UK–India Collaboration to Identify the Barriers to the Transfer of Low Carbon Energy Technology

Final Executive Summary

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Executive summary

At Gleneagles in July 2005, the G8 highlighted the importance of strengthening technology cooperation between developed and developing nations to develop low carbon energy options. Many developing countries pressed for a new approach to international cooperation in the area of clean energy technologies. As a follow-up to this, the UK Government and the Government of India decided to collaborate on a study to assess the barriers to the transfer of low carbon energy technology between developed and developing countries. This is an executive summary of the findings from this collaborative study.

Key messages

1. The transfer of low carbon technologies to developing countries is central to tackling climate change. Governments in both developed and developing countries have a key role to play in facilitating technology transfer through both national and international initiatives.
2. There is no "one policy fits all" solution to facilitating low carbon technology transfer. Relevant policy interventions vary according to the nature of the technology, its stage of commercial development and the political and economic characteristics of both supplier and recipient countries.
3. Due to the early stage of development of many low carbon technologies, vertical technology transfer (transfer of technologies from the research and development stage through to commercialisation) is as much an issue as horizontal technology transfer (transfer from one geographical location to another, including transfer from developed to developing countries).
4. In order to be sustainable, technology transfer must take place as part of a wider process of technological capacity building in developing countries. Building technological capacity relies on the transfer of knowledge and expertise as well as hardware during the technology transfer process.
5. Recipient firms must take a strategic approach to acquiring knowledge and expertise as part of the technology transfer process.
6. Less integrated approaches to technology transfer that include the use of recipient country manufacturers to supply parts and labour are more likely to improve technological capacity within recipient countries.
7. Improving firms' capacity to absorb new technologies (their 'absorptive capacity') is essential to enabling firms to take full advantage of new low carbon technologies. Different kinds of absorptive capacity may be required for technologies at different stages of development. For those at an early stage, this is likely to include competencies in related technologies as well as commercialisation skills. Improving absorptive capacity in developing countries requires bilateral and multilateral collaborative initiatives to undertake research, development, demonstration and deployment of low carbon technologies.
8. Intellectual property rights (IPRs) may be a necessary, but not sufficient requirement for successful technology transfer. New, internationally collaborative approaches to low carbon technology research and development may have an important role to play in overcoming IPR issues in future at the same time as contributing to building technological capacity in developing countries. Specific instances of IPR related barriers to acquisition of existing proprietary technologies should be addressed through dialogue on the basis of further work analyzing how other international funds and public/private initiatives have fostered technology transfer covered by IPRs.
9. The interests and power of different actors involved in technology transfer may have an important bearing on the outcome of the transfer process.

Technology transfer and tackling climate change

Low carbon technologies have a central role to play in reducing emissions of carbon dioxide. Most new low carbon technologies are being developed in industrialised countries. However, much of the potential for these technologies to make significant reductions in carbon emissions is in developing countries where fossil fuel consumption is increasing rapidly – particularly in India and China. The migration of global energy systems to lower carbon pathways therefore depends upon the successful transfer and absorption of these low carbon technologies within developing country economies.

This summary provides an overview of the central findings from a UK-India collaborative study that aims to inform intergovernmental discussions about the development and transfer of low carbon energy technologies. In particular, it aims to inform discussions under the UN Framework Convention on Climate Change (UNFCCC) and the Gleneagles Dialogue, on clean energy, sustainable development and climate change. The study focused primarily on technology transfer to India. It is, however, hoped that the insights provided by the study can inform more general discussions on low carbon technology transfer to developing countries.

The study was approached in three stages:

1. Analysis of existing literature on technology transfer and technological change.
2. Analysis of five case studies of low carbon technologies that covered technology sectors at different stages of commercialization – outlined in Table 1.
3. Analysis of the findings of the literature review alongside the findings of the case studies to draw out the key recommendations presented here.

