Mitigation Finance

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Promoting Effective Climate Finance: ODI is building an evidence base on climate finance delivery and management through a number of country case-studies. How climate finance is accessed, managed and then spent in ways that effectively reduce vulnerability, promote development and gender equity, and reduce greenhouse gases represents a major challenge for national governments as well as the international community. The tracking of this finance, at both the international and national level, faces the problem that climate-related actions are difficult to identify with precision, and this lack of clarity leads to uncertainty over estimates of spending. This series of papers explores the concept of 'climate finance' and proposes pragmatic ways forward that will strengthen the policy debate.

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Acronyms

BAT	Best available technologies
BAU	Business-as-usual
BF	Blast furnaces
BPT	Best practice technologies
CCS	Carbon capture and strorage
CDM	Clean Development Mechanism
CH4	Methane
CHP	Combined heat and power
CO2e	Carbon dioxide-equivalent emissions
DRI	Direct reduced iron furnaces
EAF	Electric arc furnaces direct reduced iron furnaces (DRI).
EV	Electric vehicle
FBC	Fluid bed combustion
GDP	Gross domestic product
GHG	Greenhouse gases
HVDC	High voltage alternative current
HVDC	High voltage direct current
IEA	International Energy Agency
IGCC	Integrated combined cycle
IPCC	Intergovernmental Panel on Climate Change
MSW	Municipal solid waste
NGCC	Natural gas combined cycle
NGOC	Natural gas open cycle
O&G	Oil and gas
O&NG	Oil and natural gas
O&M	Operations and management
OECD	Organisation for Economic Cooperation and Development
RD&D	Research, development and deployment
RPS	Renewable energy portfolio standards
SC	Supercriticial pulverized coal combustion
STEG	Solar thermal electricity generation
USC	Ultra supercriticial pulverized coal combustion
UNFCCC	United Nations Framework Convention on Climate Change

Executive summary

This paper considers what "counts" as climate change mitigation finance, with reference to the concept of additionality, by reviewing a range of activities that can reduce greenhouse gas (GHG) emissions in the five sectors that account for the largest share of global GHG accumulation: energy, transport, industry, agriculture and water. It considers the underlying policy and regulatory complexities that will affect investment in such options. It identifies a range of interventions that might support mitigation and approaches to public support of such interventions (summarised in Table 1). It emphasises the importance of support for innovation, reforming subsidies for GHG-intensive approaches, and support to strengthen institutional capacity to manage low carbon development, recognising the political economy of mitigation. Rather than offering definitive guidance, it elaborates key concepts and approaches to support deeper interrogation and discussion of the issues at hand.

Table 1: Key categories of mitigation action and associated finance

Mitigation action	Primary Objective	Public
Research, Development and Deployment	• Support innovation and accelerate technology development and deployment.	• Grants; • Credit lines; • Project loan facilities; • Project development grants; • Loan softening; • Guarantees.
Technology upgrading:	• Promote the use of best-available technologies; • Promote operational improvements and increased efficiency; • Promote investments in end-of-pipe technologies to reduce emissions.	• Contributions to state-owned entities in relevant sectors; • Credit lines; • Tax credits; • Subsidies; • Revenues from carbon market transactions (including auctions and certified emission reduction sales).
Behavioural change	• Engage and change producer and consumer behaviour; • Promote awareness of low-carbon technologies; • (and energy efficiency options) • Mutual learning.	• Contributions to state-owned enterprises in relevant sectors; • Learning processes; • Carbon finance; • Demand-side management programmes.
Institutional strengthening	• Integrate climate change mitigation into economic and development planning and policy; • Develop policies and programmes to foster investment in low carbon technologies; • Strengthen regulatory capacity to support investment in climate change mitigation.	• Contributions to salaries and administration for government and regulatory agencies; • Grant finance; • Technical assistance.

1. Introduction: What is mitigation?

While the international community has accumulated increasing experience with financing activities that mitigate climate change, in practice it can be difficult to identify mitigation actions precisely, and to associate the finance that allows such activities to transpire as climate finance. In practice, identifying mitigation actions, and classifying associated finance as "climate finance", is shaped by context and subject to substantial judgement. Greater clarity is needed on what constitutes public finance for "mitigation", informed by experience that has been accumulated over past decades.

The most commonly referenced definition that guides classification of public finance for mitigation is from the Organisation for Economic Cooperation and Development (OECD):

Table 2: Mitigation

OECD Definition: An activity should be classified as climate change mitigation related if it contributes to the objectives of stabilisation of greenhouse gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system by promoting efforts to reduce or limit GHG emissions or to enhance GHG sequestration (OECD, 2011).

Sector	Example activities
Forestry	Protection and enhancement of sinks and reservoirs of GHGs through sustainable forest management, afforestation and reforestation
Water and sanitation	Methane emission reductions through waste management or sewage treatment
Energy	GHG emission reductions or stabilisation in the energy, transport, industry and agricultural sectors through application of new and renewable forms of energy, measures to improve the energy efficiency of existing machinery or demand side management (e.g. education and training)
Transport	
Industry	
Agriculture	

This definition makes reference to the ultimate aim of the UN Framework Convention on Climate Change (UNFCCC) which is to "achieve, in accordance with the relevant provisions of the Convention, stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (UNFCCC, 1992). The Intergovernmental Panel on Climate Change (IPCC) in turn offers a narrower definition of mitigation as, "[t]echnological change and substitution that reduce resource inputs and emissions per unit of output. Although several social, economic and technological policies would produce an emission reduction, with respect to climate change, mitigation means implementing policies to reduce GHG emissions and enhance sinks" (IPCC, 2007). The OECD definition of **mitigation support** states that "financial resource, technology and capacity building activity should be classified as climate change mitigation support if it contributes to the design and implementation of GHG mitigation action in other countries" (OECD, 2009).

This paper has the primary objective of informing understanding of how public expenditure within countries – particularly developing countries—affects climate change mitigation efforts. We introduce the concept of additionality as a key consideration in determining what "counts" as climate finance. Section 3 considers the actors, time frames and political economy of mitigation, which affect (and are affected by) public expenditure. With these considerations in mind, the following five sections reflect on a range of interventions and associated financial flows that may help mitigate climate change in the energy, transport, industry, agriculture and water sectors, respectively. These five sectors are the largest contributors of global GHG emissions according to national communications to the UNFCCC (CAIT 2012; WRI 2005). We draw heavily on the work of the IPCC and the International Energy Agency (IEA), complementing their work identifying mitigation options by identifying how public finance can be used to support their realisation. The potential interventions we identify are not exhaustive. This paper is one of a series of papers that consider the challenges of identifying climate change relevant expenditure at national level: the other papers in this series consider public support for activities that reduce emissions from deforestation and degradation, and how to track adaptation finance.

2. Identifying Mitigation Options

Identifying public policies and budgeting for climate change related mitigation activities can be challenging, given intricate links with development. A growing number of governments have begun to put in place public policies that reduce total GHG emission levels (an absolute target), or reduce GHG intensities of economic activities (a relative or intensity target). Unlike absolute targets, intensity targets are measured in emissions per unit of output, linked to factors such as future GDP, and offer countries greater insulation from potential increases in the cost of mitigation (see Box 1). The Government of India, for example, has adopted an emissions intensity target. China has adopted a voluntary emission intensity reductions target under the UNFCCC, and its 5th national plan also includes an emission reduction strategy; it is now exploring introducing a formal cap on emissions (UNEP, 2010). The Government of South Africa has a target to reduce emissions by 34% relative to business-as-usual by 2020, contingent on international support[1].

In such cases, it is reasonable to expect national budgets – particularly for those sectors that are identified as priorities under such a policy framework - to include expenditures that facilitate the realisation of such objectives. Even in the absence of explicit targets, many countries recognise that investment in cleaner and more efficient technologies and approaches offer mitigation benefits, and open up new routes to meeting development goals. Least developed countries have adopted policies to this end, including extending access to energy for the poor in rural areas. For example, the Government of Uganda has adopted new tariffs to promote investment in renewable energy. Extensive programmes to expand the use of renewable energy in Nepal are underway. Governments across the world are introducing policies to support lower carbon routes to development and direct investment toward such options.

Box 1: GHG Intensity Targets

Uncertainty about future economic growth can be an obstacle to adopting absolute GHG emission caps because it means greater uncertainty on the magnitude of GHG reduction costs. GHG intensity targets link mitigation activities to future GDP, as it provides a target to limit a certain amount of carbon dioxide-equivalent (CO_2e) emissions for each unit of GDP. This has the advantage of allowing automatic adjustment to unexpected growth shocks. GHG intensity targets have been proposed as a way to reduce the impacts of uncertain mitigation costs (Marcu and Pizer, 2003; Kolstad, 2006; Gupta et al., 2007; Jotzo and Pezzey, 2007). Many large developing country economies such as China and India have adopted GHG intensity targets, finding them more acceptable policy tools given their strong but uncertain long-term economic growth prospects (Fischer and Morgenstern, 2008).

GHG intensity targets address uncertainties over mitigation costs with regard to future GDP trajectory growth, but do not necessarily address uncertainties about tackling climate change with regard to stabilising and eventually reducing future GHG emissions levels (in absolute terms) or GHG concentrations (Jotzo and Pezzey, 2007; Marschinski and Lecocq, 2006). The extent to which intensity targets can limit uncertainty on the level of mitigation costs depends on the share of GHG emissions that are linked to GDP. For instance, intensity targets are likely to be an effective tool in countries where domestic GHG emissions are strongly correlated with GDP.

2.1 Additionality

The principle of **"additionality"** takes on critical importance in the context of financing climate change mitigation. Additionality is a relative concept, as it is defined with reference to a "baseline" estimate of what would have happened without the intervention. The baseline is a hypothetical projection of the future, and is also referred to as a business-as-usual (BAU) future scenario. Additionality is central to UNFCCC and Kyoto Protocol provisions on mitigation action, and on international finance for climate change.

The concept of additionality has been applied at an operational level through the Clean Development Mechanism (CDM) of the Kyoto Protocol, wherein projects that generate emission reductions must demonstrate that these reductions are additional, relative to a hypothetical estimate of likely action without access to such finance (also known as a BAU baseline). Baselines are difficult to construct accurately, and can always be subject to debate. A technical interpretation of additionality can be complex and cumbersome.

