Chapter V
Technology transfer and the climate challenge

Introduction

In previous chapters, it has been argued that a big investment push to transform energy production and use and to diversify into activities less vulnerable to climatic shocks is the basis for an integrated response to climate and development challenges. That push is to be spearheaded by public investments but it will be sustained only by crowding private investors into an expanding green economy. It must also be accompanied by the technological advances needed to meet mitigation and adaptation challenges. Those advances will entail diffusing existing low-emissions technologies, scaling up new, commercially ready technologies and advancing new breakthrough technologies.

A rapid pace of capital formation is often accompanied by an accelerated pace of technological upgrading and learning. However, noting the familiar market failures which tend to slow or halt technological progress, chapter IV suggested that a strong public policy agenda mixing price incentives, regulation and interventionist measures, particularly within industrial policy, would also be required to ensure a continuous process of technological learning and upgrading. It also suggested that a developmental State would be needed to promote such an agenda in most developing countries. When the required technologies are not available domestically but have to be imported from abroad and adapted to local circumstances and conditions, that agenda becomes more complicated, in large part because the balance between owners and users of technology is tilted even more in favour of the former.

Technology flows through several well-known channels, the most important being trade, foreign direct investment (FDI) and cross-border technology licensing. Scientific and technical knowledge also flows internationally through research publications, research collaboration and the movement of skilled personnel. Acceleration of the flows of climate-friendly technology raises many of the same issues and challenges facing any other sort of technology. What differentiates those technologies from many—but not all—others is the urgency and scale of the transfers likely to be needed to meet the climate challenge. But there is also an underlying ethical challenge posed by climate-friendly technologies, given that the countries most responsible for climate change, or at least their corporations, are set to profit through the transfer of technologies to countries that bear little or no responsibility for the problem.

The countries most responsible for climate change, or at least their corporations, are set to profit further through the transfer of technologies to countries that bear little or no responsibility for the problem

Implementation of the appropriate measures for facilitating the transfer of clean technologies and building the local capacity to use them effectively in developing countries will require much greater collaboration among countries. Such collaboration could help bring technologies more quickly to their commercialization stage and encourage further breakthroughs in cutting-edge low-emissions technologies. However, in many developing countries where the key challenge is diffusing existing low-emissions technologies, international support is needed for research, development and deployment (RD&D), the removal of trade barriers, access to affordable financing, and effective capacity-building. Any concerted international effort to promote access to low-emissions technologies should not, moreover, suppress the ability of the developing countries themselves to produce such technologies and to become competitive on international markets.

The transfer of clean technologies and building the local capacity to use them effectively in developing countries will require much greater collaboration among countries

South-South climate technology flows could play a significant role in that transition, given the advances that have been made in some developing countries in areas such as biofuels and renewable energy

The present chapter is concerned with the international transfer and diffusion of technologies for climate change mitigation and adaptation.[1] The focus is on the "North-South" transfer of technologies, which would allow developing countries to undertake cost-effective actions consistent with and capable, ideally, of reinforcing their wider economic and social development. It identifies some of the main barriers obstructing such transfer and diffusion and proposes measures for removing or overcoming them. In response to the limited technological flows to date, resulting partly from the slow pace in blazing low-emissions development pathways and partly from the failure to fulfil promises made in international agreements, the chapter is largely concerned with how to anticipate possible future challenges. It suggests, given the scale and urgency of the climate challenge, that the international community must give much more serious attention to the kind of architecture needed to ensure greater transfers of technology so as to speed the transition to low-emissions development pathways. South-South climate technology flows could also play a significant role in that transition given the advances that have been made in some developing countries in areas such as biofuels and renewable energy. How to facilitate such flows will also require greater consideration in subsequent discussions of the technology transfer challenge.

Technology transfer for climate change: a global public policy challenge

There is agreement that technology transfer will be fundamental to enabling an effective implementation of the United Nations Framework Convention on Climate Change[2] beyond 2012. As early as 1972, the United Nations Conference on the Human Environment in 1972 (United Nations, 1972) had included explicit language emphasizing the importance of technology transfer for the achievement of environmental and developmental goals. Language that referred to technology transfer also appeared in the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer[3] (see box V.1) and the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.[4]

The United Nations Conference on Environment and Development, held in Rio de Janeiro in 1992, gave a new urgency to the transfer of environmentally sound technologies (ESTs) for climate change mitigation. Developments subsequent to the adoption of the United Nations Framework Convention on Climate Change related to technology transfer have included the adoption of the Buenos Aires Plan of Action by the Conference of the Parties to the United Nations Framework Convention on Climate Change at its fourth session, held at Buenos Aires from 2 to 14 November 1998.[5] The Conference of the Parties requested that developed countries "take all practicable steps to promote, facilitate and finance" the transfer of environmentally sound technologies to developing countries and their access thereto.[6] In particular, the Plan of Action envisions an "enabling environment … to stimulate private sector investment" in the transfer of environmentally sound technologies.[7]

1 These are a subset of environmentally sound technologies (ESTs) that are climate-related.

2 United Nations, *Treaty Series*, vol. 1771, No. 30822.

3 Ibid., vol. 1552, No. 26369.

4 Ibid., vol. 1673, No. 28911.

5 FCCC/CP/1998/16/Add.1, sect. I, decision 1/CP.4. The Plan of Action was adopted as specified in decisions 2/CP. 4-8/CP.4.

6 Ibid., decision 4/CP.4, para. 3 (a).

7 Ibid., para. 7 (d).

Box V.1

Lessons learned from the implementation of the Montreal Protocol

The Montreal Protocol on Substances that Deplete the Ozone Layer[a] was agreed in 1987 and entered into force on 1 January 1989. The Protocol was a response to the fact that scientists had showed that some man-made substances were contributing to the depletion of the Earth's ozone layer, which protects life from damaging ultraviolet radiation. The Protocol is considered one of the most successful global environmental agreements and stimulated the development and worldwide transfer of technologies to protect the stratospheric ozone layer.

The Protocol requires that Parties eliminate emissions of most ozone depleting substances. Environmentally safe substitutes and related technologies have been used to achieve this objective. Since many of these technologies are widely available only in a relatively few countries and since the global market has been slow to bring these technologies to some parts of the world, deliberated and active international technology transfer programmes have been needed to eliminate emissions of ozone depleting substances (Strelneck and Linquiti, 1995).

The Multilateral Fund for the implementation of the Montreal Protocol was established by the London Amendment to the Montreal Protocol in 1990 to assist developing-country parties to the Protocol, whose annual per capita consumption and production of ozone depleting substances is less than 0.3 kilogram (kg), in complying with the control measures of the Protocol. The Fund covers the incremental costs associated with technology transfer, including the costs of on-site engineering, equipment purchase and installation, training, and start-up. Capacity-building projects, such as the establishment of national ozone offices and regional ozone network offices, are also eligible for funding (Andersen, Madhava Sarma and Taddonio, 2007). As of April 2008, the contributions made to the Multilateral Fund by some 49 developed countries (including countries with economies in transition) totalled over US$ 2.3 billion.

Lessons have been derived from implementation of the Montreal Protocol which may be of interest to those involved in the climate change process (Andersen, Madhava Sarma and Taddonio, 2007). The lessons relevant to technology transfer include: the need for developing visionary technology assessments; empowering the financial mechanism to be a proactive instrument for technology transfer; developing and implementing training programmes; and using regulations and policies to promote technology transfer.

a United Nations, *Treaty Series*, vol. 1552, No. 26369.

In order to operationalize the relevant provisions of the Framework Convention on technology, the intergovernmental process, through the Conference of the Parties to the United Nations Framework Convention on Climate Change at its seventh session, held at Marrakech, Morocco, from 29 October to 10 November 2001, agreed on a technology transfer framework,[8] comprising the following set of key themes and areas for meaningful and effective actions:

- ***Technology needs and needs assessment***: a set of country-driven activities that identify and determine the mitigation and adaptation technology priorities, particularly of developing countries
- ***Technology information***: this component defines the means, including hardware, software and networking, to facilitate the flow of information between different stakeholders to enhance the development and transfer of environmentally sound technologies
- ***Enabling environments***: this component focuses on government actions, inter alia, fair trade policies, removal of technical, legal and administrative barriers to technology transfer, sound economic policy, regulatory frameworks and

8 FCCC/CP/2001/13/Add. 1 and Corr. 1, decision 4/CP.7, annex.

transparency, all of which are essential to creating an enabling environment conducive to public and private sector technology transfer

- ***Capacity-building***: a process that seeks to build, develop, strengthen, enhance and improve existing scientific and technical skills, capabilities and institutions, particularly in developing countries, to enable them to access, adapt, manage and develop environmentally sound technologies
- ***Mechanisms for technology transfer***: facilitators of the support of financial, institutional and methodological activities: (a) to enhance the coordination of the full range of stakeholders in different countries and regions; (b) to engage them in cooperative efforts through technology cooperation and partnerships (public/public, private/public and private/private); and (c) to facilitate the development of projects and programmes to support such ends.

An expert group on technology transfer was subsequently established as an institutional arrangement to facilitate the implementation of the technology transfer framework,[9] and enhanced action was agreed on technology development and transfer to support action on mitigation and adaptation under the Bali Action Plan.[10]

The discussion on promoting technology transfer to tackle the climate challenge has evolved in parallel with, but somewhat independently from, the recent discussion on the best ways to transfer technology to meet development goals. Essentially, the former focuses on how quickly the technological knowledge required to tackle the climate challenge can be put to widespread use in the economy, whether in that of developed or of developing countries, through learning and adaptation. The resulting agenda implicitly acknowledges the need to address various market failures that can hamper the spread of technological knowledge. In recent years, the development challenge has focused unduly on protecting the international position of the creators and owners of technology by linking intellectual property rights to multilateral trade rules such as the Agreement on Trade-related Aspects of Intellectual Property Rights (TRIPS) (World Trade Organization, 1994), and the Agreement on Trade-related Investment Measures, (ibid.), and through bilateral negotiations.[11] This puts greater emphasis on the importance of innovation. Protecting the owners of knowledge is also often taken as a measure of how committed countries are to good governance and an indication of whether or not their investment climate might be attractive to foreign firms, whose presence is seen as the surest guarantor of ways to access more advanced technologies (Maskus, 2000).