Table 1: Low carbon technologies for case studies

	Stage of technology development		
Sectors	**Pre-commercial**	**Supported commercial**	**Commercial but slow diffusion**
Low-carbon power generation technologies	Coal gasification – particularly IGCC	Biomass – including fuel supply chain issues	Improving combustion efficiency
Network/ infrastructure technologies			
Low carbon end use technologies	LED lighting	Hybrid vehicles	

Based on combined analysis of the findings of the literature review and the case studies, this section presents a summary of key areas for future action in order to facilitate the transfer of low carbon technology to developing countries. It begins by outlining six key issues that this study has highlighted as important when addressing technology transfer. After highlighting several areas that require further research, it then moves on to make recommendations for national and international policy initiatives.

Key considerations when addressing technology transfer

The analysis of the literature on technology transfer and the case studies examined during this study has highlighted a number of key issues that require consideration when addressing technology transfer. These can be summarised around six themes, namely:

1. Technological change and capacity building
2. Levels of integration in the transfer process
3. Supplier/recipient firm strategies
4. Absorptive capacity
5. Stage of technology development
6. Intellectual property rights (IPRs)

These themes are explored below.

Technological change and capacity building

An essential insight highlighted by the literature review is that technology transfer takes place within a broader context of technological change. A useful image is a drop of water (the transferred technology) hitting the surface of a pond. The pond represents the technological capacity of the country receiving the transferred technology. In the long term, it is the ripples that spread across the pond as a result of the transferred technology that are the most important consideration. These ripples represent the impact of the transfer of low carbon technologies on the overall technological capacity of recipient countries. It is this capacity that enables future innovation to take place and that is most likely to ensure long term adoption and development of low carbon technology in recipient countries. Building technological capacity is especially important in developing countries where long term economic development and poverty reduction are central concerns.

Importantly, the literature review also highlighted the fact that technological change mostly occurs as a series of incremental changes. For example, through a line of continuous incremental innovations over forty years, the Korean steel industry eventually overtook the technological capabilities of more developed economies in this industry.

Another central insight that the literature review highlighted is that there are essentially three different flows that make up the technology transfer process. These are:

