Financial assessment of the technology proposals under the UNFCCC

ECN *Xander van Tilburg, Alessia De Vita, Heleen de Coninck*
E3G *Shane Tomlinson, Pelin Zorlu*

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Energy research Centre of the Netherlands
P.O. Box 1
1755 ZG Petten
The Netherlands
Tel: +31 224 56 49 49
Fax: +31 224 56 83 38

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E3G
4th floor, In Tuition House
210 Borough High Street
London SE1 1JX
United Kingdom
Tel: +44 (0)20 7234 9880
Fax: +44 (0)20 7234 0851

Acknowledgement/Preface

This report has been commissioned and funded by the Nordic Council and has been written by the Energy research Centre of the Netherlands (ECN) and Third Generation Environmentalism (E3G). The authors would like to thank the project steering committee for guidance on this research project and Jos Sijm for his valuable input and comments. The project is registered with ECN under project number 5.0354. The contact person at ECN is Xander van Tilburg (tel: +31 224 56 4863; e-mail: vantilburg@ecn.nl).

Summary

A successful 15th Conference of the Parties (COP15) of the UNFCCC in Copenhagen should be a defining moment for mitigation and adaptation technologies. We know that limiting global average temperature increases below 2°C rise will require a step-change in global innovation and technology transfer. This is essential to avoid high carbon lock-in and move all countries onto a sustainable growth pathway. Copenhagen will be crucial to provide this global framework and ensure both the advancement and transfer of climate technologies.

The Bali Action Plan established a reciprocal relationship between developing country enhanced actions and the provision of finance, technology and capacity support by developed countries. In the process towards COP15, Parties have submitted a large body of proposals, many of which have technology related elements. As a necessary condition for consensus on a technology framework, insight is needed connecting the technology proposals and the necessary financial requirements. This report aims to facilitate such a consensus by providing estimates of the financial requirements of the current technology proposals.

The IPCC has provided a comprehensive definition of technology transfer encompassing a broad set of processes covering the flow of knowledge, experience and equipment across a range of public and private stakeholders. This definition has met with broad agreement with bodies such as the Expert Group on Technology Transfer (EGTT), but what actually constitutes successful technology transfer is subject to controversy. This controversy runs deeper than purely technology-related issues; it concerns perceptions of the climate mitigation and adaptation debate, the technological hegemony of Annex-I countries and level-playing fields, fair competition and free trade, and the role of markets. The controversy has had a paralysing impact on the negotiations on technology transfer in the years running up to Bali. However, action by all the stakeholders since Bali has made significant progress to move beyond the old deadlocks. Leading studies point out that the key technologies will need to be demonstrated and deployed simultaneously in developed and developing countries. In this study, we thus focus on two key aspects of technology transfer: capacity to access a technology and capacity to adopt and use technology in local circumstances.

Developing and delivering the technologies necessary to avoid dangerous climate change will require a shift in global investment. This shift has three components: first, the overall change in public and private investment patterns required to deliver the technologies and infrastructure; second, compensation of the incremental cost of this additional investment over business as usual investments; and third, the financial flows to developing countries required to support their low-carbon development. Making this shift happen requires a balance of ‘push’ and ‘pull’ factors along the innovation chain, with varying levels of public and private finance and policy interventions at different stages of technological development. So although the overall level of investment is expected to mainly be provided by the private sector, this investment will only occur if firms are presented with the right balance of risk and reward. Public expenditure will therefore be critical in key sectors especially areas such as energy research and development (R&D) where public expenditure accounts for over 60% of total investment.

This study has grouped the technology related submissions to the UNFCCC and their financial implications into three concrete technology packages. These packages outline different levels of ambition consistent with the potential outcomes in Copenhagen. The assessment combines a bottom-up cost assessment of the individual elements with a top-down analysis of the necessary financial support. This approach provides a concrete image of what a potential technology framework in Copenhagen may look like. The study then assesses the current proposals in the negotiating text and translates the often abstract concepts into operational actions. In some cases this is straightforward, but ambiguities in the negotiating text imply that in other instances assumptions have had to be made to operationalise the language (these are clearly detailed in the report). Many of the technology proposals cannot exist as stand-alone measures as they are based on progress in other parts of the negotiations. The plausible packages reflect this interdependency in relation to the overall level of ambition for mitigation and financing.

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1.1 Climate change and need for mitigation technology

Limiting global average temperature increases to below 2^{o}C will require a step-change in innovation and the use of low carbon technologies across all sectors. To avoid high carbon lock-in and enable all countries to move onto a sustainable development pathway technology transfer is needed, both to diffuse existing and near market solutions and to invest in advancing technology for the future. The challenge in achieving this is to create the framework and support to allow countries access to the right technologies; and to enable all countries to build the necessary innovative capacity to adapt and use these technologies in their local environments.

1.2 Current climate negotiations and reason for this study

In December 2007, as part of the Bali Road Map, the agenda was set for the climate negotiations leading to COP15 in Copenhagen (UNFCCC, 2007). The Bali Action Plan established a reciprocal relationship between developing country enhanced actions and the provision of finance, technology and capacity support. In the process towards COP15, Parties have submitted a large body of proposals, many of which have technology related elements. The Nordic Council commissioned this work to support the climate negotiations by providing estimates of the financial commitments associated with the various technology proposals.

1.3 Methodology and approach

This study combines a top-down and bottom-up methodology to produce financial estimates for the current technology proposals. The first step consists of assessing the current proposals in the negotiating text and translating these suggestions into operational actions. In some cases this is straightforward, but ambiguities in the negotiating text mean that in other instances assumptions have had to be used to operationalise the language. The definitions and assumptions for the proposals are outlined in detail in Chapter 4.

Many of the technology proposals cannot exist as stand-alone measures as they are based on progress in other parts of the negotiations (e.g. the level of overall mitigation commitments and finance). The proposals have therefore been combined into three different packages corresponding to different levels of ambition in the Copenhagen outcome. The details of the packages are outlined in Chapter 5. Where appropriate the financial analysis in this report will distinguish between the operational costs for each element (the costs associated with establishing and maintaining the initiative) and the programme costs (the flow of programme investments which will be delivered through the initiative).

1.4 Reading guide

The report first lays a foundation by elaborating on technology transfer and an overview of literature on financing and investment flows. Next there will be an analysis of the technology proposals from the negotiating texts. The proposals are analysed and a rough cost assessment is presented, based on additional assumptions where necessary. The final part of the report introduces three scenarios and associated packages of proposed mechanism implementations and their costs.

2. Low carbon technology transfer

2.1 Definition of technology transfer and its implications

The IPCC has the following very broad definition of technology transfer:

> *'Technology Transfer' is defined as the broad set of processes covering the flows of knowledge, experience and equipment amongst different stakeholders such as governments, private sector entities, financial institutions, NGOs and research/educational institutions. The broad and inclusive term 'transfer' encompasses diffusion of technologies and technology cooperation across and within countries. It comprises the process of learning to understand, utilise and replicate the technology, including the capacity to choose it and adapt it to local conditions. (IPCC, 2000).*

It thus covers a range of processes and knowledge flows. Although this definition is widely accepted, for instance in the Expert Group on Technology Transfer in the UNFCCC (EGTT; UNFCCC, 2009a), the rhetoric often reveals a narrower understanding. The most common interpretations are that technology transfer is only about transfer of hardware, comprises only the diffusion of mature technology, and that technology transfer is exclusively a North-South affair. Further 'myths' that lead to a narrow understanding of the concept can be found in box 1. In operationalising the IPCCs definition, it is important to reflect the way that innovation systems operate in the globalised world. The increasing interconnectedness of world markets mean that products and services are often developed and delivered utilising resources across a number of different countries. Thus, while the final assembly of a technology may occur in one country, the design and engineering of that technology may be in another. This interconnected marketplace makes it difficult to precisely define when a technology has been 'transferred' to a country. As such for the purposes of this report we focus on two key aspects of technology transfer: capacity to access a technology and capacity to adopt and use technology in local circumstances.

The capacity to access a technology relates to the availability of the technology (including orphan areas of research), ability to pay, and the creation of enabling market structures and regulations which will facilitate the penetration of new technologies into the market. This would include supporting new business models for disruptive innovation. The capacity to adopt and use technology relates to a countries innovative capacity to adapt technology to use it in local circumstances, provide the knowledge and training to operate and maintain the technology and to build the necessary supporting infrastructure.