When used in the context of evaluating activities relevant for climate change mitigation, attention to the principle of additionality should focus on the net emission reductions associated with such activities, relative to the BAU scenario. Causality is difficult to establish conclusively, and is not the topic of this paper. However the *intent* of expenditure is certainly an important consideration in assessing whether it counts in contributing to climate change mitigation. The principle may best be used as guidance in considering the nature of expenditure – particularly expenditures whose climate benefits may be subject to some dispute - and its relevance for climate change. At its heart, the additionality principle recognises that a response to the challenge of climate change requires effort additional to what would have happened anyway.

Additionality is fundamentally about assessing whether one, or a combination of, policy interventions is changing behaviour. The entire concept of climate change mitigation activity must therefore be built upon a careful understanding of the policy interventions, and of underlying assumptions about how behaviour is affected by these interventions.

1. South Africa Climate Change Response Strategy 2011.

3. Public expenditure on mitigation

There are a variety of different ways in which public and private finance may be directed to climate change mitigation. Climate change mitigation requires investment in a range of technologies, projects and businesses in a variety of economic sectors including energy supply and distribution, industry, buildings, transport, waste, agriculture and forestry. It also requires new capacities, systems and institutions to be put in place to manage the integration of climate change into development activities.

In many countries, particularly developing countries, the state plays a central role in the sectors where mitigation is most needed. State-owned companies continue to play a substantial role in electricity generation, transmission and distribution in most countries, even though policies and regulations to create a role for the private sector have been introduced to varying degrees. Substantial public expenditure is often therefore directed through these entities who may engage in activities that exacerbate climate change. In turn, there is a strong case to be made for re-orienting government-owned entities in the electricity sector to mitigate GHG emissions. Some measures (such as increasing energy efficiency) may be consistent with efforts to increase the financial and economic efficiency of these entities, which often require substantial public financial support. Scrutiny of the activities of state-owned enterprises involved in energy, transport, agriculture and water is important, and identifying whether and how public allocations of finance to support these entities addresses climate change considerations is crucial.

Of course, the private sector also plays a central role in a response to climate change, as many activities of private actors result in emissions. Furthermore, there is substantial private investment in activities that are relevant to GHG emissions and their mitigation. Public policies and expenditure can shape the terms and incentives for private action away from carbon-intensive activities and toward mitigation.

Institutions and Planning

Effective mitigation has substantial institutional, planning and capacity requirements within a given country context. Traditional development planning –particularly in the key sectors where mitigation is imperative, notably energy—has not tended to emphasise issues related to climate change, and levels of familiarity with the issues at hand and potential solutions are often quite low. Carbon-intensive activities often account for a large share of economic productivity, and there are strong interests who profit from such activities, and have a stake in continued dependence on carbon-intensive technologies. Vested interests have often resisted ambitious action to mitigate climate change. Public expenditure to strengthen or sustain institutional capacity to address climate change within key ministries and departments such as energy, mining, water, transport and infrastructure can have an important role in supporting mitigation. Such expenditure is likely to be recurrent, and may be difficult to identify precisely, particularly if efforts are being made to mainstream climate change considerations into the responsibilities of many different government departments and staffing arrangements.

Carbon "lock in"

There is a high level of comfort and familiarity with established conventional energy approaches to meeting energy needs. The tendency to continue to rely on established but carbon-intensive fuel is reinforced by an integrated energy infrastructure that perpetuates dependence on conventional forms of energy (Unruh and Carrillo-Hermonsilla, 2006). Many firms use technologies that are less efficient and more carbon-intensive than alternative "best available" technology options. Access to best available technologies in developing countries may be restricted by intellectual property laws, and such technologies may not be well suited to the economic nor physical environments of countries other than those in which they were developed. There is also the problem of sunk costs of 'newly' constructed facilities that employ carbon-intensive technologies. Such investments can cause operators to be '**locked-in**' to their investment, which they will use for the full operational lifetime of the facility. A focus on the services that users need in order to achieve economic goals, may unlock new and more creative routes to achieving climate change and development goals, than a focus on the supply of technologies.

Best available technology

Nevertheless, in many cases the adoption of more efficient or best available conventional technologies can reduce GHG emissions. To determine whether expenditures that allow the adoption of best available conventional technologies are actually having an impact on relative levels of CO_2e emissions against a BAU scenario, it may be helpful to compare their performance against the national average of the performance of technologies in terms of the benchmark level of efficiency or carbon intensity. Expenditure may count as mitigation if it supports the introduction of new technologies that have appreciably higher efficiencies (or lower carbon intensities) than the benchmarked national average.

Time frames

Investments in mitigation may deliver mitigation outcomes along different **time frames**. Expenditures on research, development and deployment (RD&D) of new technologies may only result in emission reductions after a significant time has passed. Such expenditure is risky, as not all investments will prove viable. However, investments in RD&D are essential to increase the range of possible interventions that could result in future GHG reductions, ultimately providing cheaper and more efficient alternatives to the carbon-intensive technologies on which we presently rely.

Rationalising subsidies

Effort is also needed to address perverse subsidies. Perverse subsidies exert adverse environmental and economic effects over the long term. There are many examples of perverse subsidies in the key sectors discussed in Section 3 such as energy, transport, industry, agriculture and water. The environmental consequences of perverse subsidies can be pervasive and profound. There is presently substantial public finance directed towards sectors and activities that generate GHG emissions, which can be considered spending that exacerbates climate change. The IEA (2011a) estimates that globally, fossil fuel subsidies cost governments more than $409 billion in 2010. Substantial public finances are directed to fossil fuel subsidies in many developing countries. Many subsidies are introduced to protect the poor; however, richer and more powerful stakeholders often capture the majority of a subsidy (IEA, 2012; IISD, 2011; Nakhooda, 2010).

Rationalising the underlying frameworks that affect the costs of responding to climate change is an important part of an effective mitigation response in any country where there is substantial scope for mitigation. It is, of course, essential to design subsidy reforms in ways that do not penalise or place further burdens on the poor. Such rationalisation, while complex to implement in practice, can offer many benefits.

Regulatory capacity

These conditions are common to both developed and developing countries, although their severity differs and is often shaped by political, economic and social circumstances. In this context there is often a real need for public expenditures at an institutional level that increase the capacity to integrate climate change considerations into planning and policy implementation – both within sectors and across sectors, given the cross-cutting nature of climate change mitigation interventions. Public expenditure in such processes and human capacities within key ministries and agencies is essential. In this context investing in the capacity of regulators of key sectors to understand and address climate change considerations, as well as the capacity of utilities – in which governments may often have a substantial ownership stake—to address these issues may also be an important and relevant expenditure.

Inclusive decision-making, stakeholder participation, and learning

It is increasingly recognised that stakeholder participation in climate change related planning and policy processes can help ensure that a more comprehensive set of issues is incorporated into the policies and measures that are adopted, provide a more complete information basis upon which decisions can be made, and ensure that the interests of different stakeholders in sectors where change may be difficult and contested can be considered and reflected (Nakhooda, 2010).

National expenditures that promote transparent and inclusive planning processes in the context of climate change mitigation can play an important role in realising effective mitigation over the long term, even if it does not deliver direct mitigation benefits in the immediate term.

Learning processes that allow stakeholders including government, private sector actors, consumers and civil society groups to reflect on the role and experiences with low carbon technology deployment and the implementation of measures to reduce demand can support the development of workable solutions (Byrne et al 2012).

3.1 Key sectors and interventions

The energy, industry, transport, agriculture, forestry and waste sectors tend to be the most significant sources of GHG emissions globally (see Table 3).[2] This paper does not include forestry activities, which are discussed separately in a dedicated ODI note[3]. The nature of interventions to realise mitigation opportunities in each of these sectors is affected by a number of important factors that will largely be shaped by country context. The policy and regulatory frameworks that govern investment in the energy sector, and in turn affect the costs and prices of different forms of energy, are a crucial consideration. The formulation of new policies, plans and strategies that shape incentives

Table 3. Economic sector contributions to global GHG emissions in 2005

Economic sector	Economic sub-sector	% of global GHG emissions
Energy	Electricity generation, transmission and distribution; on-site electricity generation (for industrial, residential and commercial facilities; oil and gas, coal extraction, refining and transportation	37.5%
Industry	Chemical, iron and steel, cement, aluminium, pulp and paper, and other industrial processes	19.0%
Transport	Road, air, shipping, train and other	14.3%
Agriculture	Agricultural soils and livestock	13.8%
Forestry	Deforestation, afforestation and harvest management	12.2%
Waste	Water, wastewater and landfills	3.2%

Source: WRI (2009)

2. The energy and industrial sectors together include extractive industries and processing facilities.
3. See C. Watson, Defining Climate-Related Forest Activities, Finance and Expenditure in National Budgetary Systems (London: ODI, 2012).

and opportunities in these sectors requires public support and expenditure. The links between technology supply and use chains, the carbon intensity of the various sectors, and the role of energy intensive and low-carbon oriented innovation in a country's economic development structure and future competitiveness strategies will affect the scope for mitigation options to be implemented, and the form of appropriate interventions. We discuss interventions in the five sectors that have the largest contribution to global GHG emissions, and present this discussion in order of each sector's potential contribution to a global mitigation effort.

4. Energy

The energy sector encompasses a broad set of activities that include supply, distribution and demand-side use. The IEA predicts that energy demand worldwide will increase 33% between 2010 and 2035, and require about $17 trillion of new investment in power plants (IEA, 2011a; IEA, 2011b). Due to the power sector's heavy reliance on fossil fuels, mitigation options involve 'de-carbonising' the power sector through increasing the proportion of low-carbon energy sources into the fuel mix of electricity generation facilities - including increasing the proportion of renewable energy. Improving transmission and distribution systems, particularly through the use of 'smart grid' technologies to optimally balance electricity flows between centres of supply and use can play an important role in reducing carbon emissions. Other parts of the energy sector also present significant opportunities for mitigation. These include primary and secondary industries involved with fossil fuel extraction, such as coal mining, oil and gas (O&G) production, refining and transmission. In addition, the energy sector includes demand-side management of energy in residential and commercial buildings. Increasing the efficiency of energy production and use, as well as measures to reduce consumption and demand for electricity, are also essential to a climate change mitigation strategy. There can, however, be 'rebound effects', in which improvements to efficiency (without attention to the need to reduce demand) can in fact lead to increased energy consumption (Sorell 2007). Efforts to this end often get quite limited attention in developing country contexts, however, despite their potential to offer both economic benefits, and unlock a greater focus on the delivery of services rather than the supply of energy.