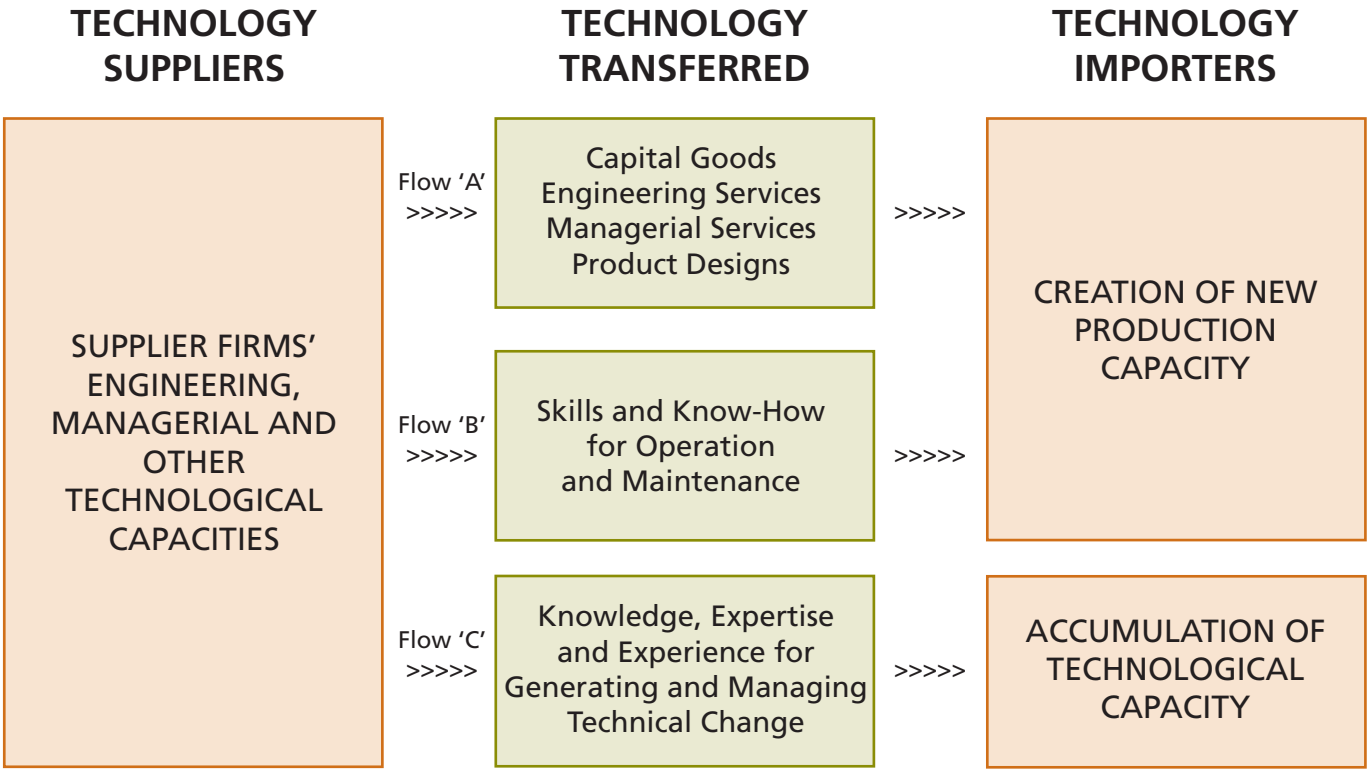
A. Capital goods and equipment

B. Skills and know-how for operating and maintaining equipment

C. Knowledge and expertise for generating and managing technological change

As Figure 1 illustrates, Flow C, the flow of knowledge and expertise, determines whether or not technology transfer results in the development of technological capacity within recipient countries. The transfer of knowledge and expertise is therefore an essential part of technology transfer.

Figure 1: The three flows of international technology transfer



Levels of integration in the transfer process

The literature review also highlighted that an important determinant of the impact of technology transfer on the technological capacity of recipient countries is the degree of integration involved. This is the extent to which technology suppliers integrate the different flows involved in the transfer process (flows A-C in Figure 1). For example, the transfer of technology might be highly integrated (e.g. involving some form of turnkey project), or highly disaggregated (e.g. via the acquisition of different items of plant from a wide range of host country equipment manufacturers). These links with host country companies are integral to knowledge generation among local suppliers. They are therefore central to developing technological capacity within recipient countries.

In the case study of hybrid vehicles, for example, it was found that Toyota is manufacturing its Prius hybrid in China. However, even though Toyota has established a joint venture with Sichuan FAW to manufacture the Prius in China, they are taking a fairly integrated approach. It seems that they are importing most of the parts directly from Japan and then assembling the vehicles in China as opposed to manufacturing the individual parts (including, presumably, the hybrid drivetrains) in China. This implies that there might be limited technological capacity building amongst Chinese firms as a result of this arrangement in the short term. In the long term, however, FAW's involvement with hybrid technology could result in the gradual development of technological understanding of hybrid drivetrains so Toyota's decision to enter into a joint venture should still be viewed as a positive step.

The LED case study also highlighted the importance of technological capacity. Indian firms dealing with LEDs currently act only as packaging vendors for international firms that actually manufacture LEDs. This means that Indian firms have not been able to develop any technological capacity in this area. In China, on the other hand,

a number of international firms have set up LED manufacturing plants leading to the development of considerable capacity building in this technology amongst Chinese firms.

Supplier/recipient firm strategies

The level of integration in the transfer process discussed above is often a direct result of strategies adopted by supplier firms. The strategies adopted by recipient firms may be equally important to the outcome of the transfer process. Recipient firms that, as part of the transfer process, strategically aim to obtain technological know-how and knowledge necessary for innovation are more likely to be able to develop their capacity as a result. Examination of hybrid vehicles within this study highlighted the example of Hyundai's approach to gaining knowledge and expertise in conventional vehicle manufacture. Managers within Hyundai have proactively taken a strategic approach to acquiring knowledge during the acquisition of foreign technology in order to expand the firm's knowledge base and shift its learning orientation from imitation to innovation.