Box 1 *Myths on Technology Transfer*

The definition provided by the IPCC is widely accepted; nonetheless, a number of myths on technology transfer still seem to foster a narrower interpretation of the term. Some of the common myths suggest that:

1. Technology transfer is only about transfer of hardware
In reality successful technology transfer is as much about the underlying systems, infrastructure and capacity as the hardware itself e.g. the need to connect renewable energy sources to the local grid and be able to maintain and repair the equipment as necessary.
2. Technology transfer comprises only the diffusion of mature technology
Cooperation around early stage technologies, such as Carbon Capture and Storage (CCS) and Concentrated Solar Power (CSP) has the potential to generate significant knowledge sharing and technology transfer, while accelerating the overall development of the technology.
3. Technology transfer is exclusively a North-South issue
In the modern global economy it is simply not true that all technology will be 'developed' in the North and then 'transferred' to the South. Many developing countries are already actively participating in technology innovation and the production of new technologies. In the future, South-South transfer is also likely to be an important means of diffusing technologies.
4. Technology transfer is only international.
Technology transfer can also happen within a country e.g. from urban to rural areas.
5. Technology transfer only includes the diffusion and not development or demonstration
Development and demonstration to adapt technologies for use in developing country local circumstances will be essential to ensure their effective dissemination. Removing barriers and providing the right enabling environment to spur private sector investment will also be essential.
6. Technology transfer does not include the transfer of knowledge and experience
The 'know-how' and knowledge associated with new technologies are an essential element to technology transfer. Joint-partnerships and licensing agreements can help facilitate this knowledge transfer.
7. Technology transfer is only required for mitigation technologies
Although mitigation technologies will be vital for developing countries it will also be important to ensure the development and transfer of adaptation technologies. Even with aggressive mitigation reductions developing countries will still face some negative climate impacts, and so technologies such as drought resistant crops, water desalination and early warning systems will be essential to manage these changes.
8. Technology transfer is the same everywhere, does not depend on the specific country context
Different countries will require different technologies and capacity to move onto a low carbon development pathway. Thus country specific strategies and planning (e.g. through Technology Needs Assessments or Low Carbon Growth Plans) are important to identify priority areas for support.
9. Technology flows naturally and does not require targeted action
Without the right capacity, financial support and enabling environment developing countries will not be able to move onto a low carbon growth path and could become 'locked in' to high carbon infrastructure.
10. The carbon market alone can deliver technology transfer
Although creating the right market pull conditions will be essential for technology diffusion, the carbon market alone is not enough. Support is also required for capacity building and the development and demonstration of technologies to help them reach a stage in the innovation cycle where the carbon market can drive full commercialisation.

By providing these two capacities all countries should be able to access and use the technologies which are necessary for low carbon development and adaptation, in support of their nationally appropriate mitigation actions (NAMAs) and national adaptation programmes of action (NAPAs). This is also consistent with the implementation of the Bali Action Plan as outlined in Box

2 below. However, we should note that this does not necessarily mean that all countries will fully own, build and operate all relevant technologies.

In the Bali Action Plan, technology became a more central issue in the climate negotiations. The framing of paragraphs 1(b)(ii) and 1(d) (see Box 2 below) establish a reciprocal relationship between developing country enhanced actions and the provision of technology, financing and capacity support. The Bali Action Plan also mandated the EGTT to "identify and analyse existing and potential new financing resources (public and private) and relevant vehicles in supporting the development, deployment, diffusion and transfer of environmentally sound technologies (ESTs) in developing countries". The Conference of the Parties (COP) also requested the EGTT to assess, based on this identification and analysis, gaps and barriers to the use of and access to these financing resources in order to provide information to Parties to enable them to consider the "adequacy and predictability of these resources." (EGTT, 2008).

Box 2 *Technology in the Bali Action Plan*

COP 13 in Bali culminated with the adoption of the Bali Roadmap which consists of a number of decisions on key issues for further negotiation for a secure climate future. The roadmap also includes a two year work plan, also known as the Bali Action Plan (BAP) which sets the course of the new negotiation process. In order to reach an agreed outcome and a decision in Copenhagen, BAP addresses the technology issue in the following articles:

BAP 1b: "Enhanced national/international action on mitigation of climate change, including, inter alia, consideration of:

(ii) Nationally appropriate mitigation actions by developing country Parties in the context of sustainable development, supported and enabled by technology, financing and capacity-building, in a measurable, reportable and verifiable manner".

BAP 1d: "Enhanced action on technology development and transfer to support action on mitigation and adaptation, including, inter alia, consideration of:

(i) Effective mechanisms and enhanced means for the removal of obstacles to, and provision of financial and other incentives for, scaling up of the development and transfer of technology to developing country Parties in order to promote access to affordable environmentally sound technologies;
(ii) Ways to accelerate deployment, diffusion and transfer of affordable environmentally sound technologies;
(iii) Cooperation on research and development of current, new and innovative technology, including win-win solutions;
(iv) The effectiveness of mechanisms and tools for technology cooperation in specific sectors";

BAP 1e: "Enhanced action on the provision of financial resources and investment to support action on mitigation and adaptation and technology cooperation".

2.2 Framing of technology and capacity debate in climate negotiations

The IPCC, EGTT and other UNFCCC documents show broad agreement on what technology transfer means. No stakeholder opposes technology transfer. However, what constitutes successful technology transfer is subject to controversy. The controversy runs deeper than purely technology-related issues; it concerns perceptions of the climate mitigation and adaptation debate, the technological hegemony of Annex-I countries and level-playing fields, fair competition and free trade, and the role of markets (Ockwell *et al*., 2008). The controversy has had a paralysing

impact on the negotiations on technology transfer in the years running up to Bali. A topic under both the SBSTA and the SBI, at none of their meetings agreement was reached on a text representing the state of affairs or providing a actionable forward. Referring it to the EGTT in Bali and documenting the topic with more background studies and work had led to more fact-based discussions and the emergence of concrete and actionable proposals that can count on support from both developed and developing countries.

2.3 Public funding for technology, mitigation and adaptation

Technology will be vital to achieve both mitigation and adaptation, but technology alone is not sufficient. Success in tackling climate change will ultimately depend on both public and private actions to achieve sustainable development. Technology is a tool to help achieve this, but it is not an end in itself.

The overlap between technology, and mitigation and adaptation is a challenge for the negotiations which can lead to an artificial separation of issues. As shown in Figure 2.1 below a large proportion of both mitigation and adaptation actions will be directly realised through technology. For mitigation this includes the use of technology to improve energy efficiency and replace high emission systems in the power, transport, industry and buildings sectors. However, there will be other areas such as reduced emissions from deforestation and degradation (REDD) where technology will not be directly responsible for emissions reductions (although it may still have a role in monitoring and reporting actions etc.). Similarly for adaptation, technologies such as drought resistant crops and water desalination will be directly responsible for increased resilience in some areas, but will not directly impact in others such as capacity building to strengthen national governance.

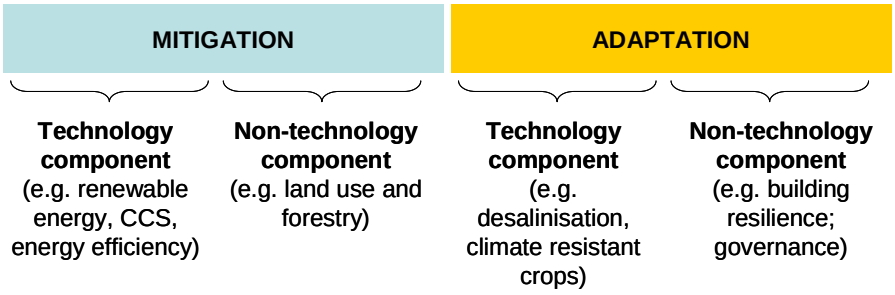

Figure 2.1 *Illustration of technology contribution to mitigation and adaptation*

Action on technology must also balance measures to deploy existing and near-market technologies to meet medium-term objectives, while simultaneously investing in developing the technologies of the future. Current technologies will be inadequate to make the deep emission reductions required by 2050 and so investments must be made now in the next generation of innovations to meet these more challenging goals.

The balance of technology and non-technology mitigation action is flexible and depends on many factors. Work by McKinsey suggests that approximately half of a 19Gt CO_2-eq. reduction by 2020 could be met through REDD and land use change, with the remaining half coming from direct technology measures (McKinsey, 2009). In this document we will focus on the technology component of mitigation and, where possible, adaptation action in the outcomes of a Copenhagen agreement. Many pathways are possible as reflected in the wide range of proposals currently being negotiated. To manage this uncertainty we use a scenario approach assuming different potential political outcomes in Copenhagen, which then underlies the technology packages in chapter 5.

3. Financing mitigation technology

3.1 Introduction

Developing and delivering the technologies necessary to avoid dangerous climate change will require a shift in global investment. This shift has three components: first, the overall change in investment patterns for both public and private spending required to deliver the technologies and infrastructure; second, the incremental cost of this additional investment over business as usual investments; and third, the financial flows to developing countries required to support their low carbon development.

3.2 Total investment flow required

The overall change in investment patterns will need to consider replacing the current capital stock at the end of its economic lifetime with low carbon options (and even early retirement of some of the infrastructure such as inefficient coal power plants) and investments in new capacity to respond to increasing demand.

The IEA technology roadmaps, consistent with a trajectory towards stabilisation at 450 ppm[1], suggest approximately $1 trillion additional investment per year between now and 2050 is needed to develop, demonstrate, deploy and diffuse key 17 technologies globally (IEA, 2008). Although significant, this is a manageable amount and is equivalent to 40% of global infrastructure investment or 1.1% of global GDP. Besides, much of this investment displaces business as usual spending on high-carbon alternatives and so the incremental cost of additional investment is much smaller. If these key technologies are delivered as set out by the roadmaps, they would contribute more than 80% of the required energy-related carbon emissions reductions in 2050. The IEA's roadmaps focus on key energy-related sectors such as buildings, transport, power and industry, yet do not include land use and forestry. It is important to note that the scenarios used are not predictions but are analyses of least-cost pathways to meet the reductions based on a set of technology, carbon and oil price assumptions.

3.3 Incremental cost over business as usual

Transition to low carbon energy and infrastructure entails an incremental cost over business as usual as low carbon technologies are generally more expensive than their incumbents. This incremental cost can relate to both the fixed investment costs (which is common for many power sector technologies) and the difference between the overall cost (including investment cost, operational cost and revenue) as outlined in Box 3 below.

[1] A 450ppm scenario is assumed to be consistent with a 2°C temperature increase compared to pre-industrial levels (IPCC, 2007).

