>1:1</td>
<td></td>
<td></td>
<td>GEF: UNDP/UNEP</td>
<td>1:1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Credit line for Subordinate Debt</td>
<td>1:2–20</td>
<td></td>
<td></td>
<td>Credit line for Senior Debt</td>
<td>1:0.5–5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grants for Technical Assistance</td>
<td>1:5–20</td>
<td>Guarantee</td>
<td>1:2–20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon Finance</td>
<td>1:6–10</td>
<td></td>
<td></td>
<td>Credit line for Subordinate Debt</td>
<td>1:2–20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loan Softening programmes</td>
<td>1:2–5</td>
<td>Grants for Technical Assistance</td>
<td>1:5–20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Equity Fund</td>
<td>1:10–20</td>
<td>Loan Softening programmes</td>
<td>1:2–5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Venture Capital</td>
<td>1:10–20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

41 Shaded boxes indicate those public policies or investment programmes that have the potential to be increased in scale to a level where financial flows may exceed USD 5 billion per annum.
As explained in Chapter 2, an estimation of the average leveraging ratios needs to be made in order to test various scenarios of the public and private shares of financing that may be required under a post-2012 international climate change agreement.

It was also explained in Chapter 7 that the overall impact of public policies and investment programmes vary. As identified in Table 14, some measures can be significantly scaled up, whereas others have limited application. For this reason, average leveraging ratios are selected taking into account the ability to scale up the various public policies and investment programmes that have been reviewed in Chapter 7.

Three sets of average leveraging ratios are arrived at in Table 15. All are derived from the summary of leveraging ratios in Table 14. The first set is an assessment of the average leveraging ratios by stage of technological maturity for existing public policies and investment programmes. The second set assumes that governments adopt an enhanced set of policies and investment programmes that have moderately improved leveraging ratios. The third set assumes that governments adopt policies and investment programmes that significantly increase leveraging of the private sector. This third scenario assumes an optimistic and very high performance set of public policies and investment programmes are employed extensively. The three sets of average leveraging ratios are then applied as scenarios in Chapter 9 to estimate the public and private share of financing.

Table 15  Average leveraging ratios of policies and measures reviewed in this dissertation according to the stage of technological maturity: Existing, Moderately Enhanced; and High Performance

<table>
<thead>
<tr>
<th>R&amp;D</th>
<th>Demonstration</th>
<th>Deployment</th>
<th>Diffusion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimated existing leverage ratio</td>
<td>Moderately enhanced leverage ratio</td>
<td>High performance enhanced leverage ratio</td>
</tr>
<tr>
<td></td>
<td>Global</td>
<td>Global</td>
<td>Global</td>
</tr>
<tr>
<td></td>
<td>1:0.5</td>
<td>1:1</td>
<td>1:4</td>
</tr>
<tr>
<td></td>
<td>1:1</td>
<td>1:3</td>
<td>1:5</td>
</tr>
<tr>
<td></td>
<td>1:2</td>
<td>1:4</td>
<td>1:10</td>
</tr>
</tbody>
</table>

Source: Author’s estimates based on Table 14, above and reviews of leveraging ratios contained in Chapter 7.
9 Estimating the public and private share of finance for climate change mitigation technologies based on average leverage ratios

As previously discussed, public financing for climate change may be restricted either because the new climate change agreement is unable to secure a full commitment from Annex II countries to provide the necessary financing for climate change, or because economic circumstances or the competing priorities for public financing do not allow for sufficient public financing to be provided.

Indeed, this is the outcome that was negotiated by Heads of State in the high level segment at COP15, which resulted in the Copenhagen Accord (UNFCCC, 2009d). While not specific in terms of the implementation details, the Accord agrees to establish a new Fund that would by 2020 channel USD 100 billion per annum in finance for mitigation and adaptation, including for technology development and transfer. The Accord states that this flow of finance will include public and private finance, although the amount of either source of finance is not specified.