Absorptive capacity

Absorptive capacity is a firm's ability to absorb new technology. If absorptive capacity is weak amongst recipient firms, they are less able to take advantage of collaborations with international technology suppliers. For example, in the case of LEDs, this study has identified that, whilst individual skills exist in India that are of relevance to manufacturing LEDs (e.g. engineering, material sciences, control electronics), the capacity does not exist to harness these skills to actually manufacture LEDs. This lack of absorptive capacity is a key barrier to LED manufacture in India. The biomass case study also highlighted a lack of capacity in rural areas of India for carrying out maintenance on briquetting machines as a key barrier to the expansion of briquette production in India.

A two-way relationship exists with regard to the absorptive capacity of recipient firms. Absorptive capacity impacts on the outcome of technology transfer (higher absorptive capacity implies a higher propensity to develop capacity as a result of transfer). It is also influenced by technology transfer, in that transfer activities have the potential to increase recipient firms' absorptive capacity depending on what flows are included in the transfer process (flows of hardware, know-how and knowledge– Figure 1 above).

Developing national systems of innovation in developing countries has an important role to play in developing firms' absorptive capacity. National systems of innovation refer to a country's infrastructure and capacity for undertaking innovation related activities such as R&D. This includes universities as well as networks of R&D facilities and expertise in the public and private sectors. The findings of all five case studies highlighted the fact that, in order to contribute to developing absorptive capacity, R&D activities must include collaboration across public and private sectors - it is within the private sector that most technology transfer activities take place. R&D activities must also include bilateral or multilateral collaboration in order to share lessons learned from experience with new low carbon technologies.

Stage of technology development

The five case studies of low carbon technologies within the study covered technologies at different stages of commercialization (Table 1 above). This is because the barriers to successful technology transfer are likely to vary according to the stage of technology development. For example, the case studies suggest that absorptive capacity is a more significant barrier to technology transfer for technologies at early stages of development than for technologies at later stages of commercialization. There may also be a need to encourage market development for these early stage technologies, as was the case for the LED, biomass and hybrid vehicles cases studies examined in this study.

The stage of technology development highlights an important issue in low carbon technology transfer, namely that transfer may be both vertical (from the R&D stage through to commercialisation) and horizontal (from one geographical location to another). The early stage of development (pre-

commercial and supported commercial) of many low carbon technologies implies a need to focus on barriers to both vertical and horizontal transfer. In some cases, such as hybrid vehicles and IGCC examined within this study, this may mean that similar barriers exist to the adoption of low carbon technologies at early stages of development in developed countries as in developing countries. However, where these technologies are owned by companies based in developed countries, generic barriers to technology transfer between developed and developing countries will also need to be addressed.

Intellectual property rights (IPRs) and commercial interests

Technology transfer can impact on the relative commercial standing of technology owners as well as owners of alternative technologies. It may also impact on the relative economic wealth of supplier and recipient countries. The interests and political and economic power of the different actors involved in the technology transfer process are therefore likely to have significant bearing on the barriers to, and outcomes of, technology transfer processes. This may be of particular relevance in the case of low carbon technologies where a wide range of powerful interests stand to be affected. One example is the supply of advanced industrial gas turbines for IGCC. Previous experience shows that suppliers from industrialised countries tend to form alliances with developing country equipment companies such as BHEL. However, in order to maintain competitive advantage, they often retain control over the design and manufacture of the most advanced, high tech parts and/or products (e.g.the first row of turbine blades, incorporating advanced materials, cooling technologies and manufacturing techniques.)

