CLIMATE CHANGE

Scientific Assessment and Policy Analysis

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Low-carbon technology cooperation in the climate regime

An exploration of opportunities, barriers and ways forward

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Wetenschappelijke Assessment en Beleidsanalyse (WAB) Klimaatverandering

Het programma Wetenschappelijke Assessment en Beleidsanalyse Klimaatverandering in opdracht van het ministerie van VROM heeft tot doel:

- Het bijeenbrengen en evalueren van relevante wetenschappelijke informatie ten behoeve van beleidsontwikkeling en besluitvorming op het terrein van klimaatverandering;
- Het analyseren van voornemens en besluiten in het kader van de internationale klimaatonderhandelingen op hun consequenties.

De analyses en assessments beogen een gebalanceerde beoordeling te geven van de stand van de kennis ten behoeve van de onderbouwing van beleidsmatige keuzes. De activiteiten hebben een looptijd van enkele maanden tot maximaal ca. een jaar, afhankelijk van de complexiteit en de urgentie van de beleidsvraag. Per onderwerp wordt een assessment team samengesteld bestaande uit de beste Nederlandse en zonodig buitenlandse experts. Het gaat om incidenteel en additioneel gefinancierde werkzaamheden, te onderscheiden van de reguliere, structureel gefinancierde activiteiten van de deelnemers van het consortium op het gebied van klimaatonderzoek. Er dient steeds te worden uitgegaan van de actuele stand der wetenschap. Doelgroepen zijn de NMP-departementen, met VROM in een coördinerende rol, maar tevens maatschappelijke groeperingen die een belangrijke rol spelen bij de besluitvorming over en uitvoering van het klimaatbeleid. De verantwoordelijkheid voor de uitvoering berust bij een consortium bestaande uit PBL, KNMI, CCB Wageningen-UR, ECN, Vrije Universiteit/CCVUA, UM/ICIS en UU/Copernicus Instituut. Het PBL is hoofdaannemer en fungeert als voorzitter van de Stuurgroep.

Scientific Assessment and Policy Analysis (WAB) Climate Change

The Netherlands Programme on Scientific Assessment and Policy Analysis Climate Change (WAB) has the following objectives:

- Collection and evaluation of relevant scientific information for policy development and decision–making in the field of climate change;
- Analysis of resolutions and decisions in the framework of international climate negotiations and their implications.

WAB conducts analyses and assessments intended for a balanced evaluation of the state-of-the-art for underpinning policy choices. These analyses and assessment activities are carried out in periods of several months to a maximum of one year, depending on the complexity and the urgency of the policy issue. Assessment teams organised to handle the various topics consist of the best Dutch experts in their fields. Teams work on incidental and additionally financed activities, as opposed to the regular, structurally financed activities of the climate research consortium. The work should reflect the current state of science on the relevant topic.

The main commissioning bodies are the National Environmental Policy Plan departments, with the Ministry of Housing, Spatial Planning and the Environment assuming a coordinating role. Work is also commissioned by organisations in society playing an important role in the decision-making process concerned with and the implementation of the climate policy. A consortium consisting of the Netherlands Environmental Assessment Agency (PBL), the Royal Dutch Meteorological Institute, the Climate Change and Biosphere Research Centre (CCB) of Wageningen University and Research Centre (WUR), the Energy research Centre of the Netherlands (ECN), the Netherlands Research Programme on Climate Change Centre at the VU University of Amsterdam (CCVUA), the International Centre for Integrative Studies of the University of Maastricht (UM/ICIS) and the Copernicus Institute at Utrecht University (UU) is responsible for the implementation. The Netherlands Environmental Assessment Agency (PBL), as the main contracting body, is chairing the Steering Committee.

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Abstract

Low-carbon technology cooperation for climate change is needed to address the challenge of scaling up development and transfer of low-carbon technology, with the ultimate aim to reduce emissions globally. This was recognised by the Copenhagen Accord of 2009, which defines a Technology Mechanism. This report reviews the technology proposals discussed in 2009 in the climate negotiations and provides costing estimates for those proposals. The aim is to make recommendations on how the technology mechanisms can be brought together in a coherent technology framework that provides reciprocity, technology coverage, enabling environments and the finance required, according to the latest insights from the technology innovation and transfer literature. It is concluded that part of the fast-track financing agreed in the Copenhagen Accord could be deployed to experiment with and gain evidence for effective international and national technology mechanisms. Jointly, they could form a Copenhagen Accord's Technology Mechanism that is effective to advance low-carbon technologies in developing and developed countries alike.

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Summary

- The objective of the UNFCCC can only be achieved if development and transfer of low-carbon technologies are scaled up significantly. Such a scale up should be conducted through mechanisms that are both environmentally and cost effective.

- In order to be effective, the mechanisms through which enhanced development and transfer would be achieved need to provide reciprocal benefits to countries that provide funding or give up sovereignty by participating. This reciprocity can be provided by bringing down barriers as perceived by relevant stakeholders, by sufficient and reliable financing, and by creating enabling environments that include appropriate capacity levels.. A basis for enabling environments could be found by applying the methodology of technological innovation system evaluation to developing countries.

- The proposals for technology mechanisms, as discussed before and during the Copenhagen climate summit, need more specification but do address all stages of technological development and the need for local innovative capabilities in developing countries. They do not explicitly use insights from the technological innovation system literature, but many aspects are addressed and other elements can be included.

- Challenges to technology mechanisms are that they would require significant financial commitments by public entities – without guarantees that these investments will pay off or mobilise private financing immediately. Given the innovative nature of such mechanisms and the long lead times, it would take time to mobilise private funding, as initial risks are high.

- Together, the technology proposals could give shape and form to the Technology Mechanism that was agreed in Copenhagen. A preliminary assessment of financial needs indicates that the public financing demands are challenging, but well within the annual fast-track funding committed by countries that signed up to the 2009 Copenhagen Accord. Using part of the fast-track funding for gaining experience with a coherent technology framework can lead to a more effective framework.

Samenvatting

- De doelstellingen van de Klimaatconventie kunnen alleen worden behaald indien ontwikkeling en overdracht van klimaatvriendelijke technologie significant worden opgeschaald. Voor die opschaling moeten milieu- en kosteneffectieve beleidsmaatregelen worden ingezet, onder meer op het gebied van technologie.

- Om effectief te zijn, moeten de beleidsmaatregelen voor technologieoverdracht en ontwikkeling wederkerigheid bieden voor deelnemende landen. Daarnaast moeten de afspraken een scala aan barrières beslechten, voldoende en voorspelbare financiering leveren, en een aantrekkelijke omgeving bieden voor klimaatvriendelijke technologie. Een dergelijke omgeving omvat bijvoorbeeld voldoende kennis en kunde. De ingrediënten van een aantrekkelijke omgeving voor technologie kunnen worden bepaald met behulp van inzichten uit de literatuur over technologische innovatiesystemen.

- In de internationale klimaatonderhandelingen, die culmineerden in Kopenhagen in 2009, zijn al verschillende technologie-instrumenten voorgesteld. Alhoewel de voorstellen nog uitwerking behoeven, kan het collectief aan mechanismen alle fasen van technologische ontwikkeling afdekken, en bovendien in de behoefte aan lokale innovatiecapaciteit in ontwikkelingslanden voorzien. De voorstellen gebruiken de inzichten van de technologische innovatiesystemen niet expliciet, maar veel functies worden wel afgedekt.

- Technologie-instrumenten vragen significante financiële bijdragen uit de publieke sector, waarvan het onzeker is of het onmiddellijk zal leiden tot het mobiliseren van voldoende privaat kapitaal. In de opstartfase zijn de risico's van nieuwe technologie vaak nog te groot voor de private sector. Er is tijd nodig om te testen of en in welke context de innovatieve technologie-instrumenten werken, en hoe ze het meest effectief kunnen worden ingezet zodat ook de private sector wordt gestimuleerd om te investeren in klimaatvriendelijke technologie.