4.1 Electricity

In most countries, the predominant reliance of the power sector on fossil fuel energy sources –particularly coal - makes electricity generation highly emission-intensive. Despite international concern for climate change, increasing global demand for energy has led to a substantial growth in carbon-intensive electricity production.

New investments in electricity generation

Increasing the proportion of low-carbon energy sources used to generate electricity has been a major focus of mitigation policy. In some countries efforts are being made to reduce reliance on carbon-intensive coal-fired power. In some cases increasing the use of natural gas (which emits substantially less GHGs than coal per unit of electricity produced) may reduce the energy intensity of the energy mix, including offering much higher efficiencies of power plants (EPA, 2012)[4]. Many countries are investing substantial resources in technologies that can produce electricity without emitting GHGs, such as renewable energy technologies and nuclear energy. Most renewable energy sources, such as solar, wind, hydro, geothermal and marine (wave and tidal power) do not emit large amounts of GHGs when in use.[5] Bio-energy (which consists of biomass and biofuels) and municipal solid waste release some GHG emissions, although far less than results from using fossil fuels.[6] Generating electricity from biomass and municipal solid waste (MSW) can avoid methane emissions that would otherwise result through waste decomposition. Renewable energy technologies may still have environmental and social risks, however, that need to be managed carefully. These risks are particularly challenging in the case of large hydropower development, which is attracting growing interest as a low carbon energy solution.

Efforts to mitigate climate change have increased interest in the potential to expand the use of nuclear power which can provide low-carbon energy, although it can pose many environmental, social and financial risks, as well as security risks. The costs of nuclear power are generally so high that they require substantial subsidies to be viable. Furthermore, the lead time to construct new nuclear facilities tends to be 11 to 13 years. (Citigroup 2009, 2012; IEA 2011). The Fukushima Daiichi meltdown in 2011 reminded many countries of the risks of developing nuclear power. Nevertheless, many large developing countries – including China, India and South Africa– have plans to substantially expand their nuclear capacity (IEA, 2011). It is not clear that nuclear power is truly 'carbon-free': the cumulative GHG emissions associated with each of the 14 stages of the nuclear fuel chain (from the mining, enrichment and transport of uranium, to the building and de-commissioning of nuclear facilities, to the handling and storage of waste) can prove significant.

By contrast, the costs of renewable energy are decreasing, in part as technologies advance along learning curves. Analysis from Bloomberg New Energy Finance forecasts that by 2016, on-shore wind turbines will be at grid parity with conventional technologies (BNEF, 2011a). Investment in renewable energy is often supported through regulatory and pricing tools. These include renewable energy portfolio standards (RPS) in which the regulator may obligate utilities to source a certain share of energy from renewable sources. Variations on the RPS may specify particular technologies from which energy should be sourced. In many cases,

4. The relative GHG reductions associated with the use of natural gas are highly contextual and depend on a number of variables, but EPA estimates suggest that on average natural gas results in half the CO2e emissions as conventional coal to produce the same unit of energy.
5. There have been concerns raised, however, about methane emissions from the reservoirs of large hydropower facilities in tropical countries (IPCC 2007).
6. Similarly, some forms of biofuel production may not reduce GHG emissions if one accounts for the full life cycle emissions, especially if they have carbon intensive inputs, or if forested land was converted to produce feedstocks.

renewable energy providers are eligible for higher tariffs – sometimes standardised through a feed-in tariff mechanism which effectively offers a public subsidy for renewable energy that offers investors some certainty and reduced risk. There are many variations on these basic tools that have the effect of directing public finance to renewable energy.

It is possible to promote combined heating and power systems (or co-generation systems) in which a heat engine or power station is used to simultaneously generate both electricity and productive heat. There is also substantial scope to reduce the GHG emissions that result from the use of conventional fossil fuels through continuous innovation and improvements to technologies. Investments could be made in the most **efficient fossil-fuel plants** (including energy efficient coal-based plants) as mitigation activities, provided such investments result in an improvement in the overall GHG intensity of energy production in the country.

In many cases, however, such technologies are already commercially viable. They also already benefit from many subsidies and systemic support (as we described in Section 2). Whether investment in, or the extension of, public subsidies for such technologies represents an appropriate or desirable use of public finance, is debatable.

Table 4 describes the major different commercial technology options for mitigation in the power sector.

Existing electricity generation

As previously noted, existing carbon-intensive energy infrastructure will have a large and longstanding carbon footprint, and countries may seek to reduce their impact through **Input changes** or through **retrofits and technological** upgrades. On the input side, it may be possible to use substantially cleaner fuels, such as gas, in facilities that previously used GHG-intensive fuels such as coal. The use of biomass together with coal can also reduce net emissions. The use of higher quality coal, particularly coal with lower moisture content, can reduce emissions and increase efficiencies. (IEA's ETP, 2010: 115). On the other hand, it may be possible to introduce better technologies into existing systems and thereby increase efficiencies and reduce inputs (for example, through introducing better turbine systems that run more smoothly). Seemingly marginal interventions can yield substantial benefits. The IEA estimates that "raising the efficiency of a [conventional coal] plant with 35% efficiency by one percentage point would reduce its CO_2e emissions by about 3%" (IEA, 2010: 116). Thus, public expenditure that is aimed at supporting retrofitting existing plants with "more advanced control systems and improving operation and maintenance (O&M) procedure" (IEA's ETP, 2010: 116) can support mitigation.

Capture and Storage

Many countries are investing substantial effort and resources in developing **carbon capture and storage (CCS) technologies and systems**. These technologies and energy system management techniques capture GHG emissions from power plants and sequester them, rather than allowing them to be released into the atmosphere. CCS technologies remain in the exploratory stages, and there are many uncertainties associated with their deployment. Given that many countries depend fundamentally on coal to meet their energy needs, there has been substantial interest in exploring the viability of this technology. The role of CCS in mitigation strategies is not uncontroversial, however these investments are certainly made with climate change mitigation as an express objective, and many governments have directed substantial public funding, particularly through grants for RD&D to explore its potential.

Transmission and Distribution

Considerable investment is needed to improve and extend transmission and distribution infrastructure for electricity. Such infrastructure connects three main components of the electricity supply chain: (1) electricity generators (power plants), (2) transmission networks (which transmit electricity over long distances to the local distribution centre), (3) distribution networks (which directly provide electricity to end-users). Expenditure that supports upgrading and extending the grid may offer mitigation benefits if it: reduces losses from electricity transmission and distribution (T&D); extends the grid to connect low-carbon electricity generation plants; dynamically optimises the operation of the grid through improving demand and supply balances of electricity, especially through the integration of smart technologies; or improves energy storage potential that can 'smooth out' intermittent power supply from various energy sources (especially from renewable electricity generation). Underlying regulatory frameworks and incentives have a substantial impact on the types of investments that are made in such infrastructure. In most countries, the government plays a substantial role in electricity transmission and distribution, although efforts to include the private sector in electricity distribution are being made. Table 5 summarises key mitigation options for T&D.

Many renewable energy technologies hold the potential for decentralised application, which could potentially make them less reliant on the supporting grid infrastructure. The use of stand-alone or decentralised or renewable energy systems for rural electrification in places where it may be costly and impractical to extend the grid has attracted substantial interest, including in least developed countries. There have, however, sometimes been challenges related to technological feasibility and maintenance, and the adequacy of the energy available through such systems for productive applications. International funds such as the Scaling Renewable Energy Programme administered by the World Bank in partnership with regional development banks, as well as the Global Environment Facility, have made concessional loans and grant finance available to developing countries who seek to invest in decentralised renewable energy options particularly to meet the needs of the poor.[7]

7. The SREP also supports larger scale and centralised renewable energy such as geothermal power.

Table 4. Potential mitigation options for the utility scale electricity generation sector

Type of mitigation option	Technology & Resource	Approach	Public finance and supporting policies
Institutional capacity improvement	All technologies: Human resource capital	• Improves regulatory capacity to direct economic actors to invest in mitigation activities. • Gathers information on least carbon-intensive technologies and practices that can reduce emissions in each sector. • Supports educational programmes to help economic actors identify best mitigation options. • Identifies key interventions in need of support.	• Increased budgets for relevant departments on climate change initiatives and programmes (information gathering, building regulatory capacity for mitigation). • Raise private sector awareness of mitigation opportunities, and seek to mobilise private sector capital.
New capital investment in electricity generation plants	Combined heat and power (CHP) plants: Coal, natural gas, oil and low-carbon energy	• Increases power efficiencies of electricity generation, up to even 90%. • Optimises use of heat to generate additional power and provide heat and cooling to end-users. • Can be located close to demand centres, thus reducing energy losses from transmission.	• R&D grants to improve viability of technology. • Deployment: Technology grants, loan guarantees, subsidies, tax credits and co-investment with private sector.
	Fluidised bed combustion (FBC): Coal, biomass and waste	• FBC technologies reduce the amount of sulphur dioxide and nitrogen oxide emissions from coal-based electricity generation. The process allows for the use of heat transfer to improve power efficiencies.	• Technology grants, loan guarantees, subsidies, tax credits and co-investment with private sector.
	Supercritical (SC) and Ultra supercritical (USC) pulverised coal combustion plants: Coal	• Increases the power efficiencies of coal-based power generation plants from an average of 32% to a range of about 42-57%. • Construction improves the ability of plants to operate at higher temperatures and steam pressures, thus increasing the power efficiency of traditional coal-based electricity plants.	• Policies which require coal plants to have higher power efficiencies (to incentivise the building of SC and USC plants instead of conventional coal plants). • Deployment: Technology grants, loan guarantees, subsidies, tax credits and co-investment with private sector.
	Integrated combined cycle (IGCC) plants: Coal	• Uses coal gasification technology to remove sulphur and nitrogen compounds from the produced synthetic gas. • Heat produced from gas combustion can be used in a steam turbine to produce more electricity. • Can produce carbon monoxide which can be used to convert CO2e for CCS. • Can produce hydrogen, which can be used to produce electricity.	• Relatively immature technology, so most public expenditure is on RD&D grants. • Deployment: Technology grants, loan guarantees, subsidies, tax credits and co-investment with private sector.
	Natural gas combined cycle (NGCC) and natural gas open cycle (NGOC) plants	• Installation of more power efficient NGCC and NGOC plants will reduce carbon intensities of plants.	• Policies which require higher consumption of electricity from natural gas than coal. Governments may own the utilities that invest in and operate natural gas plants.
	Oil fuelled plants	• Installation of more power efficient oil generation plants will improve carbon intensities of plants.	• Policies which require higher consumption of electricity from oil than coal (though this is rare as most oil consumption is directed for transport). Governments may own the utilities that invest in and operate oil plants.