The clearest specific way in which these commercially driven interests appear in technology transfer is in relation to IPR. Protection of IPRs by supplier firms can prevent recipient firms from gaining access to the knowledge necessary to imitate and then innovate on the basis of new technologies. This can act to prevent or inhibit the development of technological capacity within recipient countries. For low carbon technologies, gaining ownership or access to IPRs may therefore be a necessary, but not sufficient requirement for successful low carbon technology transfer. IPR issues are not framed narrowly in terms of access but also address other factors and barriers, such as tacit knowledge and absorptive capacity. As these factors differ by country, technology and sectors, a case by case approach may yield more useful insight in how to address IPR related barriers. For example, in case of LEDs , industry commentators felt that without improved technological capacity in India in this industry, ownership of relevant IPRs would make little difference to India's ability to manufacture white LEDs. Another example comes from the IGCC case study, where the key barrier to transfer is not ownership of IPRs but rather a lack of knowledge of whether IGCC will work with low quality Indian coal and the overall lack of worldwide successful commercial demonstration of this technology.

In some cases, in the long term, protection of IPRs for some technologies may not be a barrier to developing technological capacity in recipient countries. One possible example arose from the hybrid vehicles case study. Hybrid drivetrains are subject to strict IPRs. But, where they have been supplied to other countries, the firms owning the IPRs have had to train engineers and mechanics in the recipient country in fitting and maintaining the drivetrains. This implies the potential for companies in recipient countries to develop their own technological capabilities in hybrid drivetrains which may also filter through to the wider economy in the longer term.

An important issue that needs to be understood in relation to low carbon technologies is whether IPRs as a barrier to technology transfer might vary in importance according to the stage of technology development or the nature of the technology itself. For example, the stage of development of a particular technology may have implications in terms of the level of private investment already made in a technology and the level of returns that IPR owners need to derive before they are happy to release the IPR.

Furthermore, there is a complex relationship between the strength of the IPR regime in a developing country and the extent to which this fosters technology transfer. There may also be implications of country specific IPR regimes for different types of technologies at different stages of development.

One possible route forward in addressing IPR issues in the context of technology transfer is international collaboration on low carbon technology development. This could be on the basis of international collaborative R&D initiatives on technologies that are at a very early stage of development. As these technologies would be collaboratively developed, the IPRs could be structured to benefit the various partners involved, including with the aim of making the IPR available as a free or low cost public good. This kind of international collaborative R&D based approach has the added benefit of enabling knowledge sharing between collaborators which could aid long term capacity building in developing countries. The idea of a Global Research Alliance was put forward by the UK Commission on Intellectual Property Rights as a way of linking developmental objectives (capacity strengthening and sustainable development) with the more commercially driven IPR framework (UK CIPR, 2005).

In cases of technologies covered by existing IPRs, international initiatives and international funds, such as those established under the Convention, could potentially play a role in facilitating role in negotiating licences or buying down the costs of specific technologies to make them more widely accessible – as has happened in the case of the Montreal Protocol dealing with ozone depletion. Insights from how global private/public partnerships have addressed issues of access to proprietary technologies in other sectors, such as public health, might also provide a fresh approach to the issue of technology transfer.

Knowledge gaps and future research

As well as yielding a number of important findings, this study has highlighted several areas that require additional research. These include[1]:

1. There is a clear need for internationally comparative analysis of technology transfer to developing countries to understand what barriers to technology transfer are country-specific as opposed to generic. For example, this might explain why only 7.3% of CDM projects in India mention technology transfer in their initial project documentation compared to 55.1% in China or 83.3% in Malaysia. Understanding the different issues faced by countries at different stages of development would also be of value. One output would be to propose changes to national approval processes and the CDM project cycle that could advance the transfer of low carbon technologies.
2. Analysis of the technology needs assessment (TNA) studies submitted by countries to the UNFCCC secretariat to compare the perceived needs for technology transfer by project type, and the perceived barriers to technology transfer by country. This would distinguish between projects that include significant technology transfer, those that favour local technology and those that are "indifferent". Similarly host countries could be grouped into those whose policies favour or discourage technology transfer to see if there is a difference in the barriers they identify, and their proposals to address those barriers.