Box 3 *Various ways to look at incremental costs - an example*

The following example presents three alternative ways of looking at incremental costs: Consider a coal fired plant and a wind park, each expecting to have the same productive output. The total (up-front) investments needed for a wind park are higher than for the coal fired plant. The operational costs of the wind park are however lower.

	Coal plant	Wind park	Difference
Investment costs (fixed)	100	300❶	200 ❷
Operational costs (variable)	200	100	-100 ❸
Total costs	300	400	100 ❹

Financial support for the low carbon option could cover either: (1) the *total investment costs* of 300; (2) the *incremental investment costs* of 200 or (4) the *incremental total costs*. The *incremental operational costs* (3), and therefore the incremental total costs are sensitive to various external factors like carbon and oil prices, and policy support. Discussions over what constitutes the 'agreed full incremental cost' are at the heart of the current finance negotiations.

McKinsey estimate that global incremental investment costs, above and beyond business as usual technologies, of approximately $445 bln (€ 317 bln) annually in 2015, rising to $1.14 tr (€ 811 bln) in 2030 are required to keep us on track with a 450 ppm stabilisation target (McKinsey, 2009:42). This, unlike the IEA estimate, includes reductions from land use and forestry.

The incremental total costs[2] are much smaller compared to the incremental investment costs and depend hugely on various assumptions such as cost reduction through technological learning, oil and carbon prices. For example, McKinsey estimates if the oil price rises to $120 per barrel, this would reduce the incremental total costs by $980 bln (€ 700 bln) annually making the incremental total costs over the period very small or even zero (McKinsey. 2009:53).

It is likely that most of the total incremental cost will be covered by the private sector. However, the public sector has to scale-up support in key areas where there are clear market failures. This will be especially important in helping technologies cross the 'valley of death' between demonstration and pre-commercial financing. In addition to direct public financing, other instruments such as standards or building codes would enhance market pull for low carbon options. Depending on the specific technology and circumstances the efficacy of different policy instruments will vary (i.e. subsidies, taxes or regulation) and so a range of measures should be used.

3.4 Flow required to developing countries

In addition to developed countries action, developing countries' emissions need to substantially deviate from baseline projections in a number of key regions (European Commission 2009b). Many least-cost pathway scenarios assume that more than 30% of global abatement between now and 2030 to take place in developing countries. Therefore, if we are to deliver technologies at scale needed to stay below 2°C, developing countries will need significant financial support to decarbonise their key sectors, ensure low carbon development and build resilience to climatic impacts.

[2] See box 3 – McKinsey refers to *incremental total costs* as 'total costs of abatement' (McKinsey, 2009:53)

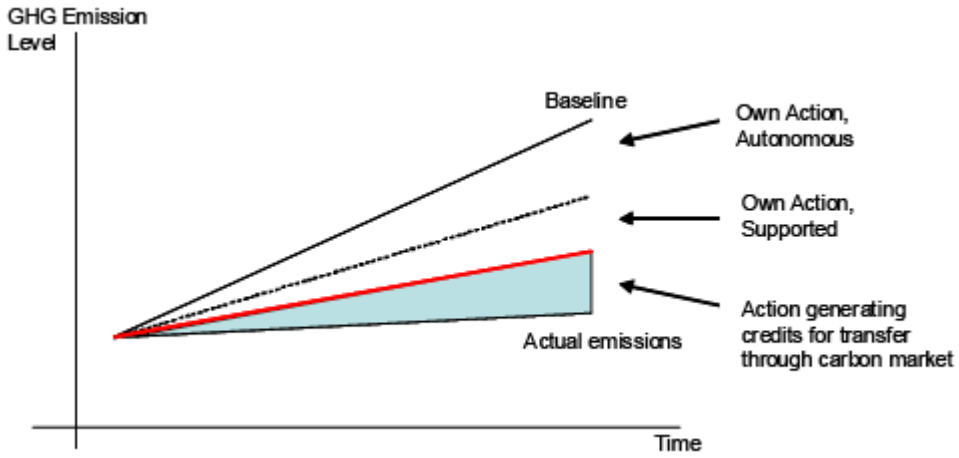

Figure 3.1 *Developing country emissions - source: (European Commission, 2009: p.6)*

The Bali Action Plan clearly establishes a reciprocal relationship between developing countries undertaking enhanced actions, such as NAMAs, to reduce their emissions and developed countries providing finance, technology and capacity-building support. Estimates suggest that emissions reduction of this scale will require financial flows within the range of **$76-111 bln pa (€ 55-80 bln pa)** between 2010 and 2020 to developing countries[3] (Project Catalyst, 2009)**.** Figure 3.1 above shows the relationship between the country's own actions implemented nationally without financial support from developed countries, *own actions supported* by financial flows from developed countries and actions that generate credits through the carbon market.

Funding to developing countries could be through both market-based mechanisms, such as the Clean Development Mechanism; multilateral financing such as the World Bank Climate Investment Funds or a technology fund under UNFCCC; or bilateral financing meeting measurable, reportable and verifiable (MRV) criteria so that it can be 'counted' towards countries meeting their UNFCCC commitments.

3.5 Private and public finance

Successful innovation requires a balance of 'push' and 'pull' factors along the innovation chain, with varying levels of public and private finance and policy interventions at different stages (see Figure 3.2 below). Global overall R&D investment in non-energy sectors is mostly undertaken in the private sector (e.g. pharmaceuticals), and is increasingly international in nature. Energy R&D, on the other hand, is mainly financed by the public sector, estimated at over 60%[4] of total energy R&D investment (Doornbosch, 2006). Therefore although the overall investment is expected to mainly be provided by the private sector, they will only invest to develop, deploy and diffuse these technologies if they are presented with the right balance of risk and reward. Therefore public expenditure, will be critical to deliver this transformation. Much of the 'green' investment up to 2008 was driven by oil price expectations and energy security concerns not climate policy. Private investors in Europe are currently not investing in low carbon transition. Potential policy failure and uncertainty beyond short timescales have a major influence on large institutional and corporate investors.

Therefore, public policy and financing has important implications for low carbon innovation. The critical issue is ensuring the right policy frameworks and incentives are set in place to solve the multiple challenges of climate change, energy security and climate resilience. Given the

[3] Estimates suggest that this is within the range of $87 bln-$133 bln (€ 65-100 bln) annually between 2010 and 2020, and includes both mitigation and adaptation.

[4] The public sector spent $9 bln in 2004 on energy R&D, whilst private industry spent $4.5 billion in 2003.

scale of private sector contribution in overall R&D, governments should seek to leverage the power of private markets to help solve the climate innovation challenges. Action is therefore required to create markets for innovation and diffusion that work in a globalised world. This will require among others the implementation of practical and collaborative technology policies both nationally and internationally. Direct public financing is also critical for capturing the public good nature of R&D and for overcoming market failures particularly in key sectors (e.g. buildings), alongside new technologies' demonstration and early-deployment stages, and 'orphan' areas of research and development. The overall goal must be to aggressively deploy the existing tried and tested technological options that can deliver mid-term reductions, and to prepare for the long-term development of game-changing technologies.

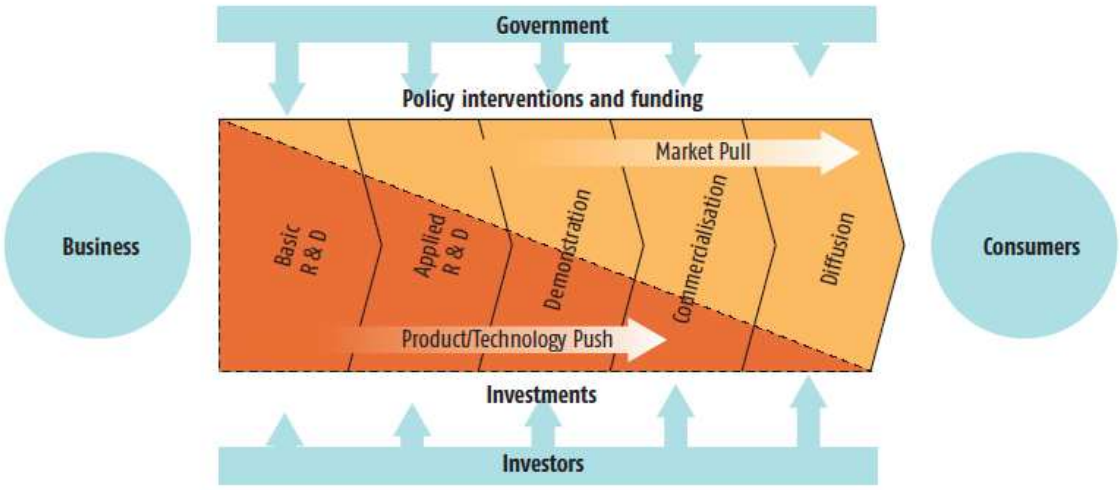

Figure 3.2 *Innovation Chain (Stern 2006)*

In order to mobilise private investments, a combination of public finance instruments such as soft loans and subsidies could provide the additional investment support for developing, deploying and diffusing technologies (UNEP, 2008a) as well as encouraging new disruptive business models. Financial markets would play an essential role in providing the capital needed to the private investors. However, given the current recession underway, a public finance service or public venture capital can be an effective policy instrument in the absence of well functioning capital markets.

4. Technology proposals

4.1 Advancing and enabling technology

As noted in the innovation chain diagram above (see Figure 3.2) there is a distinction between action to increase research, development and demonstration of new technologies, and action to enhance diffusion and dissemination of technologies once they are near to market. Balanced support for both areas is necessary to successfully enhance technology transfer. We therefore consider packages of proposals which both directly advance technology down the innovation chain, and those which build capacity and enabling conditions to facilitate wider action.

