Issues an options in technology transfer

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1 Executive Summary

Background

Technology is one of the most important driving forces in reducing greenhouse gas (GHG) emissions (IPCC 2000a). Preventing dangerous interference with the climate system, i.e. fulfilling the objective of the UN Framework Convention on Climate Change, can only be achieved through delinking economic growth and development from increasing GHG emissions. Transfer of environmentally sound technologies (ESTs) from developed to developing countries is seen as essential for lowering emissions without constraining rightful economic progress in these poorer countries. Recognizing the role of technology, Annex II commitments on promoting technology transfers were enshrined in the Convention (article 4.5).

This short briefing paper, commissioned by the Norwegian Foreign Ministry, builds on previous work on technology transfer for the Ministry, and aims firstly to present the status of technology transfer in the climate negotiations, and secondly to suggest policy approaches which may begin to bridge differences of opinion and contribute to the promotion of effective technology transfers between developed and developing countries.

Problem statement & key issues

Despite the potential of technology transfers fulfilling both development and climate policy objectives, progress on the implementation of commitments has been hampered by differences of opinion between developed and developing country groups.

The underlying contentious issue in the negotiations is how the cost burden of technology transfer shall be shared between developed and developing countries, i.e. how Annex II commitments under the Convention shall be fulfilled. The difficulty of agreeing on how to define financial additionality of Annex II efforts is an important hurdle related to burden sharing.

There is also disagreement between the two country groups about the roles of government and the private sector in technology transfer. Annex II countries generally argue that ESTs are privately owned, and should therefor be transferred through this sector. China and G-77 generally advocate stronger government involvement, and that technologies should be transferred on non-commercial and preferential terms. This disagreement is partly due to the underlying conflict of burden sharing, and partly due to different views on how technologies are (and should be) transferred.

Another key issue is the need, expressed by developing countries, for access to technologies that contribute to economic and social development, which remains the main priority of these countries.

Conclusions and recommendations

A precondition for bringing developing and developed countries closer on the issue of burden sharing related to technology transfer, is firstly to focus on transferring technologies which have both development and climate benefits, and secondly to reach a common understanding on how technologies most effectively may be transferred. Central to both is the acknowledgement of the different roles of governments and the private sector in technology transfer, and the need to build private-public institutions. To support long-term economic development, it is important to emphasize that technology transfer efforts should focus on building and accumulating technological capabilities (software: know-how and know-why) in developing countries.

The technology transfer process faces institutional, political, technological, economic, information, financial and cultural barriers, both in developed and developing countries. The most effective role of governments to overcome some of these barriers is to create the economic, legal and regulatory conditions that promote private sector trade and investment resulting in technology transfers. Private sector firms generally have a more appropriate understanding of the market place and if given the right incentives, will contribute both to economic sector development and GHG emission reductions.

The most appropriate policy interventions to create an enabling environment for technology transfers through the private sector will vary between countries. Countries are on different stages of development, have different institutional settings and have different technology needs. Building and/or strengthening public-private partnerships will have to reflect specific contexts, and it is therefore likely that technology transfers are most successful if demand driven. Some options for policy interventions are: disseminate technology information, scale back on energy subsidies, strengthen environmental regulation, provide investment credits or subsidies, build human capital and R&D infrastructure, and strengthen intellectual property protection.

To make technology transfers as effective as possible in achieving both development and climate policy objectives, there is considerable merit in building bridges between government assistance increasingly focusing on private sector development, *inter alia* through energy assistance, and private sector driven technology transfers under the Climate Convention. Generating synergies between different efforts resonates well with the recent World Bank Comprehensive Development Framework. This integration process would have to fully acknowledge the principle of additionality of efforts under the Convention.

2 Introduction

2.1 Background

Delinking economic growth and development from increasing greenhouse gas emissions is essential to prevent dangerous anthropogenic interference with the climate system, i.e. to fulfill the objective of the United Nations Framework Convention on Climate Change (UNFCCC). A crucial element in breaking this

link, and making economies and economic development sustainable, is increasingly seen to be technological change and technology transfer between and within countries, and particularly from developed to developing countries (Guertin et al 1993). The majority of the world's population has legitimate development aspirations, and environmentally sound technologies (ESTs) from the North can potentially fuel sustainable economic and social development in these poorer countries.

Despite this potential window of opportunity for developing and developed countries, the progress on the issue of technology transfer in the climate negotiations has been hampered by difference of opinion between the two country groups. The main contentious issue is how the cost burden of technology transfer shall be shared. Developing countries generally see technology transfer as a government to government process under the Convention, while developed countries generally argue that technology is owned by the private sector, and should therefore be transferred through this sector.

Technology transfer in relation to sustainable development has mainly been discussed since the Earth Summit (UNCED) in Rio 1992, and was subsequently embodied in chapter 34 of Agenda 21 and finally in Article 4.5 of the UNFCCC[1]. Furthermore, a series of special decisions were made on the transfer of ESTs by the first four sessions of COPs (Conference of Parties), most notably the COP 4 decision on establishing a consultative process to bring progress on the issue towards COP 6 in November this year. Three workshops in Africa, Asia and the Pacific Islands, and Latin America and the Caribbean have been held, a Special Report on technology transfer from IPCC is due for publication later this year, and both developing and developed countries have been invited to submit views on technology transfer. Summaries of the IPCC report and the first two workshops are included in Annexes I and II to this memo, respectively.

This short briefing paper, commissioned by the Norwegian Foreign Ministry, builds on previous work on technology transfer for the Ministry[2], and aims firstly to present the status of technology transfer in the climate negotiations by identifying the key issues (chapter 3), and secondly to present policy approaches which may begin to bridge the differences of opinion and contribute to effective technology transfers (chapter 4). The reminder of this introductory chapter will very briefly recapitulate the meaning of technology transfer in the context of climate change (see ECON (1999)).