However, neither perspective appears to comprehend the urgency of the technological challenge or its links to the idea of a big push onto a new low-emissions growth path, particularly by developing countries. In fact, as discussed in chapter II, RD&D spending on some of the key technologies needed to support this transition appears to be moving in the wrong direction. Reversing this trend will be essential for building momentum towards a low-emissions future. Such action will likely have to draw on a variety of mechanisms at the international level and will ultimately require determined leadership that puts collective security before narrow commercial interest.

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9 Ibid., decision 4/CP.7, para. 2.

10 FCCC/CP/2007/6/Add. 1, decision 1/CP.13, para. 1 (d).

11 See Littleton (2008) for a complete review.

Intellectual property rights

Incentives or obstacles

The obligation to respect intellectual property rights raises the cost of accessing technology. Whether this will constitute an important barrier to technology transfer will depend, inter alia, on whether the particular technology that is patented has cost-effective substitutes or alternatives, and on the degree of competition in the industry, which can affect the price of and the terms for licensing. Moreover, the technology covered by an individual patent may provide only a partial capability for exploiting an innovation; total capability might in fact depend on technologies protected by multiple patents or a combination of patented technologies and other forms of knowledge. Forms of legal protection of property rights such as patents and copyrights constitute only one means of protecting a technological advantage. Trade secrets and firm-specific know-how, including knowledge embodied in skilled personnel, can also be important.

There is vigorous debate over whether intellectual property rights, on balance, help or hinder technology transfer. The evidence is inconclusive and there is also variation by industry, where characteristics like market dynamism, technological sophistication, importance of RD&D, and ease of imitation and market entry come into play. There is also variation according to level of economic development. In high-income countries, stronger patent rights have been associated with higher levels of productivity, RD&D expenditures, trade flows, FDI and sophistication of the technologies transferred. However, even among these countries, there is considerable variation, and it is unclear if intellectual property rights are a cause or an effect of these outcomes. On the other hand, weak intellectual property rights in the least developed countries tend to be associated with low levels of RD&D, FDI inflows, etc. (Blyde and Acea, 2003; Smith, 2001).[12] However, cause and effect are again difficult to distinguish and even when technology is transferred to the least developed countries, the principal constraint on its wider use tends to be limited absorption capacity (United Nations Conference on Trade and Development, 2007).

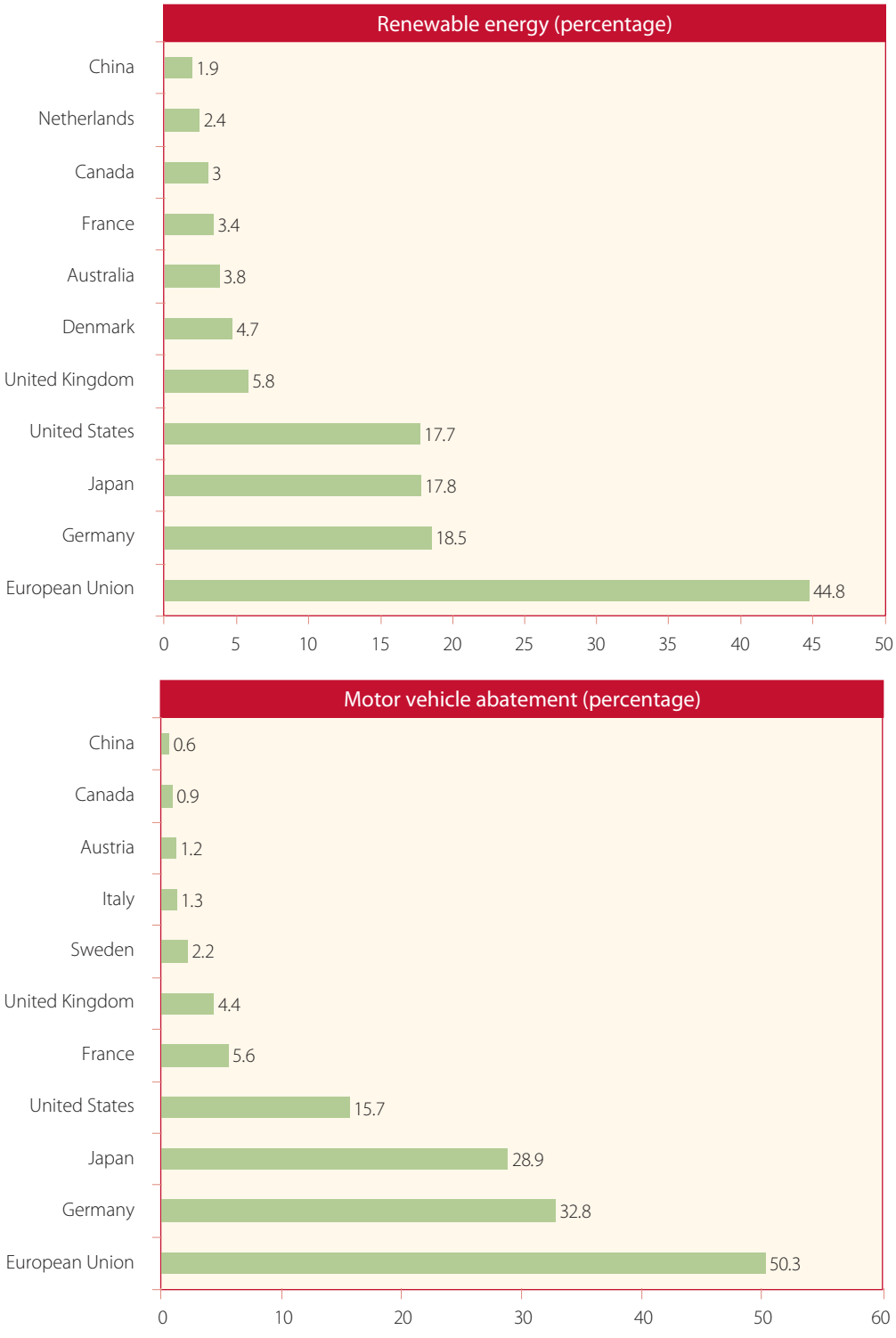
A more graduated approach is likely to be supportive of large-scale technology transfer only if it is accompanied by complementary measures with respect to financing, RD&D and technical cooperation

Given that stronger protection of intellectual property rights raises the costs of obtaining technologies, it has generally been accepted that low-income developing countries should be exempt from strong intellectual property rights-related obligations and that the strength of those obligations should only rise with levels of development (Hoekman, Maskus and Saggi, 2004). However, given that the current regime is unduly biased towards the owners rather than towards the users of technology, a more graduated approach is likely to be supportive of large-scale technology transfer only if it is accompanied by complementary measures with respect to financing, RD&D and technical cooperation, which has not been the case in recent years.

The potential trade-off between intellectual property right protection and technology development and transfer is a very important issue in the context of climate change. As is clear from figure V.1, the distribution of patent ownership of climate-related technologies is very heavily skewed in favour of advanced economies. However, to date, Barton (2007) finds mixed evidence of the importance of intellectual property rights in technology transfer. Based on the examination of three sectors (photovoltaics (PV), wind and biofuels), he concludes that, rather than basic technologies, what are usually patented are specific improvements or features. What matters more are other market distortions.

12 However, at least one investigator finds positive correlations between strong protection of intellectual property rights and economic growth—among low- but not among middle-income countries (Falvey, Foster and Greenaway, 2006).

Figure V.1
Share of patent ownership in the areas of renewable energy and motor vehicles abatement among selected countries, 2000-2004



Source: Organization for Economic Cooperation and Development (2007).

In the photovoltaics sector, the developing nations are facing a loose oligopoly with many entrants. Thus, developing countries like India and China, for example, have been able to enter and compete in the industry. In respect of biofuel technologies, intellectual property rights do not appear to be barring developing countries from accessing the current-generation technologies, as shown by the developments in many countries, including Brazil, Malaysia, South Africa and Thailand.

A much harder question to answer is what lies ahead. To the extent that developing countries make a big investment push to establish a low-emissions development pathway, the market for new technologies can be expected to expand rapidly. Unanticipated obstacles to the transfer of technologies could slow that transition, particularly the emergence of new sectors linked to these technologies, or necessitate large shifts of resources to already advanced economies through technology payments.

The most significant barriers and distortions are likely to be associated with the market power of a small number of producers located in advanced economies. The wind sector appears to be the most concentrated of the three renewable energy sectors examined in the Barton study and a tight control over intellectual property may act to deter technology transfer. Even so, some developing nations have been able to build wind farms with equipment from the global market without incurring unduly steep intellectual property costs. The challenge for these developing countries is to enter the global market for wind turbines. The existing industry leaders are strong and they are hesitant to share cutting-edge technology out of fear of creating new competitors (see box V.2). Two developing

Box V.2

Foreign direct investment (FDI) and technology transfer in the wind sector

A recent study of wind power in China examined foreign and domestic companies involved in China's wind turbine industry and compared the extent of technology transfer in four case studies. These four cases exhibited three types of ownership models, which greatly impacted the extent of technology transfer: (a) limited joint ventures, where all materials and technology are developed and owned by the foreign company but manufactured with Chinese labour and materials (for example, NEG Micon/Vestas and GE Wind); (b) joint ventures, where a foreign company develops the technology, which is then owned by a Chinese company and components are made with Chinese labour and materials (for example, Xi'an-Nordex); and (c) Chinese-owned, where a Chinese company develops and owns the technology and oversees the production of the materials (for example, Goldwind-China).

The study found that, regardless of the ownership model, very few foreign companies have transferred wind power technology. Foreign-owned companies have not challenged the local content requirement because they have been able to do well in the market and retain control of their intellectual property.

In response, the Government of China is considering the implementation of local intellectual property requirements for wind power in an attempt to push international companies to transfer more technology. Such stipulations on intellectual property requirements could be contested by international companies under the rules of the World Trade Organization or by simply limiting new FDI in this sector.