Furthermore, it is critical to ensure international technology action covers both mitigation and adaptation. The risk of sidelining 'orphan' areas of research especially on areas related to adaptation in developing countries needs to be addressed by the cooperative actions. Most of the proposals outlined below address both adaptation and mitigation technology needs including: national and regional innovation centres, capacity building, information sharing and R&D cooperation. In some proposals it will be important to ensure there is an explicit adaptation component, for example global technology roadmaps and action plans should each have an explicit mitigation and adaptation focus.

4.2 Operating costs and programme costs

This report distinguishes between *operating costs* needed to set up a mechanism or initiative and the *programme costs* which depend on the execution of programmes which in turn mobilise investments. For example a technology demonstration facility may cost $1mln per annum in operating costs to establish and run the facility and another $10 mln in programme costs which could mobilise $100 mln in additional investments from the private sector. In practice it is often hard to make a clear cut distinction between the two types of costs.

4.3 Proposals: description and cost assessment

The revised negotiating[5] text includes a number of technology related proposals, often with a high degree of ambiguity and overlapping language. In order to provide a detailed and exhaustive yet focused analysis, 10 key proposals have been chosen for the cost assessment (Figure 4.1 below). Therefore, this section provides short descriptions of the proposals and where possible reference to literature in order to provide clarity and a basis to evaluate the submission texts. It assesses the options for each proposal as laid out in the revised negotiating text and refers to the consolidated paragraphs[6]. The basic assumptions of the bottom up cost assessment and the expected outcomes are explained in the operational proposal section.

[5] In the following when referring to the negotiating text we refer to document UNFCCC, 2009b and when referring to the revised negotiating we refer to document UNFCCC, 2009c.

[6] Consolidated paragraphs by the Facilitator based on the revised Negotiating Text (UNFCCC, 2009c), B. Enhanced action on development and transfer of technology (Paragraphs 180-198) 13 August 2009.

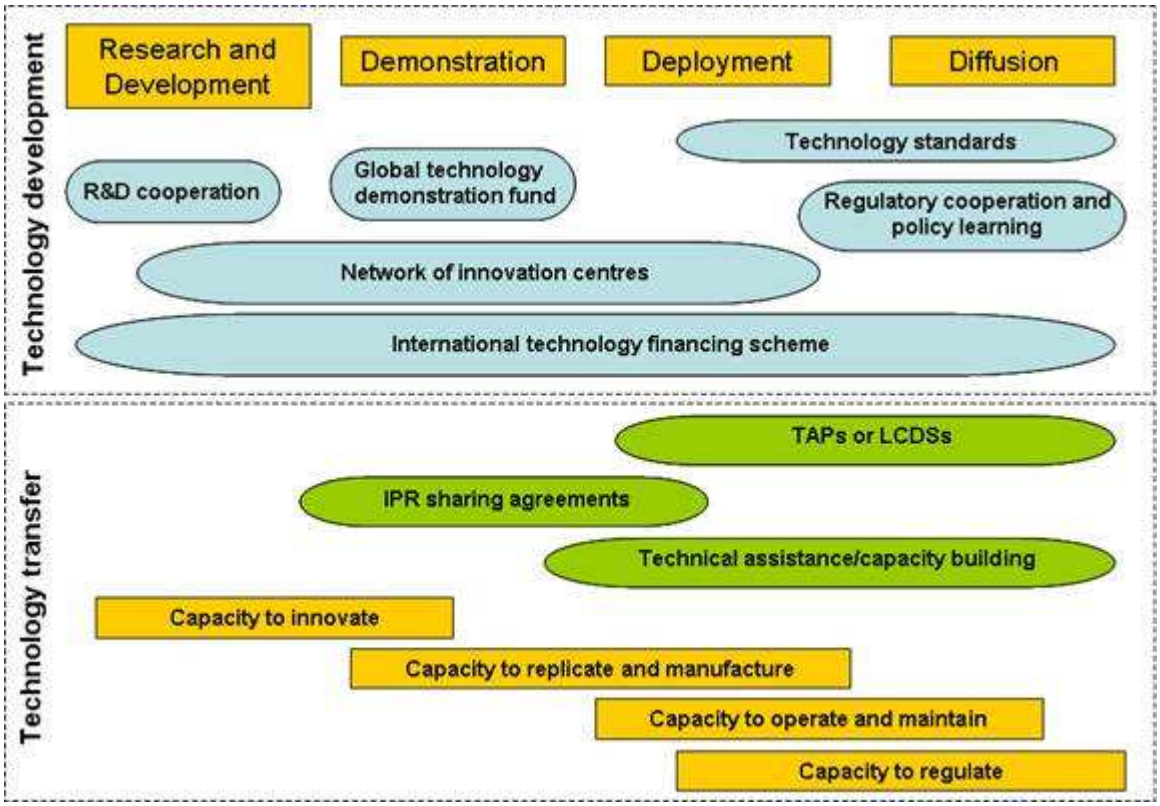

Figure 4.1 *Technology Proposals in the LCA negotiating text*

Enabling environments (Para 184)
According to the IPCC, enabling environments include "national institutions for technology innovation, involvement of social organisations, human and institutional capacities for selecting and managing technologies, macro-economic frameworks, underpinnings of sustainable markets for environmentally sound technologies (EST), institutions to reduce risks and protect intellectual property rights (IPR), codes and standards, research and technology development, means for addressing equity issues and respecting existing property rights" (IPCC, 2000).

Similarly, UNFCCC COP 7 Decision 4 suggests that "the enabling environments component of the framework focuses on government actions, such as fair trade policies, removal of technical, legal and administrative barriers to technology transfer, sound economic policy, regulatory frameworks and transparency, all of which create an environment conducive to private and public sector technology transfer" (4/CP.7, para. 12).

Negotiating text proposal
In the current negotiating text there is consensus that enabling environments are a key factor for the development and transfer of climate technologies. The non-paper 29 (UNFCCC, 2009d), within the context of enabling environments emphasises that technology-specific policies and measures should be implemented in order to "create the conditions conducive to private- and public-sector technology development, deployment, transfer and diffusion…" (para.19). These should "address barriers to technology development, deployment and diffusion, and the transfer of technologies for mitigation and adaptation" (para. 19).

Operational proposal
Enabling environments are thus expected to be the surroundings in which successful and efficient technology transfer might occur. A variety of policy and financial instruments could be

employed to strengthen enabling environments in developing countries[7]. Developed countries could provide policy support to developing countries on climate policy, energy efficiency standards and labelling, improving energy subsidy frameworks and set up a financial innovation support facility. Supportive financial instruments could include SME finance facility, risk mitigation facility, LDC credit facility for climate infrastructure, end-user finance facility, carbon finance facility, and incentive facility for first movers in industry.

Technology-related capacity building (Para 184)
Capacity building is an essential for the construction of an enabling environment (IPCC, 2000). As can be derived from the proposals and descriptions from literature, capacity building encompasses a wide range of activities related to an increment in knowledge.

COP7 decisions define capacity building as:
"…a process which seeks to build, develop, strengthen, enhance and improve existing scientific and technical skills, capabilities and institutions in Parties other than developed country Parties, and other developed Parties not included in Annex II, particularly developing country Parties, to enable them to assess, adapt, manage and develop environmentally sound technologies" (4/CP.7, para. 15).

Similarly, Neuhoff *et al*. (2009) summarise it and its underlying building blocks as:
1. The capacity to operate and maintain
   - Innovation centres
   - Technical assistance/capacity building
2. The capacity to adopt and replicate
   - R&D cooperation
   - Innovation centres
3. The capacity to innovate
   - R&D cooperation
   - IPR sharing agreements or royalty fund
   - Innovation centres
4. The capacity to regulate
   - Technical assistance/capacity building
   - Technology standards
   - Regulatory cooperation and policy learning

Depending on the level of development in a given country, capacity building may require a start from scratch or only additional support for reforming/focusing or strengthening the existing capacity (IPCC, 2000). In less developed countries with a low level of technological and institutional capacity, initially capacity building activities are more likely to focus on the capacity to operate and maintain.

Negotiating text proposal
As with enabling environments, within the negotiations there is consensus on the fact that technology related capacity building is essential in order to enhance development, deployment and diffusion of climate technologies. In non-paper 29 (UNFCCC 2009d) it is stated that "capacity building activities should contribute to the establishment and strengthening of enabling environments and accelerated technology development, deployment and diffusion in developing countries" (para. 20).

It also points out, in accordance with COP7 decisions, that capacity building related activities should be "…taking into account the various activities completed or under way on a bilateral or multilateral basis" (para. 20).

[7] The key components of the' enabling environments' cost assessment draw from UNEP submission to UNFCCC (UNEP, 2008b).

Clearly, capacity-building encompass various other proposals such as TNAs, national technology roadmaps, technology information sharing. More specifically, a programme for capacity-building for accelerated technology development, deployment and diffusion in developing countries has been proposed (para 184.2, Annex III (UNFCCC, 2009d)). This would include advice and technical assistance to developing countries on development and implementation of relevant policies, institutional and regulatory frameworks, support for enhancing public private partnerships, identification of barriers and improving access to information.