[1] Article 4.5 states that "The developed country Parties and other developed Parties in Annex II shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention. In this process, the developed country Parties shall support the development and enhancement of endogenous capacities and technologies of developing country Parties." Technology transfer is also mentioned in other articles such as 9, 11 and 12.

[2] ECON (1999) ~~looks~~ explores the notion of technological capabilities and looks at general criteria for successful technology transfers under climate change mechanisms.~~into the concep…,while~~ ECON (2000) looks at ways of combining the Norwegian Government's strategy for supporting private sector development in developing countries, *inter alia* through technology transfers, with climate change policy.~~..~~

2.2 Technology transfer in the context of climate change

Technology transfer in the context of climate change is «a broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change amongst different stakeholders such as governments, private sector entities, financial institutions, NGOs and research/education institutions» (IPCC 2000b:3).

The core elements of this definition will be explained under the following subheadings, focusing on transfer between developed and developing countries.

Three elements of technology transfer: hardware, know-how and know-why

The three types of flows identified in the above definition are in the literature on technology transfer usually termed (Aasen and Onsager 1990, Wilhite and Stenseth 1990):

(1) ***Hardware:*** equipment, machinery, capital goods, product design etc.

(2) ***Know-how:*** Competence and skills to absorb and adapt techniques to local circumstances, to fulfill intended tasks.

(3) ***Know-why***: Ability to generate and manage technological change.

Transfer of technology thus involves moving elements of (1), (2) and (3) from one context, nationally or internationally, to another. Under the UNFCCC the former element is termed "hardware", while the latter two elements make up the «software». Experiences from technology transfers show that if the hardware, the physical part of the technology, is transferred without also transferring and developing technical and managerial skills (know-how) locally, the technology will work less efficiently (or not at all) in a developing country context (TERI 1997, Pachauri et al 1997). Transfer of hardware and know-how from developed to developing countries can be seen to increase the *production capacity* of the recipient country. However, in recent years strengthening also the recipient country's *technological capacity or capability* more generally, i.e. its ability to instigate and manage technological change (element (3)), is regarded as increasingly important in technology transfer, and for long term economic development (Bell and Pavitt 1993). Incremental increases in production capacity from foreign technology transfers are important, but unless these form part of a broad, national learning process for technological capacity building, a strong dependence on foreign technology and technology assistance can evolve (Mathur et al 1998).

Vehicles for technology transfer

As indicated by the above definition, the process of transferring technology from a developed to a developing country, or even within a country, involves the participation of a wide range of stakeholders, partly depending on which type of *vehicle* is used for the transfer. When technology is transferred between countries the term "vertical or international transfer" is used, while transfer within a country

interchangeably is termed "horizontal transfer" and "technology diffusion or dissemination" (Forsyth 1998). Vertical transfers are increasingly carried out by the private sector through foreign direct investments (FDI), direct purchases, joint ventures, licensing, cooperative research arrangements and co-production agreements (Enos et al 1997). Government led transfers include government assistance, government direct investment, education and training programs etc. The wider diffusion (horizontal transfer) of technologies in a country, once introduced, follows many of the similar patterns as the initial, vertical transfer. A higher level of technological capabilities in the recipient country more generally, may however be required for successful technology diffusion (see sections 3.2 and 4.1).

Climate relevant technologies and sectors

In the context of climate change two main types of technology are relevant:

(1) Technologies that mitigate anthropogenic emissions of greehouse gases (GHGs) or enhance the capture of GHGs in sinks, and

(2) Adaptation technologies: technologies that facilitate developing countries' ability to adapt to climate change effects (adverse effects) such as coastal flooding, health impacts etc.

Transfer of technologies that mitigate emissions of GHG or enhance sinks are in principle relevant for all main economic sectors, i.e. transport, industry, energy supply, buildings, waste management (all GHG reduction), agriculture (GHG reduction and sink enhancement) and forestry (sink enhancement).

3 The status of technology transfer in the climate negotiations

This chapter first presents some country and group positions on technology transfer as these are reflected in submissions to the UNFCCC Secretariat and in statements made in the negotiations[3]. In total 13 countries (EU counted as one) have submitted general views and information on technology transfer activities. The second part of the chapter focuses on two key issues which we regard as being main obstacles to progress in the negotiations, and a third issue which is important for the successful implementation of technology transfers.

3.1 Country and group positions

The 13 Parties which have submitted written views are Australia, Japan, USA, Canada, EU, Norway, Bulgaria, Uzbekistan, Georgia, South Africa, Kenya, Egypt and China, of which the latter seven countries are non-Annex II Parties. The submissions, received at the Secretariat during 1999, are all responses to a

[3] As reported by the International Institute ~~I~~of Sustainable ~~S~~Development's Earth Negotiations Bulletin from COP 3-5 (IISD 1997, 1998, 1999). This section does not claim to be a comprehensive representation of country positions, but is a selection of relevant issues.

questionnaire contained in an annex to decision 4/CP.4 and information about technology transfer activities carried out by the Parties.

3.1.1 Annex II country views

The Annex II Parties seem to have many of the same views on technology transfers reflected in their submissions. We will in this section very briefly summarize some Annex II views from COP 3-5.

Snapshots from COP 3

- Japan outlined the Kyoto Initiative to strengthen assistance for developing countries in their efforts to combat global warming, to be operated through the official development assistance (ODA) program. The program will offer concessional loans to promote training, cooperation on energy saving technology, new and renewable energy sources, forest conservation and afforestation, and will establish information networks and workshops.
- Australia said the bulk of ESTs are privately developed and owned. Governments can create enabling conditions for technology development and recipient countries must have appropriate policies for successful transfers.