The Government has also been trying, with some success, to promote strong independent Chinese wind power companies. Among Chinese wind power enterprises, several manufacturers produce equipment that is up to 30 per cent cheaper than that produced by their foreign counterparts, but generally such equipment is not as advanced in design. For example, Chinese firms rely on 600-750-kilowatt (KW) capacity turbines, while General Electric offers 1.5-megawatts (MW) and Vestas provides 2-MW turbines. The manufacturing capacity of China is changing fast, with the nation on track to exceed the 30-gigawatt (GW) target by 2020.

Source: Lewis, 2006.

nations with significant bargaining advantages in their own right, namely, China and India, have succeeded in building important firms over the past decade. Whether other developing countries will be able to replicate that success is uncertain.

Multilateral actions to accelerate technology transfer among countries can be of several sorts: those that exploit existing flexibilities of the Agreement on Trade-related Aspects of Intellectual Property Rights, those that require a modification of that Agreement and other disciplines in the framework of the World Trade Organization, and those that are not necessarily linked to the multilateral trade framework, including initiatives to foster technology-related absorptive capacity and innovation in developing countries through international cooperation.

Taking advantage of flexibilities of the Agreement on Trade-related Aspects of Intellectual Property Rights

Several flexibilities within the TRIPS Agreement could be exploited, ranging from limiting patentability to making use of compulsory licensing or even expanding its use with a view to serving regional markets.

Limiting patentability

Patentability refers to the boundaries established to determine what inventions can be patented. Article 27 of the Agreement on Trade-related Aspects of Intellectual Property Rights states that "patents shall be available for any inventions … in all fields of technology, provided that they are new, involve an inventive step and are capable of industrial application". These relatively loose criteria for patentability leave some space for the formulation by the individual country of its own policy, including limiting patentability. Further defining the criteria and thereby limiting patentability can have a positive impact on technology transfer and innovation by reducing possible conflict with existing patents (Oliva, 2008).

Certain technologies could be excluded from patentability, especially those that are deemed necessary to tackle climate change and/or are subject to anti-competitive measures

Based on the stated goals and guiding principles of the Agreement on Trade-related Aspects of Intellectual Property Rights regarding technology transfer, certain technologies could be excluded from patentability, especially those that are deemed necessary to tackle climate change and/or are subject to anti-competitive measures, while remaining consistent with the principles of the Agreement (Littleton, 2008). Examples of such exclusion already exist within the Convention on Biological Diversity[13] and the International Treaty on Plant Genetic Resources for Food and Agriculture[14] (Littleton, 2008). As the ongoing negotiations within the World Intellectual Property Organization (WIPO) of a substantive patent law treaty would eliminate this opportunity (World Intellectual Property Organization, 2008), its impact on climate-related technology transfer should be carefully examined before those negotiations are completed.

Exempting climate-friendly technologies from patenting is one way to reduce costs. The rationale for such a proposal lies in the seriousness of the climate change issue and the threat that it poses, particularly to developing countries. Variants of the proposal include: exemption of climate-friendly technologies and products from patenting;

13 United Nations, *Treaty Series*, vol. 1760, No. 30619.

14 Food and Agriculture Organization of the United Nations, *Report of the Conference of FAO, Thirty-first Session, Rome, 2-13 November 2001* (C 2001/REP), appendix D.

exemption from patenting in developing countries only; allowing developing countries to exclude patents for climate-friendly technologies and products, if they so choose; granting of voluntary licenses on request, free of royalty; and of granting of voluntary licences automatically, with compensation given to the owner of the technology.[15]

These options could perhaps be applied on a graduated basis to countries at different levels of development, the first three to low-income developing countries and the last two to middle- and high-income developing countries. The size of the country could be another criterion for choosing the appropriate type of flexibility.[16] For small a country, acquiring a licence for climate-related technology may not be profitable even if it is a middle- or high-income developing country, unless it is able to use the licence to tap export markets. In that case, the royalty could be reduced or eliminated and/or the exhaustion of patent rights could be extended from a domestic to a whole region.

Compulsory licensing

Even when a technology has been patented, articles 30 and 31 of the Agreement on Trade-related Aspects of Intellectual Property Rights offer opportunities for allowing unauthorized, automatic use of a patented technology without the consent of the patent-holder through compulsory licensing under certain circumstances. For article 30 to be used to obtain compulsory licensing, countries would have to claim that mitigating or adapting to climate change qualified as entailing the "legitimate interests of third parties", as required by the article. A second exception allows unauthorized use by a country when "necessary for the protection of its essential security interests" (article 73 (b)) or "the maintenance of international peace and security" (article 73 (c)). Whether this condition could be invoked would depend on the existence of a threat of climate catastrophe.

Article 31 of the Agreement sets out the other conditions for allowing compulsory licensing of a patented product. There are two major criteria to be met by a member of the World Trade Organization in order for it to qualify for an exception under article 31. First, reasonable efforts must be made to gain appropriate authorization from the holder of the intellectual property rights in question (article 31 (b)). This negotiation requirement may be waived when the member determines (using its own judgement) that a "national emergency" or "other circumstances of extreme urgency" demand unauthorized use without delay. The holder of the intellectual property rights must still be notified "as soon as reasonably practicable".

Discussions leading to the recognition of public health related exceptions showed some flexibility in interpreting what constitutes "exigent circumstances",[17] opening the door to potential use of these exceptions in the climate change context.[18] Climate change is increasingly perceived as a public-health "emergency" which would justify compulsory licensing exceptions under article 31 (Third World Network, 2008). Indeed, the United States Environmental Protection Agency (EPA) had been ordered by the Supreme Court to rule if carbon dioxide (CO_2) was a pollutant that endangered public health and

15 The last two options entail exceptions to patent rights rather than limiting of patentability.

16 However, all developing countries rightly point out that the new technologies are needed to counter a global threat that was created by today's advanced countries.

17 Defined as an emergency situation requiring swift action to prevent imminent danger to life or serious damage to property, or to forestall the imminent escape of a suspect, or destruction of evidence.

18 See, for example, the Declaration on the TRIPS Agreement and public health (World Trade Organization, 2001), para. 5 (c).

welfare, in which case it would be obligated to regulate it under the 1990 Clean Air Act. On 20 March 2009, the Agency issued an "endangerment finding".[19]

Second, sales of protected assets must be predominantly in the domestic market for the entity granted the exception (article 31 (f)). Thus, exceptions related to climate change would have to be sought by firms in various developing countries to ensure an effective and rapid diffusion of the technology. Limiting the technology to one (small or poor) country, however, might prevent the capture of economies of scale which would make the technology cost-effective. Recognition of this fact in the case of the public-health exception was reflected in the temporary waiving of the domestic market requirement in countries with insufficient domestic production.[20]

The General Council of the World Trade Organization has adopted an amendment of the TRIPS Agreement[21] by which the above-mentioned domestic-market restriction would be waived for developing countries for certain pharmaceuticals so as to enable the export of those products to regional markets.[22] (As the amendment has not yet been ratified by two thirds of the membership, it has not entered into force.) This waiver could conceivably be extended to climate-friendly technologies, particularly in light of what is stated in paragraph 5 (b) of the Declaration on the TRIPS Agreement and public health, namely, that "(e) each member has the right to grant compulsory licences and the freedom to determine the grounds upon which such licences are granted". Such an amendment would certainly meet with strong resistance from owners of technologies in countries members of the Organization for Economic Cooperation and Development (OECD), who could lose potential rents. However, and even ignoring the health parallel, it can be argued that if such technologies do not currently reach developing countries, then the loss of rent occasioned by giving them compulsory access would be limited (Hoekman, Maskus and Saggi, 2004).

A regional approach can also be beneficial in respect of the rules of exhaustion, which refers to the expiration of patent protection of a specific item once it has been sold (Littleton, 2008). Article 6 of the Agreement on Trade-related Aspects of Intellectual Property Rights leaves the determination of these rules to each member. In general, exhaustion can be universal or territorial. According to the rule of universal exhaustion, the patent-holder cannot limit the distribution of the item once it has been sold. This opens the way for parallel importing and the possibility for others to compete with the patent-holder in other countries. The rule of territorial exhaustion, usually preferred by patent-holders, limits the right to sell the item without authorization from the patent-holder and thus no parallel importing can take place without the patent-holder's consent. These different systems provide different incentives for technology transfer and innovation. While parallel imports increase competition and can lead to lower prices and greater accessibility of technology, they may discourage innovation by limiting patent-holders' profits. Regional exhaustion could be an attractive compromise solution. Here, parallel importing would be allowed only when the product was sold within the region at issue. By creating geographical buffer zones for patent protection, yet at the same time allowing for parallel importing, regional exhaustion might properly balance technology transfer with incentives to innovate (Littleton, 2008).

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19 Bryan Walsh, "EPA calls CO_2 a danger—at last", *Time*, 23 March 2009.

20 See the decision of the General Council of the World Trade Organization of 30 August 2003 on the implementation of paragraph 6 of the Doha Declaration on the TRIPS Agreement and public health (World Trade Organization, 2003), para. 2 (a) (ii).

21 See the decision of the General Council of 6 December 2005 on the amendment of the TRIPS Agreement (WT/L/641).

22 Ibid., attachment, annex, para. 3.

Modifying the Agreement on Trade-related Aspects of Intellectual Property Rights[23]

Climate-related technology exceptions could be sought along the lines established to secure exceptions for essential medicines

Climate-related technology exceptions could be sought along the lines established to secure exceptions for essential medicines, as described above. A new "Declaration on TRIPS and climate change" might clarify existing flexibilities and offer new incentives for transfer of environmentally sound technologies. In particular, exceptions for least developed countries and small island developing States could be pursued, given that, in these countries, trade and investment flows appear to be not as responsive to protection of intellectual property rights and the dangers posed by climate change are particularly acute.[24] As suggested earlier, such a modification would have to take into account the uncertain and ever changing nature of the climate change problem and address adaptation as well as mitigation technologies.