In Table 16 the public and private shares of finance are estimated under three scenarios as described in Chapter 8. Even under the most optimistic scenario for leveraging private sector investment, USD 30–100 billion per annum would need to be made available by the public sector for investment into climate change mitigation technologies.
Table 16 Three leveraging ratio scenarios for public and private investment shares based on UNFCCC (2009b) estimates of additional financing needs for technology to 2050 (Author’s estimates based on UNFCCC (2009b), Table 14, above and reviews of leveraging ratios contained in Chapter 7)

<table>
<thead>
<tr>
<th>USD Billion</th>
<th>TOTAL</th>
<th>R&amp;D</th>
<th>Demonstration</th>
<th>Deployment</th>
<th>Diffusion &amp; Commercial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Global</td>
<td>Global</td>
<td>Global</td>
<td>Global</td>
<td>Developing</td>
</tr>
<tr>
<td>Total annual additional finance</td>
<td>339.3–834</td>
<td>25.8–170</td>
<td>At least 27–36</td>
<td>55–139</td>
<td>At least 10–38.5</td>
</tr>
<tr>
<td><strong>SCENARIO 1</strong></td>
<td>Estimated existing leverage ratio</td>
<td>1:0.5</td>
<td>1:1</td>
<td>1:4</td>
<td>1:2</td>
</tr>
<tr>
<td>Private</td>
<td>271.6–621.4</td>
<td>8.6–56.7</td>
<td>13.5–18</td>
<td>44–112</td>
<td>7.7–25.7</td>
</tr>
<tr>
<td>Public</td>
<td>67.4–213.6</td>
<td>17.2–113.3</td>
<td>13.5–18</td>
<td>11–27</td>
<td>3.3–12.8</td>
</tr>
<tr>
<td><strong>SCENARIO 2</strong></td>
<td>Moderately enhanced leverage ratio</td>
<td>1:1</td>
<td>1:3</td>
<td>1:5</td>
<td>1:4</td>
</tr>
<tr>
<td>Private</td>
<td>289.4–672.3</td>
<td>12.9–85</td>
<td>20.25–27</td>
<td>45.8–115.8</td>
<td>8–30.8</td>
</tr>
<tr>
<td>Public</td>
<td>49.85–161.7</td>
<td>12.9–85</td>
<td>6.75–9</td>
<td>9.2–23.2</td>
<td>2–7.7</td>
</tr>
<tr>
<td><strong>SCENARIO 3</strong></td>
<td>High performance enhanced leverage ratio</td>
<td>1:2</td>
<td>1:4</td>
<td>1:10</td>
<td>1:8</td>
</tr>
<tr>
<td>Private</td>
<td>299.3–734.2</td>
<td>17.2–113.3</td>
<td>11.6–28.8</td>
<td>50–126.4</td>
<td>8.9–34.2</td>
</tr>
<tr>
<td>Public</td>
<td>30–99.8</td>
<td>8.6–56.7</td>
<td>5.4–7.2</td>
<td>5–12.6</td>
<td>1.1–4.3</td>
</tr>
</tbody>
</table>
The reverse can also be tested by asking what leveraging ratios would be necessary if public investment is limited to USD 50 billion or USD 100 billion per annum. In order to test this scenario it is assumed that actual investments are roughly proportional to the investment needs across the various stages of technology (as contained in Figure 11 in Chapter 6, above).

In scenario one it is assumed that total additional public investment in R&D increases by USD 5 billion per annum, demonstration investments by USD 5 billion per annum, deployment investments by USD 15 billion and diffusion investments by USD 25 billion. In scenario 2 where USD 100 billion is allocated per annum, USD 10 billion per annum for R&D, for demonstration USD 10 billion per annum, deployment USD 30 billion and diffusion USD 50 billion. The results are presented in Table 17, below.

Under these scenarios, it may be achievable to meet financing needs for climate change if public financing is limited to an additional USD 100 billion per annum, however, if public finance is limited to an additional USD 50 billion per annum, significant increases in the average leveraging ratios would be required for technologies in the deployment and diffusion stage, and it would seem unlikely that sufficient investment in R&D could be achieved, particularly if the high end of the range is to be realised and leveraging ratios in the order of 1:33 are required.