- De verschillende voorstellen voor internationaal technologiebeleid kunnen invulling geven aan het Technologiemechanisme zoals vastgesteld tijdens COP15 in Kopenhagen. Een assessment in deze studie van de mogelijke benodigde investeringen voor de verschillende mechanismen geeft aan dat de bijdrage fors is, maar nog ruim binnen de jaarlijkse "fast-track" financiering zoals die in het Akkoord van Kopenhagen is toegezegd. Het gebruik van een gedeelte van de "fast-track" financiering voor het krijgen van ervaring met een technologieraamwerk zou tot een effectiever internationaal klimaatbeleid kunnen leiden.

1 Introduction

The use of low-carbon technology is essential for addressing the climate challenge. Most technologies that according to modelling studies are technically mature face cost, economic and social barriers. Others are still in the demonstration phase and need further development in order to be commercially viable (IPCC, 2007; IEA, 2008; EGTT, 2009). A technology framework therefore has to specifically address all phases in the technological innovation chain. This innovation chain thinking signifies a new chapter in the low-carbon technology development and transfer discussions in the UNFCCC, as previously development of technology was not specifically addressed by the international climate negotiations. It also allows for new proposals on mechanisms, arrangements and forms of organisation to take root.

Currently 90% of R&D is done by just a few countries and regions: the United States, the European Union, Japan and China (EGTT, 2009). There is no international funding mechanism for R&D into low-carbon technology. International collaboration in demonstration of essential technologies, such as CO_2 capture and storage and renewable energy, is limited (EGTT, 2009; Tomlinson et al., 2008). The deployment and diffusion stages in developing countries are currently addressed by ODA funding, by limited national support and by project funding, such as through the Clean Development Mechanism (CDM). Many of these mechanisms are not yet of sufficient size or do not work well for end-use sectors such as transport and buildings. The climate negotiations have so far not led to a result that provides developing country parties, global companies, manufacturers and producers robust and long-term certainty on the effectiveness of a climate regime. The necessity to scale up mechanisms to deliver sufficient technology transfer is recognised in the UNFCCC and the climate negotiations, last in the Copenhagen Accord that established but did not define a 'Technology Mechanism'. If such a Technology Mechanism would prove successful, it could allow for more meaningful cooperation between developing and developed countries in mitigation and adaptation.

An intensified effective technology framework will not be a simple matter as the technology challenge is complex and diverse. Many parties and research institutes have made proposals to address the climate and technology challenge. This report aims to provide insight in whether the proposals that have been made over the period leading to the Copenhagen climate summit might work for different actors by 1) analysing the barriers to technology development and transfer from an actor perspective, and 2) look into the different proposals and discuss their effectiveness and potential public costs. The focus of the report is on low-carbon technologies.

2 Approach and leading principles

A technology mechanism is most effective if it addresses all barriers to technology cooperation and transfer at the same time. If one barrier remains unaddressed, the technology cooperation and transfer may still not occur. Based on the extensive literature on technology (see Bazilian et al. (2008) for a review), a number of leading principles that a technology framework should comply with can be defined upfront. A technology framework should:

- Provide reciprocity to relevant parties and stakeholders by being in line with their interests.
- Be sensitive not only to what barriers objectively are, but also to how barriers are perceived by those who should act, such as investors, local government and consumers.
- Focus not only on technology hardware, but promote enabling environments, including through development of human capacity and other functions in technological innovation systems (Bergek et al., 2008).
- Address the finance gap in a credible, consistent and sustainable way.
- As a whole, address all stages in technology development chain.

The approach in this report has the following steps:

- Identify relevant actors for technology cooperation and transfer, across the innovation chain and identify, from the perspective of the actors, which barriers are important (Chapter 3).
- Discuss the effectiveness of various technology-related proposals and whether they meet the principles (Chapter 4).
- Discuss the public funding required for the options (Chapter 5).
- Discuss the embedding of the proposals in an overall regime. Here, special emphasis will be given to the linking to NAMAs and an R&D framework (Chapter 6).

3 Barriers to technology transfer and cooperation

Implementing technology transfer is an important element of the current international climate negotiations. Although there is a substantial body of theoretical work on transferring technologies to developing countries, there is very little practical and empirical evidence for functioning technology transfer schemes. Currently, the transfer of low-carbon, mitigation technologies needed to address climate change has not reached the momentum and speed needed to reach the Convention's objective of avoiding dangerous climate change (IPCC 2007; UNFCCC, 2009). While economic growth and increased emissions are projected to take place mainly in the developing world, low carbon technologies are generally owned by firms in the developed world.

Technology transfer is a 'broad set of processes' including know-how, experience and equipment transfer as well as the decisions taken by stakeholders on a daily basis (IPCC 2000). Schnepp et al. (1990) explicitly add an economic dimension: "….a process by which expertise or knowledge related to some aspect of technology is passed from one use to another for the purpose of economic gain" (cited in Ockwell et al. 2008). This notion of economic gain points at an important direction for addressing the barriers, since different actors will have different incentives and priorities, as they have different perceptions of economic gain.

Various studies have identified barriers to technology transfer (IPCC, 2000; EGTT, 2009; Ockwell, 2007). An important distinction is between the geographical and spatial aspects of technology transfer (sometimes called 'horizontal technology transfer', e.g. implementing a technology that is already applied widely in one country's context in the context of another country) and the development aspects (sometimes called 'vertical' technology transfer, e.g. bringing a technology from the R&D phase to the demonstration of deployment phase), meaning the maturing of a technology in general (Ockwell, 2008). In addition, various barriers are specifically related to sector characteristics, such as the lack of norms or standards in the building sector (IPCC, 2000).

The most notable UNFCCC mechanism to assess technology needs are Technology Needs Assessments (TNAs). TNAs are documents, generated from the viewpoint of developing country governments, about technology and technology transfer needs and potential actions. Many TNAs, however, fail to recognise the complexities in country, sector and technology contexts and have not led to significant follow-up. Moreover, they often reflect a government-only view on technology transfer needs, which may differ from the perspective of other essential actors, such as investors, consumers, users, equipment suppliers or project developers.

3.1 Actors that perceive barriers

In the analysis of barriers to technology transfer, various stakeholders can be distinguished on whose actions technology transfer critically depends (Ockwell, 2007):

Governments play a central role. They stimulate and support technological development and innovation at a national level through e.g. research support, which is currently mostly done through special policy programmes and universities in developed countries. In addition, policies and measures, regulations, standards, taxes and subsidies facilitate the diffusion of low-carbon technologies nationally. Governments can also support the transfer of technologies, to developing countries or elsewhere, e.g. by granting export guarantees. This is most often done by developed country governments. For diffusion and transfer, governments tend to play an indirect role, providing the right enabling environment to catalyse the implementation of technologies and processes by the private sector, and keeping oversight. This indirect role for a myriad of technologies and processes can complicate the task for governments, particularly when capabilities and resources are constrained.

Private sector project developers and product manufacturers play a crucial role in implementing technologies locally. Different private sector actors are active along the production chain - from multinationals and highly specialized technical companies to local business providing the construction, supply, operation and maintenance of the equipment.

Product developers and researchers. While part of technology development takes place at universities and research laboratories, innovation activities are also conducted in the private sector. Their aim is to reap the economic benefits from product development - through revenues from intellectual property rights and by increasing product sales and profits. In many developing countries, particularly in least-developed countries, the capabilities to do research and development are very limited.

Finance sector is key in providing capital for projects.. The international finance sector generally has a lot of funds available, but there are a variety of barriers that hinder investments into clean technologies in developing countries, including a lack of information on non-conventional technologies in new countries to perform a thorough risk assessment and poorly developed local financial markets Therefore, risks of new low-carbon technologies are perceived as high. Local finance institutions, which exist in most developing countries, have more limited capacity to provide finance, and in general very low awareness on clean technologies. Multilateral development banks and development finance institutions are specifically equipped to deal with substantial investments in developing countries, but very often have a low risk tolerance towards new technologies. The insurance sector can play a role in risk management, but currently plays a minor role.