Strong, integrated pro-competition provisions would also promote technology transfer. The class of restrictive business conditions considered in article 40 of the Agreement on Trade-related Aspects of Intellectual Property Rights could be expanded, and compulsory licensing under article 31 could be facilitated for environmentally sound technologies. As noted by Matsushita, Schönbaum and Mavroidis (2006), "many developing countries take the view that compulsory licensing should be required if the public interest is injured due to an abuse of patent monopoly". With their growing clout in the World Trade Organization, these members could redefine and expand the concept of "abuse" in this context beyond licensing restrictions to include other intellectual property rights-related practices which erect barriers to climate-friendly technology transfer (Hutchison, forthcoming).[25] Developed countries could also take the lead here by mandating compulsory licensing for climate-related intellectual property rights held domestically, a strategy that has yet to be tried out.[26] Pro-competition provisions would, however, meet with strong resistance from intellectual property right holders who exert great influence with several members of the World Trade Organization.

Procedures for challenging patents could be made less cumbersome so as to lower costs for developing countries (Stiglitz, 2008). Creation of a straightforward pre-patent opposition process could further reduce costs and prevent abuses.

Licensing guidelines might be promulgated that provide for fixed, moderate fees for environmentally sound technology patent licensees. In cases where the protected asset clearly has environmental benefits, the intellectual property right holder would bear the burden of proof in demonstrating why compulsory licensing would be unwarranted (Scherer, 1984; Stiglitz, 2008). A tiered application fee system for intellectual property rights could waive payments for patent-holders who authorize transfer of climate-friendly technologies to developing countries (Barton and Maskus, 2006; Maskus, 2004).

If the granting of full licences is an unrealistic option, then temporary licences could be granted along the lines established for conferral of plant breeders' exemptions and farmers' privileges under the International Treaty on Plant Genetic Resources for

23 The present section draws on Littleton (2008).

24 However, many developing countries insist that the issue is, again, not their ability to pay, but ensuring that those responsible for the climate problem carry the burden.

25 On the other hand, excessive fear of increased competition might, on balance, hinder technology transfer.

26 For example, the United States of America could mandate that climate-friendly technology patent-holders license their technologies abroad under specified terms. Admittedly, agreement on this proposal would be quite difficult to achieve, for political reasons.

Food and Agriculture.[27] For example, intellectual property right holders could provide developing-country users with technologies for a limited period, with the expectation of receiving payment once the technology was "tropicalized", that is to say, adapted to local requirements. This proposal would work with climate-change adaptation technologies as well as with mitigation technologies.

Mechanisms through which to evaluate progress on technology transfer could benefit from being strengthened

Mechanisms through which to evaluate progress on technology transfer could benefit from being strengthened. Such mechanisms might be TRIPS Agreement-based or might involve multiple World Trade Organization Agreements (Maskus, 2004). The problems with current evaluation are the result of both: non-transparency and lack of a viable enforcement mechanism. In the absence of formal enforcement, "naming and shaming" would at least provide some measure of accountability.

There are, of course, great political difficulties involved in modifying any World Trade Organization Agreement. Technology transfer measures can often disadvantage intellectual property right holders, who have great political influence in developed countries. Moreover, despite the acknowledgment of development goals, it is equal treatment of nations that is at the heart of the TRIPS Agreement. However, equal treatment of technologies may not be as crucial, as evidenced by the progress in respect of essential medicines. Global action to address climate change is certainly not a zero-sum game, and any World Trade Organization member hoping for modification of the TRIPS Agreement in this area will need to stress common interests in advancing the global public good of a stable climate. Still, issues of fairness will also need to be addressed in any reform effort.

Further options for addressing intellectual property rights-related issues and innovation incentives

The institutional role of the World Trade Organization in the area of climate change has "barely begun to be thought through" (Evans and Steven, 2009, p. 32). However, mixing trade disciplines with climate concerns raises serious issues, particularly for developing countries. A few other proposals for facilitating technology access and diffusion, which may or may not be integrated in a World Trade Organization framework, are provided here:

Open-source information access and increased sharing of public RD&D results

Difficulty of access to information on available technologies is a constraint on technology transfer and adoption. One proposed solution is to establish an information access agreement. As far back as 1992, there were calls for an information clearing house of climate-friendly technologies (see, for example, chap. 34 of Agenda 21 (United Nations, 1992)). Some efforts have been made by UNFCCC in supporting its technology transfer framework and in undertaking technology needs assessments. However, such efforts need to be expanded and better integrated with wider development challenges.

The Multilateral System of Access and Benefit-Sharing of the International Treaty on Plant Genetic Resources for Food and Agriculture could be a model for an agreement on access to climate-friendly technologies (Halewood and Nnadozie, 2008). Along these lines, Barton and Maskus (2006) have proposed a formal agreement on access

27 Breeders' exemptions allow breeders to use protected varieties of plants to create new varieties through experimentation. Farmers' privileges permit farmers to save and reuse protected seed varieties for subsequent harvests.

to basic science and technology "to ensure widespread access to essential scientific results and to enhance the transfer of basic technological information to the developing world at reasonable cost". As a World Trade Organization agreement, this instrument could take advantage of the dispute settlement mechanisms and other institutional structures.

Establishing such an agreement would encounter some difficulties. For one thing, drawing an acceptable line between "basic" and "applied" research would be a challenge. So as to favour climate-friendly technologies, the notion of what is "basic" could be construed more broadly in the context of global public goods (Barton and Maskus, 2006). In borderline cases, guidelines concerning which research results were confidential and which could be made public would need to be established.

Dedicated funding mechanisms

Governments can subsidize technology development and transfer, either individually or in concert

Governments can subsidize technology development and transfer, either individually or in concert. Subsidies, tax breaks and other fiscal incentives of individual countries constitute the most straightforward method of funding. They can direct the focus of private firms towards particular sectors like those encompassing climate change-related technologies by reducing the risk level of RD&D projects (Stiglitz, 2008). However, the financial impact of individual Governments is limited. Moreover, such expenditures are exploitable by "free riders" on the global level (Barton and Maskus, 2006).

A coordinated international funding mechanism would help solve the free-rider problem

A coordinated international funding mechanism would help solve the free-rider problem. Possibilities in this regard include a trust fund encouraging RD&D directly in developing countries (Roffe, 2002), a patent acquisition fund established to buy intellectual property rights from patent-holders (United Nations, Department of Economic and Social Affairs, 2008) and a fund that covers the difference in cost between the environmentally sound technologies and the business-as-usual technology for developing-country firms (like the Multilateral Fund for the Implementation of the Montreal Protocol, see box V.I).

A technology prize system could circumvent intellectual property rights-related problems. Within such a system, the performance characteristics of a desired technology would be defined, a contest would be announced for its development, and a prize would be awarded to the successful innovator in exchange for the intellectual property rights. Prizes help to both reduce wasteful spending on marketing and lower incentives for anti-competitive behaviour (Stiglitz, 2008). Prizes, like advance purchase funds/agreements, work best with a specific, clearly-defined objective (such as a vaccine for a specific disease).

Technology development and transfer mechanisms

At the international level, a technology transfer mechanism could be established under the auspices of the Conference of the Parties to the United Nations Framework Convention on Climate Change

At the international level, such a mechanism could be established under the auspices of the Conference of the Parties to the United Nations Framework Convention on Climate Change, supported by a secretariat and various expert panels set up to examine the various dimensions of the technology challenge in developing countries and, where appropriate, to provide technical assistance on the range of technology options available for mitigating and adapting to climate change. This model has been successfully employed within the institutional structure of the Montreal Protocol on Substances that Deplete the Ozone Layer and could be adapted to the climate change context.

At regional and national levels, centres dedicated to low-emissions technology innovation and diffusion could be created and linked to and through the international

mechanism. They would have an important role to play in making technologies accessible and affordable in developing countries. At least in the initial stages, these centres are likely to be publicly funded, though the precise mix of donor, public and private funding would vary across countries and over time. What particular mixture of basic research, field trials, business incubator services, venture capital funding, technical advice and support, and policy and market analysis is adopted will be very much contingent on local conditions and challenges.

Technology transfer through investment

Accessing clean technologies through foreign direct investment

Many descriptions of foreign direct investment (FDI) emphasize that it is the exploitation of firm-specific advantages, including intellectual property and leading technologies, that allows large corporations to undertake risky and costly activities outside their immediate domestic and regional locations. Hosting such firms has been seen as one way for developing countries to close the technological gap between them and more advanced countries. In recent years, the policies devised by developing countries to attract those firms have undergone a shift from providing the firm with a protected local market to liberalizing country rules on FDI and trade, including through the creation of export processing zones. The expectation was that this would help break not only the technological constraint but also the foreign-exchange constraint on growth. The results have often been disappointing, particularly in cases where FDI has been a substitute for local domestic capacity-building efforts (United Nations, 2006).

FDI tends to be a lag variable in the growth process: even when it does materialize, active policies are needed to ensure that there are valuable spillovers into the local economy

While technology may be physically transferred from the home to the host country through FDI, the question remains what sort of linkages the transfer creates with the rest of the host economy. How large are the technology spillovers and do they, as Hirschman (1971) asked almost 40 years ago, act as "a spur to the expansion of missing local inputs" or do they actually "harm the quality of local factors of production"? Answering these questions in greater detail would require a long detour extending beyond the remit of this *Survey*. However, worth noting in what is an already extensive literature are two broad findings which will have a bearing on the role of FDI along any new low-emissions pathway. First, FDI tends to be a lag variable in the growth process; that is to say, it is attracted by various factors such as market size, presence of suppliers, human capital, etc., which are the result of a successful development push. Second, even when it does materialize, active policies are needed to ensure that there are valuable spillovers into the local economy.[28]

Those spillovers can occur in a number of ways: through the movement of skilled personnel between a multinational subsidiary or joint venture and other firms, through technology imitation by competitors, and through technology sharing with suppliers, customers or business partners.

Strong intellectual property right protection is not necessary for extensive foreign investment to occur, as the case of China clearly demonstrates. The country's large market and rapid growth have compelled foreign companies to invest, even at the risk of losing control of proprietary technologies. Countries with "weak" intellectual property right regimes, for example, the Republic of Korea, Taiwan Province of China and Brazil in the pre-TRIPS Agreement era have been among the major technology borrowers (Correa, 2005, p. 228).