1 The authors would like to thank Erik Haites, Margaree Consultants Inc, Toronto, for his helpful comments and suggestions.

3. Much technology transfer literature focuses on the challenges faced by developing countries in accessing technologies. Additional work may be required to build on the smaller body of work (e.g. Watson, 1999) that analyses perceptions of barriers to technology transfer within firms, governments and other actors in developed countries. The US, for example, believes that barriers to the transfer of low carbon technologies could result from the actions of developing countries and not just the actions by American firms. Further work is planned in the US to analyse this issue. When the results become available in 2006/7, it could be useful to compare any technology-specific barriers with the lessons from this study and the TNAs from developing countries.
4. Valuable work could be done towards the development of specific assessment criteria for international financing, information sharing and R&D mechanisms based on the ability of these mechanisms to contribute to long term low carbon technological development. This should include criteria to assist in the identification of suitable institutional structures within which these mechanisms would be most effective. As part of this, there is a need for ongoing evaluation of various mechanisms designed to deliver R&D collaboration and other technology transfer objectives. This could include, for example, analysis of the Asia Pacific Partnership, FutureGen, and the Carbon Sequestration Leadership Forum.
5. A review of the mandate of the UNFCCC Expert Group on Technology Transfer (EGTT) is envisaged at the Conference of Parties meeting in Nairobi in November 2006. Since the EGTT was established, several international bodies and initiatives, such as the World Bank, IEA and Asia-Pacific Partnership, have increased their work on low carbon technology and innovative financing of these. This presents an opportunity to study how the EGTT can work with these other initiatives in its future work.
6. Further analysis needs to be done of IPR issues within the context of specific technologies and problems with the aim of developing an approach that brings together relevant stakeholders to address specific problems on a case by case basis. An area with considerable potential highlighted by this study is the scope for bilateral and multilateral collaboration on R&D for new low carbon technologies to help overcome IPR barriers.
7. Examining lessons learnt from successful examples of technology transfer (such as wind turbines in India) would be complementary to the analysis carried out in this report of technologies that have not yet been successfully transferred.
8. More detailed analysis of the specific technologies examined in this study over a longer time period than was possible during this study would be valuable. This would enable consultation with a wider number of actors and stakeholders and the development of more concrete actions that could be taken to facilitate transfer. The potential for developing underground coal gasification in India also warrants future detailed investigation.
9. The potential for integrating PV with LED lighting in rural areas that was highlighted in this study points towards an important area that requires focussed research. This would involve the analysis of specific development oriented technology transfer such as that facilitated by NGOs. This could be linked with a focus on matching the needs of developing countries with technology transfer activities.

Government influence on technology transfer

Governments in both recipient and supplier countries have a key role to play in facilitating low carbon technology transfer. There are three main motivations for government involvement:

1. Reducing carbon emissions contributes to reducing the economic, social and environmental costs of climate change.
2. Many low carbon technologies are currently at pre-commercial or supported commercial stages of development and may therefore require some form of government support to facilitate their wider adoption.
3. Early investment in technologies that are likely to be of more domestic importance in future may be worthwhile. Governments might also wish to gain competitive advantages in new technologies with a view to developing future export markets.

Government involvement is usually designed to overcome barriers to low carbon technology transfer. However, unless it is undertaken with proper awareness of the full range of issues highlighted in this summary, government involvement can also introduce new barriers to technology transfer. Government involvement requires initiatives at both the national and international level.

National level government initiatives

Domestic policy environment: Clearly defined and enforced domestic carbon emissions policies are integral to encouraging low carbon technology transfer. For example, the hybrid case study highlighted the fact that China's recent introduction of a strict policy limiting carbon emissions from new vehicles, together with processes for enforcing this policy, has led to Toyota to enter into a joint venture with a Chinese company to manufacture hybrid vehicles in China.