Users and local population eventually, when implemented, the end-users and local population will to some extent be confronted with the technology. This can be very direct as user of the equipment or knowledge, but it can also be expressed in alterations of the supply of goods that is available to end users. Acceptance of technology is paramount to successful technology transfer.

Table 3.1 Technology development, diffusion and transfer actor categories and subcategories

Category	Subcategory
Governments	- Developed country governments - Developing country governments
Private developers	- Multinational companies - Local companies
Financing sector	- Multilateral development banks (MDB) and development financial institutions (DFI) - Local commercial financial institutions (CFI)
Users and local population	- Local communities, consumer groups, etc.
Product developers and researchers	- Research centres, universities, R&D departments in private companies

3.2 Types of barriers

Broadly, three types of barriers can be distinguished: technology-related, finance-related and barriers that are linked specifically to national circumstances. Technology-related barriers fall in two categories: firstly, the adjustment and adoption of a technology in a new social, cultural, economic, climatic and geographical environment (or technology transfer), and secondly barriers related to fully new technologies (technology development). Both types are considered here, as both are of importance.

Finance-related barriers are most often discussed. Development of technology is risky and the return on the investment, in a private company or even in a public sector, is often unclear, even in hindsight. Both public and private R&D funding is therefore often under pressure, especially during economic downturn when short-term problems are pressing and demand all resources.

In addition to this innovation market failure, the valley of death between technological proof of concept and the first stages of deployment (i.e. the demonstration phase) can be observed broadly: full-scale demonstrations are too capital-intensive for governments and too risky for private technology developers.

For the diffusion and transfer of technology, barriers are more related to the cost difference between conventional technologies and their low-carbon alternatives. In addition, the information level on unconventional technologies with capital providers is relatively low, and a lack of appropriate institutions or financial infrastructure to establish functioning companies still exists. Information barriers lead to high transaction costs for the transfer of technology and therefore higher costs.

Lastly, local conditions are highly influential to the success of technology transfer, but they are heterogeneous depending on various factors like location, economic conditions and stability of the recipient country. Nonetheless several barriers can be generalized, or are present to some extent in all developing and even developed countries.

3.3 Barriers from an actor perspective

In this section, three groups of barriers are assessed from the perspective of various actors. Using the actor perspective creates the opportunity to highlight some very specific barriers and identify differences among types of actors. They are summarised in the table 3.2, and discussed in the following paragraphs.

3.3.1 Technology barriers

Technology barriers represent barriers for a large array of actors. These are:
- Insufficient R&D efforts and coordination
- Limited availability of R&D results to a broader group of stakeholders
- Lack of information on reliability and lack of documented assessment of past successes and failures, resulting in lack of confidence in technologies.

A number of barriers preventing effective and successful technology transfer have a distinct technological character. The first group of barriers is related to the availability and development of new technologies. National governments and product developers indicate that the level of R&D is insufficient for fast development of low-carbon technologies, but face a lack of resources to fund more.

Second, stakeholders in the actual implementation process (i.e. project developers, companies and financiers, but also governments) indicate that data availability is a problem on the technology itself, but also on costs and potentials. So barriers occur from both the amount of R&D and the effective dissemination of results.

Last, there are barriers related to reputation and perceived technological reliability. Especially the finance sector is very sensitive to failures - a possible reason is that in the absence of thorough technical knowledge they primarily react to past successes, reputation and observable results. Confidence is also an important barrier to acceptance by the (local) end-user population.

Table 3.2 Summary of technological, finance and local barriers from the perspective of different actors. When there is a dot in the cell, the actor perceives the barrier

	Developed country government	Developing country government	Multinational companies	Local companies	Development finance (MDB & DFI)	Commercial finance (CFI)	Local finance (banks)	End-users (local)	Researchers & commercial R&D
Technology barriers									
Insufficient R&D efforts and coordination	•	•		•					•
Limited availability of R&D results		•			•	•	•	•	
Lack of information on reliability and assessment of past failures and lack of confidence in technologies			•			•	•	•	
Finance barriers									
Lack of capital availability: risk/return profile doesn't match investors' mandate			•		•	•	•	•	
Lack of support: costs are too high to recover through the (distorted) market	•	•	•	•	•	•	•	•	•
Market inefficiency: there is no market for attracting reasonably priced capital	•	•		•		•	•		
Difficult to obtain high quality information to make a good risk assessment			•			•	•	•	
National circumstances									
Lack of institutional structure and substantial regulatory risk			•	•	•	•	•		
Lack of reliable information on local circumstances and high transaction costs			•	•	•	•	•		
Limited knowledge of local needs	•			•	•		•	•	•
Successful cooperation with local actors difficult			•		•	•			

3.3.2 Finance barriers

Finance barriers include:

- Lack of capital availability: risk/return profile doesn't match investors' mandate
- Lack of support: costs are too high to recover through the (distorted) market
- Market inefficiency: there is no market for attracting reasonably priced capital
- Lack of information on risks to make a good financial risk assessment and structuring of investment

The first type of finance barrier that low-carbon technologies encounter is the availability of capital. Commercial finance institutions (CFIs) and multinational corporations, with large-scale access to capital, are often hesitant to invest into new technologies as they lack the specific experience. Due to their lack of awareness and understanding, they consider such low carbon technologies as high risk. Similarly multilateral development banks in the past have often been cautious to become involved with new and innovative technologies, but their mandate is more suited for high-risk environments.

Second, most low-carbon technologies are more costly than the conventional alternative. As a consequence, not all costs of a project can be recovered through the market by selling energy, products or even through selling carbon credits if that is a possibility. In addition, many countries, developed and developing, have implicit policies supporting conventional technologies (e.g. coal). The actors confronted with this barrier are the commercial project developers and financiers who are unable to make their project bankable and national governments who face large support costs to meet policy targets.

The next two types of finance related barriers are caused by the fact that markets have not been fully developed. The absence of an efficiently working capital market is mostly associated with developing countries and has consequences for both local entrepreneurs (who lack access to capital) and international commercial parties (who don't have access to markets for insurance). In addition, there is often a lack of access to reliable and high quality information on technology and local conditions. In practice this is why for large endeavours, international investors sometimes team up with local banks - but a good and 'honest' risk assessment is perceived as a barrier by all commercial actors.

3.3.3 Barriers related to national circumstances

The investment and technology enabling environment is shaped by national and local circumstances. Some of these circumstances can form barriers, such as:

- Lack of institutional capacity and structure, and substantial regulatory risk
- High transaction costs
- Limited knowledge of local needs
- Successful cooperation with local actors difficult

Insufficient human and institutional capacity, as well as the lack of physical infrastructure and the lack of codes and standards are seen as barriers by most companies. For developing country parties as well as local companies and banks, the lack of the institutional capacity to solicit ideas and missing information is a major impediment.

Financial institutions and project developers quote changes in laws and regulations (i.e. regulatory risk) as one of the most important barriers to successful scale up of low-carbon technologies. This type of risk is hard to transfer or hedge against. Stability and predictability are determining conditions for any successful support schemes or enabling environment.

Obtaining local knowledge of the project conditions and applicable regulations is paramount to making a risk assessment, but oftentimes difficult. This relates specifically to diffusion into new jurisdictions, countries or areas. Actors interested in diffusing technology elsewhere face high transaction costs - costs associated with risks that may not be related to the technology but rather to the inability to assess. These transaction costs are often overseen in analyses on costs of technology transfer, but are perceived as a barrier by commercial actors. National governments, responsible for implementing support schemes, are also confronted with this barrier as it affects their policy effectiveness.

