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Executive Summary

This discussion paper presents some early findings from the study on **Emerging Asia contribution on issues of technology for Copenhagen**. It is part of an ongoing research and dialogue among five key Asian developing countries, namely China, India, Indonesia, Malaysia and Thailand. The objective is to contribute to the forthcoming UNFCCC's COP 15 negotiations at Copenhagen in December 2009 from the nongovernmental perspective, on technology transfer issues pertaining to climate change.

The institutes from the respective countries who have been engaged in the study are:

- The Energy and Resources Institute (TERI), India
- Energy Research Institute (ERI), China
- Institut Technologi Bandung (ITB), Indonesia
- Thailand Environment Institute (TEI), Thailand, and
- Universiti Tenaga Nasional (UNITEN), Malaysia.

The paper focuses on 3 key mitigation technologies viz. clean coal, solar and bio-fuels as specific case studies from the countries.

Effective and timely development and transfer of technologies (TT) to the developing countries is crucial for a concerted global action towards reduction of green house gas (GHG) emissions and addressing the concerns of sustainable development objectives. According to the definition provided by the Special Report of the IPCC Working Group III "Methodological and Technical Issues in Technology Transfer", the definition of TT is very broad and involves diffusion of technologies and technology cooperation across and within countries. It talks about three major dimensions necessary to ensure effective technology transfer and these are capacity building, enabling environment and a suitable mechanism for TT.

GEP (Global Economic Prospects, World Bank, 2008) reports in general that most developing countries lack the ability to generate innovations. The lack of advanced technological competencies in these countries means that technological progress in the developing countries can occur essentially through the adoption and adaptation of new-to-the-market or new-to-the-firm technologies. However, transfer of technology has not taken place at a level and pace conducive to supporting action on mitigation of climate change. The need for technology transfer has been clearly recognized in the UN Framework Convention on Climate Change (UNFCCC) in 1992 and often repeated in the negotiations. But there have been divergent views by the Annex I and non-Annex I

countries in this regard. While Annex I countries have generally been pushing for easing commercial flows of technology in terms of reducing tariff barriers, regulatory barriers and increasing the absorption capacity in the developing countries, the non-Annex I countries advocate for non-commercial technology transfer, and collaborative arrangements for increasing their adaptive capacity and establishment of financial mechanisms for meeting the costs of license fees and collaborative R&D ventures. It is important to note at this point that commercial flows are not adequate to meet the climate change challenge adequately, unless grants or non-commercial flows come in to leverage the scale of operations.

In the context of the multilateral negotiations on climate change, the Asian region is especially complex, having a mix of developed and major developing countries such as India and China. Asia's energy consumption is growing rapidly, making it a challenge to meet Asia's energy needs comprehensively while keeping the GHG emissions low. The concerns need to be streamlined for setting out an emerging Asia contribution on issues of technology within the multilateral framework on climate change.

The study examines the need for the select climate friendly technologies in the countries, respective government positions in developing these technologies indigenously, availability of the state of art technologies in the countries vis-à-vis the available global technologies and the domestic barriers. Further, it examines the intellectual property rights (IPR) issues in technology transfer and finally establishes linkages between an appropriate financial mechanism and technology transfer.

Based on the inputs from the five key emerging Asian countries on issues of transfer of select climate change mitigation technologies, this discussion paper deals with certain policy aspects of technology transfer issues particularly with a focus on IPR and financial mechanism aspects.

Status of the select technologies in the Asian countries

In order to discuss mechanisms for transfer of technology to developing countries, it is essential to understand the specific technology needs of these countries. Therefore, this paper attempts to study the respective country position with respect to the three key mitigation technologies. It looks at the needs and development plans of the countries, status of these technologies in the countries vis-à-vis availability in the global market and the barriers faced in developing these technologies domestically.

An analysis of the Technology Needs Assessment (TNA) reports and other policy documents of the countries in question reveal that the focus is on technologies pertaining to advanced fossil fuel like clean coal and renewable options such as solar, bio-fuel, biomass and biogas.