Snapshots from COP 4

- Noting the need for an enabling environment and the potential of the clean development mechanism (CDM), Canada and Australia said that the private sector should be the main vehicle for technology transfer.
- Canada supported work on inventories for sources of new technology and gap identification.
- Australia supported analysis of barriers to technology transfer and suggested SBSTA draw on its roster of experts.
- USA said that communications between Parties on technology transfer were hindered by the differing understanding of the issues. Technology transfer should be based on country specific needs and proposed that reference be made to successful programs.
- The US and EU said that the aim of the consultative process should be «meaningful and effective» action.
- Norway recognized the role of industry in technology transfer.

Snapshots from COP 5

- Several Parties said technology transfer should be driven by the private sector. Australia, the US and the EU highlighted the potential role of the CDM in technology transfer.
- Switzerland underscored consideration of specific national circumstances.

3.1.2 Non-Annex II country views

A brief outline of some country and group positions by non-Annex II Parties from COP 3-5 and from written submissions are presented below.

Snapshots from COP 3

- China, supported by India and Iran, observed two tendencies: developed countries are only interested in transfer of technical information, while developing countries deem technology transfer on non-commercial and preferential terms most important; and some countries emphasize market mechanisms. China called for action from developed countries consistent with Agenda 21, the Convention and previous COP resolutions.
- Iran identified obstacles facing developing countries seeking transfers of technology at their own expense due to restrictions imposed by developing countries. Shifting responsibility for transfers to the private sector contradicts the spirit of Agenda 21.
- Zimbabwe outlined the country's difficulties with basic economic development and the financial impact of El-Niño. Technology transfer has become a critical issue.
- South Africa said access to technology and transfer of technological know-how would play a crucial role in meeting energy implications of moving towards sustainable development.

Snapshots from COP 4

- China emphasized the role of national governments and international organizations, and argued that technology transfer should be on non-commercial and preferential terms. Technology transfer commitments relate to the Convention (Article 4.5) and should not be linked to the Kyoto Protocol.
- G-77/China proposed a Technology Transfer Mechanism (TTM) "to assist developing country Parties to obtain their needed environmentally sound technologies and know-how, conducive to addressing climate change, on non-commercial and preferential terms and thus contribute to the ultimate objective of the Convention". There was consensus on the capacity building section of the G-77/China proposal, which called for efforts to enhance endogenous capacities and provide enabling environments. The US opposed the G-77/China proposal for a TTM since it would be difficult to agree on its terms of reference. The US also opposed the reference to "non-commercial and preferential terms", recalling that this reference was rejected when the Convention was being negotiated.
- G-77/China said that their participation in mitigating climate change depends on the effective implementation of developed country Party commitments in the field of technology transfer and financial resources.

Snapshots from COP 5

- The Philippines, with Saudi Arabia and China, stressed that technology transfer was a commitment under the Convention and opposed linking it to the CDM.

- G-77/China indicated that developing countries are constrained by lack of necessary technologies and know-how, appropriate institutions and financial resources, and regular fora to exchange ideas and build positions.
- Several developing country Parties said that transfer of ESTs is the only way to guarantee that developing countries will develop in a sustainable manner.
- AOSIS (Association of Small Island States) have through all COPs stressed the need to consider adaptation, not only mitigation technologies. AOSIS noted that financial and human resources limitations have stifled progress in adaptation and highlighted the potential of CDM in this regard.
- Bhutan and Bangladesh called for special attention to the needs of the least developed countries.

Some points from non-Annex II submissions

- Chinas basic position is outlined in four points
  - Technology transfer to developing country Parties is a commitment of developed country Parties under the Convention.
  - Such transfer is on a grant or concessional basis, i.e. on non-commercial terms.
  - The flow of technology should be from developed to developing countries.
  - The roles of governments, particularly in developed countries, are crucial.
- China stresses the need to transfer publicly owned technologies, and points to lack of political will of developed country governments as the main barrier.
- China thinks that the CDM under the Kyoto Protocol should have a component of technology transfer, but that technology transfer under CDM should be additional to commitments in the Convention.
- Kenya assigns an important role to the private sector in technology acquisition in developing countries, but emphasizes that lack of funds for most local industries to purchase environmentally and modern technologies continues to be a major barrier. Governments need to be assisted to put in place appropriate enabling environments for industry to receive these technologies, foster their development, transfer and diffusion.
- The South African submission stresses the need to strengthen the technological infrastructure in Africa, and that this is essential for sustainable technology transfer initiatives. South Africa acknowledges that the private sector is playing the major role in technology transfers through normal market mechanisms, and that CDM is a potentially important market based transfer mechanism.

3.2 Key issues

3.2.1 The roles of private and public sectors

The difference of opinion between Annex II and non-Annex II countries on the roles of governments, public and private sectors in transfer of technology is a major hurdle in the negotiations. This disagreement is partly due to different interpretations of Annex II commitments in the Convention, and partly due to different understandings of how transfers take (and should take) place. The former dissension is closely linked to the issue of financial additionality, i.e. that Annex II efforts in promoting technology transfers under the Convention (Article 4.5) should be additional to other existing and planned ODA programs. This section will briefly address the latter part of the disagreement and clarify the roles of government and private sector in technology development and transfer, preparering for a description of policy options in chapter 4.1.

Technology development and commercialization

Technology is developed through a complex interplay between government, public institutions and the private sector. In most Annex II countries technology is developed by public research institutions, R&D departments of (large) firms, private or public Universities, or semi-private research institutes (with public support). The R&D process generally needs support by government partly through fundamental educational, juridical (e.g. intellectual property protection) and macro-economic policies and partly through direct, public R&D initiatives. The motivation for public involvement is that education and research have society benefits beyond what private sector firms and institutes would generate through their own initiatives.