4 Technology cooperation proposals and their consequences

In order to meet the principles in Section 2.2 and build an effective Technology Mechanism, the technology cooperation proposals need to address all stages of the innovation change and the barriers identified in Section 3. This section discusses a number of technology cooperation proposals and assesses in a qualitative way whether they meet the principles in Section 2.2. To facilitate this assessment, the options are divided in research, development and demonstration, and deployment and diffusion options. In addition, Section 4.4 provides a more general assessment of how the proposals address the innovation chain.

4.1 Options for Research, Development and Demonstration

Most proposals on cooperation on research, development and demonstration of low-carbon technology address the *technology and finance barriers* to project developers and investors in new technology start-ups. The principle by which this type of technology cooperation is led relates to promoting enabling environments by building innovation capacity in developing countries (Ockwell et al., 2009) through R&D cooperation, centres of excellence and sharing of knowledge in networks of innovation centres, overcoming the finance gap by increasing budgets for R&D and demonstration, and providing reciprocity by generating common benefits while allowing for national competitive advantage. In addition, some address *barriers related to national circumstances*, particularly in the case of networks of innovation centres.

4.1.1 R&D cooperation

As of yet, there are few international funding sources for low-carbon technology R&D (EGTT, 2009). A strong disincentive for international cooperation on R&D is that countries who fund research would also like to receive the benefits from that research. International R&D cooperation, however, could make available new technologies more globally.

The level of cooperation in international R&D for low-carbon technology can vary. Coninck et al. (2008) discuss the shallowest type of R&D cooperation as knowledge sharing and coordination, which does not envisage joint research of any form. They evaluate a number of existing agreements of this category, such as the Carbon Sequestration Leadership Forum and the Methane-To-Markets partnership. Knowledge sharing and coordination can vary from labelling agreements to international research coordination. This type of international R&D cooperation has relatively low costs, can result in a high level of exchange of information between stakeholders from different countries and in raised awareness of the opportunities, pitfalls, and barriers of the low-carbon technologies. In R&D cooperation, knowledge sharing and coordination agreements can identify RD&D needs and increase efficiency in R&D, but do not necessarily enhance the rate of innovation or the spread of low-carbon technologies.

A stronger option for international R&D cooperation is an international R&D fund with windows for key low-carbon technologies (WRI, 2008). This would require significant international coordination and possibly a separate body, but would result in more innovation and wider awareness and availability of low-carbon technology.

The negotiating text of September 2009[1] states that national technology research, development and demonstration (RD&D) programmes should be strengthened, but there are still divergences as to who will provide the funding. It proposes the enhancement of North-South, South-South and triangular cooperation to promote technologies and should provide all countries with the opportunity to participate in joint R&D programmes in various forms. The EGTT (2009) recommends a fourfold increase in spending on low-carbon R&D globally.

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1 Annex V, Para. 32, page 157, FCCC/AWGLCA/2009/INF.2, 15th September 2009.

4.1.2 Network of Innovation Centres

In general, two forms of the energy innovation centres have been proposed based on the proposals in the September 2009 negotiation text[2]:

1. Global Energy R&D Network: Modelled on the CGIAR, a network of 10-20 energy R&D Centres of Excellence could be set up, the majority of which in developing countries. The individual centres could have a regional focus, such as a Centre on CSP in North Africa, or on bio-ethanol in Brazil.
2. Network of Energy Innovation and Technology Transfer Centres: A denser network of one innovation centre per developing country or cluster of similar countries could serve the purpose of modifying mature technologies, creating an enabling environment for the technology, and making them available locally. The model for such institutes might be more like the Carbon Trust (2008).

The former is mostly aimed at technologies in the R&D phase, whereas the latter more on technology adoption, enabling environments and technology transfer.

The original proposal by India (Mathur, 2009) indicated that the Innovation Centres should be practical and as much product-oriented as possible. Such a condition could be included in the mandate of the centres and should be considered in the recruiting process. Although the centres would operate independently, there should be extensive provisions for and encouragement of interaction, information exchange and mutual learning between the centres. In addition, the centres should be embedded in the local context. In the CGIAR model, the use of existing centres worked better than starting a new Centre from scratch.

4.1.3 Global Technology Demonstration Fund

Murphy and Edwards (2003) identify the ‘valley of death’ for energy technologies in the demonstration phase. The Valley of Death is characterised by a lack of cash flow from a technology that leaves the publicly funded R&D phase; Governments may be unwilling to provide the large amount of funding required for scale-up, while the private sector still perceives too high risks to take up the project as a commercial project.

The EGTT (2009) identified 24 low-carbon technologies currently in the demonstration phase, in the transport, energy, buildings, industry and forestry sectors. Some, but not all, of those technologies can be considered to be in the valley of death. The technologies that have the highest mitigation potential but are also most cost-intensive are various applications of CO_2 capture and storage in different sectors (industry, coal-fired and gas-fired power), demonstration of hydrogen fuel cell infrastructure and production, marine energy and concentrated solar power. In forestry, the demonstration phase primarily applies to practices for forest management - more to ‘orgware’ than to hardware which is less likely to suffer from Valley of Death effects but faces other barriers associated to the demonstration phase.

Proposals for a Global Technology Demonstration Fund have been made by several parties and institutes (UNFCCC, 2008; WRI, 2008). Depending on the technology, different types of spending could be imagined:

- Venture Capital fund: revolving, high-risk investment fund, combined with public funding
- Loan guarantees and soft loans: project developers can get loans for demonstrations against attractive conditions
- Incremental costs: subsidy fund for incremental costs of demonstrations. This could be combined with funds for international R&D collaboration, as the transition from the R&D into the demonstration phase is often rather gradual.

The September negotiating text[3] mentions demonstration in various paragraphs of Annex IV. Several funds have been proposed (Annex IV, para. 25) among which the Multilateral Climate

[2] Annex V, Para. 47, page 172, FCCC/AWGLCA/2009/INF.2, 15th September 2009.
[3] Annex IV Enhanced action on the provision of financial resources and investment.

Technology Fund that should provide full costs of activities among which demonstration activities and a Technology Risk Facility to assist technologies from demonstration to commercial maturity (Annex IV, para 25, 7).

4.2 Options for deployment and diffusion

4.2.1 Technology Action Plans/Low-Carbon Development Strategies

Technology Action Plans (TAPs) and Low Carbon Development Strategies (LCDS) are two names for strategy plans containing different actions to ultimately achieve the goals of the Convention – either the realisation of a specific technology or a set of technologies, or low-carbon development. Currently, low-carbon development strategies, or low-carbon growth plans, are most commonly mentioned (Project Catalyst, 2009; World Bank, 2009; Kim et al., 2009; European Commission, 2009). LCDSs are an international vehicle for matching developing country action in the field of mitigation with possible support by the international community. LCDSs, in the EU view, are defined as the structure for developing countries to contribute their contribution to the global mitigation effort. LCDSs build on Article 4.1b of the Convention and could be a place where nationally appropriate mitigation actions (NAMAs) are described, barrier analyses are made and specifications of financial and capacity support needs are given. LCDSs could vary in level of ambition but should be in line with the common but differentiated responsibilities and respective capabilities of developing countries, as well as their sustainable development strategies.

Actions could include policies and measures for different sectors of the economy, such as feed-in tariffs or portfolio standards for renewable energy, emission standards for personal vehicles or buildings, capacity building or financing programmes.

In order to have sufficient support for and ownership of a LCDS in a country, a careful multi-stakeholder process is envisaged for agreeing on a strategy (Project Catalyst, 2009; Tilburg et al., 2009b). LCDSs could facilitate the monitoring of single actions contained in it, allowing to monitor how much of the expected emission reductions have been achieved over time (Ellis et al., 2009). The plan could include the financing needs of the actions and how these could be covered; linking mitigation action and support (Kim et al., 2009). This would allow for the financing problems to be addressed from the start, and identify potential international support. It would also be possible to modify the plans if circumstances demand or if the results are below expectation.