28 On the links between FDI and development, see Kozul-Wright and Rayment (2007, chap.4).

Technology or knowledge transfer through FDI is not automatic, but depends on complementary investments by both foreign and local firms

Recent research on FDI as a vehicle for technology transfer (Todo and Miyamoto, 2006; O'Connor and Lunati, 2008) has pointed to a few conditions that influence the extent of technology, or knowledge, spillovers. Todo and Miyamoto used industry panel data from Indonesia to examine knowledge spillovers between subsidiaries of Japanese multinational corporations and Indonesian firms. They concluded that the spillovers were significant only when the Japanese subsidiaries had invested in RD&D themselves; otherwise, the spillovers were negligible. Other studies found that the RD&D undertaken by local firms also affected the extent to which knowledge spillovers from foreign-invested firms occurred. Miyamoto (2008) found a significant positive relationship in Indonesia between the training investments of local firms and the extent of knowledge spillovers from foreign ones. All of these findings lead to the conclusion that technology or knowledge transfer through FDI is not automatic, but depends on complementary investments by both foreign and local firms.

The Government of China will need to consider a more comprehensive and integrated policy approach, one that seeks to bolster local learning

There has been little research undertaken to date on the role of FDI spillovers in supporting a transformative low-emissions growth path. However, the case of wind technology in China suggests that hosting FDI is, by itself, no guarantee (see box V.2). A recent study of China's automotive industry (Gallagher, 2006) is also instructive in this regard. The transportation sector is part of an interconnected bloc of related sectors that are expected to lead China to the next stage of industrial development. The sector has grown particularly rapidly since the early 1980s, thanks in part to joint ventures with foreign automobile companies producing largely for the growing domestic market. This growth has, in turn, contributed in recent years to China's very rapid growth in oil imports. Until 2000, the sector had been subject to few regulations and standards on emissions. Since then, stricter regulations have been introduced in an effort to force foreign firms to transfer cleaner technologies. However, the evidence suggests that, while these firms have introduced more modern pollution control technologies, they have been reluctant to introduce cutting-edge technology and the overall impact of their efforts has been dwarfed by the scale effect of rising car ownership. The study concludes that market incentives are, by themselves, unlikely to help China jump to the next stage in terms of cleaner vehicles, such as fuel-cell vehicles, given prohibitive prices and the control exerted over intellectual property by foreign firms. The study showed that the current producers of hybrid vehicles, for example, have been unwilling to transfer hybrid-vehicle technologies for production inside China. Rather, the Government will need to consider a more comprehensive and integrated policy approach, one that seeks to bolster local learning in the automotive sector through support for RD&D and engineering training, including through overseas study, and efforts to foster demand for cleaner automobiles in response to higher prices and tighter regulations. While these measures can provide clear signals to private investors, both domestic and foreign, to move towards cleaner technologies, wider national planning initiatives to improve and expand public infrastructure will also be needed to ensure that the transportation system evolves in line with climate objectives.

CDM and technology transfer

The market-driven Clean Development Mechanism (CDM) was established under the Kyoto Protocol to the United Nations Framework Convention on Climate Change[29] to help developed countries meet their emission targets, by encouraging firms in the private sector to contribute to emission reduction efforts and through investments in developing countries. Although they do not necessarily entail FDI, many of these projects involve

29 United Nations, *Treaty Series*, vol. 2303, No. 30822.

transnational corporations from the advanced countries. It was expected that such private sector transfers would assist in the transfer of environmentally sound technologies to developing countries.

A few studies have tried to determine to what extent technology transfer is actually occurring through the Clean Development Mechanism process. Most recently, the United Nations Framework Convention on Climate Change Registration and Issuance Unit CDM/SDM (Seres and Haites, 2008) issued its own report on the Clean Development Mechanism and technology transfer. Based on documentation for 3,296 registered and proposed CDM projects, it found that roughly 36 per cent of the projects, which accounted for 59 per cent of the estimated annual emission reductions, claimed to involve technology transfer, indicating that projects claiming technology transfer were, on average, substantially larger than those that made no technology transfer claim. It also found that about 30 per cent of unilateral projects, 40 per cent of projects with foreign participants and 30 per cent of small-scale projects claimed technology transfer, as compared with 36 per cent of all projects. The study found that the technology transferred originated mainly from Japan, Germany, the United States of America, France, and the United Kingdom of Great Britain and Northern Ireland, which accounted for over 70 per cent.

One reason for the high rates of technology transfer in Mexico and Brazil is that in those countries, foreign companies have a significant involvement in CDM projects, which is less the case in China and India

Studies find wide variation across countries in the reported technology transfer associated with CDM projects. Dechezleprêtre, Glachant and Ménière (2009) focused on four countries accounting for about three fourths of all CDM projects: Brazil, China, India and Mexico. While 68 per cent of projects in Mexico included an international transfer of technology, the rates for India, Brazil and China were 12 per cent, 40 per cent and 59 per cent, respectively. One reason for the high rates of technology transfer in Mexico and Brazil is that in those countries foreign companies have a significant involvement in CDM projects, which is less the case in China and India. Seres and Haites (2008) observed that such cross-country variation could also be attributable to trade policy, with some countries imposing significantly higher tariffs on imported equipment than others. This factor's being a handicap to technology deployment clearly depends on whether domestic technological capabilities are effective substitutes. Technology transfer in a specific type of CDM project generally declines over time, suggesting a progressively greater reliance on local knowledge and equipment.

So far, the operation of the Clean Development Mechanism has been on much too limited a scale and has been too heavily concentrated in a few developing countries to allow it to initiate and sustain the kind of big push towards cleaner technologies recommended in this *Survey*. Moves towards the creation of a simplified Clean Development Mechanism, including sectoral or technological benchmarks, might make it more effective in raising technological standards in the longer run. However, this is likely to take time.

Trade and climate-related technology transfer

As a consequence of the fact that Governments are becoming more serious about addressing climate change, there has been a revival of the North-South trade and environment debates on how to distinguish between legitimate environmental and health protection measures, as allowed in the World Trade Organization, and disguised trade protectionism measures. Despite the establishment of a World Trade Organization Committee on Trade and Environment in 1994 to address contentious trade and environment issues, such as how to speed up the transfer of environmentally sound technologies while remaining World Trade

Organization-compliant, not much progress has been made. The few clarifications provided have emerged instead from World Trade Organization dispute panels considering whether importing countries could ban import of tuna and shrimps from countries that did not use devices to avoid by-catches of dolphins and endangered turtles. More of these trade disputes are to be expected, given the absence of prior agreements on how to handle the measures being proposed to account for the carbon-intensity of traded goods and on subsidies to encourage the development of lower-carbon energy sources.

We review these issues below as well as some proposals that have been put forth with regard to speeding up the transfer of climate-related technologies in ways that take into account the principle of common and differentiated responsibilities as embodied in the United Nations Framework Convention on Climate Change and its equivalent within the framework of the World Trade Organization, namely, the principle of special and differentiated treatment for developing countries. Nations agreed upon these principles based on the understanding that they reflected the differences in capabilities and in the responsibility for the cumulative greenhouse gas emissions causing climate change. There was also recognition of the fact that developing countries aspired to attain higher levels of economic development and social well-being for their citizens.

For instance, under the Kyoto Protocol, developing countries do not have binding greenhouse gas reduction commitments although they must collect data and undertake mitigation and adaptation measures. The level and extent of developing countries' mitigation actions will depend in turn on promised financial, technological and capacity-building support from developed countries.

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Trade-related actions that have been proposed include faster liberalization of trade in climate-related environmental goods and services, making the intellectual property rights regime more lenient with respect to climate-related environmental goods and services, and revisiting the Agreements on Subsidies and Countervailing Measures, contained in the Marrakesh Agreement (World Trade Organization, 1994), to allow subsidies that foster investments in low-emissions technologies.

The potential benefits of trade liberalization to the environment, including climate change, and development have been highlighted since the adoption of Agenda 21 (United Nations, 1992). Principle 12 of the Rio Declaration on Environment and Development (ibid.) states that Governments should "promote a supportive and open international economic system that would lead to economic growth and sustainable development in all countries, to better address the problems of environmental degradation". Trade is important because imported capital goods and services provide an additional channel to access environmental technologies and know-how generated in developed countries, other than FDI or licensing.

Trade liberalization on its own is not sufficient, however, for effective technology transfer. Indeed, despite unprecedented market liberalization, and several commitments to the transfer of technology in both the United Nations Framework Convention on Climate Change and the Kyoto Protocol thereto, as well as within the World Trade Organization, evidence of technology transfer is slim. It was thought that early liberalization of environmental goods and services would contribute to environmental goals by lowering prices of environmental goods and services relative to their non-environmental or mainstream counterparts, thus facilitating and promoting more environmentally sustainable production and consumption. To support climate actions, the World Bank (2008a) proposed accelerated liberalization of products, technologies and services used in Clean Development Mechanism projects to reduce equipment and other

Trade liberalization on its own is not sufficient, however, for effective technology transfer

costs. Liberalization of environmental goods and services has been slowed owing not only to the failure to conclude the Doha Round but also to the lack of a definition of what constitutes environmental goods and services and the different views held by the North and the South regarding which tariffs should be lowered more quickly.

Liberalization of trade in climate-related environmental goods and services

As a general rule, developing countries rely much more on tariffs to generate revenues than do developed countries, which have the institutions in place to collect income and sales, or value-added, taxes. Significant reduction of these tariffs means lower revenues for investment in social and infrastructure development.