Table 4. Continued

Type of mitigation option	Technology & Resource	Approach	Public finance and supporting policies
	On-shore wind turbines	• Refers to turbines installed on land, and preferably near coasts with high wind speeds • Refers to turbines installed in water bodies (lakes or off the coast). Though these technologies are less mature than on-shore wind, they have the potential to generate more electricity as they encounter higher wind speeds	• These are general renewable energy policies, which may be tailored or prioritised to meet the needs of particular technologies. • Technology supply development: RD&D grants to support technological firms, pilot projects, and innovation in specific geographies. • Policies to increase demand: - Feed-in tariffs - Renewable portfolio standards - Renewable auctioning mechanisms (expenditures to administer auctioning mechanism). • Deployment: Technology grants, loan guarantees, subsidies, tax credits and co-investment with private sector.
	Solar PV (crystalline silicon, thin-film)	• Solar PV and thin-film refers to the use of semi-conductive material to generate electricity by sunlight falling onto it.	
	Solar thermal electricity generation (STEG)	• STEG or concentrated solar power uses mirrors or lenses to concentrate sunlight onto a small area to generate heat, which is then used to drive a turbine (usually a steam turbine) that can generate electricity.	
	Large hydro and run-of-the river	• Hydropower refers to systems that convert the energy captured from falling water into electricity. The ecological consequences of large hydro infrastructures have led to significant controversies over the future building of these projects. Run-of-the-river systems are smaller hydro systems that have fewer ecological consequences. One of the risks of hydro systems in general is the variability in rainfall that can reduce the amount of electricity generated.	
	Anaerobic digestion: Biomass	• Anaerobic digestion refers to organic waste (from sources such as agriculture, forestry, pulp and paper, and landfill) that is broken down by bacteria in a closed container that excludes air. This process yields methane (CH_4) which can be combusted to produce heat, which can also be used to run a steam turbine that produces electricity.	
	Gasification: Biomass	• Biomass gasification is a process that converts organic compounds to produce a mixture of gases (syngas) which can be used as a fuel that can be combusted to produce electricity.	
	Incineration: Biomass	• Biomass incineration facilities can be installed in municipal solid waste (MSW) sites, or any other sources of organic waste. Biomass incineration refers to the direct incineration of organic compounds to produce heat that can be used to run electricity generation turbines. The direct combustion of biomass waste is controversial as it still releases CO_2e emissions. Thus it is advocated that such incineration plants have scrubber systems or CCS systems installed on them to further reduce CO_2e emissions. It may also release toxins that have harmful environmental health effects.	

Table 4. Continued

Type of mitigation option	Technology & Resource	Approach	Public finance and supporting policies
	Geothermal: Flashpoint, Dry steam power, Binary Plant	• Geothermal energy refers to when systems of technologies capture the heat in the Earth's crust (or from geothermal springs) that can be used to run steam turbines to produce electricity.	
	Marine: Wave	• Wave power refers to when electricity is generated from the surface movement of ocean currents. Considerable RD&D is still needed to develop the technology beyond the early design stage. Further resource constraints include finding appropriate sites that have enough powerful wave currents to generate electricity. Additional constraints include extending the power grid to wave power systems.	
	Marine: Tidal	• Tidal power refers to when electricity is generated from tidal flows. The technology is relatively immature and requires more investment in RD&D to become commercially available. Further resource constraints include finding appropriate sites that have enough difference in tidal levels to generate electricity. Additional constraints include extending the power grid to tidal systems.	
	Nuclear power	• The electricity generation from nuclear power does not emit any carbon emissions. However the entire 14 stages of the nuclear cycle are very energy intensive. If certain stages in the cycle depend on fossil fuels, nuclear energy also becomes carbon intensive – and thus not carbon free.	
Input change	Fuel switch from coal to gas	• Gas produces half the amount of CO_2e emissions as coal.	• Carbon pricing policies that incentivise a switch from coal and an increase for natural gas (to promote fuel switch). Such policies can include emission limits, carbon trading or carbon taxes.
	Cogeneration of coal and biomass	• As biomass has less carbon content than burning coal, increasing its input proportion in a coal plant will reduce the overall CO_2e emissions from the plant.	• Carbon pricing policies that incentivise reduction of coal consumption. Such policies can include emissions limits, carbon trading or carbon taxes. • Investments in promoting supply of biomass to coal plants.
Technological upgrading	Improved quality of coal consumption through installing coal drying technologies	• Reducing the moisture content of coal improves the thermal efficiency of coal-based power plants.	• Deployment: Technology grants, loan guarantees, subsidies and tax credits.

Table 4. Continued

Type of mitigation option	Technology & Resource	Approach	Public finance and supporting policies
Refurbish-ment	Retrofits and refurbishments, improved operational and maintenance procedures: Coal, natural gas, oil	• Improved power efficiencies of plants can reduce carbon intensities of plants.	• Grant programmes/funds for retrofits and refurbishments.
End-of-pipe	Scrubber systems: Thermal pollutant technology	• Reduces the amount of SO2 and NOx emissions that are also emitted from fossil-fuel generation plants.	• Policies that price air pollution to incentivise installation of scrubber systems. These include SO2 and NOx emission limits, trading schemes and environmental taxes. • Deployment: grant programmes/ funds, loans.
	Carbon capture and storage	• Captures and treats CO_2e emissions so that they can be transported and stored in saline reservoirs or retired underground oil and gas wells.	• As these technologies are relatively immature, most expenditures are on RD&D (especially investing in pilot projects).

Note: this table indicates key characteristics and considerations, and is not comprehensive.

Source: IEA (2010); Biomass Energy Centre (2011); BNEF (2012); Combined Heat and Power (2012); DOE (2009; 2010); EPA (2006); EPIA (2011); Goodward, J. et al. (2011)

4.2 Demand-side Management for residential and commercial buildings

The consumption of energy for lighting, heating and cooling in residential and commercial buildings also presents a significant opportunity for GHG mitigation (IPCC, 2007). Buildings have long life spans, and often are not designed to reduce their GHG impact and maximise efficiency. Table 6 summarises some important mitigation options for commercial and residential buildings. The challenges for reducing the emissions from existing buildings is that their structural inefficiencies have 'long life spans' , and it may not always be easy to introduce technological solutions that can address energy use and associated emissions. In such cases, it is often necessary to find ways to change behaviour, as well as seeking to retrofit buildings with new technologies that can support emission reductions. On the other hand, there are many opportunities to ensure that new buildings constructed meet the highest possible standards of efficiency which reduce their carbon impact, while also delivering high quality services to users.

Consumers, whether at household level or at business level, may need access to finance to make large investments that increase the efficiency of their energy consumption. While these investments are likely to pay for themselves by reducing the costs of energy consumption, the payback period is may be quite long in many cases. Individuals and companies both tend to prioritise activities that will generate new returns and revenues over investments that reduce costs in the absence of clear incentives and support for the latter. Governments have often made such finance available through a variety of public finance tools, including creating dedicated lines of access to credit on terms of varying levels of concessionality, or establishing rebate schemes that help share the costs of investment in more efficient technologies with consumers. For example, the Thailand Revolving Energy Efficiency Fund offers debt finance to companies seeking to make investments in more energy-efficient equipment; loan re-payments are re-invested in the fund.

In many developing countries energy efficiency and energy services that deliver GHG emission reductions are being incorporated into programmes to develop affordable housing services. For example, efforts to improve access to decent housing in shanty towns and poor areas of South Africa implemented through the Reconstruction and Development Programme are being integrated with programmes to roll out solar water heaters that reduce the need for electricity for heating, while increasing access to hot water. Such programmes may be implemented through a variety of public finance arrangements, including direct subsidies for housing offered to users and public-private partnerships to invest in new housing programmes.

Table 5: Potential mitigation options for electricity transmission and distribution

Mitigation option	Approaches	Public finance and supporting policies
Extension of the electricity grid to new low-carbon electricity generation	Increased low-carbon electricity generation reduces the BAU emissions intensity from the country's overall electricity mix.	• Public expenditure on RD&D for grids (with regard to investment in energy storage technologies, high voltage, direct current (HVDC) lines and building electric vehicle charging stations). • Public policies that explicitly state that they will undertake the following initiatives can be indicated with public budgetary spending. • Such policies and spending will occur in conjunction with transmission and grid operators (if these entities are not government owned).
Installation of HVDC lines	HVDC transmission lines can transmit electricity across long distances while comparatively reducing the amount of electricity lost from traditional high voltage, alternative current (HVAC) lines.	
Refurbishment of existing grid lines	Refurbishments improve the amount of losses from aging grid infrastructure.	
Building charging stations for electric vehicles	The increased number of electric vehicles (EVs) require sites where EVs can be charged, but where EVs can also discharge electricity that they have stored (in sites where electricity prices are high due to low supply of electricity, in which case EVs can 'sell' electricity that they have stored).	
Improve energy storage potential (e.g. installation of lithium ion batteries)	Improves the ability of electricity generators who provide intermittent electricity supply. That is, they can only generate electricity when input sources are available – such as renewable electricity generators. By being able to store surplus electricity produced from renewable electricity generators during times of low demand, energy storage technologies can provide electricity to the grid when electricity demand is high.	
Training programmes and software programmes for improved operation and maintenance of grids	Improves the ability for grid operators to optimise supply of electricity from generators to match up to electricity demand times. This also includes ability for grid operators to prioritise increasing the proportion of low carbon electricity (when it is most appropriate).	• Public expenditure on institutional building programmes that are done in conjunction with T&D operators.
Integration of smart technologies	"Smart technologies" include a wide range of options that improve the ability for any actor involved with electricity production, transmission and consumption to get information on the supply and demand of electricity in the grid system. In providing such real-time information, actors can determine when is the best time to supply and demand electricity, thus smoothing out electricity consumption over time and reducing the stress on both generation and transmission. Smart grid technologies can be used to help address the intermittency of energy production from renewable energy technologies. There is a substantial role for telecommunications networks in supporting the transmission of large amounts of data in real-time.	• Public support for RD&D programmes for smart technologies and pilot projects. • Public expenditure and procurement policies to integrate smart technologies into the grid. • Public policies that incentivise utilities to integrate smart technologies into the grid system, as well as with end-users. • Deployment: Technology grants, loan guarantees, subsidies, tax credits to end-users. Often similar programmes can be undertaken (in conjunction with supportive policies) to incentivise private utilities to install energy-smart technologies.