LCDSs or TAPs should be developed by the countries themselves, but international assistance can provide countries with appropriate information services, technical assistance and capacity building. The plans could be developed stepwise, from simpler to more complicated forms, allowing several barriers to surface and be addressed simultaneously. It seems important not to rush the process. Awareness of the country needs and development strategies, followed by deeper knowledge of appropriate technologies and finance possibilities and conditions could all be integrated into the plan.

In the September 2009 negotiating text LCDSs are part of the proposals in Annex III B, Enhanced action on mitigation (para. 83). The proposals refer to an overall plan that should be elaborated by developing countries containing among other aspects a low emission pathway, descriptions of all NAMAs, i.e. mitigation actions, financing possibilities and barriers. LCDSs therefore also include actions on technology. TAPs can be found in Annex V (para. 19-22) of the negotiating text, they should aim at “accelerating research, development, diffusion, transfer and use of environmentally sound technologies”. They should sustain the technologies in all stages of development and should also include policies and institutional arrangements to support existing and future technologies.

4.2.2 Technology standards and labelling

International technology standards have been successfully implemented for health, safety and environment, such as environmental standards in marine oil shipping and safety standards in airplanes. Technology standards and labelling could also be imagined for certain sectors with the aim of increasing energy efficiency and lowering emissions. For technology - or emission - standards, history has shown that most standards are developed in one country or region and subsequently adopted by regions around the world. This goes for instance for the air pollution standards for personal vehicles developed in the European Union (Euro IV etc).

Technology standards can be imagined in almost every sector, but particularly those sectors where market mechanisms have proven less effective (Coninck, 2009). Examples of such sectors include buildings and transport; sectors where many energy efficiency measures are possible but where social barriers, principal-agent problems and low price elasticities play a determining role. The main activity would be to agree on an internationally applicable standard, which depends much on the characteristics of the sectors, such as whether products are globally traded. In addition, crucial associated activities in a technology standard agreement could include sharing of experiences between countries and help with regulation provided the country complies with a standard (as is done in the Montreal Protocol).

In the September negotiating text some of the paragraphs relating to technology mention the use of technology standards, such as common performance standards. At this point in the negotiations harmonization of standards is contested.

4.2.3 International technology financing scheme

Currently, the Clean Development Mechanism (CDM), and the Special Climate Change Fund (SCCF), which is operated by the GEF, as well as financing schemes by the GEF and multilateral development banks are the international mechanisms supporting technology diffusion in developing countries. These mechanisms provide funding and focus amongst others on technology transfer. As of March 2008 $14 million had been pledged for the Technology Transfer Programme in the SCCF (Haites, 2008). The GEF's climate change related work as a whole has an overall budget of several billion over several years. The GEF funding is considered part of the financial mechanisms under the Convention. It currently relies only on voluntary contributions by mostly Annex II Parties. The CDM has a multi-billion dollar turnover and results mainly in large-scale technologies in industrial sectors and renewable energy being deployed. Combined, current mechanisms are not sufficient to cover the financing needs for technology development and diffusion in developing countries (EGTT, 2009).

Introduced in EGTT (2009), an international technology financing scheme would be a strong expansion of the funding structures for low-carbon technology. It is described as follows:

"(..) a new international technology financing scheme would be established under the Convention with a mandate to scale up collaborative action on technology development and transfer, covering all stages of technological maturity. The required funds would be raised through the Convention. The new international technology financing scheme would involve a range of substantial yet targeted financing instruments and funding windows."

The scheme would provide a number of windows for different activities in all stages of development. The funding emphasis, however, would have to be on the deployment and diffusion stages as those require most funding. EGTT (2009) distinguishes a centralised and a decentralised variant of the technology financing scheme. The details of the scheme are not in EGTT (2009), but if the scheme would be agreed in principles, details could be filled in later.

In the September negotiating text an international technology financing scheme was included in the proposed Financial and Technology Mechanism which should ensure the fulfilment of the commitments for financial resources under the convention. In the Copenhagen Accord, however, a Technology Mechanism is mentioned in isolation without including specific financing aspects.

4.3 Options for technology transfer

4.3.1 Technical assistance and capacity building

Numerous studies suggest that deployment of low-carbon technology is seriously hindered by the lack of capacity to absorb a technology. However, this capacity to absorb new and low-carbon technologies differs strongly across countries and local circumstances. Bazilian et al. (2009), based on the technology transfer literature, have provided an overview of different types of capacity building and technical assistance that could be provided under different circumstances. They distinguish three types of technology-related capacities:

- Capacity to operate and maintain: technical expertise to operate, repair and maintain the technology. International cooperation can provide technical assistance and basic capacity building. Particularly in low-income countries, technical assistance on this type of capacity is an important part of the enabling environment. In higher-income countries, the operation and maintenance capacity building needs are likely to be limited as there is already a pool of basic human skill present.
- Capacity to adopt and manufacture: A technology that needs to be adapted to infrastructure, climate, resource-mix, and usage patterns requires a set of skills that is additional to merely operating a technology - the capability to adjust a technology to local circumstances and replicate it for further use in the country. International cooperation can ensure early exchange of information, so as to accelerate the learning process (e.g. IEA implementing agreements) and provide more tailored support to complement domestic capacities. Higher-income developing countries with a well-developed private sector and a highly educated workforce are not likely to require international support for this capacity type; low-income countries are likely to require this support.
- Capacity to innovate: Even if a technology is used and replicated in a country, technology transfer is only fully completed if the capacity to innovate is present in a country - when there is an innovative industry that is able to do research and improve and re-export the technology. This requires good higher education institutions in the country and well-developed entrepreneurial activity in the private sector, as well as a financing infrastructure and conducive investment climate. International collaboration can provide information that supports a shift of the focus of R&D activities to activities that contribute to low-carbon economic growth.

Funding for technical assistance and capacity building could be arranged on a bilateral basis, in conjunction with technology-action plans or low-carbon development strategies as discussed in Section 4.2.1, and/or in conjunction with the more diffusion-oriented version of network of innovation centres (see Section 4.1.2).

In the negotiations, Parties converge on the idea that capacity building is an essential element of technology transfer. It is generally accepted that capacity building should take place under the guidance of the Convention and should include several elements including analysis, training activities and technical assistance. The training activities should create the human resources that are "…necessary for the design, implementation, and operation and maintenance of these [cost-effective] applications" (Annex V, para. 30). There is no consensus as to who should provide the funding.

4.3.2 Regulatory cooperation and policy learning

Bazilian et al. (2009) also discuss the 'capacity to regulate' as an essential element of the type of capacities that are required for technology transfer and large-scale deployment and diffusion of technologies; in other words, to create an enabling environment. Private sector investors for technologies in the deployment and diffusion stages need a conducive environment and a facilitative domestic regulatory framework including, possibly, carbon cost internalisation, access to financing, and possibly initial subsidies to overcome cost-related barriers.

As governments of developing and developed countries may struggle with the implementation of these measures, international collaboration can offer a multitude of support, such as: the sharing of experiences to create confidence in managing the necessary policies, access to technical assistance for institutional reform and transparent monitoring and reporting to facilitate international learning and identification of best practice and suitable regulatory designs. Furthermore, the design of incentive schemes (e.g. patents and licences, and other research support mechanisms) can be tailored so as to facilitate international learning, knowledge-exchange and cooperation. An example of regulatory cooperation is an initiative by UNEP (2008) to set up 10 “regional networks of climate change officials that provide a means for sharing knowledge, exchanging information and experience, and accelerating technology transfer through cooperative regional efforts”, comprising some 147 countries.

4.3.3 IPR sharing agreements

The degree to which intellectual property rights are a barrier to technology transfer is contested in literature. While some argue that IPR on energy technologies is only a very limited problem (Barton, 2007), others review evidence that it can inhibit the access to technology in some areas, and that there is reason for addressing the issue (Ockwell et al., 2008). Cooperative IPR agreements to address the issues perceived around IP can take different forms. One possibility is to install a fund for payment of royalties. The size of this fund does not need to be large, according to Barton (2007) but should be sufficient to take away concerns of access to technology. Iliev and Neuhoff (2009) suggest that, to overcome barriers for industry players to participate in cooperative IPR agreements, the public sector could help identify where such intervention could be beneficial and speed up its realisation.