The commercialization of technology (i.e. its direct use in manufacturing processes for commercial purposes), however, is a process often left to the private sector, and thus ownership of most technologies reside with that sector. Private sector generally has a more appropriate understanding of the market place and the requisite marketing and financial resources. In practice only a small share of technologies is owned by governments represented by state owned firms or research institutes.

Technology transfers: Through private firms under government directions

Because of the private sector firms' superior knowledge of technology markets and the commercialization process, the majority of technologies are therefore also *transferred* by private sector firms (Forsyth 1999). A small share of technologies, often those which are still on the R&D stage, may however be transferred through cooperation between government institutes.

This is however not to say that governments have no role to play in *transfer* of technology. The responsibility of creating an enabling environment for transfer through the private sector resides with governments, both for transfers within and across countries (Chung 1998, OECD 1997). In addition, the interests of firms (maximize economic rents) may not necessarily coincide with a state's efforts to promote technology transfer for climate mitigation and adaptation (Evans 1999).

In theory, technologies would diffuse through the private sector if it was profitable for firms to adopt new technologies. However, since many ESTs are not yet commercially viable, a more active role of government may be required to facilitate technology diffusion.

The developing countries' concern that market driven transfers will be expensive, not give sufficient access to technologies and not support necessary capacity building for national technology diffusion, is relevant. In light of the above, it is clear that governments have a central role to play in providing the right incentives for private led vertical transfers, and in building public-private partnerships for the wider diffusion of technology hardware and technological capabilities nationally.

The disagreement about whether CDM can be an important vehicle for technology transfer, is linked to the discussion above. CDM is a mechanism for foreign private-led investment in GHG mitigation, and will most likely involve elements of technology transfer. It is contentious whether technology transfer under the CDM could be used to fulfill Annex II commitments. Regardless of the political development on this issue, we think that a cautious and sensitive approach acknowledging CDM as a potential vehicle for technology transfer can be important both for development and climate mitigation objectives (chapter 4.3).

3.2.2 Development needs and climate mitigation objectives

The second key hurdle in the climate negotiations is not specific to the issue of technology transfer, but has been and is a major obstacle to the effective implementation of the Convention more generally. The developed countries have through their carbon intensive industrialization caused the problem of GHG build-up in the atmosphere. Even though the responsibility resides with these countries, unilateral GHG emission reductions by the Annex II countries will be futile. This is because the developing countries are predicted to be the main GHG emitters in a few decades if they follow an equally carbon intensive development path.

The main priority for developing countries is to bring their populations out of poverty and enter a sustainable economic development process. It is therefore unacceptable to these countries if Annex II countries focus on transfer of emission reducing technologies that not also yield productivity gains and contribute to economic development. Many ESTs may, however, fulfill this criterion in addition to also abating local pollution. Section 4.3 looks at policy options that encourage private initiatives to tap the gains where the potential for GHG mitigation and local development is highest.

3.2.3 Barriers to successful transfer of technology

A common understanding between developing and developed countries in the negotiations on the key issues treated in the two previous subsections is vital for implementation of technology transfer activities under the Convention.

There are, however, a whole range of generic issues which will need to be considered and taken into account for these technology transfer activities to be successful, once started. A «successful» technology transfer should satisfy the following three conditions (Wilhite and Stenseth 1990):

(1) In a purely technical sense, the technology functions as intended

(2) The receiver masters the technology (obtains know-how)

(3) The receiver has the ability to develop the technology and to adapt it to new circumstances (obtains know-why)

Experience from decades of development projects involving technology transfers, shows however that making technology transfers succeed is a highly difficult task. As Forsyth (1998:4) states: ”The entire concept of technology transfer is controversial because it suggests that technology is an easily identifiable commodity that may be given, relatively quickly and successfully, from one country to another”. On a generic level this is the main problem of technology transfer: a technology developed in a complex context, made up of a set of cultural, political, economic, geographical and biological factors, to serve a highly specific purpose, is taken out of that context and implanted in a completely different context to serve an often ”foreign imposed” purpose (Fløysand 1996, NORAS 1991, 1992).

In light of this, barriers to successful technology transfer may take a wide range of forms (based on FCCC/TP/1998/1):

(1) ***Institutional:*** lack of legal and regulatory frameworks, limited institutional capacity and excessive bureaucratic procedures;

(2) ***Political:*** instability, interventions in domestic markets (e.g. subsidy distortions), corruption and lack of civil society;

(3) ***Technological:*** lack of infrastructure, lack of technical standards and institutions for supporting standards, low technical capabilities of firms and lack of technology knowledge base;

(4) ***Economic:*** instability, inflation, poor macroeconomic conditions and disturbed and/or non-transparent markets;

(5) ***Information:*** lack of technical and financial information and of a demonstrated track record for many ESTs;

(6) ***Financial:*** lack of investment capital and financing instruments;

(7) ***Cultural:*** consumer preferences, work culture, social biases;

(8) ***Legal:*** intellectual property protection and unclear arbitration procedures.

Section 4.2 will look at possible policy interventions that may lower the barriers to successful transfer of ESTs to developing countries, through building public-private institutions.

4 Policy options: Towards COP 6 and beyond

This chapter examines potential policy options that can begin to bridge the gaps of opinion towards COP 6, and beyond, and contribute to the promotion of effective technology transfers between developed and developing countries. Section 4.1 stresses the need to build public-private institutions within and between countries, section 4.2 looks at the most relevant barriers which can be addressed through these institutions, and 4.3 ends the chapter by discussing ways of targeting synergies between climate policy and development needs.