With respect to liberalization of environmental goods and services, the goals are different for developing and developed countries

With respect to liberalization of environmental goods and services, the goals are different for developing and developed countries. The former want access to adaptation technologies while protecting their nascent environmental goods and services industries so as to eventually become competitors in these emerging industries. Developed countries that have comparative advantages in capital- and technology-intensive environmental goods and services propose early liberalization of those goods. Another obstacle to agreeing on a definition of a list of "eligible" environmental goods and services or climate-related technologies hinges on the lack of specificity with which goods and services are tracked for customs and duty purposes. They are tracked through the World Customs Organization Harmonized Commodity Description and Coding System (HS) and have been harmonized to only a six-digit level. Because the six-digit level is still highly aggregated, it lumps together goods that serve for both environmental and non-environmental use, such as "pumps for liquid", which are often used in manufacturing wind turbines but also in other industrial processes. Liberalizing these goods under this HS code would result in a relinquishment of tariff revenues from all such pumps as well as expose local enterprises, often small and medium-sized, to international competition.

Developed countries have been slow to meet their obligations in respect of the technology transfer, capacity-building, and financial assistance required to allow developing countries to acquire needed climate-related technologies

Thus, developing countries fear that the negotiations on environmental goods and services are yet another attempt at prying open their markets. Meanwhile, they observe that developed countries have been slow to meet their obligations in respect of the technology transfer, capacity-building and financial assistance required to allow developing countries to acquire needed climate-related technologies.

Developing countries would have more policy space if they were not required to lower the tariffs on "environmental goods" to low levels or zero

Developing countries would certainly retain more policy space if they were not required to lower the tariffs on "environmental goods" to low levels or zero in compliance with binding World Trade Organization commitments. They would then have the option to develop their own industries and products while maintaining tariffs that were appropriate to this objective, or to liberalize the applied tariffs on certain environment-related products. This is important because, increasingly, World Trade Organization tariffs reductions are bound; in other words, they cannot be raised again once lowered.[30] Without proper safeguards, the acceleration of liberalization of tariffs on environmental goods and services would reduce the policy options available to developing countries for promoting local production along their low-emissions development pathway (Khor, forthcoming).

30 During the Uruguay Round of multilateral trade negotiations, developing countries increased the proportion of imports whose tariff rates were "bound" (committed and difficult to increase) from 21 per cent to 73 per cent. Data available at the World Trade Organization website, http://www.wto.org/english/theWTO_e/whatis_e/tif_e/agrm2_e.htm (accessed 13 May 2009).

The second definitional issue concerns traditional environmental goods and services such as water treatment, waste collection technologies, etc., versus environmentally preferable products (EPPs). The initial list of environmental goods and services proposed by the developed countries mirrored the list of Asia-Pacific Economic Cooperation (APEC) and included typically capital- and technology-intensive products. Environmentally preferable products, instead of providing an end-of-pipe solution to pollution, reduce pollution during the production process or during the use phase of a product. Well-known examples are organic foods and coffee, and goods whose manufacture emits less or which are more energy-efficient in use, such as hybrid cars. The debate over environmentally preferable products in the World Trade Organization is at heart a debate about whether (and how) the World Trade Organization can distinguish between otherwise similar products based on their processes or production methods (PPMs).

The most favoured nation and national treatment principles now embodied in the World Trade Organization prevent discrimination among "like products" originating from different trading partners, as well as between a country's own and like foreign products. Developing countries, fearing that developed nations could use processes or production methods as the basis for non-tariff barriers (by imposing high process-related environmental standards hard to achieve by developing countries), have always taken the position that if the end products have the same physical characteristics, then they are "like products" regardless of how they were produced. However, recent dispute panel findings over the shrimp import and turtle by-catch issue mentioned above seem to indicate that, as long as measures to protect the environment (the endangered turtle species in this case) are non-discriminatory between domestic and international producers, or among international producers, they are World Trade Organization-compliant under article XX of the General Agreement on Tariffs and Trade (GATT), which allows exceptions to World Trade Organization trade rules to protect human, animal or plant life or health. Latin American countries recently proposed including sustainable agricultural products on the list of environmental goods and services, clearly an opening towards environmentally preferable products.[31]

Given the lack of progress at the multilateral level, the International Institute for Sustainable Development (Cosbey, 2008) has suggested that efforts might be pursued in bilateral and regional trade agreements and/or through plurilateral agreements similar to the World Trade Organization procurement agreements, whereby members could opt for voluntary agreements which come into effect only when enough countries have joined. Other proposals have insisted that the technologies be demand-driven, whereby developing countries would assess their adaptation and mitigation needs and/or development goals and put the technologies concerned on the list.

Embodied carbon

The contentious environmentally preferable products, or processes and production method-related, issue has been revived in the talks on border adjustments which would apply different tariffs to goods entering a country or bloc based on the carbon emitted in their production processes, or the carbon embodied in them. Lawyers disagree among themselves over the details, but they all seem to conclude that most border carbon adjustments would be hard to implement in such a way as to be compliant with current World Trade Organization rules.

31 This proposal, as well as the proposal of Brazil to include bioethanol, was resisted by the OECD countries.

As developed countries are putting in place policies to tackle climate change, their energy- and carbon-intensive industries fear having to compete with producers that do not face higher energy prices in non-Annex I countries. Developed-country Governments may also fear so-called carbon leakage—the relocation of such industries to non-regulated countries, with associated economic costs and no environmental benefit. A number of developed countries are thus proposing border adjustments that would "correct" for the differential in carbon emitted in the production of imported goods. If all developed countries join a regime of binding quantitative emission targets, then these measures would be directed largely at developing countries, notably the major emitters. The intention is to encourage them to become part of a regime of binding targets as well.

Developing countries will eventually have in any case to make significant cuts in their emissions from business-as-usual trajectories if the probability of catastrophic climate change is to be limited. However, for reasons outlined in earlier chapters, they cannot be expected to do so on the same terms or in the same time frame as developed countries, or without financial and technological support from developed countries.

Using stronger measures as a stick to induce developing countries to take on binding commitments is likely only to erode trust between North and South

Using stronger measures as a stick to induce developing countries to take on binding commitments is likely only to erode trust between North and South, especially as developed countries have yet to make the firm offer of a carrot of substantial financial and technological support to developing countries.

Not only may border adjustments be unnecessary, they are also unlikely to achieve their goal

Not only may border adjustments be unnecessary, they are also unlikely to achieve their goal (Cosbey, 2008). They may not be necessary because only a few energy-intensive sectors (steel, aluminium, paper, chemicals and cement) would be affected, and these are only responsible for a small proportion of economic activity in the developed world. In the United Kingdom, for example, their share of gross domestic product (GDP) is only 0.5 per cent (ibid.). Border adjustments may not reach their goal because they are likely only to reroute trade through countries with strong climate measures. China's export of carbon-intensive goods to the United States, as a proportion of China's GDP, for instance, is not getting close to even 1 per cent. Also, if the border measures cover only basic materials (such as aluminium), they hurt the domestic producers that use this input in their processes. If they covered manufactured goods (such as aluminium-frame bicycles), it would become very difficult to estimate border adjustments. As described above, if they are to be in compliance with the non-discrimination principle of the World Trade Organization and the principle of common and differentiated responsibilities under the United Nations Framework Convention on Climate Change, they will be extremely difficult to design.

Without the appropriate incentives and support, lower fossil fuel prices are likely to increase consumption of these carbon-intensive fuels in developing countries without comparable domestic policies

The need for financial and technological support to developing countries is made even more urgent inasmuch as, when developed countries put in place measures to discourage the use of fossil fuels, their decreased demand for those fuels will exert downward pressure on world coal and oil prices. Without the appropriate incentives and support, lower fossil fuel prices are likely to increase consumption of these carbon-intensive fuels in developing countries without comparable domestic policies (Fortunato, 2009; Cosbey, 2008).

Low-emissions energy subsidies

The push to decarbonize economies will require Government incentives (as well as regulations)

In addition to the issue of embodied carbon, subsidies to support lower-carbon energy sources may also raise questions of World Trade Organization compliance. The energy sector produces two thirds of the greenhouse gas emissions that cause climate change. Policies to curb climate change focus on taxing or capping CO_2 emissions from fossil fuels and/

or on providing subsidies to alternative energy sources. However, the push to decarbonize economies will require Government incentives (as well as regulations) and it is therefore imperative that countries clarify which subsidies would be World Trade Organization-compliant. This issue may be easier to resolve than the above issues of environmentally preferable products and liberalization of environmental goods and services because there is a precedent: There had been an exception for environmental subsidies under the Agreement on Subsidies and Countervailing Measures which lapsed in 1999 and could be revived to allow climate-related subsidies that do not injure competitors in other countries.

If the non-actionability of these subsidies could be renewed, both developed and developing countries would be allowed to subsidize general research (assistance for research activities by firms or higher education or research establishments on a contract basis with firms) on climate mitigation and adaptation, without fear of trade sanctions (Hoekman, Maskus and Saggi, 2004).

With regard to carbon trading systems, it is unclear whether free allocation of emissions allowances would be considered subsidies under the Agreement on Subsidies and Countervailing Measures, as there is no body of jurisprudence on this point (Hufbauer and Kim, 2009). It is worth noting that under the Agreement on Subsidies and Countervailing Measures, countervailing duties could not be applied on countries that failed to take actions on climate change. A lack of action does not constitute "a subsidy" under the Agreement.[32]

The multilateral investment agreement, the Agreement on Trade-related Investment Measures, has few obligations. However, the 2,500 bilateral investment agreements and the bilateral investment chapters in regional trade agreements contain strong measures. In the North American Free Trade Agreement (NAFTA), the expropriation was so broad and led to so many arbitrations that the United States, Canada and Mexico agreed to clarify and limit the definition of which investors could claim expropriation under the Chapter concerned. These arbitrations have, in some cases, had a chilling effect on countries considering stronger regulations. The fear is that investors could claim that the new regulations constituted unfair and inequitable treatment. Clarification on which climate-related investments could constitute indirect expropriation would be warranted in order to give countries the policy space within which to put in place appropriate regulations without the fear of having to pay excessive compensation to foreign companies.