However, some argue that the barriers related to IPR are broader than royalty fees alone. For example, access to information in patents may be limited in developing countries. If this is the case, access to information on patents could be organised. Some even argue that low-carbon technologies should be ‘public technologies’ (UNFCCC, 2008): fully publicly available and not protected by IP. Tomlinson et al. (2008) suggests a ‘protect and share’ provision in a technology framework, containing advance purchase commitments, creation of segmented or parallel markets and compulsory licensing. Iliev and Neuhoff (2009) suggest that public institutions can facilitate the maturing of low-carbon technology by “focusing on early push for standards, transferring IPRs to a standards management body, and disengaging when a market is mature enough”.

In the negotiations and the negotiating text (Annex V para. 33-36) to date there is little convergence on how to regulate IPR issues. Some proposals ask for the removal of barriers created through IPR, others ask for the exemption from patent regulations for LDCs or for a compulsory licensing agreement such as the Doha declaration. It remains unclear what the outcomes of the negotiations will be.

4.4 Contribution to climate change mitigation and technology barrier removal

Given the almost complete absence of international collaboration on R&D and demonstration of low-carbon technologies and the need for actual investments in technology, it is likely that a well-implemented and balanced technology framework would remove barriers and contribute to climate change mitigation. The nature of many technology activities, however, particularly those facilitating technology transfer, advancing technology and creating an enabling environment, make measuring the contribution to climate change mitigation in quantified emission reductions inherently difficult. What is possible to evaluate, however, is whether the proposals are effective in contributing to different innovation stages or to technology transfer and to removing barriers.

4.4.1 Contribution to climate change mitigation

R&D cooperation, such as knowledge sharing and coordination, joint R&D, international funding for R&D, and a *network of specific innovation centres* of excellence would only contribute to climate change mitigation if the technologies that are developed through these instruments can access the market and become commercially viable. The network aspects of networks of innovation centres or centres of excellence could overcome barriers related to information availability, including lack of information on local circumstances and R&D results.

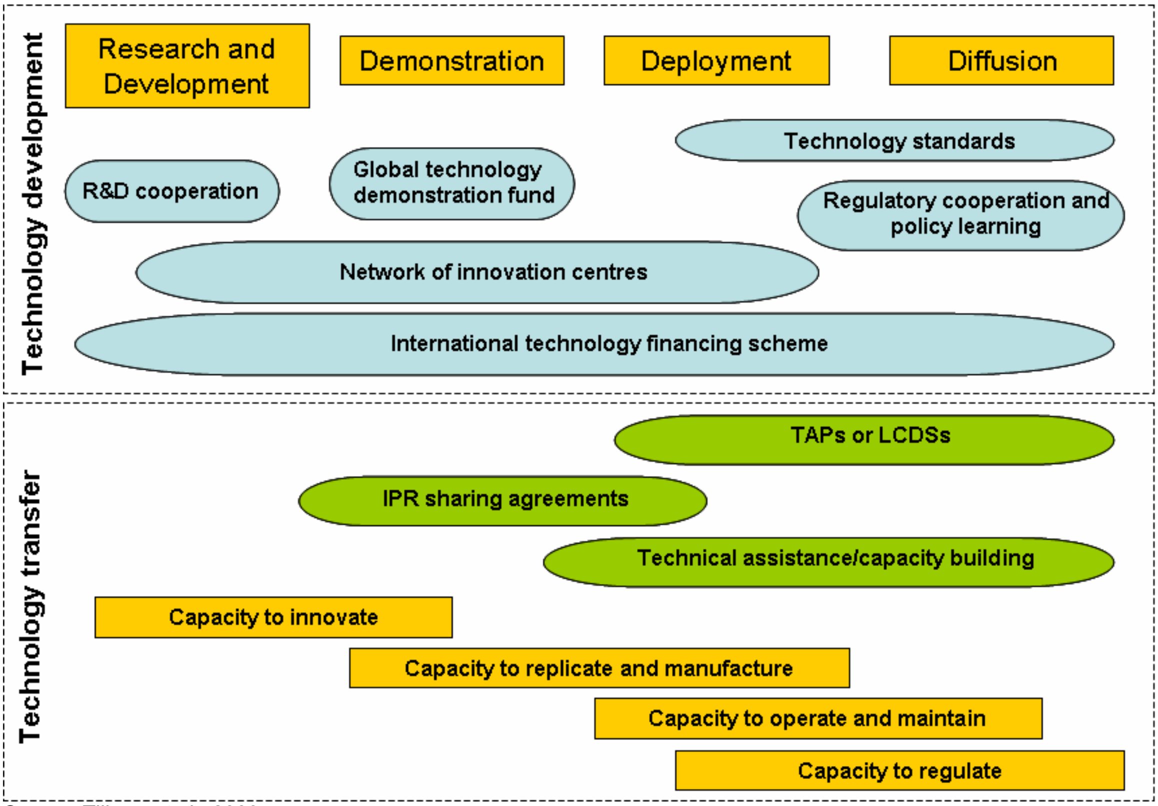
Technology demonstration instruments, such as the instruments included in proposals for a *Global Technology Demonstration Fund* (loan guarantees or an incremental costs fund), but also national *innovation centres*, are likely to help overcome the financial risks related to demonstration in new contexts, and attract private finance. The cost-effectiveness of loan guarantees could be high as the revenues are in principle recycled back into the fund and could be used again. Key points for scope and impact are whether the financial instrument can be easily accessed by project or product developers. Investments in the demonstration phase should be done with a view to subsequent successful deployment and diffusion stage. Road-mapping for technologies, such as the IEA roadmaps (e.g., IEA, 2009) could guide decisions for this.

An *international technology finance scheme* would not only focus on lack of finance, but also on capacity building needs, risk aversion of commercial financial institutions and even R&D and demonstration. Having different funds available at different stages of the development of a technology is important because of the various types of public and private funding required, as the risk profile differs between the innovation phases and other circumstances.

Technology standards and labelling would contribute to facilitating the market entry of a product in the deployment or diffusion phase. Labelling is the softer variant and provides users, such as finance institutions, product developers and consumers, with quality regulation for the low-carbon products (varying from buildings to components of wind turbines), which can be a barrier to diffusion. Measuring the impact of labelling in consumer goods is a long-term effort that requires baseline measurements before labelling, and measurement afterwards. Even when such data is available, it is difficult to clearly attribute the impact of the instrument, as the impact may not dependent exclusively on the action.

Technology standards are stronger instruments and could bring down finance barriers if financial institutions would be more willing to finance investments in companies supplying the goods or installations subject to a standard. Standards have been shown to be quite effective, but are sometimes politically difficult to realise or can lead to economic loss and even bankruptcy of companies dependent on incumbent technology that is phased out through a strict standard, which can be politically unacceptable. Quantitative results are clearer from technology standards as attribution is easier, such as the number of energy efficient appliances sold after standardisation. Collectively, the impacts of technology mechanisms can be large and cover technology maturity phases as well as different type of capacity. For instance, technology IPR sharing agreements could enhance the capacity to innovate in developing countries (see Figure 4.1 for an overview).

There is a need for further research and evaluation of the impacts and possible benefits of the technology proposals, however , as the evidence and past experiences with them are limited. Trust in the mechanisms will have to develop gradually. Measuring effectiveness and building trust would be served by two conditions: first, agreements in the proposals to make the outcomes measurable, to report regularly on progress to an overarching institution, possibly the UNFCCC; second, to allow for flexible and phased implementation - so that later countries can learn from frontrunners and international institutional capacity is built gradually.