4.1 Building public-private institutions

In the broadest sense, institutions are a set of governance mechanisms that incentivise and constrain economic activity. In the context of climate change and technology transfer, institutions refer both to the stakeholders involved in technology transfer and technological change and the formal and informal rules and norms that regulate the interaction between them.

Technological change requires and involves continuous changes in the surrounding social, economic and cultural fabric of societies. The aim of technology transfers goes beyond incremental changes in production capacity or reduction of GHG emissions, to be an important factor in the long-term process of building know-how and know-why for managing technological change in developing countries. This wider perspective on technology transfer, which we also stressed in chapters 2 and 3, is essential for instigating technological change necessary for achieving both development and climate policy objectives in developing countries.

Most studies of technology transfer experiences increasingly emphasize the role of the private sector in the vertical transfer of technology, i.e. the point-to-point relocation of technology via mechanisms such as foreign direct investment, licensing etc (Hill 1992). The role of developing and developed country governments in this process is mainly to provide pull and push incentives, respectively, for the private sector, e.g. through open trade and investment policies as well as providing a stable economic environment for investors (Thorn 1998, Goldman et al 1997). As seen in chapter 3 these incentives constitute the enabling environment for vertical technology transfers. Investors would, in the long-term, find the best ways of transferring technologies (through long-term partnerships, direct investments etc.) and make them work locally, since investors (by definition) have economic stakes (Montes 1997). Governments rely on enterprises to make the investments that translate public R&D and related investments into employment opportunities and economic growth (OECD 1997). It is our opinion that encouraging foreign investments is an essential first step in achieving the wider goal of building technological capabilities (Najmabadi and Lall 1995).

Foreign technology should be, as we have argued, an input into local efforts of technology development, and not entirely substitute for it. The concept of a “National System of Innovation” captures the range of technology institutions and

structures in a country. Building technological capabilities will encourage the wide diffusion of imported technologies by enabling local actors to master and gradually improve the technologies. Technological accumulation on a wide-spread level is a lengthy process which requires government support for technology education and training as well as R&D infrastructure. Human capacity building, both technical and non-technical, in relation to technology diffusion and development is stressed as essential in most studies of technology in developing countries (e.g. Aw and Batra 1998, Lau 1997, Kim 1993).

The important role of governments in the development and diffusion of technologies through the private sector, makes a case for close private-public partnerships. Examples of such could be research institutes, information centres, joint training programs, close cooperation in universities etc. Long-term public-public and private-private partnerships within and across countries have also been put forward as important for successful technology transfer and diffusion (Wilhite and Stenseth 1990).

To sum up, public-private institutions that govern a country's development of indigenous technologies and adoption of foreign technologies constitute a central part of that country's National System of Innovation. Important elements of this system are an enabling environment for investment and transfer of ESTs, accumulation of human capital through education and training, and networks of partnerships across public and private sectors in both developed and developing countries.

4.2 Interventions that lower the barriers

This section will focus on the technology diffusion process in developing countries and look at interventions involving private-public institutions, which can reduce barriers to horizontal technology transfer. The most relevant barriers which can be tackled by building public-private institutions, from chapter 3.2.3 are (in their original order): (1) institutional, (2) technological, (5) information, (6) financial, (8) legal. These barriers were generally also identified as the most important by non-Annex II countries (van Berkel and Arkesteijn 1998).

Studies of technology diffusion generally find that relatively profitable, small-scale, and simple innovations are adopted fastest. In addition they have found that new technologies are adopted faster by firms that are large, have well-trained staff, incur high regulatory costs when using an existing technology, have infrastructure complementary to the new technology, are in fast-growing industries, invest more in R&D, pay relatively low prices for inputs used intensively by the new technology, and have relatively old existing capital (Blackman 1997)

A broad range of firm-level, sector-level, and country-level characteristics determine whether or not and how quickly technologies are adopted, and there are likely to be systematic differences between developing countries and industrialized countries in nearly all of these characteristics. For instance, many technologies in developed countries are profitable because they are labour-saving, a characteristic which would often reduce the profitability in developing countries.

Blackman (1997) sees seven types of policy levers available to influence the speed of diffusion of ESTs in developing countries:

(1) ***Information:*** Economic theory suggests that the dissemination of information about new technology is likely to be a critical determinant of diffusion. Government intervention to enhance the dissemination of technical information is justified. Policy options include demonstration projects, advertising campaigns, testing and certification of new technologies, subsidies to technological consulting services, encouraging public-private and private-private partnerships.

(2) ***Input prices:*** Particularly energy prices have a critical impact on the adoption of energy saving technologies. In many developing countries and economies in transition energy is subsidized. Removing or scaling back subsidies and/or introducing energy taxes will create strong incentives to adopt energy saving technologies.

(3) ***Regulation:*** Firms subjected to stricter environmental regulation are more likely to adopt ESTs. Making environmental services more expensive through emission taxes or direct standards will reduce emissions. Many barriers to stricter public-led environmental regulation, such as institutional and financial, exist in developing countries. NGO and grassroots efforts to deter polluters by stigmatizing them can be an effective substitute.

(4) ***Credit:*** Lack of access to credit is identified as the most important barrier by non-Annex II countries (van Berkel and Arkesteijn 1998). Subsidizing credit for specific types of investments has been a common policy response. These programs, both public and private, have had mixed results. Common problems are the diversion of loans by borrowers, low repayment rates, politization of lending decisions etc. There is growing support for the view that the costs of "targeted credit" outweigh the benefits. A wiser approach to overcoming the financial barrier is to focus on improving banking which, in developing countries, is often hamstrung by unstable monetary policy, interest rate restrictions, and weak property rights.

(5) ***Subsidies:*** An obvious mechanism for speeding the diffusion of new technology is for government to subsidize it. But subsidies, in addition to being quite expensive, are likely to be subject to many of the same problems as targeted credit.