Status of technologies in the countries

With respect to the specific clean coal technologies, very little progress has been made in the countries except China and India. Presently, concerted efforts are being made in India to adopt super-critical technology for a large number of coal-based power plants. During 12th Five Year plan period (2012-17), around 67 per cent of the total planned capacity addition will be based on supercritical plants. Supercritical boilers are being regularly installed in new power stations in China and the country has also indigenised to a large extent the ultrasupercritical technology. China is now becoming active in the development of IGCC technology, with several demonstration projects under construction or in planning. By June 2009, the first IGCC power plant of GreenGen Project approved by NDRC (National Development and Reform Commission) has started construction. Presently there are more than 15 IGCC projects in the pipeline waiting for approval. In Malaysia and Thailand, the use of renewables is paid more attention and there clean coal has to do more with pollution control technologies rather than low carbon technologies. Though the need for clean coal technologies are clearly spelled out in the TNA report for Indonesia, however, those that will be implemented in Indonesia are limited to fluidized bed combustion, sub-critical technology (for advance thermal technology), and coal upgrading as indicated by electricity supply plan by the State Power Utility of the country.

The global solar thermal market is dominated by USA, Spain, Germany and Israel and at a nascent stage in the developing Asian countries. In India, in the last three decades, a lot of developmental work has been done in the field of solar photovoltaic and solar thermal technologies resulting in a basket of technologies/products that are at various stages of commercialization or R&D. Recently the Indian government has finalised its solar energy mission under the National Action Plan on Climate Change (NAPCC). Under this the MNRE is implementing schemes for expanding the use of solar energy in the country by utilizing various new technology options, like solar concentrators. The Chinese research institutes are also conducting research on solar energy utilization technology development in a big way. In Thailand, PV technologies using amorphous and crystalline silicon (also called 1st generation PV) are commercially available. Malaysia, which is currently using PV technology, has begun research on ways to reduce its costs and increase its efficiency. In Indonesia, the government is promoting utilization of solar PV but the pace is very slow.

Bio-fuel is also at an early stage in the developing countries of Asia. The technology for producing bio-diesel from cellulosic products is not commercially available in India. For bio-diesel, India's current choice of technology is transesterification of vegetable oil. In China, recently, biomass ethanol projects have attracted great enthusiasm. It is considering to make a major effort to carry on basic and applied work on domestic technology development to convert lignocellulosic biomass to ethanol. The Thai government has set up strategic plans for production and use of bio-fuels. Second-generation bio-ethanol technologies and biomass gasification technologies are already available. In Indonesia, biodiesel technology is available but bio-ethanol is not available. In Malaysia, the Malaysia Palm Oil Board (MPOB) has developed its own in-house bio-diesel technology in 1982.

Barriers to technology development in the countries

The study of barriers to developing technologies indigenously revealed that approaches to the identification of the barriers varied from country to country. The types of barriers that the countries have faced can be broadly divided into six categories - (i) Economic and market, (ii) Lack of a favourable environment, (iii) Institutional, (iv) Social acceptance, (v) Technical, and (vi) Lack of adequate skills and training. The country studies in this regard suggest that economic and market barriers, such as lack of financial resources and high capital costs, were faced by all the countries. Lack of favourable environment and incentives were also present across countries in the form of lack of emission norms and inappropriate pricing. Interestingly, institutional barriers like lack of demonstration projects, adequate codes and standards were found to be a major barrier only in India and China.

Perspectives on Intellectual Property Rights (IPRs) and technology transfer

The role of technology transfer in promoting actions that mitigate climate change is now recognized and agreed by various actors and at different fora. However, the role of IPRs in facilitating or restricting technology transfer has been at the centre of much debate. The differences emerge with respect to the questions of who/what is responsible for the lack of it, the role that IPRs can play in restricting or facilitating it, and what measures should be taken to promote transfer of climate relevant technologies.