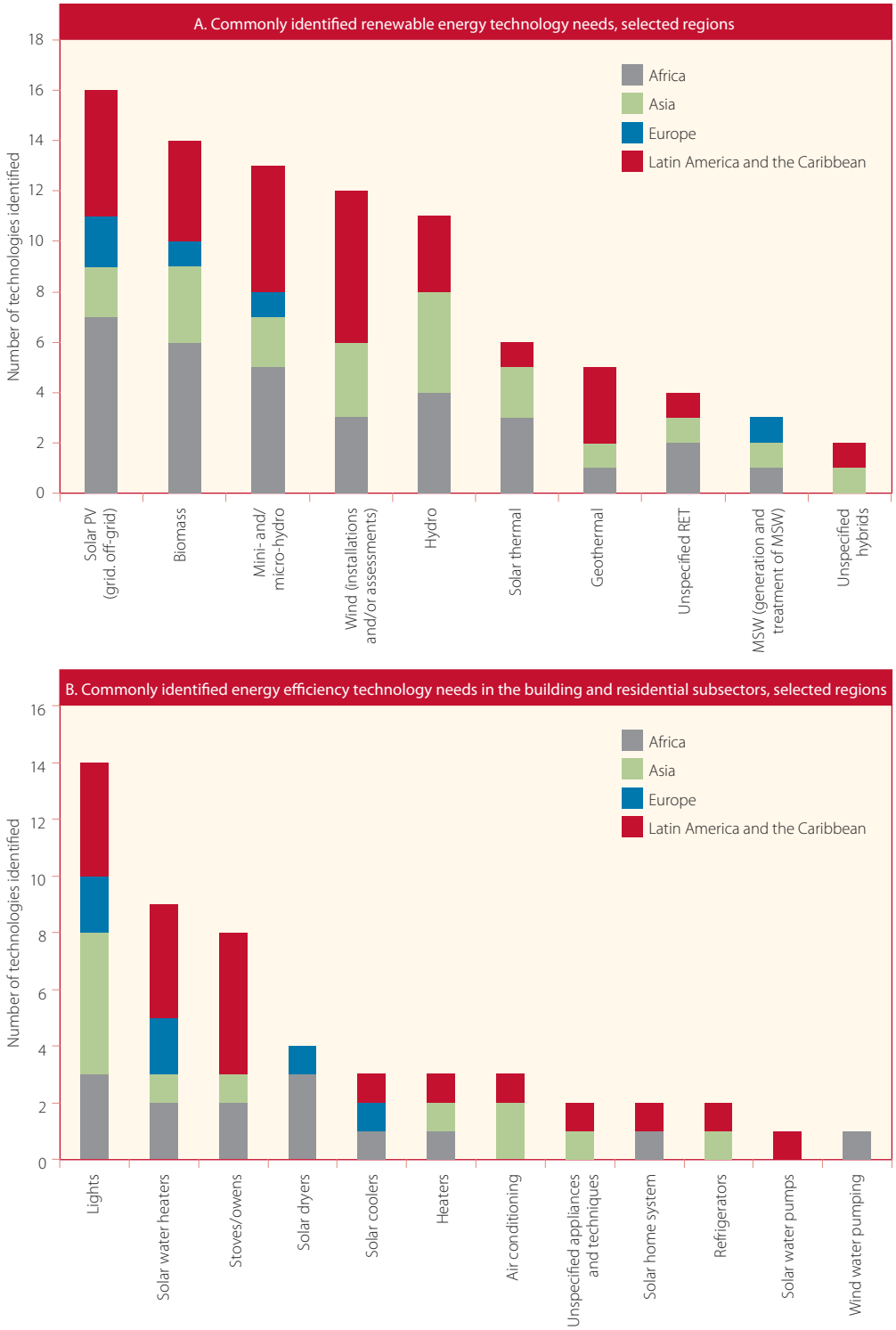
International policies and measures to build capacity in developing countries

Technology absorption requires investment in both physical and human capital. The faster the pace of capital formation, the greater the likelihood of such absorption. However, as discussed in chapter IV, promoting local technological learning and capacities will be critical to the successful use of technological knowledge in meeting the climate challenge. As figure V.2 suggests, technology needs will differ from region to region. But, in all cases, active government policy will be a component of successful outcomes (see chap. IV). Moreover, the global nature and urgency of the climate challenge imply that the rapid dissemination of appropriate technological options will require international collaboration.

The global nature and urgency of the climate challenge imply that the rapid dissemination of appropriate technological options will require international collaboration

32 Previous experience indicates that successful efficiency efforts can lead to the "rebound effect" whereby overall consumption increases. Measures will have to address the absolute consumption of energy.

Figure V.2
Commonly identified renewable energy technology needs and energy efficiency technology needs in the building and residential subsectors, selected regions



Source: United Nations, United Nations Framework Convention on Climate Change (2006).
Abbreviations: PV, photovoltaic; MSW, municipal solid waste; RET, renewable energy technology.

This is particularly true in the area of RD&D, where developing countries lag significantly and risk falling further behind as new technologies emerge. Important examples of technologies that will be critical to a new development pathway include carbon capture and sequestration (CCS), low-emissions biofuels, and breakthroughs in renewable energy sources such as solar panels. Moreover, developing countries also need access to best practices with respect to adaptation technologies, in the areas of agriculture, disaster management and urban planning. These technologies are often closely interrelated and link the climate threat to other threats, such as food and energy security. Consequently, developments in all these areas are best addressed through a structured global programme and funding (Stern, 2009, p. 173). Publicly funded research holds out the best hope of developing greater coordination among the myriad research institutions, in the private sector, the non-profit sector and academia, that are already working to meet these challenges and is moreover more likely to ensure the widest dissemination of the results (box V.3). Transparent and readily accessible research is all the more important because regulatory and legal frameworks, such as standard-setting, are likely to emerge on the basis of these results.

Publicly funded research holds out the best hope of developing greater coordination among the myriad research institutions, in the private sector, the non-profit sector and academia

Particularly with respect to cutting-edge technologies, well-educated engineers and managers are essential.[33] Enhanced education and sustained training programmes are needed in the areas of technical, administrative, financial, regulatory and legal skills (United Nations, United Nations Framework Convention on Climate Change, 2003). In addition to making improvements in domestic education, developing countries, in order to

Mechanisms to retain and bring back trained labour include wage flexibility, repatriation grants, and incentives to start technology firms

Box V.3

Intellectual property rights and publicly funded technologies

The issue of publicly owned technology transfer was addressed at the United Nations Conference on Environmental Development, held in Rio de Janeiro in 1992. Agenda 21[a] (chap. 34, para. 34.18 (a)) states that Governments and international organizations should promote the "Formulation of policies and programmes for the effective transfer of environmentally sound technologies that are publicly owned or in the public domain". Implementation of this provision has been very weak.

Developed-country Governments sponsor a range of research and development (R&D) activities geared towards developing climate technologies. For example, in 2001 Governments within the European Union (EU) spent almost 350 million euros for R&D in renewable energy, more than half of the total expenditure (EU Directorate-General for Research, 2006). Public sector spending is equally important in the United States of America. For example, for the wind, biofuels and photovoltaic sector, the United States Department of Energy spent approximately USA 356 million (2008 budget) (Barton, 2007, p. 7).

Sathaye, Jolt and De La Rue du Can (2005) surveyed Government-sponsored R&D in the United States, Canada, the United Kingdom of Great Britain and Northern Ireland, the Republic of Korea and other countries members of the Organization for Economic Cooperation and Development (OECD) and found that it is a common practice for Governments to grant ownership of intellectual property rights (patents, copyrights, trademarks, etc.) to the recipient research institutions. In the United States, for example, Government-sponsored research usually ends up being patented (Barton, 2007, p. 8).

Given the role that Governments play as the main driver of R&D for climate technologies, it will be necessary for modalities for the transfer of publicly funded climate technologies to developing countries to be explored. OECD countries, which tend to hold ownership of most of the technology needed for mitigation and abatement, are in a strategic position to influence technology flows directly through their influence on the private sector or on public institutes which receive funding for their R&D and thus should be more active in transferring technologies to developing countries.

a United Nations (1992)

33 One advantage of traditional knowledge and technology, on the other hand, stems from the fact that sufficient human capital is probably already in place in developing countries.

guard against a "brain drain", can offer incentives to students. Mechanisms to retain and bring back trained labour include wage flexibility, repatriation grants, and incentives to start technology firms. Developed countries, for their part, should subsidize offshore training, conference attendance and, in some cases, temporary employment for graduates from developing countries. Grant proposals for research on environmentally sound technologies involving developing-country teams could also receive special consideration (Maskus, 2004). Capacity-building might also be pursued through cooperation agreements that increasingly accompany regional trade agreements among OECD countries. These would help developing countries conduct an assessment of the obstacles to their low-emissions energy development. Aid-for-trade programmes should also be tapped in this regard.

What is clearly required is a massive international effort (United Nations, Department of Economic and Social Affairs, 2009). Table V.1 presents various innovative mechanisms to promote technology development and transfer. Three closely related initiatives could plant the seeds of greater international collaboration in developing the skills and technologies needed to tackle climate change:

Table V.1
Innovative mechanisms to promote technology development and transfer

Mechanism	*Rationale*	*Issues to consider*
Publicly supported centres for technology development and transfer	Green revolution model of technology diffusion: makes technologies available to developing countries without intellectual property right protection	Suitable for mitigation or only for adaptation technologies
Technology funding mechanism to enable participation of developing countries in international R&D projects	Resultant intellectual property rights could be shared; patent buyouts could make privately owned technologies available to developing countries	Is there sufficient incentive for participation by developed-country private sector technology leaders?
Patent pools to streamline licensing of inventions needed to exploit a given technology	Developing-country licensees will not have to deal with multiple patent-holders	What are the incentives to patent-holders? Would government regulation be needed?
Global R&D alliance for research on key adaptation technologies	Model of research on neglected tropical diseases	Is such an approach suited to mitigation technologies?
Global clean technology venture capital fund	Fund located with a multilateral financing institution which will also have the rights to intellectual property	Will new technology ventures be viable commercially if they do not own intellectual property?
Eco-Patent Commons for environmentally sustainable technologies	Approach initiated by the private sector to make certain environmentally sound technologies available royalty-free on a "give-one, take-one" model	Voluntary, private incentives appear weak. What about those companies without a patent to contribute?
Blue Skies proposal of European Patent Office: differentiated patent system with climate change technologies based on a licensing of rights	Complex new technologies based on cumulative innovation processes need to be treated differently from, for example, pharmaceuticals	Appears to address concerns similar to those addressed by the patent pools proposal: more specifics needed on implications for technology access
More favourable tax treatment in developed countries for private sector R&D performed in developing countries	More proactive, technology-push approach by developed-country Governments	May face domestic political constraints
Technology prizes	Reward innovation without awarding intellectual property rights to innovators	Requires a well-specified research objective

Source: United Nations, Department of Economic and Social Affairs (2008).