(6) ***Human capital, infrastructure, and R&D:*** There is a strong argument for subsidizing education, technical training, infrastructure and R&D, inter alia focusing on ESTs.

(7) ***Intellectual property restrictions (IPRs):*** IPRs such as patents and licences have countervailing effects on technology diffusion. On the one hand, they stimulate R&D, which in turn stimulates technology diffusion. Furthermore, and more important for developing countries, IPRs encourage foreign investment. On the other hand, IPRs attach significant costs to adoption of new technologies which can retard diffusion. In many developing countries, adaption of existing technologies, rather than the creation of substantially

new ones, accounts for the bulk of productivity growth. IPRs may therefore have a negative impact on technology diffusion in developing countries.

Which of these policy options would be practically feasible depends on country-specific circumstances but also on general charcteristica of developing countries. Some of these policies involve up-front economic costs that are more immediate and payoffs that are more delayed than others, making them unattractive to decision makers with short time horizons (e.g. investment in banking, human capital and environmental regulation). Policy options would generate political support in both developing and developed countries to the extent they contribute both to achieving climate and development policy objectives, a topic more closely treated in the next section.

4.3 Targeting synergies between climate policies and development needs

Decades of experience from development efforts of poorer countries has generally shown that the private sector is the driving force of economic and social progress. Harnessing efficient market mechanisms to reach societal goals is the key to welfare of populations. Recent experiences from the NICs (Taiwan and South Korea), and also from emerging developing countries in Asia, South America and Africa support this hypothesis. But, as mentioned in the introduction, the challenge in the context of climate change and technology is to make private sector investments in technology development and transfer achieve the objectives of both environment and development policies.

Targeting synergies between these two objectives involves firstly identifying technology areas and sectors where the potential for such synergies is highest, and secondly establishing and utilizing public-private institutions that enhance the vertical and horizontal flows of these technologies. Many of the policy options presented in the previous section achieve both objectives to some degree. Information, human capital and infrastructure policies will enhance productivity; rationalizing energy prices will boost allocative efficiency (i.e. use investment resources more efficiently); improving banking should stimulate saving and investment; and strengthening environmental regulation should produce environmental benefits.

Technology transfers contribute the most to development, in our opinion, if they are private sector driven and contribute to industrialization in developing countries. Technology transfer investments that are integrated in developing country economies and form part of broader strategies for private sector driven economic development, generate synergies between different efforts. This resonates well with the recent World Bank Comprehensive Development Framework which seeks a better balance in development efforts by emphasizing the interdependence of all elements of development – social, structural, governance, environmental, economic and financial.

Increasingly government to government development assistance is focusing on developing private sector activities. As described in previous sections, technology transfers are inextricably linked to private sector activities. There is a large potential to explore synergies between more traditional development assistance,

inter alia in the field of energy assistance, and technology transfers under the Climate Convention. It is important, however, in such a process to acknowledge the clear obligation of Annex II countries to make efforts in technology transfer *additional* to those development efforts that are undergoing and planned for the future, independently of the Convention. It would clearly be hard to disentangle and categorize efforts from this integrated approach, but we are of the opinion that the benefits of such an approach could be considerable.

When technology transfers are private sector driven, with clear economic stakes both for recipient and transferer/investor, experience shows that success is more likely to be achieved. Duplication of mistakes previously made in government-led technology transfer programs must be avoided in projects/investments under the Convention. The private sector must see incentives that favour investments in the development and transfer of ESTs. One such incentive mechanism that may play a role in the transfer of technologies for development and emission reductions, is the CDM (see BOX 4.1). We are of the opinion that the CDM will involve elememts of technology transfers and that it is fruitful, regardless of the outcome of the negotiations on additionality of CDM efforts, to explore the potential of this mechanism to create synergies between development and climate policies through technology transfers.

CDM as a vehicle of technology transfer: The cases of renewable energy technology and energy efficiency technologies for industry.

The majority of Activities Implemented Jointly (AIJ) projects which have been implemented since the start of the pilot phase in 1995 have involved elements of technology transfer. Most of the projects in developing countries, however, have been forestry projects with a lesser degree of "hardcore" technology transfer for sustainable development. CDM, which is to start this year, has the aim of both contributing to sustainable development and GHG mitigation in developing countries. As opposed to AIJ, CDM allows for crediting against Annex I commitments and may give strong private sector incentives for investments in vertical transfers of energy technologies to developing countries. We give two examples of types of technologies which target synergies between development needs and climate objectives (see e.g. Goldemberg 1998):

(1) Renewable energy technologies have been seen as a type of technology which has a high potential of contributing to both sustainable development and GHG mitigation in developing countries (Forsyth 1999, GEF 1999). Examples are technologies utilizing wind, micro-hydro, biomass, geothermal and solar energy, energy sources which are of abundant supply in most developing countries. Forsyth (1999) emphasizes the importance of private-public partnerships in transfer of renwable energy technologies. Large-scale rural electrification programs were more likely to succeed when high-technology applications, ~~were~~ supplied from international investors, ~~but~~ were then embedded locally with the assistance of specialist development agencies ~~that could provide local expertise~~. As an example he cites a project in the Phillipines where photovoltaic technology was supplied by BP Solar (Australia), yet supported by a variety of official aid agencies.

(2) New processes, efficient energy and resource use, substitution of materials, changes in design and manufacture of products resulting in less material use, and increased recycling, can substantially reduce GHG emissions (IPCC 2000). Transfer of technology means both improving the efficiency of existing technologies as well as introducing new technology "hardware". Many GEF projects have targeted increased energy efficiency of developing country industries (GEF 1999). Using energy and materials more efficiently in production of goods that have the same (or better) qualities, cuts production costs and has potential for spurring economic growth and development

5 Conclusions

Progress on the issue of technology transfer from Annex II to non-Annex II countries under the Climate convention is hampered by differences of opinion on burden sharing and different understandings of the roles of governments and the private sector in technology development and transfer.