Reviewing the debate in literature and negotiations, one can easily distinguish between concerns of Annex I and non-Annex I positions. While annex I countries allege, inter alia, that absence of strong IPR regimes in developing and least developed countries act as a disincentive for technology transfer to take place, developing countries hold that their regimes are TRIPs compliant and technologies protected by strong IPRs are making access to technology even more difficult. It must be mentioned here that all the countries studied (China, India, Indonesia, Malaysia, Thailand) have TRIPS-compliant IPR regimes domestically and have even legislated on some of the flexibilities available under TRIPs.

IPR as a barrier

The actual impact of IPRs on technology transfer and also the issue of IPR costs acting as a barrier is often context specific depending upon the maturity of the technology, region, the time horizon, number of patent holders etc. The research and the country studies suggest that although IPR access is necessary in some cases, it is not sufficient for accessing the clean technologies. However, even where it does not stop access per se, it does slow down the rate of diffusion of technologies considerably. Intellectual property costs in technology transfer are contentious. While one of the ways in which IPRs are believed to restrict technology transfer is through high license costs, it is also alleged that IP costs are not that substantial in a project to act as a real barrier in technology transfer. However, the issue of IP cost in a technology transfer project is itself debatable, as often IPR influences not just in the form of licence fees and royalties but leads to purchases, import of associated equipment, losing stake in joint ventures etc., all of which do not get reflected as IP costs.

In order to promote technology transfer of climate relevant technologies, countries and multilateral fora would have to explore existing and innovative mechanisms to facilitate technology transfer. These can be both within the flexibilities provided by TRIPs (compulsory licensing, checking anti-competitive practices) and outside the TRIPs framework (technology acquisition fund, mandatory price negotiations, technology sharing arrangements). The discussion paper discusses the different options available in detail.

Linking an appropriate financial mechanism with technology transfer

IPRs alone cannot be the determining factor in either restricting or facilitating transfer of technology. One of the other factors that act as a barrier is availability of financial resources. The study examines financial resources required as a means to facilitate technology transfer. It reports that existing financial mechanisms are inadequate to mobilize resources and effecting technology transfer on the scale required to address the climate change challenge. In terms of the 3 specific mitigation technologies covered in the study, it was found from the GEF records that in India out of the total 44 national projects on climate change, GEF has supported only four projects, three of which covers renewable energy technologies and one on coal bed methane. If calculated percentage wise, it can be seen that out of the total GEF grant in these 44 projects, only 16 per cent involved clean technologies. In

China, out of the 82 national projects, only 2 of such projects involved renewable energy development, thus catering to 10 per cent of the total grant. In Thailand, out of the 11 projects, none involved clean technologies. Hence in order to overcome barriers to technology transfer and fill in the gaps between the needs for such technologies and the degree to which these technologies are adopted in developing countries, it is important to consider the enhancement or scaling up of existing mechanisms and also creating new mechanisms. Article 4.3 of the UNFCCC convention clearly points *out "The developed country Parties and other developed Parties included in Annex II shall provide new and additional financial resources to meet the agreed full costs incurred by developing country Parties…….They shall also provide such financial resources, including for the transfer of technology, needed by the developing country Parties to meet the agreed full incremental costs of implementing measures".*

The strong proposal made by G-77 and China on a multilateral climate technology fund (MCTF), which should be operational under the COP, can be considered in this regard. Such funding sources would be new and additional over and above ODA. The Governments of developed countries would use capital from their various environmental and energy taxes, from revenue from the auction of pollution rights and from the public finance budget for making this fund effective and functional. This fund should also take care of issues like technical expertise, know how in recipient country and the enabling environment factors, cost of technology transfer, including licence costs and deployment costs.

Another option could be setting up of a publicly funded global venture capital fund, which would aim at promoting collaborative R&D in the commercialization of clean technologies.

MRV (measurable verifiable and reportable) indicators to track the flow of climate friendly technologies will have to be introduced. In the absence of MRV indicators, it will be very difficult for the developing countries to defend their situation in terms of their technology and financial needs.