Note: this table indicates key characteristics and considerations, and is not comprehensive.

Source: IEA (2010); Goodward, J. et al. (2011).

Table 6. Technical mitigation options for residential & commercial buildings

Mitigation option	Approaches	Public finance and supporting policies
Building more sustainable buildings	• Use more efficient construction materials and techniques. • Design buildings to use energy more efficiently and to generate their own energy (elaborated further below).	• Government policies to introduce efficiency standards for buildings.
Retrofit of existing buildings	• Use insulation to reduce heating losses. • Upgrade existing technologies (heating and electricity) to reduce losses.	• Governments may change pricing structures to incentivise greater efficiency of use and to reward reduced consumption. • Some governments are investing in energy efficiency trading programmes to incentivise investments in efficiency (e.g. the Government of India is acting on its energy efficiency commitments by introducing a "Perform, Achieve and Trade" Scheme in which companies can trade energy efficiency improvements with other less efficient companies). • Funds for technology grants, loan guarantees, subsidies, tax credits to end-users to retrofit their buildings.
Implement energy-efficient and low-carbon technologies	• Demand-side monitoring technologies: smart meters that can track domestic electricity consumption and reduce unnecessary consumption. • Efficient home appliances include: air conditioning systems, space heating, refrigeration and lighting. • Integrating energy supply technologies: solar thermal heating, heat pumps/exchange, small-scale renewable electricity generation. • Introduce Solar Water Heating systems.	• Public expenditure on RD&D and pilot programmes. • Deployment: Funds for technology grants, loan guarantees, subsidies, tax credits to end-users to install technologies. • Public expenditure on programmes to raise end-user awareness: may choose to invest in processes to establish and harmonise minimum efficiency standards for appliances, and then to label appliances so that consumers can make informed choices about what to purchase.

Note: this table indicates key characteristics and considerations, and is not comprehensive.

Source: IEA (2010); Goodward, J. et al. (2011).

Table 7. Potential mitigation options for coal

Technological option	Approaches	Public finance and supporting policies
Oil and natural gas: refurbishing pipelines	• Prevents the unnecessary escape of CH_4 emissions. • Improves the operational efficiencies of the system.	• Policies that require reduction of flaring at oil wells. • Public expenditure in improved institutional capacity and training for best practice techniques for oil companies (especially if they are national oil companies).
Changing operational practices to reduce flaring at oil wells		
Direct inspection & maintenance of entire systems at O&NG plants		
De-gasification systems for deep underground coal mining with trapped CH_4	• Network of wells are drilled into the mine, where gathering systems pull the CH_4 to the surface. Once brought to the surface, the CH_4 can then be trapped, and if stored, can be used as a fuel for on-site electricity generation.	• Public expenditure on technology installation and safety programmes to prevent excessive CH_4 escaping.
Sealing abandoned coal mines	• Sealing mines helps prevent fugitive CH_4 emissions from escaping.	• Public policies that require abandoned mines to be sealed. These can be supported by public funds.

Note: this table indicates key characteristics and considerations, and is not comprehensive.

Source: EPA (2006).

4.3 Fossil fuel extraction and processing

The oil and natural gas (O&NG) industry is involved in the production, processing, transportation, storage and distribution of these fossil fuels (US EPA, 2006). These systems take oil and/or natural gas from underground reservoirs to processing plants, where they are further refined.

O&NG emissions, primarily methane or CH_4 can be released at any stage of the process. However the largest emissions occur during equipment/pipeline leaks and venting activities, where natural gas may be flared. General abatement options that can be applied at all stages of the O&NG industry include refurbishment of equipment (especially pipelines), changes in operational practices (such as reducing flaring) and regular direct inspection and maintenance (DI&M). Again, the use of public finance for such interventions may be controversial. In many countries, excessive gas flaring may not actually be legal; questions have been raised about whether it is appropriate to create incentives for compliance through climate finance rather than simply seeking to enforce existing regulations (which in turn, might involve some enforcement and regulatory capacity).

Coal mining also releases high amounts of trapped methane (CH4), especially when mining occurs at greater depths from the earth's surface due to greater concentration of CH_4. Other factors that affect the amount of CH_4 released from coal mines are the type of coal mined and the type of mining operation that is used to extract coal from mines. Although the majority of emissions from the coal industry occur during the mining stages, there is also potential to abate emissions during the processing and handling of coal (see Table 7).

5. Transport

The transport sector encompasses many different modes of travel for passengers and freight, including automobiles, buses, trucks, trains, ships and airplanes. In many developing countries access to reliable transport services is very limited, although they play a crucial role in supporting economic development (IEA, 2010). Transport sector emissions are growing rapidly, particularly as growing affluence in developing countries increases the use of individual cars (IPCC, 2007).

Interventions can be designed to reduce the carbon intensity of transport services. The adoption of higher standards of vehicle efficiency and better fuel standards can have a significant impact on GHG emissions. There is significant interest in the scope for fuel substitution – for example in some countries such as Brazil, substantial investments have been made in the development of biofuels that are blended with petroleum. While biofuels can play a role in reducing GHG emissions, their real impact needs to be considered in a context based on a robust analysis of the lifecycle of GHG emissions. In some cases the inputs to biofuel production may be extremely GHG intensive. The impact of these policy interventions will be important to monitor over time, to see if they do in fact lead to substantial mitigation.

Structural changes to transport systems and urban planning can have a central role in delivering mitigation and developmental benefits. Densification of cities to avoid sprawl may be part of such a strategy. Such changes can include supporting the shift to public transport systems such as efficient bus and train systems, incorporating integrated systems and encouraging walking and cycling. Measures to discourage the use of personal vehicles and cars including through pricing schemes such as congestion charging, fuel taxes and a number of other regulatory tools, can also have an impact. All these options involve convincing individual users that it is in their interests to make different choices, and also involve dealing with incumbents that may have an interest in GHG-intensive transport systems that dominate most economies at present.

Investment in transport and efficient public transport systems is often the mandate and function of local and municipal government. The introduction of climate compatible transport solutions is interwoven with processes of local and municipal planning and administration.

The scope for mitigation through interventions in the transport sector is increasingly well recognised. However, the issue of how to categorise finance for transport interventions that deliver mitigation benefits, but are not primarily focused on reducing GHG emissions, is difficult. It has been notoriously difficult to demonstrate the additionality of public transport oriented programmes in the experience of the CDM. New investments in transport systems may involve an increase in emissions in absolute terms in the immediate term. It is therefore often difficult to justify baseline estimates of what would have happened in the future under a business as usual scenario. Table 8 summarises some key options for mitigation in the transport sector.

6. Industry

There are many industrial activities that result directly in GHG emissions, as well as indirectly, from industries' consumption of electricity and heating from utilities, and fossil-fuel based transport. The five main industries that account for about 77% of direct CO_2e emissions from industry are iron and steel, cement, chemical and petrochemical, pulp and paper, and aluminium. These sectors are energy intensive and account for about two thirds of total industrial energy use.

The energy efficiencies and carbon intensities of industrial activity have improved in many countries. In some countries, the cost of energy is so low, however, that industries have been slow to adopt more efficient practices. Even where efficiency gains have been made, two significant factors affect the continued increase in CO_2e emissions from industry. The first is the "rebound effect", where the

Table 8: Potential mitigation options for transport

Mitigation Option	Approaches	Public finance and supporting policies
Investment in institutional capacities	• Strengthening urban and national transport planning systems. • Education, awareness and training programmes. • Consumer loyalty programmes that incentivise low-carbon travel.	• Public expenditures on low-carbon transport planning and associated institutional capacity.
Infrastructure improvement	• Creating cycling and pedestrian walkways. • Electric vehicle charging centres. • Improving route capacity and connectivity of existing buses, subways and trains.	• Government expenditure on improving infrastructure and infrastructure access.
Fuel switching away from petroleum fuels (applicable to all transport types)	• Increase low-carbon biodiesel. • Use electricity (electric vehicles or electro-magnetic trains). • Use hydrogen (when commercially available).	• Public policies on biofuel blends for cars that are sustainably sourced. • Public expenditure on RD&D for electric vehicles and hydrogen. • Public investment in electro-magnetic trains as part of public transport solutions.
Road transport	• Incentivise buying light vehicle duty automobiles that have lower carbon emissions per kilometre, or carbon emissions per volume of gas. • Investments in efficient catalytic converters with cars that run on internal combustion systems in order reduce vehicle emissions. • Incentivising deployment of electric vehicles, plug-in hybrid electric vehicles and fuel-cell vehicles. • Improving bus transport to increase passenger capacity.	• Public policies on vehicle emission standards for cars. • Public expenditure on RD&D for improving vehicle emission standards of cars (including in catalytic converters, electric vehicles and fuel-cells). • Public expenditure to increase bus transportation capacity and routes.
Trains	• Use electric trains rather than trains powered by fossil fuels.	• Public investment (or co-investment with private companies) in electric trains and improving train infrastructures.
Aviation	• RD&D into less carbon-intensive jet fuels, including biofuel blends. • Increasing proportion of new airplanes to old ones (as new ones are more efficient due to better materials, aerodynamic bodies). • Improving air travel routes and logistical operations to reduce delays and unnecessarily long distances.	• Public policies on air emission standards, including mandating that airlines engage with carbon trading or pay carbon taxes. • Public expenditure on improving institutional capacities of airports and international cooperation to improve air routes.
Shipping	• Improving efficiencies of routes. • Increasing efficiency and reducing fuel consumption.	• Public policies on shipping emissions standards, including mandating that shipping companies engage with carbon trading or pay carbon taxes.

Note: this table indicates key interventions and characteristics, and is not comprehensive.
Source: IEA (2010); Goodward, J. et al. (2011); IPCC 2007

proportional increase in industrial output outweighs any gains in efficiencies or carbon intensities. The second is that a greater percentage of industrial activity (especially in the five sectors mentioned above) occurs in emerging economies, where the most efficient or least carbon-intensive technologies are not always used. There are, therefore, often opportunities to reduce carbon emissions in developing country contexts.