Agreement on burden sharing is a difficult political issue which can only be resolved based on a common understanding on the principles of how technologies can be most efficiently transferred and what purpose these technologies should serve in recipient countries.

An essential first step in creating a common ground for discussion of burden sharing is to focus on environmentally sound technologies which both contribute to economic development and GHG emission reduction in developing countries. To support long-term economic development, technology transfer efforts should focus on building and accumulating technological capabilities ("soft technologies": know-how and know-why) in developing countries.

A second step is to address the different roles of government and the private sector in technology transfer. The technology transfer process faces institutional, political, technological, economic, information, financial and cultural barriers, both in developed and developing countries. The most effective role of governments to overcome some of these barriers is to create the economic, legal and regulatory conditions that promote private sector trade and investment resulting in technology transfer. Private sector firms generally have a more appropriate understanding of the market place and if given the right incentives, will contribute both to economic sector development and GHG emission reductions.

The most appropriate policy interventions to create an enabling environment for technology transfers through the private sector will vary between countries. Countries are at different stages of development, have different institutional settings and have generally different technology needs. Building and/or strengthening public-private relationships will have to reflect the local context, and it is therefore likely that technology transfers will be most successful if demand driven. Some options for policy interventions are: disseminate technology information, scale back on energy subsidies, strengthen environmental regulation, provide investment credits or subsidies, build human capital and R&D infrastructure, and provide intellectual property protection.

To make technology transfers as effective as possible in achieving both development and climate policy objectives, there is considerable merit in building bridges between development assistance (increasingly focusing on private sector development), *inter alia* through energy assistance, and private sector driven technology transfers under the Climate Convention. Generating synergies between different efforts resonates well with the recent World Bank Comprehensive Development Framework. This integration process would have to fully acknowledge the principle of additionality of efforts under the Convention.

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Annex I

Summary of IPCC Special Report on Methodological and Technological Issues in Technology Transfer

This annex will very briefly sum up the most important points made in the summary for policymakers of the IPCC Special Report on Technology Transfer, that was released early May this year.

The report starts out by emphasizing the importance of technological innovation and the rapid and widespread transfer and implementation of technologies and know-how for both climate mitigation and adaptation. Furthermore these technologies should support sustainable development. The report also states that additional actions for the transfer of technologies, particularly to developing countries, are needed to meet the UNFCCC objective.

The report's definition of technology transfer is reproduced in chapter 2 of this memo. The trends of technology transfers are difficult to measure, particularly when the software elements of technology are included. Financial flows from developed to developing countries can be used as proxies. The report finds that the flows of ODA have decreased in recent years, and that the share and level of private financial flows (foreign direct investments, commercial lending and equity investments) have increased considerably, particularly favoring Latin America and East and South East Asia. From this it is concluded that the importance of the private sector in technology transfers has increased substantially. It is, however, also acknowledged that governments have important roles to play in providing an enabling environment as well as a more direct involvement. It is stressed that governments can facilitate important partnerships between the different stakeholders involved in technology transfer.

The report identifies several distinct stages in the technology transfer processes: identification of needs, choice of technology, assessment of conditions of transfer, agreement and implementation, adjustment to local conditions and replication. Barriers to transfer of ESTs are context specific and may arise at each of these stages.

To overcome barriers and making technology transfers more effective the report focuses on three dimensions: capacity building, an enabling environment and mechanisms for technology transfer.

Capacity building

Building human, organizational and information assessment and monitoring capacity is required at all stages of the transfer process. Important in human capacity building is «focussing less exclusively on developing technical skills and more on creating improved and accessible competence in associated services, organizational know-how, and regulatory management» (p5).

By building "organizational capacity" is meant strengthening existing and building new networks between stakeholders involved in technology transfer, both

within and between countries. The need for a participatory approach is emphasized.

Building capacity of assessing and monitoring technology information, particularly in developing countries, is seen as essential. The role of the private sector in providing and assessing information, i.e. through specialized consulting and evaluation services and over the Internet, is gradually increasing.

Enabling environment and extra government efforts

Both developing and developed country governments are seen to have central responsibilities in creating an enabling environment for technology transfers through both private and public sectors. Legal protection and stable macro-economic environments which reduce investor risks are examples of two important elements. Beyond providing sound framework conditions, governments may also be required to mobilize extra efforts since many ESTs are not commercially viable.

Mechanisms for technology transfer

The Report emphasizes the importance of National Systems of Innovation (NSI) which "integrate the elements of capacity building, access to information and an enabling environment into comprehensive approaches to EST transfer" (p6). Elements of a NSI may be targeted capacity building, strengthening scientific and technical educational institutions, innovative financial mechanisms, local and regional partnerships etc.

Important international mechanisms for technology transfer include ODA, GEF, multilateral development banks (MDBs) and the Kyoto Mechanisms (CDM/JI). ODA is still significant for developing countries and transfers of technology. GEF is an operating entity of the UNFCCC Financial Mechanism targeting incremental, one-time investments in mitigation projects that test and demonstrate a variety of financing and institutional models for promoting technology diffusion, thus contributing to a host country's ability to understand, absorb and diffuse technologies.

The report summary ends with a sectoral study of buildings, transport, industry, energy supply, agriculture, forestry, waste management, human health and coastal adaptation. The roles of private and public sectors vary between sectors. Central lessons are: (1) net-working among stakeholders is essential for effective technology transfer, and (2) most effective technology transfers focus on products and techniques with multiple benefits.