CHAPTER 1 Introduction

Background and rationale

Effective and timely development and transfer of technologies to the developing countries is crucial for a concerted global action towards reduction of green house gas (GHG) emissions and addressing the concerns of sustainable development objectives. This view has come to the fore in discussions at the post-2012 framework for international climate policy. There is however, a need to have a deeper understanding of several issues currently affecting the development and transfer of technologies worldwide. In particular, the identification of mechanisms for overcoming barriers and obstacles to technology transfer and for enhancing international cooperation is a major priority.

The definition of technology transfer as provided by the Special Report of the IPCC Working Group III "Methodological and Technical Issues in Technology Transfer", is very broad and covers a broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change amongst various stakeholders. It includes the process of learning to understand, utilize and also replicate the technology, including the capacity to adapt to local conditions and integrate it with indigenously developed technologies. There are three major dimensions necessary to ensure effective technology transfer and these are capacity building, enabling environment and a suitable mechanism. Capacity building is required at all levels of the technology transfer process in order to adapt and acquire new skills. In order to have capacity building take place effectively, there has to be a conducive environment through appropriate economic policy, regulatory framework and political stability for ESTs to diffuse commercially. Mechanisms for TT involves the various ways and means through which TT can take place like technology assessments, demonstration projects, local and regional partnerships among various stakeholders for the transfer, an appropriate financial instrument to facilitate the flow or transfer from developed to the developing countries etc.

The UN Framework Convention on Climate Change (UNFCCC) in 1992 had clearly recognized its parties' commitment to promote and cooperate in development, application and diffusion, including transfer of technologies as per their common but differentiated responsibilities and national priorities (Article 4.1.c). The 13th Conference of Parties (COP) at Bali in 2007 came out with an action plan, whereby 'technology development and transfer to support action on mitigation & adaptation' was formulated as a specific action point. This is going to be a key issue at the 15th COP at Copenhagen in 2009, which is going to focus on the future of a climate change regime after 2012. The Expert Group on Technology Transfer in their submission in the Bonn Talks held in June declares that

'A robust technology transfer programme under the Convention is required to catalyse the transition to low emission & climate resilient development'

FCCC/SB/2009/3/ Summary

While UNFCCC agreements contain many references to technology transfer to developing countries, the focus of implementation has generally been on creating an environment conducive to foreign investment and building capabilities to absorb and utilize imported technologies in the developing countries. Less emphasis has been placed on measures which Governments of technology supplier countries or the developed countries can and should take to facilitate and accelerate technology transfer. Also, until now, have there been no effective methods of measurement, reporting and verification of the extent of environmentally sound technology transfer.

GEP (Global Economic Prospects, World Bank, 2008) reports in general that most developing countries lack the ability to generate innovations. The lack of advanced technological competencies in these countries means that technological progress in the developing countries can occur essentially through the adoption and adaptation of new-to-the-market or new-to-the-firm technologies. Adoption and adaptation again depends on two factors - the extent to which it is exposed to a foreign technology and also the ability to absorb. Though the first factor is exogenously controlled by the developed countries, the later depends very much on the overall macroeconomic environment, which influences the willingness of entrepreneurs to take risks and the level of basic technological literacy and advanced skills among the population, which in turn determines a country's capacity to undertake necessary research to understand, implement, and adapt new and advanced technologies.

At the climate change negotiations, there have been divergent views by the Annex 1 and non-Annex I countries, although all parties to the UNFCCC agree upon the role that technology can play in mitigating and adapting to the impacts of climate change. While Annex I countries have generally been pushing for easing commercial flows of technology in terms of reducing tariff barriers, regulatory barriers and increasing the absorption capacity in the developing countries, the non-Annex I countries advocate for non-commercial technology transfer, and collaborative arrangements for increasing their adaptive capacity and establishment of financial mechanisms for meeting the costs of license fees and collaborative R&D ventures. Details of the respective positions vis-à-vis technology transfer are mentioned in table 1 in the annexure.