- ***A multilateral technology fund*** to support an international programme on the diffusion of climate technology and to strengthen and coordinate regional and national RD&D efforts in developing countries. Such a fund could be housed in the secretariat of the United Nations Framework Convention on Climate Change and draw on the existing network of scholars and scientists within the Intergovernmental Panel on Climate Change (IPCC) in the design of its programmes. Financing such a programme can draw lessons from the experience with the Global Environment Facility (GEF) (see box V.4 and chapter VI). The steady decline in public RD&D in the energy sector is an indication of the urgency of establishing such a fund. A comprehensive programme would need to focus on the full range of technological challenges at the basic science, applied RD&D, demonstration, deployment and commercialization stages of developing cleaner technologies. However, coordinated funding for the development, demonstration and deployment of critical technologies such as carbon capture and sequestration and the next generation of biofuels, in which developing countries have a particular interest, would have to be high up in the agenda. Given the public nature of RD&D, it would be essential to ensure dedicated and predictable financing for such a fund, using the kinds of instruments discussed in the chapter VI. Such a fund could act as a focal point for the coordination of ongoing research in climate technologies at the international and national levels and among public, private and non-profit organizations, while ensuring open access to all available research in line with the urgency of the challenge.
- ***A human skills transfer programme.*** A scaled-up human capacity development effort could complement the fund and would consist of a temporary (perhaps only a virtual) movement of skilled unemployed/underemployed workers from developed countries (engineers, technicians, primary education teachers, experts in sustainable agriculture, and qualified blue- and white-collar workers) into developing countries to provide workforce and vocational "train the trainers"-type training. An innovative means of accomplishing this would be "reverse outsourcing", that is to say, programmes utilizing the Internet and other communications technologies, through which long-distance training services in critical areas would be provided by developed countries to developing ones. During a recession, many highly skilled technicians, teachers and professionals are laid off. Even if only 5 or 10 per cent of them participated in a technology transfer corps organized through the development cooperation agencies for periods ranging from six months to two years, significant skills and know-how transfer could be effected. This would be a win-win solution for developing countries requiring more help and for cash-constrained developed countries obliged, nonetheless, to pay unemployment insurance.
- ***A public technology pool.*** The results of fully funded public research on climate technologies should not be the basis of private patents: it should be made available at low or no cost to all countries. A technical secretariat would be needed to monitor, collect and disseminate such research, to act as a clearing house for existing publicly funded technologies and to actively promote access to those technologies, particularly for developing countries. Such a body could work alongside the Global Technology Fund to ensure the widest dissemination of future research sponsored by that Fund.

Box V.4

The Global Environment Facility

Technology transfer is seen as playing a critical role in the global response to the challenges of climate change. Indeed, promotion of and cooperation in the transfer of environmentally sound technologies derive from a commitment embodied in the United Nations Framework Convention on Climate Change. In order to pursue these goals, the Convention proposed the creation of a financial mechanism. The Global Environment Facility (GEF) serves as that mechanism for the Convention.

Over the past 17 years, the Global Environment Facility has been financing projects to promote the transfer of environmentally sound technologies under the guidance of the Conference of the Parties to the Convention. During this period, about $2.5 billion for climate change projects has been allocated, which leveraged approximately $15 billion in co-financing. Most financing is in the form of grants to developing countries and countries with economies in transition. Through its Small Grants Programme, the Facility has also made more than 10,000 small grants directly to non-governmental and community organizations.

Some examples of environmentally sound technologies supported by the Global Environment Facility are described below.

Energy-efficient lighting and appliances

The Global Environment Facility has built a portfolio promoting energy-efficient appliances and technologies in developing countries. GEF-supported interventions typically focus on instituting energy-efficiency standards and labels, consumer education, and testing and certification of appliances. In countries where there is substantial manufacturing capacity, the Facility has also supported enterprises in developing new energy-efficient appliance models and in acquiring technical information and knowledge from more advanced countries.

In Tunisia, for example, 10 out of 12 local appliance manufacturers are offering more energy-efficient models. In China, the GEF project to promote energy-efficient refrigerators adopted a two-pronged approach comprising technology push and market pull. Technology push is achieved through technical assistance to refrigerator and compressor manufacturers, technology upgrades, and designer training programmes, while market pull is achieved through the promulgation of energy-efficiency standards.

Since the mid-1990s, the Global Environment Facility has supported the dissemination of efficient lighting technologies in more than two dozen countries. The Facility has also launched a global efficient lighting initiative, approved by the GEF Council in 2007, to accelerate the phase-out of inefficient lighting through the United Nations Environment Programme (UNEP) and the United Nations Development Programme (UNDP); at the same time, support is being extended to more countries and programmes at the national level.

Industrial energy-efficiency technologies

The Global Environment Facility has funded more than 30 projects in the industrial sector to promote technology upgrading and the adoption and diffusion of energy-efficient technologies. Some projects focus on the development of market mechanisms such as energy service companies, the creation of dedicated financing instruments, and technical assistance to stimulate investments in new technologies. Other projects are designed to identify one or more subsectors where specific technologies can be promoted. The range of industries includes construction materials (brick, cement and glass), steel, coke-making, foundry, paper, ceramics, textiles, food and beverage, tea, rubber and wood. A number of projects also promote energy-efficient equipment such as boilers, motors and pumps, as well as cogeneration in the industrial sector. In some projects, the Facility has promoted South-South technology transfer; one such project has entailed the transfer of energy-efficient brick kiln technology from China to Bangladesh.

Box V.4 (cont'd)

High-efficiency boilers

The China Efficient Industrial Boilers project had received a $32.8 million grant from the Global Environment Facility to (a) upgrade existing boiler models by introducing advanced combustion systems and auxiliary equipment from developed countries; (b) adopt new high-efficiency boiler models by introducing modern manufacturing techniques and boiler designs; and (c) provide technical assistance and training for boiler producers and consumers. Completed in 2004, the project successfully supported international technology transfer of boiler technologies which benefited nine boiler manufacturers and nine boiler auxiliary equipment makers. With GEF support, the manufacturers in China acquired advanced efficient boiler technologies, built prototypes, and began commercial production. Through technical assistance, the project also led to the revision and formulation of national and sector standards, while strengthening the technical capacity of China's boiler sector.

Solar water heaters

Although solar water heater technology is sometimes perceived to be simple, such a perception can in fact be misleading. The quality of the fittings, of the solar collectors and of the installation has substantial impact on satisfactory operation. Accordingly, inexpensive materials, poor workmanship and shoddy installation have often resulted in non-functional units and abandonment of installations. GEF experience has shown that knowledgeable staff and the observance of high standards are critical to the successful dissemination of this technology.

In Morocco, for example, early solar water heaters had tended to be of low quality. As a result, they fell into disuse and the market languished. Through a Global Environment Facility project, the older non-functioning installations were repaired, new higher-quality standards were adopted, and technicians and staff were trained to ensure that future installations would be of satisfactory quality. In addition, to encourage production and sale of the higher-quality units, a subsidy was offered to early adopters of water heaters who met the new standard. These initiatives revived the market, which is now growing rapidly, along with the industry as a whole.

Waste to energy

A number of projects have supported utilization of methane from municipal waste, in the form of either solid wastes in landfills or liquid biological wastes. Many of these projects have qualified for Global Environment Facility support as both renewable energy projects and short-term response measures because of their cost-effectiveness. The Facility played a role in helping increase the uptake of these technologies; now its support is no longer needed, as the projects are eligible for funding and highly profitable when implemented under the Clean Development Mechanism.

The India biomethanation project, whose implementation had been proposed in the early 1990s, was designed to exploit India's endogenous capacity to adapt and replicate biogas technology for industrial wastes. A pre-existing challenge had arisen from the fact that biological waste from agroprocessing and related industries deposited substantial quantities of methane and other pollutants into nearby waters. The intent of the project was to produce the methane in a controlled environment, and then capture and use it to produce energy.

Concentrating solar power

The Global Environment Facility, together with India, Mexico, Morocco and Egypt, developed a portfolio of four concentrating solar power demonstration plants. The projects built (typically 30 megawatt) solar fields as part of hybrid gas-turbine plants. Successful hybridization of the gas-turbine and solar power plants would enable the projects to dispatch power at will, thereby making them more economically attractive.

Conclusion

A rapid pace of investment will not be sufficient to meet the climate challenge unless it is accompanied by a technological transformation, with increased capacity to produce, operate and deploy climate-friendly technologies. However, for many developing countries, the cost of accessing those technologies could prove prohibitive. Although developed countries have committed themselves to leading the change towards cleaner technologies and ensuring that developing countries are not left behind, neither commitment has been fulfilled. Innovative transfer of both technologies and know-how will be required to meet climate change objectives in the context of both mitigation and adaptation.

This chapter has identified possible obstacles to the transfer of technology that could arise internationally with respect to intellectual property rights, corporate behaviour and trading rules. To date, these factors have not proved prohibitive. However, they are likely to take on greater significance if developing countries embark on a big push towards a low-emissions, high-growth development pathway. Anticipating those obstacles and devising ways around them constitute an urgent task of the international community. This would require consensus, since it might entail the amendment of World Trade Organization rules and special climate waivers based on the urgency of the rapidly evolving climate situation. It will also require careful attention to the implications of the World Trade Organization principles of non-discrimination and United Nations Framework Convention on Climate Change principles, especially that of common and differentiated responsibilities and capabilities. This has to be based on ability and historical obligations. Since any post-2012 agreement is likely to retain these principles, the challenge will be to ensure the coherence and compatibility of their applications.