Operational proposal

Technology related capacity building aims to provide substantial amount of technical and advisory support to developing countries. This crucial function has been integrated into most of the proposals such as network of national/regional innovation centres, cooperative RD&D, enabling environments and technology information platform. Therefore, our cost assessment in this section is limited to the establishment of international academic exchange programmes, including undergraduate and PhD exchanges and visiting lecture/ fellowships. These would help build capacity in developing countries and strengthen innovation/knowledge networks between developed and developing country institutions.

Technology information (Para 194, 195)

UNFCCC notes that the technology information component of the UNFCCC framework could provide information on technical parameters, economic and environmental aspects of environmentally sound technologies and the identified technology needs of Parties not included in Annex II, particularly developing country Parties, as well as information on the availability of environmentally sound technologies from developed countries and opportunities for technology transfer (TT:CLEAR).

Negotiating text proposal

Among the Parties, there is convergence on the idea of developing a technology information sharing platform for both mitigation and adaptation. This would build on the existing technology information platforms, which would be strengthened and linked together. Key matter of divergence seems to be on whether information on IPR and licensing would be included in this platform.

Operational proposal

A technology information platform could consist of a database collecting information on sector-specific technologies, best practice dissemination both in the public and private sector, costs of technologies, barriers and manufacturers of technologies. Our analysis assesses the cost of establishing such an open-access database with a strong assumption that there are no legal barriers in providing such information.

Technology roadmaps (Para 181, 184, 185)

Technology roadmaps would provide a pathway for technology development and can operate at the global, regional and national level. There are already a number of climate technology roadmaps available both at the national and international level, such as Japan's Cool Earth programme (Top Runner Programme 2008) and IEA's energy technology roadmaps (IEA 2008).

Negotiating text proposal

The revised text includes proposals for technology roadmaps both at the national and global levels. Despite substantial amount of overlap in the revised text, there is still significant divergence between parties on how detailed roadmaps will be and which specific technologies should be covered within them.

Operational proposal

National technology roadmaps are very important in refining the technology objectives and the means to achieve the desired outcomes. Regional and national technology roadmaps could link with technology needs assessments and low carbon growth plans to help countries transition onto a sustainable growth pathway. Therefore, our cost estimate focuses on the preparation of the technology roadmaps at the global level. Global technology roadmaps would set out the overall trajectory for technology development and deployment and identify key milestones and areas for international cooperation. These would identify the current state of the technology, relevant key stakeholders, and the gaps between current efforts and required level of commercialisation/diffusion of the technologies within a given timeframe.

Technology action plan (Para 181, x1):

A Technology Action Plan (TAP) can be conceptualised as a planning instrument for technology development and diffusion. A TAP or a series of prioritised TAPs for key technologies would identify barriers and propose specific measures to accelerate R&D, deployment and diffusion of both adaptation and mitigation technologies. These would include international cooperation for market development, global demonstration programmes and support for orphan areas of research.

Negotiating text proposal

A TAP would develop an effective strategy to identify and propose specific measures to overcome the economic and technical barriers and to assess the required steps to accelerate research, development and transfer of environmentally sound technologies for both mitigation and adaptation. There is a high level of similarity between different TAP options in the revised negotiating text. However, there is substantive divergence around whether TAP should be linked to financial resources for its implementation and any institutional arrangements.

Operational proposal

The TAP would build on existing or emerging work of relevant institutions such as global technology roadmaps and work collaboratively with them to avoid duplication. A number of institutions both inside and outside the UNFCCC could be tasked with developing TAP or multiple TAPs, including a new technology institution under the UNFCCC, the Major Economies Forum (MEF). In our analysis the delivery of national level TAPs are covered through the Technology Needs Assessment (TNA) and Low Carbon Growth Plan (LCGP) process. The delivery of global TAPs is covered through the Global Technology Roadmap process which is assumed that it would draw from the TAPs already being developed by the MEF.

Technology needs assessments (Para 184)

Technology Needs Assessments (TNAs) are a set of country-driven activities that identify and determine the mitigation and adaptation technology priorities of Parties, particularly developing country Parties. They also may identify regulatory options and develop fiscal and financial incentives and capacity building following consultation with stakeholders within the country. These assessments then can form the basis for a portfolio of adaptation and mitigation technology projects and programmes, which would help those countries access technologies and know-how for implementation. Currently, 70 countries have completed their TNAs with a varying degree of coherence and detail for implementation.

Negotiating text proposal

The LCA consolidated text points out two distinct options regarding TNAs: one which would see TNAs as a separate process and one which links them or combines them with other national planning processes such as NAMAs and NAPAs and national low carbon growth strategies/plans.

Operational proposal

All proposals call for efforts on TNAs to be enhanced. Additional capacity building support will be necessary if all countries are to successfully complete TNAs. In the immediate term, financial support is needed to complete remaining developing country TNAs. These could be linked to national low carbon growth strategies/plans, NAMAs and NAPAs to ensure coherency at the priority setting and implementation stages. However, whether TNAs would be linked to other processes or will constitute a stand alone process would have a cost implication. Our cost assessment assumes that an integrated TNA as a component of Low Carbon Growth Plan (LCGP) process would be the best option but also more expensive compared to a stand alone TNA.

Cooperative R&D and demonstration (para 186)

International R&D cooperation on key technologies is essential in increasing the speed and scale of innovation within given timeframe we need to act. Cooperation particularly in high risk/cost technology areas where a single country would not be willing to bear all risks would also reduce the cost of innovation while capturing its global public good aspect.

International cooperation for demonstrating key technologies at scale would help overcome the potential 'valley of death' as otherwise they might remain under-funded and never reach the market (UNFCCC, 2009a). As demonstration phase requires large amount of financing and usually involves high risk investment, cooperation between countries and public-private partnerships would reshape the risk and opportunity landscape.

Negotiating text proposal

Parties agree that a substantial increase of private and public energy-related RD&D is needed. More specifically, public energy RD&D is suggested to double by 2012 and increasing it to four times its current level by 2020. In addition to that, enhanced North-South, South-South and triangular cooperation is considered a priority area. However, it is not clear whether all countries or only developed countries should scale up their national efforts, what would be the key areas for joint RD&D between developed and developing countries, and how these activities would be financed. There are several proposals as means of cooperative R&D, such as innovation centres (see below), joint R&D programmes, twinning arrangements, joint ventures, large scale demonstration projects, technology deployment projects, cooperation framed around specific sectors and gases and also aspects more related to adaptation such as cooperation on climate observation and warning systems for enhancing resilience.

It is well-understood that large amounts of capital would be needed to develop, demonstrate and deploy key technologies. In the party submissions several funds (Multilateral Clean Technology Fund-MCTF, Clean Technology Fund under the World Climate Change Fund- WCCF) are mentioned.

Operational proposal

Cooperative efforts on RD&D could deliver two main functions: capacity building to help developing countries' own innovation systems and establishing innovation and knowledge sharing networks between countries. This is assumed to be delivered through a global partnership of existing R&D institutions in developed and developing countries. Cooperative efforts should focus on a portfolio of key technologies determined by the global technology roadmap. We assume that this would be built on a similar model to the Consultative Group for International Agricultural Research (CGIAR). This would not replace but rather complement other existing national, bilateral or multilateral R&D and demonstration initiatives. Joint projects on R&D, demonstration and early deployment would require international coordination support and programme support which forms the basis of our cost assessment.

Voluntary technology agreements (para. 192-193)

Voluntary agreements assume "self-regulation which is voluntary in character, that involves stakeholders of which at least one is the State that is either a substitute or that is a device for

implementing or going beyond environmental law and policy, and that is aimed at sustainable development" (Bizer, 1999).

Many major international agreements under the UN and its agencies such as the Rio Declaration and the Montreal Protocol have articles addressing technology transfer. Further agreements such as the Climate Technology Initiative (CTI) developed by the IEA which is voluntary in nature includes "setting up national advice and technological development plans, offering prizes for technological development, enhancing markets for emerging technologies and promoting collaboration between states on technology research and development" (IPCC, 2000). The Implementing Agreements under the IEA are further examples of voluntary agreements.

Negotiating text proposal

The revised negotiating text refers to voluntary technology agreements as partnerships within or outside the convention and could include the private sector civil society and governments at all levels. Furthermore, they could consider R&D, large-scale demonstration projects, technology deployment projects, cooperation on specific sectors or gases, and cooperation on climate observation and warning systems for enhancing resilience.

Operational proposal

Since many elements of voluntary technology agreements proposal are already reflected in other proposals and also due to their voluntary nature, we suggest these agreements would constitute a memorandum of understanding between interested parties. Therefore, they would not incur direct cost; governments will conclude these agreements using their bureaucratic resources and would allocate programmes financing at their discretion if an agreement is done.

Incentive mechanism/matchmaking body for technology transfer (Para x1, 190, 191)

In order to promote financing for the diffusion and transfer of already existing technologies in developing countries, various national and international incentive mechanisms have been developed. For example GATS (The General Agreement on Trade in Services) which is originally a treaty of the World Trade Organization (WTO) runs a financial matchmaking service through its Secretariat. At the national level, the UK government has established the UK Trade & Investment (UKTI) programme that helps UK-based companies succeed in an increasingly global economy by providing them with knowledge, advice and practical support.

Negotiating text proposal

There is agreement among parties that an incentive or matchmaking mechanism and a technology leveraging service are needed. Yet there seem three distinct proposals on how to achieve this[8]:

- A new technology leveraging service which would provide an interactive facilitation service for actions defined in NAMAs, NAPAs and TNAs.
- Domestic regulation which would incentivise technology transfer (such as tax exemption and export subsidies).
- Programme spending bilaterally/ multilaterally**.**

Operational proposal

Given the second and third options would not necessarily need to take place within UNFCCC, our cost analysis focuses on the first option. This assumes the establishment of a body under UNFCCC with a brokering role between developing countries, private sector and public funds (including a technology fund under UNFCCC). This matchmaking body would base its activities on developing country NAMAs and LCGPs, and focus on key sectors initially.