Relevance of Asia and emerging Asian economies

In the context of the multilateral negotiations on climate change, the Asian region is especially complex, having a mix of developed and developing countries such as India and China. Asia's energy consumption, which is dominated by GHG emitting fossil fuels, has been rising continuously. According to EIA estimates, non-OECD Asia has the most robust growth potential with energy consumption rising by 104 percent between 2006 to 2030 (IEA, 2009). Moreover, it hosts more than half of the world's population, comprising much of the world's poor and energy-starved people. It is thus a big challenge to meet Asia's energy needs comprehensively while keeping the GHG emissions low. Transfer of clean technologies plays a big role in addressing this challenge.

As mentioned, Asian region is a complex mix of diverse economies and concerns, however, at the climate change regime, concerns of emerging Asia have been more or less common. Yet, they need to be streamlined for setting out an emerging Asia contribution on issues of technology within the multilateral framework on climate change.

With this background, this discussion paper has been developed with inputs from five key emerging Asian countries on issues of transfer of climate change mitigation technologies, with a focus on policy aspects of technology transfer and the role of international mechanisms.

Objective and scope

This project is a part of an ongoing research and dialogue among five key Asian developing countries, namely India, China, Indonesia, Thailand and Malaysia. The objective is to contribute to the forthcoming UNFCCC's COP 15 negotiations at Copenhagen from a nongovernmental perspective, on technology transfer issues pertaining to climate change.

The institutes from the respective countries who have been engaged in the study are:

- The Energy and Resources Institute (TERI), India
- Energy Research Institute (ERI), China
- Institut Technologi Bandung (ITB), Indonesia
- Thailand Environment Institute (TEI), Thailand, and
- Universiti Tenaga Nasional (UNITEN), Malaysia.

The paper focuses on 3 key mitigation technologies viz. clean coal, solar and biofuels as specific case studies. However, the conclusions and recommendations thus reached holds true for

ESTs in general. In chapter 2, the need for the select climate friendly technologies in the countries, availability of the state of art technologies in the countries vis-à-vis the available global technologies and the domestic barriers have been looked at. Chapter 3 looks at perspectives on the debate of whether the intellectual property rights regime acts as a barrier, or whether it is conducive to the development and transfer of technologies. The paper also discusses the scope of innovative mechanisms within the TRIPS regime and beyond to facilitate technology transfer. Finally chapter 4, critically analyses the UNFCCC provisions on financial aspects of development and transfer of technologies, analyses the country positions and provide some recommendations in this regard.

Reference

IEA. 2009
International Energy Outlook 2009
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CHAPTER 2 Status of the select technologies in the Asian countries

Introduction

According to a number of studies (projections made by EIA, ESCAP and WEO), energy demand in Asia will reach more than 7000 million tonne of oil equivalent (mtoe) by 2030 from 3,732 mtoe in 2006. China and India alone accounts for about 60 per cent of the total Asian energy consumption. Rapid economic and population growth will drive much of the increase in energy demand. Industrialisation, urbanisation, and the replacement of non-commercial biomass fuels by commercial fuels will also contribute to an increase in demand. While higher demand for energy from developing Asia has prompted concerns about energy and climate security, long-term cooperative options need to be explored internationally to ensure production and use of energy in a sustainable manner, which will also reduce GHG emissions.

It is now widely recognized that one of the key ways in which future emissions can be avoided is through the development and use of cleaner or environmentally sound technologies (IPCC, 2007). Firms in developed countries own many of technologies. Understanding how these technologies might be transferred to developing countries is crucial. But before that, it is also important to study the specific technology needs of the countries. As mentioned earlier that in the context of the countries chosen for the study, the three specific technologies viz. clean coal, solar and biofuels have immense mitigation and market potential. In this chapter an attempt has been made to study the respective country position with respect to these technologies in terms of the needs and development plans, status of these technologies in the countries vis-à-vis that available in the global market and the barriers that countries face in developing the technologies domestically.

TNA analysis

Technology Needs Assessments (TNAs) are central to the issue of understanding the perceived technological need for mitigating and responding to climate change. TNA, particularly available for the developing country parties, is a country specific assessment, where prioritization of technology needs is done on the basis of a multicriteria analysis by taking into factors such as development benefits, climate change, market, environmental protection, etc (UNFCCC 2006). According to the UNFCCC, *"the purpose of technology needs assessments is to assist in identifying and* *analyzing priority technology needs, which can form the basis for a portfolio of EST projects and programmes which can facilitate the transfer of, and access to, the ESTs and know-how in the implementation of Article 4, paragraph 5, of the Convention".* Table 2.1 below shows the summary of TNA assessments in the select countries.