Although each industrial sector has specific technological and process upgrading that it can deploy, there are certain general mitigation strategies that all sectors can implement.

The first general set of strategies that industries can undertake is to invest in the best available technology (BAT), as well as in best practice technologies (BPT), and refurbish facilities to reduce inefficiencies.

A second strategy is to reduce the amount of CO_2e emissions that come from consumption of electricity and heat. About 34% of total industry emissions come from consumption of electricity from utilities (IEA's ETP, 2010: 161). Industries may invest in on-site electricity generation from **low-carbon fuels such as biomass and waste**, or build on-site renewable electricity generation (if regulatory frameworks allow such investments). There is also immense scope for cogeneration/combined heat and power in industrial processes. In addition, industries may consider **recycling material** which can conserve energy (as the re-processing of recycled material is less energy intensive than raw material) and reduce CO_2e emissions from landfills. Some industries may also consider installing CCS technologies onto their plants as a long-term initiative. Table 9 summarises some of the key options available.

Public support for efforts to reduce the CO_2e emissions from industry can take a variety of forms. It can include investment in RD&D to improve the range of BAT that are available to industry. It also involves expenditures that allow for the uptake of such technologies by firms, including low-interest loans, grants and tax credits. Public policies such as emissions standards, carbon taxes and programmes that place a cap on national emissions and allow trading can all incentivise private actors to invest in such mitigation options.

Table 9. Potential mitigation options for carbon-intensive industries

Industry	Approach	Mitigation option	Public finance and supporting policies
Aluminium	New capital investment	• BAT in alumina smelting and refining technologies (e.g. extract alumina ore and process them into usable sheets).	• Equipment standards and labelling. • Credit lines for upgrading equipment.
Cement	New capital investment	• Use of dry kilns, which include pre-heaters and precalciners rather than conventional wet kilns to produce clinker. Dry kilns use less energy in producing an equivalent volume of clinker.	• Credit lines for upgrading equipment.
	Input substitution	• The process of creating clinker releases CO_2e emissions. Reducing the amount of clinker used to make cement by replacing with it fly ash (a by-product of iron and steel production) reduces overall CO_2e emissions. • Reduce the amount of coal used to heat kilns by using low-carbon fuels such as biomass.	• Efficiency and processing standards. • Credit lines for equipment upgrades.
Chemical and petrochemical industry	New capital investment	• Use best practice technologies (BPT), including membrane technologies and catalysts, once they are commercially available.	• Grants for research and development support. • Loans and credit lines.
	Fuel switching	• Instead of producing chemical products from fossil fuel sources, use bio-based products that are less carbon intensive (and release less CO_2e emissions when decomposing).	• Incentives for biofuel development and innovation, including research and development.
Iron & steel	New capital investment	• Instead of using blast furnaces (BF) to produce and refine iron, invest in electric arc furnaces (EAF) or direct reduced iron furnaces (DRI). Both use higher percentages of scrap metal than BF, while DRI have the added benefit of being heated with natural gas.	• Equipment standards. • Loans and credit lines for upgrading. • Incentives such as tax credits for scrap metal reuse.
	Fuel switching	• Use biomass wastes and other low-carbon fuels to heat furnaces.	• Fuel standards.
Pulp & paper	New capital investment	• Rather than building separate facilities for producing pulp and paper, build integrated pulp and paper mills that use CHP policies. This improves the energy efficiencies of production. • Install black liquor and biomass gasification technologies which extract fuel sources that can be used to power integrated pulp and paper mills. • Once commercially available, install water removal technologies that reduce the amount of water used for pulp washing and paper production.	• Access to credit lines and loans or tax incentives for CHP and integrated facilities. • Grid access and preferential tariffs for excess power. • Credit lines and loans to support equipment improvement.

Note: this table indicates key interventions and characteristics, and is not comprehensive

Source: IEA (2010).

7. Agriculture

The most significant source of CO_2e emissions comes from methane (CH_4) released from animal husbandry (EPA, 2006). Animals' digestive processes result in enteric fermentation which produces methane; changing animal diets, or using certain antibiotics may reduce these emissions. The second issue is methane from organic wastes such as manure. Manure can be concentrated in pools, in which case biogas technologies (such as anaerobic digesters) can be used to flare the methane, fuelling electricity generation. Biogas technologies can also be used for reducing CO_2e emissions from organic residues from agricultural cultivation.

A second source of CO_2e emissions from agriculture is through the use of nitrogen-based fertiliser for increasing agricultural yields from soil, which releases GHG nitrogen oxide. Reducing the use of nitrogen fertiliser through improved soil management practices can reduce CO_2e emissions. More generally, the production of chemical fertilisers and pesticides that are widely used in the agriculture sector is GHG intensive. Land use change can also be very GHG intensive, but addressed in a separate paper on reducing emissions from deforestation and degradation (Watson 2012).

Agriculture is also often very energy intensive, relying on electricity for processing and for transport services. There are many opportunities to improve the efficiency of electricity and energy use within the agricultural sector, and the use of less carbon-intensive agricultural inputs. There are also often opportunities for the agricultural sector to generate low carbon energy including by using biomass wastes for electricity generation and producing low carbon fuels for transport. Subsidies to the agricultural sector may perpetuate carbon-intensive practices: for example, in some countries agricultural inputs such as electricity and liquid fuels may be subsidised for poor farmers. Addressing such subsidies with due consideration of the scope for mitigation benefits may be important.

The government can incentivise agricultural firms to adopt mitigation practices through investing in awareness raising policies and instituting policies for more sustainable agriculture. Governments can help agricultural firms and smaller farms adopt biomass digesters through low-interest loans, tax credits and grants.

8. Water & Sanitation

The largest share of CO_2e emissions from water and sanitation facilities comes from methane (CH_4) and nitrogen oxide (N20) emissions released from wastewater from residential and commercial (R&C), agricultural and industrial facilities (EPA, 2006). However, agricultural farms and large-scale industrial facilities (such as the pulp and paper industry and meat and poultry industries) can have on-site wastewater treatment facilities.

There are two main technological options that can be used to reduce CH_4 emissions. The first is to install biogas technologies, such as anaerobic digesters, which enclose filtered wastewater to produce CH_4 emissions that can be flared. Anaerobic digesters can also use the produced CH_4 emissions as a fuel to drive electricity generation technologies. The electricity produced can be used to supply the on-site facilities. If there is a surplus of electricity, it can be used to supply the power grid. National budget expenditures which invest in such technologies (especially for electricity generation from wastewater treatment plants) can be considered mitigation expenditures.

9. Financing mitigation

Mitigation expenditures are often integrated into (or a sub-component of) broader expenditures. For example, expenditure on staff, processes and institutions that address climate change mitigation issues will be a sub-component of the personnel and administrative expenditures of a Ministry of Energy. Also, if a solar water heater programme which offers climate change mitigation benefits is incorporated into a housing development programme, then a sub-component of the budget for the housing programme may represent mitigation expenditure, rather than the entirety of the related spending. On the other hand, if the whole programme is designed to maximise the efficiency and minimise the carbon impact of the development, then it may be appropriate to count the whole expenditure as linked to climate change mitigation.

The preceding discussion has emphasised the importance of expenditure on institutional, human, and technical capacity to implement policies and regulations that seek to support mitigation. It may be quite difficult to discern what "counts" as mitigation support, especially if there are efforts underway to "mainstream" climate change into government departments. In such cases, it may be helpful to seek evidence that mitigation related considerations are being incorporated into operational objectives and work plans, and the performance objectives of key staff. Similarly, we would highlight the important role that state-owned enterprises and public-private partnerships play in the energy, transport, water and agriculture sectors, and therefore in any efforts to reduce GHG emissions. Carbon-intensive practices in these sectors are often heavily subsidised. Understanding the goals and objectives of public support for public utilities is therefore a crucial component of any analysis of mitigation expenditure.

Ideally, the individual components of expenditure can be identified, and those that have an impact on climate change could be quantified. This may not always be the case, and is often quite difficult in light of current budgeting constraints. A qualitative analysis of the scope and objectives of a programme may allow an estimate of the share of finance that can be "counted" towards climate change, however, this is inherently a subjective exercise. In this sense, the classification of mitigation relevant budget expenditure has an element of judgement and "art" to it, rather than a precise science. Clarity about the assumptions made, and their underlying rationale, is essential when such judgement is (necessarily) exercised.

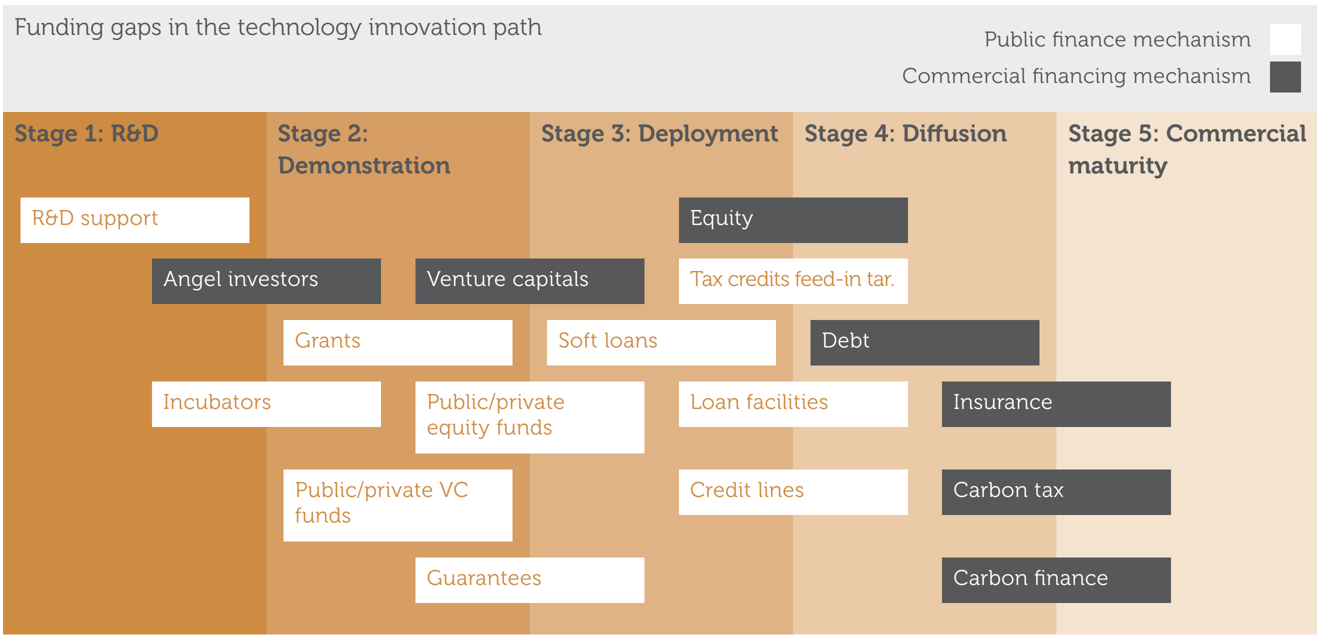
There is a need for ongoing improvement and enhancement of emergent low carbon technologies (Tawney et al., 2011; Byrne et al., 2012). The role of finance for mitigation can therefore usefully be considered in the context of an innovation pathway consisting of: (i) R&D, (ii) demonstration, (iii) deployment, (iv) diffusion and (v) commercial maturity (Haites et al., 2008). An evolving mix of policy and support instruments can help realise mitigation options with this pathway in mind, including regulations and codes, fiscal incentives, public finance mechanisms, market mechanisms, voluntary agreements and information dissemination (represented in Figure 1).