[8] One of the proposals on setting voluntary quantifiable emissions reduction and allocating AAUs for trading purposes has been left out of the options we considered as it doesn't comply with the existing target setting/trading architecture

National and regional technology innovation centres (Para 197, 198)
Global innovation landscape is a diverse but extremely fragmented, especially when faced with the immense challenge of increasing the scale and speed of innovation at unprecedented rates. One of the main barriers to optimal innovation is that it is largely dealt with at the national level and tends to be viewed as an extension of R&D policy (OECD 2005). Therefore, action is needed at the multilateral level to build on national efforts and address cross-border issues of risk management and networks of innovation. These would not replace existing institutions but rather aim to provide better coordination at the global level, strengthen access to information, advice and partnerships, coordinated and well-targeted use of public money for nationally appropriate targets under global objectives, leveraging private capital and urge the creation of a stronger push and pull for climate technologies.

Various similar structures already exist including the Carbon Trust proposed Low Carbon Technology Innovation and Diffusion Centers. The latter mainly focuses on near-market or existing solutions. The proposed network initially consists of "five national Low Carbon Technology Innovation and Diffusion Centers in archetypical locations, structured to suit local conditions, supported by a secretariat that maintains a global perspective, monitors progress for the Centers and ensures knowledge transfer. A range of activities, shaped by the characteristics of the host country and appropriate to different stages of the technology and market cost curve, could be utilised by the Centers".

Negotiating text proposal
There is a general consensus between Parties on the need for a network of innovation centres to support technology development and transfer. However, there is significant divergence on how these centres might be structured and operate. One option is for a network which would focus on knowledge sharing, capacity building to enterprise creation and incubator services, partly funded by mobilising private and public capital rather than directly undertaking RD&D within the network. The latter would need to be reflected in its design. Another option would be to have a RD&D focused network of innovation centres. These would have regional centres with specific research topics and could have programmes running additionally to their basic research. The research topics could be complementary and a secretariat could provide overall coordination between regions.

Operational proposal
Our cost assessment assumed two different models of network of innovation centres: In the first model, the network represents an umbrella partnership of existing institutions with a focus on information sharing and limited capacity building. This would consist of 4 international technology cooperation centres and 10 cooperative implementation centres located in developing countries. In the second model, the network of innovation centres focuses on near-market and existing technologies. The proposed network consists of, initially, five national or regional centers and is supported by a secretariat that maintains global coordination. It provides support on enterprise creation and incubator services; funded mainly by public sector, it mobilises private capital. Also, technology-related capacity building will be delivered through an extended arm of regional hubs within the network. Similarly, the programme costs would widely differ depending on the projects and their geographical extent. Our cost estimate varies under different technology packages in Section 5, reflecting different possible outcomes in Copenhagen.

Institutional arrangements, including funds (Para 196)
Technology discussions under UNFCCC are currently held in a fragmented landscape consisting of SBI, SBSTA, AWG-LCA and AWG-KP. In addition to these, the Convention's financial mechanism has limited provisions through the Special Climate Change Fund (SCCF) for technology transfer and capacity building, and through its flexible mechanism CDM. The importance of technology as a building block requires a dedicated platform where overall objectives can be set and progress evaluated. Similar structures exist within other multilateral agreements

such as the Multilateral Fund Secretariat of the Montreal Protocol and within global public-private partnerships such as the Global Fund for HIV/AIDS, TB, and Malaria.

Negotiating text proposal

There is an emerging consensus on the need for a body to oversee the overall implementation of future technology action. However, there is significant divergence on the functions and institutional arrangement which this body would have.

Operational proposal

A spectrum of options exist for the institutional arrangements ranging from the use of an enhanced Experts Group on Technology Transfer, a new executive body within the UNFCCC or the use of an external agency such as the World Bank. The functions of the body also vary significantly from a solely advisory role to a more enhanced facilitative or executive role. The proposed institutional arrangement consists of the establishment of a new professional body under UNFCCC. However, regardless of the agreed structure, the functions and the mandate of the new body should be clearly communicated. This body would produce or commission TAP or/and roadmaps, assess progress for implementation, MRV actions and contributions, support countries with their TNAs and NAMAs. As most of these functions have already been covered in other proposals, our analysis in this section focuses on the cost of administering such a body and its associated supporting panels. The Executive body would also promote knowledge sharing arrangements as part of public-private partnerships, review potential IPR barriers and help coordinate increased technology information in an integrated approach with the technology roadmaps. Under the most ambitious technology package in Section 5, a dedicated Technology Financing Facility would also be established under the UNFCCC. The Facility would have two windows, one for research, development and demonstration and one for diffusion.

5. Technology packages

5.1 Introduction

To analyse the cost implications of different technology outcomes in Copenhagen we have developed three technology packages in relation to the level of ambition, and strength of mechanisms which could be agreed.

5.2 Technology packages

The technology packages only relate to the technology specific components of the agreement. As noted previously, there is a significant overlap between achieving adaptation and mitigation outcomes and the diffusion of existing and near market technologies. We have therefore assumed that the majority of this action will be covered through the general mitigation and adaptation mechanisms an agreement, rather than the specific technology component. These packages therefore only relate to the specific technology parts of the Copenhagen outcome with a focus on elements such as strategic planning, RD&D for new technologies, information sharing, technology capacity building, and the creation of enabling environments.

In all of the packages we assume that the agreement in Copenhagen follows an 'inside-outside' approach; with some support being directly provided through instruments under the control of the UNFCCC, and some public support being provided outside through bilateral and other multilateral mechanisms and then 'counted' back in through MRV criteria. This is reflected in the different levels of ambition for the packages with lower ambition requiring more action outside the UNFCCC.

Technology Package 1 - Low Ambition
The low ambition package can for example be consistent with a situation where Annex I countries set an overall target of a 10% reduction below 1990 by 2020 and non-Annex I would agree on a 5-10% deviation below business as usual (BAU). Parties agree to a long term vision of a 50% global reductions by 2050 but without a review in 2015. Financial pledges for mitigation support in developing countries are around $10 bln per annum.

Action and support for technology is based on a non-binding 'pledge and review' system which results in countries putting forward individual NAMA proposals, rather than integrated low carbon growth strategies. To assist developing countries in achieving this, financial support (limited to an average of $50,000 per country) is provided to undertake Technology Needs Assessments (TNAs). A technology information platform is established, primarily consisting of a database and website, to facilitate understanding of available technologies. A global technology roadmap is commissioned to set out pathways for key technologies but this is not linked to a review mechanism to track progress.

The Experts Group on Technology Transfer (EGTT) continues in its current form. A technology 'match-making' facility is established under the UNFCCC to match technology NAMAs with support. However, it is assumed that the key mechanisms for delivering this support are largely located outside of the UNFCCC. A network of innovation centres is created, building on existing institutions. This aims to establish 4 technology cooperation centres and 10 implementation centres in developing countries. The primary role of these centres is to provide limited capacity building support and to facilitate the creation and implementation of voluntary technology oriented agreements. An international academic exchange programme is also established to share knowledge and build capacity in developing countries.

Technology Package 2 - Moderate Ambition
The moderate ambition package can, for example, be consistent with a situation where Annex I countries set an overall target of a 20% reduction below 1990 by 2020 while non-Annex I agree on a 10%-15%deviation below BAU. Parties agree to a long term vision of a 60% global reductions by 2050, with a review in 2015 linked to a 2°C target. Agreement is built on strong legal basis; strong MRV and monitoring mechanisms with public transparency are established. Limits on trading emphasise the need for domestic transformation despite lower levels of targets and finance. Good design of implementation and automatic funding mechanisms gives a firm foundation to strengthen commitments on mitigation and finance in the next five years despite initial lower ambition. Financial pledges for mitigation support in developing countries are around $60 bln per annum.

A new technology executive body under UNFCCC is established to be responsible for commissioning global technology roadmaps, reviewing progress and reporting back to COP. The Executive body would also promote knowledge sharing arrangements as part of public-private partnerships, review potential IPR barriers and help coordinate increased technology information in an integrated approach with the technology roadmaps. The roadmaps would be linked to Technology Action Programmes using the current plans being developed in the Major Economies Forum (MEF) as a starting point.

Developing countries agree to put forward overall low carbon growth plans. To assist with the technology component of these plans, additional financial support at an average of $200-500,000 per developing country is provided. This enables the low carbon growth plans to include an analysis of national roadmaps for technology and the identification of transformational 'leapfrog' technologies to support their long-term decarbonisation. A technology 'match-making' body (which could be part of a wider match-making service) is established to link actions with support. However, we still envisage that the majority of this support will be provided outside of the UNFCCC.

A network of regional innovation centres is established with an increased remit and funding to both provide incubator services for new technologies and to set the agenda for technology related capacity building support working with other organisations (such as the regional development banks). A cooperative technology research, development and demonstration platform is agreed, building on the model from the Consultative Group for International Agricultural Research (CGIAR). This platform has a dedicated programme budget to undertake RD&D activities linked to the global technology roadmaps and country low carbon growth plans.

Dedicated support is also provided to build enabling regulatory environments in developing countries and to build capacity to adapt and use technologies in local circumstances. An international academic exchange programme is also established to share knowledge and build capacity in developing countries.