Table 2.1 TNA in select countries

Countries	TNA	Focus areas
India	x	
China	x	
Indonesia	√	1) Advanced thermal power technology like super critical, ultra supercritical and IGCC power plants; 2) Efficiency improvement in existing coal power plants; 3) Coal upgrading; 4) New and renewable energy in power plant (nuclear, geothermal and biomass); 5) CCS technologies
Malaysia	X	
Thailand	√	1) Biogas from pig farms, 2) Biogas from agro-based industries, 3) Biogas from domestic waste management 4) Biomass and 5) Solar technology (thermal energy for hot water production, industrial product heating, and agricultural post harvest processing as well as pesticide production)

Source Adapted from the country studies

While India has provided some information on perceived technology needs to the UNFCCC as part of its initial national communication in the year 2004, it has not yet produced a full TNA report. However, National Energy Map for India –Technology Vision 2030 prepared by TERI in 2006, has given a clear direction for development of efficient coal based power generation technologies like IGCC. Also the Integrated Energy Policy document of the Government of India (2006) has mentioned about mounting a number of technology missions like clean coal, solar, bio-fuels, biomass plantation, bio-gas plants etc in a time bound manner.

China submitted its initial national communication with support from UNEP in 1998, where the focus area was on advanced fossil fuel technologies. China's National Climate Change Programme prepared under the auspices of NDRC in 2007 talks about optimizing the energy mix by developing low-carbon and renewable energy.

For Indonesia, Thailand and Malaysia, the governments are paying high attention towards technology developments in solar and bio-fuels considering the huge potential of these energy sources in the countries. Though Malaysia has started implementing clean energy technologies, particularly with a focus on solar and biofuels, it has not done any TNA study yet. In Indonesia, TNA assessment was recently performed by the Ministry of Environment and Ministry of Research and Technology of the Republic of Indonesia and was submitted to the UNFCCC in March 2009. This deals only with mitigation technologies and the need for clean coal has been clearly highlighted (see table 2.1). In Thailand, after submission of its initial national communication in 2000, TNA was conducted by the Ministry of Natural Resources and Environment and submitted to UNFCCC in 2003, which again prioritized the need for technologies based on solar and biomass.

Country positions and development plans with respect to these technologies

China

Coal

China has started working on IGCC since 1978, and listed it a national key project for technology development. However, because IGCC was a new technology, and the local manufacturers already had strong competitiveness over super critical and ultra-super critical technologies, IGCC technology development was slow in the initial years. However, with continuous pressure of energy saving and emissions, China has attached more importance to IGCC in recent years. At the end of 2005, China Huaneng Group Co. made a proposal of "Clean Coal Electricity Strategy" and has initiated the GreenGen Project, which focus on IGCC development. Since 2006, the development and application of IGCC have been widely implemented by a great number of leading corporations. By June 2009, the first IGCC power plant of GreenGen Project was approved by NDRC and has started construction.

Solar

China is investing in a massive way for developing solar technologies. The Institute of Optics and Electronics of CAS, Changchun Institute of Optics, Fine Mechanics and Physics, and Shanghai Institute of Optics and Fine Mechanics are the leading bodies in this respect. In 2005, the first tower structure solar thermal power system of 70kW was built and has been generating power successfully in Jiangning, Nanjing. In the 11th five year, the Chinese Academy of Science issued a study on the key technologies and demonstration system of tower structure solar thermal power as one of the 863[1] key projects. A 10 MW CSP (concentrating solar

[1] The 863 program or State High-Tech Development Plan is a program funded and administered by the government of the China intended to stimulate the development of advanced technologies in a wide range of fields for the purpose of rendering China independent of financial obligations for foreign

power) project has started construction in early 2009 in the Yunnan Province. In 2009, a 100 MW CSP project in Aba county in Sichuan Province is under preparation and is expected to start construction in May 2010.