While estimates are made in Table 14, the extent to which the policies and investment programmes surveyed may be able to be scaled up is unknown, and this will have a significant bearing on where at the international level the greatest effort should be made. Ideally, the total investment scale of each policy would be estimated and together with leverage ratios and other factors in mind, a more useful assessment of financial needs could be made. It is clear that a mix of policy instruments is required for international climate change policy but the exact mix in different regions is not known.
Table 17  Implications of restricted public funding for leveraging ratios if total investment continues to meet UNFCCC (2009b) estimates of additional financing needs for technology to 2050 (Author’s estimates based on UNFCCC (2009b), Table 14, above and reviews of leveraging ratios contained in Chapter 7)

<table>
<thead>
<tr>
<th>USD Billion</th>
<th>TOTAL</th>
<th>R&amp;D</th>
<th>Demonstration</th>
<th>Deployment</th>
<th>Diffusion &amp; Commercial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Global</td>
<td>Global</td>
<td>Global</td>
<td>Global</td>
<td>Developing</td>
</tr>
<tr>
<td>Total annual additional finance</td>
<td>339.3–834</td>
<td>25.8–170</td>
<td>At least 27–36</td>
<td>55–139</td>
<td>At least 10–38.5</td>
</tr>
<tr>
<td>SCENARIO 1– 50 Billion Public Investment per annum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Required leverage ratio</td>
<td>1:6–1:16</td>
<td>1:4–1:33</td>
<td>1:4–1:6</td>
<td>1:2–1:8</td>
<td>1:0–1:3</td>
</tr>
<tr>
<td>Private</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>289.3–784</td>
<td>20.8–165</td>
<td>22–31</td>
<td>35–124</td>
<td>1-29.5</td>
<td>206.5–464</td>
</tr>
<tr>
<td>Public</td>
<td>50</td>
<td>5</td>
<td>5</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td>SCENARIO 2– 100 Billion Public Investment per annum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Required leverage ratio</td>
<td>1:2–1:7</td>
<td>1:1–1:15</td>
<td>1:1–1:2</td>
<td>1:0–1:3</td>
<td>1:0–1:1</td>
</tr>
<tr>
<td>Private</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>239.3–734</td>
<td>10.8–155</td>
<td>12–21</td>
<td>5–94</td>
<td>0–20.5</td>
<td>181.5–439</td>
</tr>
<tr>
<td>Public</td>
<td>100</td>
<td>10</td>
<td>10</td>
<td>30</td>
<td>18</td>
</tr>
</tbody>
</table>
10 Conclusions

A post-2012 international climate change agreement cannot hope to leverage private sector investment on the scale needed unless ambitious climate change targets are agreed by Annex I Parties and actions are taken by developing countries to significantly reduce emissions below the business as usual scenario. These commitments and actions will be the key drivers for the private sector, which will respond to these long-term policy signals by adjusting their investment strategies.

While the concept of leveraging the private sector is commonly used within the negotiations for a post-2012 international climate change agreement (and also in many existing national responses to the issue), there has been limited assessment of how individual public policies and investment programmes can achieve leverage and what would be the optimal level of public finance needed to ensure that the total level of public and private investment is realised.

In Chapter 3, many methodological issues associated with the using the concept of leveraging were identified. These will need to be addressed if the concept can be used successfully as a policy objective and as an evaluative tool. Similar methodological issues are apparent when accounting for greenhouse gas emission reductions. However, in accounting for emissions reductions, relatively sophisticated methodologies have been established by Parties under the Convention to handle issues such as double counting, defining boundaries, accounting for leakage and testing for additivity. The Convention processes, perhaps under the authority of the Subsidiary Body for Scientific and Technological Advice, should develop the accounting standards and methodologies for the leveraging effects of public policies and investment programmes.

There is also the need for post-hoc evaluations of financing for technology development and transfer under the Convention. Most of the leveraging ratio estimates that are available in the literature for public policies and investment programmes report only projected rather than actual private sector investment. It would be useful to know when significant changes between projected and actual private sector leveraging are occurring, because it may indicate where a different mix of financing policies or mechanisms is required.

Creating the enabling environment necessary to attract private sector investment is crucial for the success of public policies and investment programmes aimed at leveraging the private sector. Without greater effort to establish this enabling environment both in developed and developing countries, the efficiency of public policies and investment programmes may be severely impaired. Elements of a successful strategy to address the enabling environment for private investment where identified in Chapter 5.