Technology Package 3 - High Ambition
This package would add considerable ambition to current domestic mitigation commitments, and lay a firm foundation of institutions for moving forward towards a 2ºC regime.

The high ambition package can, for example, be consistent with a situation where Annex I countries set an overall target of 25%-30% reductions below 1990 by 2020 and non-Annex I countries agree on a 15-30% deviation below business as usual. Parties agree to a long term vision of a 60% global reduction by 2050, with a review in 2015. This is accompanied by ambitious forestry and technology development goals. Financial pledges for mitigation support in developing countries are around $100 bln per annum.

The High Ambition package has the same elements as in the foundation scenario but with the addition of a dedicated Technology Financing Facility under the UNFCCC. We assume that this facility would follow a similar model to the Global Fund for HIV/AIDS, Malaria and TB. The Facility would have two windows, one for research, development and demonstration and one for diffusion (the diffusion window is assumed to be related directly to the mitigation financing and so is not explicitly modelled here). The Facility is linked to the match-making body to provide a joined-up support system under the UNFCCC.

In addition to the Technology Financing Facility this scenario also has scaled-up programme support for the regional innovation centres, cooperative RD&D platform and capacity building which reflects the overall higher level of ambition in this scenario. This includes a specific commitment by developed countries to double public RD&D support by 2012 and quadruple such support by 2020 with a 10% share being reserved for international cooperation with developing countries.

5.3 Investments and costs

Cost estimates are provided within a 5 year window to reflect the fact that programmes have a multi-year scope and to smooth expenditure estimates from the initial scale-up phase. We have not explicitly modelled the time profile of expenditure for each component but it is envisaged that this would be lower in the initial years, owing to limited absorption capacity, and increase over time. Specific elements which have a shorter time profile (e.g. completion of technology needs assessments) are noted in the individual tables. The overall time horizon for the implementation of the packages, is expected to be 2012-2017 with possible extensions thereafter.

Technology Package 1 - Low Ambition

Key assumptions for overall level of mitigation and financing ambition:

- Annex 1 countries agree to an overall 2020 target of a 10% reduction below 1990 levels.
- Non-Annex 1 countries agree to a 5-10% deviation below business as usual by 2020.
- Long-term (LT) vision of 50% global reductions by 2050, but no automatic review of this target.
- Financial pledges for mitigation support in developing countries of $10 bln per annum.

Table 5.1 *Costs of the low ambition technology package [mln. USD over five year]*

LOW AMBITION TECHNOLOGY PACKAGE	**Operational cost**	**Additional programme support**	**Total**
Technology needs assessments (TNAs): as a separate process from developing country low carbon growth plans, NAMAs and NAPAs, all NAI countries will receive financial support (50 k per country) to complete/strengthen their TNAs.	7.5 (delivered over 1-2 years prior to 2012)	N/A	7,5
Technology information platform consists of a database collecting information on sector-specific technologies, best practice dissemination both in the public and private sector, costs of technologies, barriers and manufacturers of technologies.	16	N/A	16
Global technology roadmap would set out the overall trajectory for key technologies' development and deployment and identify milestones and areas for international cooperation. This assumes 20 full-time staff will be working on this throughout two years, and that most underlying data is already available.	4.4 (over 1-2 years prior to 2012)	N/A	4,4
Matchmaking body for technology transfer consists of a new technology matchmaking service under UNFCCC which would provide an interactive facilitation service for private sector, governments, and multilateral financial institutions in order to deliver actions defined in NAMAs, NAPAs and TNAs.	31-41	N/A	31-41
Network of innovation centres represents an umbrella partnership of existing institutions with a focus on information sharing and limited capacity building. This would consist of 4 international technology cooperation centres and 10 cooperative implementation centres.	100	100	200
International academic exchange programmes, including undergraduate and PhD exchanges and visiting lecture/fellowships are also assumed to be a part of technology related capacity building.		500	500
Total over 5 years	**159-169 mln.**	**600 mln.**	**759-769 mln.**
Total per annum	**32-34 mln.**	**120 mln.**	**152-154 mln.**

Technology Package 2 - Moderate Ambition

Key assumptions for overall level of mitigation and financing ambition:

- Annex 1 countries agree to an overall 2020 target of a 20% reduction below 1990 levels.
- Non-Annex 1 countries agree to a 10-15% deviation below business as usual by 2020.
- LT vision of 60% global reductions by 2050, reviewing in 2015 linked to a 2^{o}C target.
- Financial pledges for mitigation support in developing countries of $60 bln per annum.

Table 5.2 *Costs of the moderate ambition technology package [mln. USD over five year]*

MODERATE TECHNOLOGY PACKAGE	**Operational cost**	**Additional programme support**	**Total**
New technology executive body under UNFCCC is established and responsible for commissioning global technology roadmaps, review progress and report back to COP. It is run by a centralised secretariat of 30 staff.	34	N/A	34
Technology component of low carbon growth plan are assumed to be prepared as a part of a single overall process in which developing countries will produce low carbon growth plans, NAMAs and NAPAs. All NAI countries will receive additional financial support (USD 200-500 k per country) to support the technology component of the plans.	29-76 (2-5 years)	N/A	29-76
Technology information platform consists of a database collecting information on sector-specific technologies, best practice dissemination both in the public and private sector, costs of technologies, barriers and manufacturers of technologies.	16	N/A	16
Global technology roadmap would set out the overall trajectory for key technologies' development and deployment and identify milestones and areas for international cooperation. This assumes 20 full-time staff will be working on this throughout two years, and that most underlying data is already available.	4.4 (1-2 years prior to 2012)	N/A	4,4
Matchmaking body for technology transfer consists of a new technology matchmaking service under UNFCCC which would provide an interactive facilitation service for private sector, governments, and multilateral financial institutions in order to deliver actions defined in NAMAs, NAPAs and TNAs.	31-41	N/A	31-41
Network of innovation centres is assumed to focus on near-market and existing technologies. The proposed network consists of, initially, five national or regional centers and supported by a secretariat that maintains global coordination. It provides support on enterprise creation and incubator services; funded mainly by public sector, it mobilises private capital. It also delivers technology-related capacity building through regional hubs in Asia, Africa, Latin America and the Middle East.	170	931	1.100
Cooperative R&D and demonstration is assumed to be delivered through a global partnership of existing R&D institutions in developed and developing countries. This partnership would focus on a portfolio of key technologies to be developed, demonstrated and deployed within a given timeframe. Public-private partnerships would also be encouraged, especially in demonstration and early-deployment stages. Overall 300 staff would run the partnership, ensure knowledge sharing and measure progress.	124	2.500	2.624
Enabling environments component draws from a UNEP submission and includes a variety of policy and financial instruments to strengthen enabling environments in developing countries. Policy support include financial innovation support facility, climate policy support, improving energy subsidy frameworks, and energy efficiency standards and labelling. Instruments include SME finance facility, risk mitigation facility, LDC credit facility for climate infrastructure, end-user finance facility, carbon finance facility, incentive facility for first movers in industry.		1.625	1.625
International academic exchange programmes, including undergraduate and PhD exchanges and visiting lecture/fellowships are also assumed to be a part of technology related capacity building.		500	500
Total over 5 years	**408-465 mln.**	**5.6 bln.**	**6.0 bln.**
Total per annum	**82-93 mln.**	**1.1 bln.**	**1.2 bln.**

Technology Package 3 - High Ambition

Key assumptions for overall level of mitigation and financing ambition:

- Annex 1 countries agree to an overall 2020 target of a 25-30% reduction below 1990 levels.
- Non-Annex 1 countries agree to a 15-30% deviation below business as usual by 2020.
- LT vision of 60% global reductions by 2050, reviewing in 2015 linked to a 2°C target.
- Financial pledges for mitigation support in developing countries of $100 bln per annum.

Table 5.3 *Costs of the high ambition technology package [mln. USD over five year]*

HIGH AMBITION TECHNOLOGY PACKAGE	**Operational cost**	**Additional programme support**	**Total**
New technology executive body under UNFCCC is established and responsible for commissioning global technology roadmaps, review progress and report back to COP. It is run by a centralised secretariat of 30 staff.	34	N/A	34
Technology facility consists of a dedicated fund under UNFCCC with two operating windows, one for supporting RD&D and the other for existing and near market technologies. It is run by its own secretariat of about 250 staff. Operating cost as a percentage of total expenditure is set reasonably low (less than 5%).	310	RD&D Window (USD 50,000)	50.310
Technology component of low carbon growth plan are assumed to be prepared as a part of a single overall process in which developing countries will produce low carbon growth plans, NAMAs and NAPAs. All NAI countries will receive additional financial support (USD 200-500 k per country) to support the technology component of the plans.	29-76 (2-5 years)	N/A	29-76
Technology information platform consists of a database collecting information on sector-specific technologies, best practice dissemination both in the public and private sector, costs of technologies, barriers and manufacturers of technologies.	16	N/A	16
Global technology roadmap would set out the overall trajectory for key technologies' development and deployment and identify milestones and areas for international cooperation. This assumes 20 full-time staff will be working on this throughout two years, and that most underlying data is already available.	4.4 (1-2 years)	N/A	4,4
Matchmaking body for technology transfer consists of a new technology matchmaking service under UNFCCC which would provide an interactive facilitation service for private sector, governments, and multilateral financial institutions in order to deliver actions defined in NAMAs, NAPAs and TNAs.	31-41	N/A	31-41
Network of innovation centres is assumed to focus on near-market and existing technologies. The proposed network consists of, initially, five national or regional centres and supported by a secretariat that maintains global coordination. It provides support on enterprise creation and incubator services; funded mainly by public sector, it mobilises private capital. It also delivers technology-related capacity building through regional hubs and in Asia, Africa, Latin America and the Middle East.	170	2.431	2.601
Cooperative R&D and demonstration is assumed to be delivered through a global partnership of existing R&D institutions in developed and developing countries. This partnership would focus on a portfolio of key technologies to be developed, demonstrated and deployed within a given timeframe. Public-private partnerships would also be encouraged, especially in demonstration and early-deployment stages. Overall 300 staff would run the partnership.	124	1.000	1.124
Enabling environments component draws from a UNEP submission and includes a variety of policy and financial instruments to strengthen enabling environments in developing countries. Policy support include financial innovation support facility, climate policy support, improving energy subsidy frameworks, and energy efficiency standards and labelling. Instruments include SME finance facility, risk mitigation facility, LDC credit facility for climate infrastructure, end-user finance facility, carbon finance facility, incentive facility for first movers in industry.		1.625	1.625
International academic exchange programmes, including undergraduate and PhD exchanges and visiting lecture/fellowships are also assumed to be a part of technology related capacity building.		500	500
Total over 5 years [USD]	**718-775 mln.**	**55.5 bln.**	**56.3 bln.**
Total per annum [USD]	**144-155 mln.**	**11.1 bln.**	**11.3 bln.**