As technologies move out of the laboratory into the early commercialisation stages, private capital may be particularly difficult to secure because of business, technology and policy risks, high initial production costs and a wide range of market barriers. Public finance and related interventions can reduce barriers, bridge gaps and help share risks with the private sector. Appropriate policy mixes that support a response to climate change are likely to evolve over time, as technologies and markets mature, volumes increase and cost reductions are realised. The need to invest in improving mitigation technologies, which may be "supply side" focused, should not detract from the imperative to invest in changing existing incentives that encourage carbon intensive development, by looking at real needs for energy, water and agriculture services and how best to meet them.

With these considerations in mind, Figure 1 presents some of the major forms of public finance that may be deployed to support mitigation action, with a focus on the need to support continuous innovation and improvement of technologies. It draws heavily on the work of the UNEP Sustainable Energy Finance Initiative. We briefly discuss each of these approaches, with a focus on the need to finance continuous innovation and improvement of mitigation technologies in order to drive down costs, perceived risks and associated returns to prospective private investors (see Figure 1). The discussion is not comprehensive, however, and we recognise that substantial effort is being invested in advancing our understanding of how best to structure public support for mitigation, and that new forms and instruments are constantly under development.

Governments may invest directly in **research and development** to improve the viability of low carbon technologies, reduce their costs and improve macroeconomic competitiveness of new technologies.

Figure 1: Funding technology innovation



Sources: Buchner et al. (2011) Tawny et al. (2011) UNEP SEFI (2008).

Government support has often been integral to innovation. There is a clear need for investment in research and development processes that can foster the improvement of technological viability and accelerate processes of learning and adoption. Governments may support public sector institutions to undertake RD&D for mitigation, or provide grants to universities, research institutions, or private sector actors to advance research and development. Public finance may also be used to support **incubator programmes** which provide strategic and business development support, including advice on corporate finance, management, market research and engagement, and guidance on intellectual property protection.

Venture capital, whether public or private, may be especially suited to supporting the development of technology, taking it from the end of the R&D phase through to demonstration. Public venture capital funds such as the China Environment Fund and the UK Carbon Trust Venture Capital Fund have sought to help open bottlenecks in deal flow. They can also support companies that take longer to get returns and would not attract private investment, but have a net global benefit.

Public finance may be invested in equity funds that invest in projects and companies such as equipment manufacturers, project developers, project specific special purpose companies, independent power producers and energy utilities. Equity funds can take many different forms. Private equity funds may specialise in one technology sector, or pursue a range of investment opportunities that support climate mitigation. Equity funds can be structured to provide a variety of financial products, including **venture capital** for new technology developments, early stage equity for project development activities, or **late stage equity** for projects that are already fully permitted and ready for construction.

Many governments have opted to extend **credit lines** to private financial institutions to address the lack of liquidity to meet medium- to long-term financing requirements of investments that yield mitigation benefits. Credit lines may be offered at concessional rates to induce borrowing and direct credit to target sectors and projects, and effectively help reduce the costs of certain kinds of investments. When the credit risk of mitigation projects is high, credit lines can also be structured on a limited or non-recourse basis so that the financial institution that develops the mitigation project shares in the risk of the loans on-lent by the financial institutions. Credit lines are often well suited to large-scale projects. The Thailand Energy Efficiency Revolving Fund, which uses a small share of revenues from electricity sales to capitalise a fund that offers credit lines for investments in improving energy efficiency, is one innovative example.

When a commercial financial institution has adequate medium- to long-term liquidity, but is unwilling to provide financing due to high perceived repayment risk, **guarantees** may be used to mobilise domestic or international finance by taking on credit risk. Typically, guarantees cover a portion of the outstanding loan principal, rather than the whole sum. There is growing interest in the use of guarantees to draw in private investment and reduce the cost of capital by taking on underlying risks.

Where commercial financial institutions are unwilling or unable to provide financing, public **loan facilities** may fill that gap. As opposed to credit lines which operate within the conventional lending practices of commercial financial institutions, **loan facilities** are created by governments as special vehicles to provide debt financing directly to projects, typically on a project finance basis. Such facilities may be particularly warranted in situations where there are large numbers of economic projects that are unable to make it to financial closure because commercial financial institutions lack the capacity or liquidity to provide the needed financing.

Project development, which spans from pre-feasibility to financial structuring, can be a lengthy process that can require substantial capital reserves. Like early-stage technology innovation, project development does not immediately generate positive cash flows to service debt. The development risks in this phase are high and loans from the commercial financial institutions are often difficult to access. **Soft loans** may be used to bridge such financing gaps. By providing debt capital at concessional interest rates, soft loan programmes may be structured to allow deferred repayment, often until projects reach a revenue-generating stage. Debt may be forgiven if ventures do not materialise. Soft loan programmes can help give confidence to technology innovators and project developers by sharing some of their costs. In so doing, they can leverage commercial financing by demonstrating the viability of technologies and projects. Similarly **loan softening programmes** may be used to provide an incentive to commercial financial institutions as an interest subsidy, or as a partial guarantee, or some combination, rather than extending credit. Either way, the benefit of the support is expected to be passed on to the commercial financial institution's customers in the form of lower interest rates, lower front-end deposits and extended loan repayment periods. Many multilateral development banks have worked with commercial financial institutions in developing countries as intermediaries to enhance their ability to provide finance for energy efficiency and renewable energy programmes, including programmes implemented by smaller and medium-sized local companies.

Tax incentives may be used to expand domestic mitigation activities. **Tax credits** improve a project's financial position ultimately driving the deployment of a technology if the credit is large enough to make it cost competitive. There are tax incentives also in support of the agriculture and forest sectors, for preserving open spaces, and government sharing of costs for biodiversity protection. **Carbon taxes** work by prompting regulated entities to internalise the cost of their carbon emissions. The money raised with carbon taxes may be used to create funds with the objective to finance feed-in tariff programmes or other incentive-based schemes. **Feed-in tariffs** are typically associated with renewable electricity production. Feed-in tariffs correspond to the payment to renewable energy producers. The appeal of this instrument is that it can provide revenue certainty and reduce risk for developers, which can correspondingly lower the cost of capital for developers. Finally, **carbon finance**, including revenues from the Clean Development Mechanism of the Kyoto Protocol, can be an important source finance for mitigation projects.

Mitigation finance in a global context

This paper has considered public expenditures and associated policies that are relevant for climate change mitigation, with a focus on considerations for developing countries. This raises important issues to consider, given that climate finance needs to be understood in the context of commitments made under the UN Framework Convention on Climate Change by developed country governments to help developing countries mitigate and adapt to climate change.

Self-financed action within developing countries is not a substitute for developed countries delivering on their commitments to mobilise and deliver climate finance to developing countries. Annex I presents an overview of the major dedicated international funds that have been established to help finance mitigation in developing countries, which include the Global Environment Facility, the Clean Technology Fund and the Scaling Renewable Energy Programme. Internationally mobilised climate finance is most likely to be effective, however, when it seeks to fill gaps in existing finance, given emergent national priorities, address underlying issues of institutional capacity, and support efforts to strengthen underlying policy and regulatory frameworks. Analysis of current expenditure and institutional priorities may allow more thorough understanding of where international finance (particularly grant and concessional finance, as well as a variety of other public and private forms of finance) can have the most impact.

10. Conclusion

The question of what constitutes mitigation finance when considering expenditure at national level is subjective, and difficult to boil down to a fine science. This paper has sought to identify key sectors in which climate change mitigation is needed, and indicate a range of interventions that may support mitigation, as well a variety of approaches to financing such interventions, with a focus on the role of public finance in this context. While sophisticated tools to estimate GHG reductions from interventions have been developed, they are often complex to apply in practice, and also subject to interpretation and manipulation. They are also difficult to apply to key interventions that are likely to deliver mitigation at scale, such as support for research, development and innovation, or reforms to institutional arrangements and governance that may support more effective mitigation and low carbon development over the long term.

Within national contexts, as a result of national circumstances, constraints and interests, governments may choose to make investments in a variety of "low hanging" opportunities – particularly within the conventional energy sector - that deliver mitigation benefits at low cost by upgrading fossil fuel based technologies. The long-term effects of such investments on the environmental and social sustainability of a country as a whole may be debatable. The case for public finance for such investments may also be disputed. We have made reference to key controversies , and highlighted some considerations that may help inform whether and under what circumstances investments in such options might—or might not—result in real mitigation benefits, without taking a position on whether such interventions constitute an appropriate use of climate finance.

It is clear that a wide variety of interventions are necessary to succeed in mitigating climate change, and will include investment in options that can reduce GHG emissions, as well as reducing investment in activities that cause climate change. The private sector can and does play an important role in climate change mitigation, but its role and objectives may be substantially shaped and influenced by national circumstances, policy and public finance.

Bibliography

Baumert, K., Pershing, J. and Herzog, T. (2005) *Navigating the Numbers Greenhouse Gas Data and International Climate Policy*. World Resources Institute (WRI), Washington DC.