Source: Tilburg et al., 2009a.

Figure 4.1 Summary of technology proposals in technology development (light blue) and technology transfer (green). The position of the proposals indicates whether they address different innovation stages (R&D, demonstration, deployment, diffusion) and capacity needs (capacity to innovate, replicate and manufacture, operate and maintain, and regulate

4.4.2 Contribution to barrier removal

In Section 3.2 we determined a number of barriers to technology development and transfer, and related them to the actors by whom they are perceived. Table 4.1 gives an overview of whether the technology mechanism described in this report address these barriers.

The main barrier addressed by *R&D cooperation* is expected to be the lack of R&D and the lack of coordination in this field. If the cooperation will include regions where the technology might be applied, it might also contribute to increased knowledge of specific local needs and help with the cooperation with local actors at further stages of deployment. The *network of innovation centres* will help address multiple barriers with the main focus being to provide information and to enhance confidence in technologies. This will apply for the barriers related to all three types of barriers identified, technological, financial and local. As the centres will be regionalised, cooperation with local actors and knowledge of local needs will be facilitated.

The main aim of the *global technology demonstration fund* will be to provide additional financial aid to allow technologies to reach market maturity. It will therefore aim at addressing financial barriers related to lack of investors with the appropriate mandate and reduce costs for technology development.

TAPs and LCDSs are meant to provide the appropriate information to allow the policy and regulatory frameworks on a national level to aim at a low carbon development pathway and allow the introduction of new technologies. They are expected to address barriers related to national conditions and should reduce risks for investors. International *technology standards and labelling*, possibly installed by single countries or in TAPs or LCDSs, would contribute to increased 'standardized' information about technologies, thus providing security for investors in companies that produce the products, and end-users.

To support national or local financing structures *international technology financing schemes* may be used. *Technical assistance and capacity building* should provide local stakeholders with the necessary instruments and knowledge to develop the institutional and regulatory structures to enhance security for the financial sector. Regulatory cooperation and policy learning addresses similar barriers but from a government actor perspective. IPR sharing agreements should contribute to addressing more participative R&D, as well as reducing the costs of technologies.

Table 4.1 Barriers addressed by the technology options

	R&D cooperation	Network of innovation centres	Global technology demonstration fund	Technology action plans/low carbon development strategies	Technology standards	International technology financing scheme	Technical assistance and capacity building	Regulatory cooperation and policy learning	IPR sharing agreements
Technology barriers									
Insufficient R&D efforts and coordination	•	•					•		•
Limited availability of R&D results			•		•		•		
Lack of information on reliability and assessment of past failures and lack of confidence in technologies		•	•	•	•		•		
Finance barriers									
Lack of capital availability: risk/return profile doesn't match investors' mandate			•	•	•	•			
Lack of support: costs are too high to recover through the (distorted) market			•			•			
Market inefficiency: there is no market for attracting reasonably priced capital						•			
Difficult to obtain high quality info. to make a good risk assessment		•			•				
Local conditions									
Lack of institutional structure and substantial regulatory risk				•	•		•	•	
Lack of reliable information on local circumstances and high transaction costs		•		•			•		
Limited knowledge of local needs	(•)	•		•					
Successful cooperation with local actors difficult	(•)	•		•		•			

All barriers seem to be addressed by more than one of the proposed technology mechanisms, with the exception of one barrier "Market inefficiency: there is no market for attracting reasonably priced capital".

5 Public financing for technology proposals

Based on EGTT, UNFCCC and UNEP documents, what would the proposals require in terms of public financing, and how would they lead to more private financing?

Currently there is an information gap on the amount of financing resources currently invested for both mitigation and climate technology development. Rough estimates indicate that between USD 70 and 165 billion are currently available for mitigation technologies (EGTT, 2009). Financing for technology transfer is estimated to be below USD 2 billion (EGTT, 2009). Of the financing resources available for the development and the transfer of climate technologies at least 60% is from businesses, while approximately 35% comes from governments. Of the governmental part, around 95% comes from national governments and the remaining comes from multilateral sources and Convention mechanisms. One of the ways of expressing the ability of public money to mobilise private investments is through ‘leveraging ratios’. UNEP SEFI (2008) estimates that leveraging ratios can be 1:3 to 1:15. However, this ratio depends strongly on the development phase and the country context and therefore has limited use for policymakers.

The current Convention mechanisms that help increase private funding through cost-effective public expenditures and eliminate barriers as perceived by the different actors include Technology Needs Assessment (TNAs), the Kyoto mechanisms, and the GEF. In addition, there are vehicles through multilateral banks. TNAs provide information to the public and private sector about the needs of developing countries for environmentally sound technologies, The aim of the TNA’s is also to ultimately contribute to enabling environments, including regulatory frameworks that should incentivise investments and human capacity. However, TNAs are not perceived as very effective, possibly due to limited budgets and lack of follow-up. The CDM and JI are market based mechanisms that provide a framework to increase the attractiveness of investments in clean energy by permitting the sale of carbon credits. One of the mandates of the GEF in the area of climate change is to have a catalytic role in investment into clean energy technologies

The multilateral development banks are developing new financial products as a vehicle for attracting public and private sources. Depending on the maturity of a technology the balance between public and private funding and the approach to risk sharing differs. Resources could be increased by allowing for several parallel objectives e.g. aiming at achieving MDG and climate mitigation, even though the use of ODA for climate projects is seen as controversial.

Table 5.1 provides estimates of the public funding needs of technologies mechanisms discussed in Section 4. The costs of technology proposals depend highly on how they are expected to be implemented - in an ambitious way for most countries and technologies or in a more moderate start-up phase. All costs are over five years unless stated otherwise. The estimated overall costs for technology packages according to Tilburg et al. (2009a) range between 152 mln and 11.3 bln USD, depending on the level of ambition of the separate building blocks (i.e. technology options) of the different packages.

Table 5.1 Costs of technology options

Technology option	Mln USD over five years	Other denomination
R&D cooperation*	1124-2624*	Cooperative R&D and demonstration
Global technology demonstration fund*		
Network of innovation centres	200-2601*	Network of innovation centres
Technology action plans/low carbon development strategies	0.2-0.5**	Technology needs assessments/technology component of low carbon growth plan
Technology standards	75**	Energy Efficiency standards and labels
Technical assistance and capacity building	-	
Regulatory cooperation and policy learning	40**	Regional climate change networks
IPR sharing agreements	-	
International technology financing scheme	1250**	See Table 5.2

* based on Tilburg et al. 2009a; ** based on UNEP 2008.

R&D cooperation and demonstration (RD&D) are merged into only one option in Tilburg et al. (2009a). The costs range between 1.1 and 2.6 bln USD. The lower cost is from the high ambition scenario, and those costs are lower as in this scenario, also a technology facility will exist with reinforcing elements in this field that takes over many of the costs. The higher value comes from the moderate ambition scenario where this option is the main one pertaining to RD&D. A global effort, such as through the UN or the way CGIAR is governed (by UNDP, FAO and the World Bank), is expected to run and coordinate the RD&D efforts.

The cost assessment for the **network of innovation centres** ranges between 200 and 2601 mln USD. The network would focus on existing and near to market technologies. The differences in costs are mainly due to the rising additional programme support costs depending on the ambition of the efforts of the international community. The structure is base on the Carbon Trust model (Carbon Trust, 2008).

Technology standards are assumed to cost 75 mln USD for five product standards in 100 countries over five years (UNEP, 2008), this value can be scaled up or down according to ambition.

Regulatory cooperation and policy learning is assumed to be based on regional climate exchange networks as mentioned in UNEP (2008). With 40 mln USD it should be possible to provide ten networks covering 147 countries (UNEP, 2008).

Technology action plans (TAP) and **low carbon development strategies** (LCDS) will possibly require similar efforts as technology needs assessments (TNA) which have been priced between 200 and 500kUSD (Ghana TNA; UNEP, 2008). Depending on the total amount of countries receiving financial support to undertake this effort the total amount of financing will vary.