With well designed policies and programmes, leveraging effects can cascade from simple direct effects through to broader, more amplified effects on the private sector, particularly where there is a suitable enabling environment. The concept of a cascading leveraging effect was introduced in Chapter 3, and evidence of this effect, while limited, was found in Chapter 7. This suggests the need for integrated approaches to policy design, emphasising a combination of financial and technical resources, with complementary policy reforms, if the objective is to enhance the engagement of the private sector in helping to solve the issue of climate change.

Apart from the obvious quantitative gap in financing for technology development and transfer, there are also many qualitative gaps which may be equally as important, particularly if the aim is to facilitate mitigation in developing countries. These gaps may be partially addressed by measures aimed at leveraging the private sector, however, they often require complementary policies and measures that can support private sector investment in clean technologies. Public policies and investment programmes aimed at leveraging the private sector should attempt to address both the issue of the quantity of investment that is required (such as through agreed
quantitative goals for financing) while targeting the qualitative gaps, such as those identified in Chapter 6.

This dissertation has reviewed the specific gaps in the existing financing system and has identified a wide range of financing options that would address these gaps. Leveraging ratios of public policies and investment programmes vary considerably at each stage of the technology innovation cycle, as was apparent from the survey of leveraging ratios contained in Chapter 7. However, on average, leveraging ratios tend to follow a trend whereby the leveraging potential increases as a technology moves from the R&D stage, into the demonstration, deployment and diffusion stages of technological maturity. This is consistent with the theory of incremental costs as described in the literature and summarised in Chapter 4.

There is an opportunity to improve policies and investment programmes by sharing lessons learned and adopting best practices so as to enhance the quantity of finance leveraged from the private sector. In some cases, there may be no substitute for public financing. In others the potential role of the private sector may remain unclear, as is often the case for technologies for adaptation. Private sector financing may also be considered undesirable by some Parties who believe that the public sector is the most appropriate institution to finance responses to climate change. Ultimately, these are political choices that will be made by Parties through the bargaining and negotiation process currently underway within the UNFCCC towards ratifying a new international agreement for the period 2012 and beyond.

Regulatory approaches to enhance energy efficiency are the most effective means of reducing emissions without the need for large-scale public expenditure. Public expenditure on energy efficiency measures should be reserved for the removal of key market and social barriers, loan guarantees and loan softening and measures that build capacity and ensure institutions are effective in supporting private investment. With a supportive policy regime in place, the returns on investment from fuel and other cost savings can be a sufficient incentive to motivate large reductions in projected emissions growth, so long as the opportunity cost is not perceived as greater. However, regulatory approaches that mandate energy efficiency outcomes are notoriously unpopular or difficult to enact. Political realism is needed when it comes to assumptions about the extent to which such regulatory approaches will be used in practice, at least in the short to medium term. To what extent they will be used is very difficult to predict, but caution should nonetheless be used when estimating financing and technology needs.

Options for stimulating private sector investment in R&D are more limited than in other stages of the technology innovation cycle. Due to the risks involved and the public good nature of R&D in highly advanced technologies that dramatically reduce or even sequester greenhouse gases, there will be a larger public role for financing R&D. Options such as inducement prizes may be effective in enhancing innovation and private investment in R&D, however, the overall effect of these instruments will be minor in scale. Parties are proposing a quadrupling of R&D investment over the next 5–10 years, and if invested effectively, large technological advances will be possible and large flows of private sector finance to R&D will be achieved. The key will be how to direct this flow of finance to support the capacity of developing countries.

In regard to demonstration technologies, the European Union has recently innovated within the EU-ETS to create an earmarked allocation of permits to support demonstration projects. This approach shows merit since by attaching an additional incentive for demonstration to a carbon financing instrument there is the potential to increase private sector leveraging above and beyond what could have been achieved through grants and other direct subsidies. In Chapter 6, the case was presented for the introduction of a large international venture capital fund to fill the existing gap in early stage venture capital in all countries outside of the United States.