Biomass Energy Centre (2011) *Types of Biomass systems*. Available at: http://www.biomassenergycentre.org.uk/portal/page?_pageid=75,225212&_dad=portal&_schema=PORTAL [Accessed 28 April 2012].

Bloomberg New Energy Finance (2011a) "Onshore wind energy to reach parity with fossil-fuel electricity by 2016". Press Release Available at: http://www.newenergyfinance.com/PressReleases/view/172 [Published on 10 November 2011].

Bloomberg New Energy Finance (2011b) "Bloomberg New Energy Finance Summit. Day 2: Keynote Speech". Presenter: Michael Liebriech. Presentation given at the Bloomberg New Energy Finance 2011 Summit in New York City. Available at: http://www.newenergyfinance.com/free-publications/presentations/ [Presented on 5 April 2011].

Bloomberg New Energy Finance (2012) "Global Trends in Clean Energy Investment". Presenter: Michael Liebriech. Presentation provided to the Clean Energy Ministerial in London. Available at: http://www.newenergyfinance.com/free-publications/presentations/ [Presented on 25 April 2012].

Buchner, B., Falconer, A., Hervé-Mignucci, M., Trabacchi, C. and Brinkman, M., (2011) *The Landscape of Climate Finance*, CPI Discussion Paper (2011).

Byrne, R. et al. (2012) Innovation Systems in Developing Countries. CDKN Policy Brief 1. Available at: http://unfccc.int/ttclear/pdf/Call%20for%20Inputs/EE/ECN_EE.pdf

Combined Heat and Power (2012) *Combined Heat and Power: Bringing Energy Together*. Available at: http://www.chpa.co.uk/what-is-chp_15.html [Accessed 20 April 2012].

Department of Energy (2009) *Fluidized Bed Technology – Overview*. Available at: http://www.fossil.energy.gov/programs/powersystems/combustion/fluidizedbed_overview.html [Accessed 17 April 2012].

Department of Energy (2010) *Municipal Solid Waste*. Available at: http://www.epa.gov/cleanenergy/energy-and-you/affect/municipal-sw.html [Accessed 18 April 2012].

EPA (2006) *Global Mitigation of Non-CO_2 Greenhouse Gases*. United States Environmental Protection Agency, Washington, DC.

EPA (2007) *Natural Gas*. Available at: http://www.epa.gov/cleanenergy/energy-and-you/affect/natural-gas.html [Accessed 18 April 2012].

EPIA (2011) *Solar Generation 6. Solar Photovoltaic Electricity Empowering the World*. European Photovoltaic Industry Association, Brussels.

Gallagher, K.S. (2006) "Limits to leapfrogging in energy technologies? Evidence from the Chinese automobile industry." *Energy Policy*. Vol. 34 (4): 383–394.

Goodward, J. et al. (2011) "Is the Fit Right? Considering Technological Maturity in Designing Renewable Energy Policy." Issue Brief. World Resources Institute (WRI), Washington, D.C.

Gupta, S. et al. (2007) "Policies, Instruments and Co-operative arrangements". In Metz, B. et al. eds, Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Inter-Governmental Panel on Climate Change, Cambridge University Press, Cambridge.

Haites E., Higham, A., de Coninck, H. (2008) Financial Sources and Vehicles for Climate Change Technology Development, Deployment, Diffusion and Transfer. Report for EGTT.

IEA (2010) *Energy Technology Perspectives: Scenarios and strategies to 2050.* International Energy Agency, Paris.

IEA (2011) *World Energy Outlook*. International Energy Agency, Paris.

International Institute on Sustainable Development (2012) *Climate Change and Energy, Providing sustainable solutions in turbulent times*. Available at: http://www.iisd.org/climate/ [Accessed on 3 May 2012].

IPCC (2007) *Fourth Assessment Report on Climate Change*. Cambridge University Press, Cambridge.

Jotzo, F. and Pezzey, J. (2007) "Optimal Intensity Targets for Greenhouse Gas Emissions Trading Under Uncertainty", *Environmental and Resource Economics*, Vol. 38, No. 2.

Kolstad, C. (2006) "The Simple Analytics of Greenhouse Gas Emission Intensity Reduction Targets", *Energy Policy*, Vol. 33, No. 17.

Marcu, M. and Pizer W. (2003) "Special Supplement on Defining and Trading Emission Targets", *Climate Policy*, Vol. 3, Supplement 2.

Nakhooda, S. et al. (2007) *Empowering People: A governance analysis of electricity*. World Resources Institute (WRI), Washington DC.

Nakhooda, S. and Ballesteros, A. (2010) *Towards a Sustainable Energy Future: A review of the MDBs' investments in energy policy*. World Resources Institute (WRI), Washington DC.

Perkins, R. (2003) "Environmental leapfrogging in developing countries: A critical assessment and reconstruction", *Natural Resources Forum*. Vol. 27: 177 – 188.

Sorrell, S. (2007) *The rebound effect: An assessment of the evidence for economy-wide energy savings from improved energy efficiency*. Report by the Sussex Energy Group for the UK Energy Research Centre, London, UK. http://www.ukerc.ac.uk/support/tiki-index.php?page=ReboundEffect.

Streck, C. (2010) *The Concept of Additionality Under the UNFCCC: Implications for Environmental Integrity and Equity*. London: University College of London.

Tawny, L. et al. (2011) 2 degrees of Innovation. World Resources Institute (WRI), Washington DC.

UNEP (2010) *The Emissions Gap Report*.

UNEP Sustainable Energy Finance Initiative (SEFI) (2008). *Public Finance Mechanisms to Mobilise Investment in Climate Change Mitigation - An Overview of the Mechanisms Being Used Today to Scale Up Climate Mitigation with a Particular Emphasis on the Clean Energy sector*. UNEP, Paris.

Unruh, G.C. and Carrillo-Hermonsilla, J. (2006) "Globalizing Carbon Lock-in: The impact of and policy toward carbon lock-in in industrializing countries". *Energy Policy*, 34.

World Business Council on Sustainable Development (2012) *Cement Sustainability Initiative*. Available at: http://www.wbcsdcement.org/ [Accessed 28 April 2012].

World Resources Institute (2012) Climate Analysis Indicator Tool (CAIT). Available at: http://cait.wri.org

World Resources Institute (2009) "World GHG Emissions Flow Chart". Available at: http://cait.wri.org/figures.php?page=/World-FlowChart [Accessed 5 May 2012].

World Steel Association (2012) *Sustainability: Sustainable Steel*. Available at: http://www.worldsteel.org/steel-by-topic/sustainable-steel.html [Accessed 2 May 2012].

Annex I: Objectives and activities of major multilateral funds for mitigation

Initiative	Objectives	Activities
Clean Technology Fund (CTF) of the Climate Investment Funds administered by the World Bank in partnership with Regional Development Banks	To scale up financing for demonstration, deployment and transfer of low-carbon technologies with significant potential for long-term GHG emission savings. **Instruments:** The CTF provides loans, guarantees and a very small amount of grant finance for project preparation and technical assistance.	• Activities supported by the CTF include programmes within the: • Power Sector: Renewable energy and highly efficient technologies to reduce carbon intensity. For example, investment in national financial institutions that will lend to renewable energy projects, or large scale investments in grid renewable energy facilities such as wind farms and concentrating solar thermal power. • Transport Sector: Efficiency and modal shifts. For example, investments in bus rapid transit systems in Colombia. • Energy Efficiency: Buildings, industry and agriculture. For example, investment in a credit line for energy efficiency offered by national financial institutions and industrial energy efficiency.
Global Environment Facility (GEF), an international fund that supports implementation of multilateral environmental agreements	To help developing countries and economies in transition contribute to the UNFCCC objective to mitigate and adapt to climate change and enable sustainable economic development. **Instruments:** The GEF only provides grant finance.	• Promoting the demonstration, deployment and transfer of innovative, low-carbon technologies, for example demonstration projects on Concentrating Solar Thermal Power. • Promoting market transformation for energy efficiency in the industrial and building sectors, • Promoting investment in renewable energy technologies; • Promoting energy-efficient, low-carbon transport and urban systems; • Supporting enabling activities and capacity building.
Global Energy Efficiency and Renewable Energy Fund (GEEREF), administered by the European Investment Bank (EIB) and capitalised by the European Commission	To accelerate the transfer, development, use and enforcement of environmentally sound technologies for the world's poorer regions, helping to bring secure, clean and affordable energy to local people. **Instruments:** The GEEREF provides grant finance to funds that invest in renewable energy and energy efficiency to help reduce the cost of capital.	• Renewable Energy – including but not limited to small hydro, solar, wind, biomass and geothermal; • Energy Efficiency – including but not limited to waste heat recovery, energy management in buildings, cogeneration of heat and power, energy storage and smart grids.
International Climate Initiative (ICI)	To finance and support climate change mitigation, adaptation and biodiversity projects with climate relevance to help trigger private investments of a greater magnitude. **Instruments:** Grants	• Energy efficiency and renewable energy projects (e.g. a grant contribution to the Morocco Ouarzazate CSP plant). • Capacity building initiatives (e.g. support for carbon market innovation and the development of nationally appropriate mitigation actions, a renewable energy mapping atlas). • Monitoring and accountability initiatives.

Annex I: Continued

Initiative	Objectives	Activities
Scaling Renewable Energy Programme (SREP) of the Climate Investment Funds administered by the World Bank in partnership with Regional Development Banks	To demonstrate the economic, social and environmental viability of low carbon development pathways in the energy sector in low-income countries by: • Exploiting renewable energy potential to assist low income countries foster transformational change to low carbon pathways; • Highlighting economic, social and environmental co-benefits of renewable energy programmes; • Helping scale up private sector investments to achieve SREP objectives; • Enabling blended financing from multiple sources to enable scaling up of renewable energy programmes; and • Facilitating knowledge sharing and exchange of international experience and lessons. **Instruments:** Loans and grants	• Activities supported by SREP include financing for renewable energy use and generation, specifically for proven "new" renewable energy technologies. For the purposes of SREP, new renewable energy technologies include solar, wind, bioenergy and geothermal, as well as hydropower with capacities normally not exceeding 10MW per facility. SREP finances the development of an investment plan, and then the implementation of particular renewable energy projects.

Source: Climate Funds Update (www.climatefundsupdate.org)

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