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UNFCCC (2009d): *Non-paper No. 29, 9/10/09 @ 10:00 CONTACT GROUP ON ENHANCED ACTION ON DEVELOPMENT AND TRANSFER OF TECHNOLOGY Streamlined text and concepts contained within the reordering and consolidation of text in the revised negotiating text* (FCCC/AWGLCA/2009/INF.2, annex V) Non-paper by the co-chairs, http://unfccc.int/files/kyoto_protocol/application/pdf/technology29091009v03.pdf

Annex 1 - Assumptions underlying the operational proposals

Cooperative R&D and demonstration
Cooperative R&D and demonstration is assumed to be delivered through a global partnership of existing R&D institutions in developed and developing countries. This partnership would focus on a portfolio of key technologies to be developed, demonstrated and deployed within a given timeframe. Public-private partnerships would also be encouraged, especially in demonstration and early-deployment stages.

Overall 300 staff (100 each dealing with joint R&D, demonstration and early deployment projects) would run the partnership, ensure knowledge sharing and measure progress. This would leverage further RD&D and research staff hours in participating institutions. The programme cost under Moderate Ambition package is in line with existing cooperative R&D institutions such as the CGIAR (i.e. $500 mln. p.a.). We assume that under High Ambition package, there will be less separate programme funding; nonetheless this will be compensated by the Technology Facility's RD&D window.

Enabling environments
The enabling environments component draws from a UNEP submission (UNEP 2008b) and includes a variety of policy and financial instruments to strengthen enabling environments in developing countries. Policy related instruments are assumed to support: 100 climate policies ($50 mln); the removal of 50 perverse subsidies ($200 mln); 100 financial products ($50 mln); 5 product standard programmes in 100 countries for energy efficiency standards and labels ($75 mln). Financial instruments include the launch of 200 SME through a SME finance facility ($100 mln); a risk mitigation facility that includes $2 bln domestic lending across 15 climate technology markets ($200 mln); an LDC credit facility for climate with $2 bln financing in 10 countries ($500 mln); an end-user finance facility with the creation of 50 lending sectors benefiting 20 mln people ($200 mln); a carbon finance facility covering 200 projects ($50 mln); an incentive facility for first movers in the industry for 20 technologies in 50 countries ($200 mln).

Global technology roadmap
A global technology roadmap would set out the overall trajectory for key technologies' development and deployment, as well as identify milestones and areas for international cooperation.

It is assumed that 20 full-time staff will be working on the roadmap throughout two years, and that most underlying data and statistics are already available. The assumptions are based on the IEA roadmap project.

International academic exchange programmes
International academic exchange programmes, including undergraduate and PhD exchanges and visiting lecture/fellowships are assumed to be part of technology related capacity building. These are additional to existing programmes and would be specific to climate change and technology.

It is assumed that the programme will sponsor 2500 student exchanges, 400 PhD exchanges and 100 lecture/fellowships.

New technology executive body
A new technology executive body under UNFCCC would be established and responsible for commissioning global technology roadmaps, reviewing progress and reporting back to COP.

It is assumed that the body will be run by about 30 staff, similar to the Multilateral Fund Secretariat. Any supporting bodies, such as technical panels, are not considered in the cost assessment.

Matchmaking body for technology transfer

A matchmaking body for technology transfer would consist of a new technology matchmaking service under the UNFCCC which would provide an interactive facilitation service for private sector, governments, and multilateral financial institutions in order to deliver the actions defined in NAMAs, NAPAs and TNAs.

The matchmaking body is staffed with 80 personnel, including expert and non-expert staff, working across key sectors. Non-personnel costs are also included in the cost assumptions.

Network of innovation centres

Under the Low Ambition package, a network of innovation centres represents an umbrella partnership of existing institutions with a focus on information sharing and limited capacity building. This would consist of 4 international technology cooperation centres (i.e. $2.5 mln. p.a. per centre) and 10 cooperative implementation centres ($1 mln. p.a. per centre) that will be located in developing countries. These would have limited programme funding.

Under the Moderate and High Ambition scenario, network of innovation centres is assumed to focus on near-market and existing technologies, as these packages include other supportive mechanisms for RD&D. The proposed network consists of, initially, five national or regional centers and supported by a secretariat that maintains global coordination. It provides support on enterprise creation and incubator services; funded mainly by public sector, it mobilises private capital. It also delivers technology-related capacity building through 10 regional hubs (employing 150 people in total). This structure is in line with the Carbon Trust model, and the costs reflect the bottom and top ranges in their study (i.e. $1-12.5 bln over 5 years in 5 pilot countries).

Technology component of low carbon growth plans

The technology component of a low carbon growth plan is assumed to be prepared as a part of a single overall process in which developing countries will produce low carbon growth plans, NAMAs and NAPAs. All NAI countries (i.e. 151) will receive additional financial support ($200-500 k per country) to support the technology component of their plans. The amount of financing is based on support provided for good quality TNAs (such as Ghana's TNA - $200k per country) and the UNEP's technology submission (i.e. $500 k per country) (UNEP 2008b).

Technology facility

The technology facility would consist of a dedicated fund under UNFCCC with two operating windows, one for supporting RD&D and the other for existing and near market technologies. It would be run by its own secretariat of about 250 staff. Operating cost as a percentage of total expenditure is set reasonably low (less than 5%).

The details for the costs of the technology facility have been based on the Global Fund for HIV/Aids, Malaria and TB, and includes both personnel and non-personnel expenditure. The programme cost assumes that a third of the proposed increase in public energy RD&D spending (i.e. the European Commission proposed quadrupling by 2020, requires $30 bln additional public money) will be spent in developing countries (i.e. $10 bln p.a.).

Technology information platform

A technology information platform consists of a database collecting information on sector-specific technologies, best practice dissemination both in the public and private sector, costs of technologies, barriers and manufacturers of technologies.

The cost includes running a searchable global database which requires regular updating (similar to WIPO Patentscope). There might be additional costs for collecting data which are not reflected in this assessment.

Technology needs assessment

Technology Needs Assessments (TNAs) are a set of country-driven activities that identify and determine the mitigation and adaptation technology priorities of Parties, particularly developing country Parties. They are to be seen as a separate process from developing country low carbon growth plans, NAMAs and NAPAs.

Under Low Ambition package, it is assumed that all 151 NAI countries will receive some financial support ($50 k per country) to complete/strengthen their TNAs. The amount of financing is based on a proportion of the amount which was provided to some countries with good quality TNAs (such as Ghana's TNA). In other packages, TNAs are considered as a component of low carbon growth plans.

Table A.1 *Link between proposal and operational elements*

Operational name	**Proposal name**										
	Enabling environment	Technology oriented capac-ity building	Technology information	Technology roadmap	Technology action plan	Technology needs assess-ment	Cooperative R&D and dem-onstration	Voluntary technology agree-ments	Matchmaking body / incen-tive mechanism for technol-ogy transfer	National and regional tech-nology innovation centres	Institutional arrangements, including funds
Technology needs assessment								N/A			
Technology information platform											
Global technology roadmap											
Matchmaking body for technology transfer											
Network of innovation centres											
International academic exchange programmes											
New technology executive body											
Technology component of low carbon growth plans											
Cooperative R&D and demonstration											
Enabling environments											
Technology facility											

E3G
4th floor, In Tuition House, 210 Borough High Street
London SE1 1JX, +44 (0)2079575700

Cost of technology proposals

This study has grouped the technology related submissions to the UNFCCC and their financial implications into three concrete technology packages. These packages outline different levels of ambition consistent with the potential outcomes in of the COP15 negotiations in Copenhagen, December 2009.
The assessment combines a bottom-up cost assessment of the individual elements with a top-down analysis of the necessary financial support. This approach provides a concrete image of what a potential technology framework in Copenhagen may look like. The study then assesses the current proposals in the negotiating text and translates the often abstract concepts into operational actions. Many of the technology proposals cannot exist as stand-alone measures as they are based on progress in other parts of the negotiations. The plausible packages reflect this interdependency in relation to the overall level of ambition for mitigation and financing.

ECN
Westerduinweg 3, 1755 LE Petten, The Netherlands
+31 (0)224564431