Technical assistance and **capacity building** may cover a very wide range of practical options. Several examples can be found in Annex I National Communications (e.g. see Kuusisto et al., 2006). Capacity building is expected to take place as parts of other technical options and therefore cost cannot be given separately.

IPR solutions are assumed to take place based on agreements. The costs of agreements are negligible when compared to the costs of the other options. Even if a royalty fund would be organised that pays for the royalty fees for specific countries or technologies, the costs would still be very low, in particular when compared to other needs such as a demonstration fund.

The option on **international technology financing schemes** is made up of several building blocks as identified in Table 5.2, totalling 1250 mln USD.

Table 5.2 Summary of identified initiatives possibly under a financing scheme

Initiative	Scope	Size	Funding [USD]
SME finance facility	Facilitate the scale-up of seed financing and later stage bank financing to climate entrepreneurs	Two hundred SMEs launched	100 mln
Risk mitigation facility	Establish fund guarantee programmes to share market and technology risks, targeting the mobilisation through local commercial banks of domestic lending for climate projects	Two billion of domestic lending across 15 new climate technology markets	200 mln
LDC credit facility for climate infrastructure	Provide affordable long term financing on concessional terms for low carbon infrastructure projects	Two billion financed in 10 countries	500 mln
End-user finance facility	Help the domestic banking community to begin financing the uptake of cleaner technology amongst households and small business	Fifty lending sectors created, benefiting 20 million people	200 mln
Carbon finance facility	Facilitate first-of-a-kind carbon transactions based on new methodologies and approaches	Two hundred projects served	50 mln
Incentive facility for first movers in industry	Provision of targeted support for first-movers investing in cleaner energy technologies through financial assistance and information which can help reduce transaction costs	Twenty different technologies in 50 countries	200 mln
Total			**1250 mln**

Source: UNEP, 2008.

6 Recommendations for building an international technology cooperation framework

A number of useful technology mechanisms have been proposed under the climate negotiations that, collectively and coordinated by the UNFCCC but with elements outside of its umbrella, can develop and transfer low-carbon technologies. The challenge is how to mend these mechanisms and proposals into a coherent framework that adheres to the leading principles discussed in Section 2: ideally, it should takes away barriers as perceived by the most relevant actors, provide reciprocity, closes the finance gap, creates enabling environments including all variants of capacity, and addresses the different stages of technological development.

Sections 4 and 5 have discussed whether this could be the case, given the limited information and experience currently available about the mechanisms. It can be concluded that the sum of all the technology proposals comes a long way towards meeting the principles, but that there are uncertainties about the effectiveness and challenges around implementation. If the perspective of any actor is not directly taken into account, it is that of the private sector: in most proposals, there is a relatively large role of public actors.

Uncertainties and challenges related to the scale of the effort can be addressed by making the system as a whole more robust and coherent. This can be done by allowing for information availability and exchange between countries, regions and technology development centres, that aim at learning and self-correction if elements fail to deliver. Institutional arrangements, including international oversight and expert review teams, combined with more nationally-oriented reviews for domestically operational mechanisms, can complement each other.

Interaction, knowledge exchange and networking are key. The added value and reciprocity for countries that invest human or financial resources in the technology framework is lost when centres of excellence operate on their own without embedding into national decision making processes, when low-carbon growth plans are not aligned with international developments In order to allow for reciprocity for countries or other stakeholders to materialise, a framework should allow for strategic positioning of countries, but maintain a high degree of openness in order to eventually let benefits of innovation become available broadly.

Figure 6.1 gives an (incomplete) illustration of how the technology mechanisms could cover stages of technological development as well as allow for interaction between countries and the international level. It shows, for instance, that elements of national technological innovation systems, such as market formation, can be enhanced by international mechanisms, such as standards. It shows how international technology standards (top right box) can build on international RD&D efforts (top left) but also how they can be used in national innovation centres of excellence for local demonstration and capacity building (lower left). In turn, such centres can fulfil functions in technology innovation systems in countries or regions (lower right) and build local R&D capabilities.

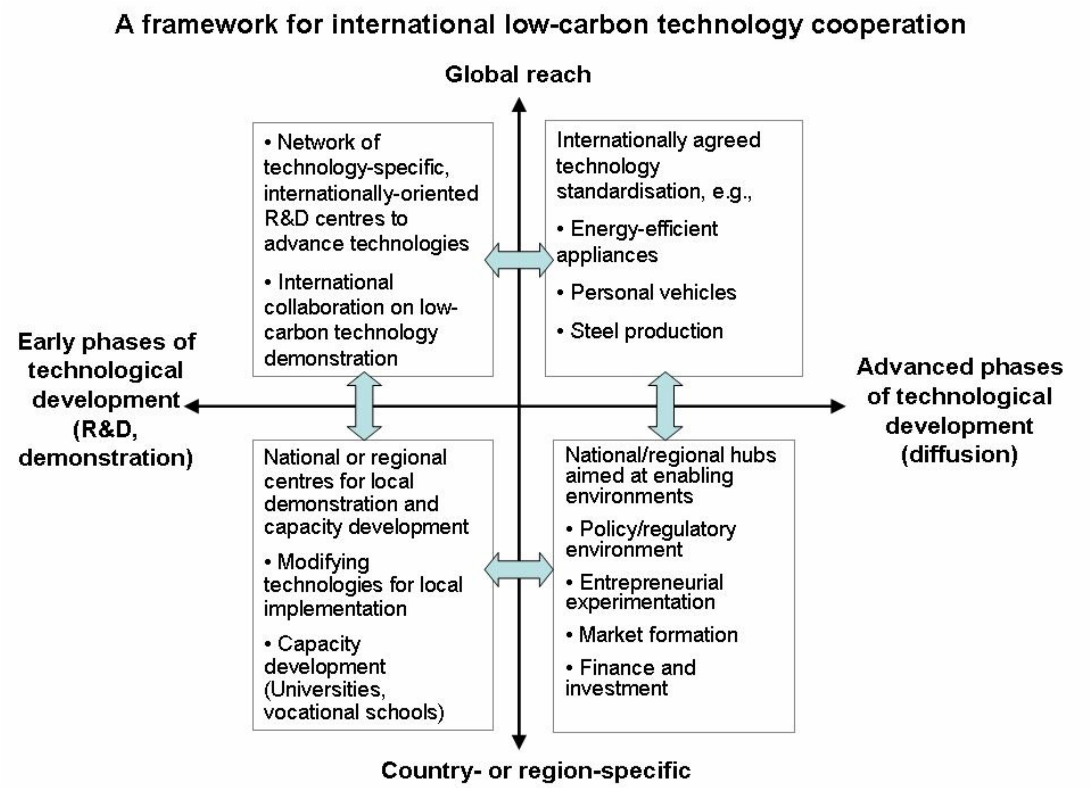


Figure 6.1 A possible technology framework with national and international mechanisms that respond to early and advanced phases of technology development and transfer. The arrows indicate that means of interaction need to be designed, possibly coordinated by the UNFCCC. The bullets are examples of areas to which the mechanisms could apply

The framework in Figure 6.1 as a whole would provide benefits for building local innovative capabilities and for development and transfer of technology. However, it would also require significant financial commitments by public entities. Given the innovative nature of such investments and the long lead times, it would take time to mobilise private financing, as risks remain high in the beginning.

A recommendation would therefore be to start with countries that have relatively good chances of an effective system, such as countries with a relatively high level of development and other functions of the technological innovation system already in place. It also seems wise to start internationally with sectors where incremental costs are low or even negative, and other barriers need to be removed. In such a way, experience could be gained with the mechanisms.

The public funding requirements are challenging but seem to be within the fast-track financing committed in the Copenhagen Accord of 2009. It would be commendable if part of this fast-track funding would be used for gaining experience with a coherent technology framework.

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