Annex II

Summaries of workshops on technology transfer

As mentioned in the introductory chapter, three regional workshops with broad participation have been held as part of the consultative process on technology transfer: Tanzania, Africa (16-18 August 1999), Philippines, Asia and the Pacific (17-19 January 2000) and El Salvador, Latin America and the Caribbean (29-31 March 2000). At the time of writing, preliminary reports only from the first two workshops have been made public, and short summaries of these are presented below.

Africa

Results from the first workshop held in Africa illustrate the relevance of the concepts presented in this memorandum. The workshop concluded that there is a clear need not only for hard technologies (such as equipment) but also for the soft technologies (capacity building and know-how) that will make it possible for appropriate technologies to be chosen and sustained. Following are some lessons from the first workshop (based on SBSTA (1999)) as referred in ECON (1999)):

- Climate change has not been the main focus for many African countries. Economic development issues, such as food and water security, energy security, improving the quality of life and habitat and sustainable economic growth and employment, take priority. Technology transfer under the Convention would need to address a country's priority areas in addition to meeting any climate objectives.
- In order for countries to identify specific technology needs human and organizational capacities are needed to conduct technology assessments.
- Barriers to technology transfer to Africa include economic and financial (poor economic situation and the structure of markets), organizational and institutional (a business environment that discourages private sector participation, general lack of capacity), human resources (lack of appropriate training in the region), technological (lack of institutional infrastructure to support development and implementation of appropriate technology standards and regulations based on local conditions), technology information (lack of adequate access to information).
- Capacity building is an important component to reducing or removing barriers.
- Technology transfer presents an opportunity for international co-operation under the Convention, and could be based on the development of strategic partnerships and governments, the private sector and other stakeholders.
- The private sector needs to be more involved, particularly since it is an important stakeholder in activities related to technology transfer. This was seen as important since overall ODA levels have declined and are not expected to increase.

Asia and the Pacific

The discussions in the African workshop focused on identifying barriers and stakeholder roles in technology transfer, while the Latin American workshop moved on to asking *how* barriers can be identified and addressed, and how stakeholders can be brought together in a framework for action under the UNFCCC (SBSTA (2000)). Following are some lessons from the Asian workshop (based on SBSTA *ibid*.)

- *Technology needs and technology needs assessments:* Developing country Parties within the region noted that ESTs should simultaneously address basic human needs and be compatible with nationally determined socio-economic, cultural, environmental and sustainable development priorities. Identification and assessment of technology should be led by the developing Parties themselves, but with assistance and support from developed countries when needed.

- Participants emphasized that technology transfer is a complex process that to be successful must not be a one-step event, but a long term process of partnerships and cooperation among various stakeholders. Adaptability of technology to local markets and situations was seen as important.

- Many participants emphasized the importance of considering both adaptation and mitigation technologies, and that the range of possible adaptations to climate change is large and spans many socio-economic, ecological and environmental categories. Opinions were that needs in this area are being overlooked. Governments were seen as playing an important role in the transfer of adaptation technologies. Initial focus should be on adaptation technologies that also have development benefits.

- *Technology information:* Increasing the flow of high quality and high relevance technology information from developed to developing country stakeholders was seen as important. Enhancing the capacity of existing regional organizations to assess this information was recognized as an essential first step. To make technological information as useful as possible, some participants suggested establishing a technology data base maintained by the UNFCCC or a technology information clearing house. Quality, access, reliability and comparability of information on ESTs were put as key words for successful technology transfers under the UNFCCC.

- *Barriers to technology development and transfer:* Barriers and constraints to the transfer of ESTs exist in both developed and developing countries, and barriers from all categories (chapter 3.2.3) are relevant in the Asia and the Pacific region context. Key barriers manifest themselves differently in different countries and sectors, so it was agreed that the identification, analysis and prioritization of barriers must be a country-driven process involving all stakeholders.

- *Overcoming barriers: The role of technology cooperation and assistance.* Participants noted that technology cooperation efforts need to be better targeted and coordinated. Main focus should be on transferring technologies that are appropriate for local conditions (which are not necessarily the easiest to transfer). Technology partnerships, both in R&D, financing and business, project implementation and management etc.,

between stakeholders within and across private and public sectors were seen as important.

- *Overcoming barriers: The role of governments.* There was a general consensus that one of government's most effective roles is to create the economic, legal and regulatory conditions that promote private sector trade and investment resulting in technology transfer, including the removal of market barriers and building human capacity. Providing this enabling environment was seen to be the responsibility of both developed and developing countries. In subregions and/or sectors where markets are not yet well developed governments would need to play a more direct role through creating direct incentives such as credit arrangements, R&D funds etc.
- *Overcoming barriers: The roles of the private sector, NGOs and IGOs.* Participants recognized that the private sector is an important vehicle for the development and transfer of technologies.
- *NGOs:* NGOs were seen to have an important part to play in facilitating the integration of climate change objectives into industrial, economic and development policy, as well as informing small and medium sized enterprises and contribute to capacity and awareness building.
- *IGOs:* The Intergovernmental Organizations such as GEF, World Bank, Climate Technology Initiative, regional development banks, could be more effective with greater emphasis on capacity building and coordination with national objectives. Several participants suggested that the UNFCCC could play a larger role in dealing with the information barrier.
- *Capacity building:* Capacity building in relation to technology transfer was seen to be important in four main areas:
- Capacity to conduct technology needs assessments, prioritization, planning, implementation, monitoring and evaluation.
- Transfer of know-how and practices ("technology software") was seen as essential. Important also to assess existing capacities and the identification of gaps.
- Capacity building activities are most effective for successful technology transfer if they utilize and enhance existing endogenous capacities and technologies.

The best way to build capacity was seen to be through pilot or demonstration projects, because of the simple benefits of learning-by-doing.