National systems of innovation: As mentioned above, national systems of innovation are integral to developing absorptive capacity among national firms. Governments have a clear role to play here in supporting and encouraging R&D initiatives, facilities and networks across both the public and private sectors. This will also benefit from governments' engagement with bilateral and multilateral information sharing activities such as the UNFCCC's TT:CLEAR initiative.

Intellectual property rights (IPRs): Insufficient protection of IPRs can be a deterrent to international firms transferring technologies. A well defined and enforced national IPR legal structure is therefore important to encourage transfer of some low carbon technologies.

Political stability: Political instability in some countries might act as a deterrent to foreign investors, particularly where new commercial technologies are concerned.

Enabling business environment: As well as political stability, there is also a linked need to focus on creating an enabling economic, social and business environment to encourage technology transfer. For example, certain large power station equipment manufacturers interviewed during this study highlighted a number of problems with doing business in India that made them reticent to engage in technology transfer activities.

Infrastructure: National governments have an important role to play in ensuring that the appropriate infrastructure is in place to foster technological development. For example, the intermittent or non-existent supply of electricity in many rural areas of India was cited as a key problem in rolling out biomass technologies in India.

Creating markets: Three of the four pre-commercial and supported commercial technology case studies (LEDs, biomass and hybrid vehicles) highlighted a need for national policy intervention to help create domestic

markets for these technologies. As well as a clearly defined domestic policy environment as outlined above, this could also include government procurement initiatives and targeted information campaigns (aimed at, for example, the construction industry) that promote the use of these technologies.

Access to finance: For some smaller scale financing issues, there may be a role for national government intervention. For example, the biomass case study highlighted how investors in the technology often had problems with cash flow due to the seasonal nature of biomass availability. They were unable to overcome this by borrowing as biomass is traditionally viewed as waste and banks are unwilling to lend against it, even though banks are willing to lend against briquetting machinery which is viewed as a capital asset. Governments may therefore wish to intervene to try to address such misunderstandings in relation to novel new low carbon technologies.

International government initiatives

In the case of climate change, extensive institutional arrangements and funding provisions exist pursuant to the Convention to provide a framework for further action with the Expert Group on Technology Transfer (EGTT) play a focal role in this process. Since the Gleneagles Summit the role of other multilateral institutions such as the World Bank and IEA has also come to the fore. Although outside of the UNFCCC/Kyoto process, a number of supportive initiatives have also been established to further international technology development and transfer, such as the Asia-Pacific Partnership (Hoehne et. al.2006).

Collaborative R&D and technology demonstration and diffusion: One of the most important issues that this study has highlighted is the need for bilateral and multilateral collaboration between developed and developing countries on R&D, demonstration and diffusion (RDD&D) of low carbon technologies. This is central to developing technological capacity in developing countries through sharing knowledge and experiences in relation to specific low carbon technologies. For example, industry respondents to this study cited a lack of transparent information on international experience with coal based Integrated Gasification Combined Cycle (IGCC) power generation technologies as one key barrier to the use of this technology in India. This type of concern was also shared by briquetting companies who saw a lack of communication and information sharing as a key barrier to technological development. The biomass case study also demonstrated how collaborative R&D between an Indian briquette manufacturer and a Dutch University led to specific technological improvements. The LED case study also highlighted collaborative R&D as the central requirement for developing technological capacity in this industry in India.

The International Energy Agency's (IEA) implementing agreements provide one potential vehicle for achieving collaborative RDD&D, either bilaterally or multilaterally. There is, however, a need to revise the focus of the implementing agreements so that as well as fostering information sharing they are also able to deliver more output oriented projects as well as demonstration projects. They also need to focus on engaging developing countries. Energy R&D carried out under the European Union's Framework Programme could also provide a potential funding vehicle for collaborative R&D that includes developing countries such as India.