Early deployment of technologies is crucial to drive down the cost of new technologies and to enable developing countries to ‘leap frog’ the emissions intensive development pathways of de-
veloped countries. However, these will rely upon financial transfers from developed to developing countries. Furthermore a project-by-project approach cannot hope to reach the scale necessary. Instead a policy-scale approach is needed, where developing countries receive financing for the introduction of policies (such as feed-in tariffs, renewable obligations and targets) that also remove barriers, create markets and directly deploy new technologies.

Ultimately, emission reductions require a shift in global financing toward a low to zero emissions economy. Ideally, they would function so effectively that they would be emissions-positive, thereby undoing the current accumulation of emissions that is threatening to destabilize the climate system. A large shift will need to occur at all scales an in all sectors. The widespread diffusion of low emission technologies is the largest challenge and requires the largest investments; however, the potential role for the private sector is also the greatest. Progress has been made through the creation of the CDM which is beginning to approach a formidable scale. However, the CDM will not be sufficient and the best hope for the widespread diffusion of technologies in the foreseeable future is a complex mix of policies and measures. In addition to regulatory measures mentioned previously, finance facilitation and creation of a very active and well resourced project development pipeline is particularly important. There is evidence that financiers are unable to identify enough quality investment opportunities. Creating projects and programmes and matching these with financiers is likely to be very cost-effective.

During the course of this study, many policies and measures have been identified that are relatively ineffective in mobilising the private sector. The redesign of many mechanisms functioning at the sub-national, national and international levels could yield significant benefits in total financing. As part of (and in preparation for) the post-2012 international climate change agreement, Parties should review their climate change policies and measures, learn lessons from elsewhere and identify enhancements to existing measures and new options to address gaps and barriers to financing and emissions reductions. This might best occur as part of a new global effort to develop a coherent system of national climate change strategies.

This dissertation has demonstrated that even with optimistic scenarios for private sector leveraging, public financing will be crucial to achieving the objectives of the Convention. Even with the introduction of superior policy tools that are more effecting in mobilising the private sector, there are limits to the extent to which Annex II governments can limit their financing responsibilities to address climate change if the objectives of the Convention are to be met, given the need to fund the incremental costs of mitigation technologies in developing countries. The analysis contained in this dissertation suggests that governments should collectively be aiming to raise public finance in the order of USD 50–160 billion per annum as part of the post-2012 climate change agreement, assuming a moderate increase in the average private sector leveraging effect of public policies and investment programmes. Costs for financing of adaptation responses will be additional to these costs, although there may be some opportunity for adaptation and mitigation responses to be combined to some extent so that both adaptation and mitigation outcomes are achieved simultaneously, in which case it may be possible to achieve required results at an overall reduced cost.

The required public finance could flow through a range of public institutions, both inside and outside of the Convention. However, this dissertation argues that the role of the financial mechanism of the Convention is crucial, and that there is a need to raise its prominence and financial and political authority so that it can shape the overall financial landscape as it affects climate change. Based on the assessment of the finance gap and the scenarios for leveraging of the private sector, this dissertation lends weight to the concept as contained in the Copenhagen Accord (UNFCCC, 2009d) to establish a new ‘fund of funds’ under the Convention (the Copenhagen Green Climate Fund). It should contain at least USD 50 billion per annum of public finance for mitigation, and it should aim to leverage an additional USD 300 billion per annum from private sources through innovative public financial mechanisms and public-private partnerships, such as those reviewed in Chapter 7. The remaining USD 100 billion per annum of
public finance would be channelled through a range of other public financial institutions and mechanisms outside of the Convention, including at the national level, and would aim to leverage an additional USD300–400 billion per annum. The overall result in terms of financial flow from both public and private sources would be in the order of USD 750–800 billion per annum by 2020.

If public finance is significantly restricted then greater emphasis on consessional finance and regulatory approaches to public policy will be necessary. Based on the survey of the literature contained in Chapter 7, public policy and investment programmes are available for technologies in the deployment and diffusion stages that could generate the required total investment under a scenario where public finance is restricted to USD 50 billion per annum. However, it is unlikely that sufficient investment in R&D could be mobilized under this scenario, which would impact on the ability to achieve longer term emission reductions needed for more ambitious global goals, such as the target contained in the Copenhagen Accord (UNFCCC, 2009d) of limiting average global temperature increases to below two degrees Celsius.
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