Intellectual property rights (IPRs): As noted above, lack of access to IPRs may act to prevent recipient countries from gaining access to the knowledge necessary to improve their technological capacity. There may therefore be a role for bilateral and multilateral government collaboration in R&D for low carbon technologies that are at very early stages of development with public ownership of IPRs and in fostering targeted initiatives that aim to bring together relevant stakeholders to address specific IPR problems. The potential for new kinds of global public/private partnerships, drawing on the experiences of global arrangements that have been agreed internationally to support access to anti-retroviral drugs for low income countries,

have not been fully explored in the climate context. More detailed work analyzing the potential application of these approaches to the climate context, bearing in mind the unique features of climate change, might create a fresh approach to discussions.

High costs of new technologies: Many low carbon technologies are new or still being developed and therefore entail higher costs for acquiring and/or using/operating them. National governments as well as international governmental bodies may therefore play a role in financing initial uptake of these technologies. International financing initiatives to date have included the Global Environment Facility (GEF) and the Clean Development Mechanism (CDM).

Need for private sector involvement: Government intervention in technology transfer must recognise the central role that private investors play in the transfer process. Failure to engage with private companies has been a key issue in hampering the long term success of government led initiatives such as the Japanese Green Aid Plan.

Information barriers: Poor knowledge of available technologies and financing opportunities reduces demand for new technologies. Bilateral and multilateral information sharing initiatives such as TT:CLEAR have an important role to play in overcoming these barriers. The success of such initiatives does, however, rely on national governments to properly engage with them, for example through the submission of technology needs assessments which are a central part of the TT:CLEAR initiative. As mentioned above, information sharing was seen as a central barrier to the transfer of LED and IGCC technologies. It was also seen as important for helping thermal power plants and boiler manufacturers to optimise the performance of thermal power plants in India.

Markets for carbon: Creating prices for carbon through economic instruments has the potential to enable the carbon reduction benefits of low carbon technologies to be reflected in the market. Although the EU ETS and CDM are playing an important role in providing a price signal, globally the incorporation of the social costs of carbon is still at an early stage. The inclusion of the social cost of carbon emissions within market prices will support the financing of some low carbon technologies by helping to make these more competitive relative to less environmentally sound technologies. However, there are many institutional and regulatory barriers that also need to be examined if the full suite of low carbon technologies is to be taken up in developing countries.

Under the Kyoto Protocol to the UNFCC, the Clean Development Mechanism (CDM) is provides a market price for carbon in the context of developing countries. It allows investors from industrialised countries listed in Annex I of the Convention to generate Certified Emissions Reductions (CERs) by investing in projects that reduce greenhouse gases in developing countries. Current analysis of technology transfer aspects of CDM projects show that some technology transfer is happening in developing countries but perhaps less than might be expected. Countries can try to rectify this by focusing on the kinds of technology they wish to promote and through policy towards CDM projects and programmes. The low number of registered CDM projects that intend to transfer technology in India as compared to other developing countries such as China suggests, however, that there may be some India-specific barriers to technology transfer via the CDM. Examination of India's CDM national approval processes in comparison with those of other countries, and the extent to which these might address this problem requires further study.

Multilateral institutions such as the World Bank have a particularly important role to play. The Bank has recently outlined some additional multilateral finance mechanisms that could be implemented. Following Gleneagles, the World Bank and Regional Development Banks are working on an energy investment framework that aims to address cost, risk, institutional and information barriers to scaling up public and private investment in low carbon technology.

Options that have been put forward include a Clean Energy Financing Vehicle that would blend carbon finance and capital grants for highly efficient technologies. They also include proposals to help upgrade the efficiency of existing capital equipment, to provide venture capital, and to develop candidate projects for financing via other mechanisms. As outlined above, the success of such mechanisms will depend on a range of domestic factors such as absorptive capacity, supportive institutional and regulatory frameworks as well on the availability of the technologies in question. There is also an inherent need to ensure that any technology transfer activities that are financed under such mechanisms are aimed at moving beyond just the demonstration of low carbon technologies. Rather they need to be carefully structured to respond to the issues outlined in this report with the explicit aim of contributing to long-term low carbon technological capacity building in developing countries.

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