Bio-fuels

In December 2006, the NDRC and Ministry of Public Finance issued the Notice on Strengthening the Management of Biomass Ethanol Project Construction and Promoting the Healthy Development of Biomass Industry, clearly putting forward the requirement of relying of non- food biomass to produce ethanol. At the end of 2007, approved by NDRC, COFCO (China Oil and Food Co)[2] has built a project of fuel ethanol with cassava as the raw material in Beihai, Guangxi. This is the only ethanol company using non-food biomass approved by the NDRC.

India

Coal

In India, about 70% of the electricity generated comes from coal. As the demand for electricity is expected to rise dramatically over the next decade, coal will continue to be the dominant energy source. Government of India has set a target of 216 GW power generation capacity by March 2012, of which thermal generation accounts for about 53-54%. According to the CEA (Central Electricity Authority) projections, power demand will rise by 794 GW by 2031, and of this 466 GW will be based on coal, which is 6 times the present coal based installed capacity. Hence for India it is critical to promote technologies that not only meet the near-term needs of the country, but also set the coal-based power sector on a path that would allow it to better respond to future climate challenges.

Solar

India has the world's largest decentralized solar energy programme. The country is richly endowed with solar energy resource. The average intensity of solar radiation received on India is 200 MW/km square (megawatt per kilometre square)[3]. With a geographical area of 3.287 million km square, this amounts to 657.4 million MW. However 88 per cent of the land is utilized for agriculture, forestry, industry, housing etc. Thus, only 12.5% of the land area amounting to 0.413 million km square can be used for solar energy installations. Even if 10% of this area can be used, the available solar energy would be 8 million MW, which is equivalent to 5909 mtoe (million tons of oil equivalent) per year. In the last three decades, a lot of developmental work has been done in India,

technologies. The name 863 comes from the fact that the program was created in the year 1986 in the third month.

[2] Founded in 1952, COFCO is a leading grain, oils and foodstuffs import and export group in China and one of its largest food manufacturers

[3] http://www.indiaenergyportal.org/subthemes.php?text=solar

in the field of solar photovoltaic and solar thermal technologies. Presently, the country has a basket of technologies/products that are at various stages of commercialization or R&D. During the 11th Plan period, the key proposed areas of R&D and technology development are solar PV poly silicon and other materials, (ii) efficient silicon solar cells, (iii) thin films materials and solar cell modules, (iv) concentrating PV systems, etc. In solar thermal, the focus of research and development activities during 11th Plan period is to be on developing suitable advanced solar collectors to provide industrial process heat and developing technologies for solar thermal power generation. Recently the Indian government has finalised its solar energy mission under the National Action Plan on Climate Change (NAPCC). Under this the MNRE (Ministry of New and Renewable Energy) is implementing schemes for expanding the use of solar energy in the country by utilizing various new technology options, like solar concentrators. Tata BP Solar, a joint venture between the giant Tata Group of India and BP Solar of the UK (and one of the oldest semiconductor manufacturers in India) is in the advanced stages of a $100 million investment in a 128 MW solar cell manufacturing plant close to its existing facility near Bangalore, which will eventually be scaled up to 180 MW[4].

Bio-fuels

Bio-fuels are seen by the government as a potential alternative source of energy. Government of India started its bio-fuels mission in 2003 and on 9th October 2005, Bio-diesel Purchase Policy was declared to provide assured market to farmers and entrepreneurs. In its National Bio-fuel Policy, announced on 11 September 2008, an indicative target of 20% blending of bio-fuels (bio-ethanol and bio-diesel) by 2017 has been proposed. It has also been made clear, owing to debates regarding bio-fuels vs. food security, that bio-diesel production will be taken up from non-edible oil seeds in waste/degraded/marginal lands and the import of Free Fatty Acids (FFA) would not be permitted. To reduce the import dependency indigenous production of bio-diesel feedstock on community / government / forest waste lands has been given priority over plantation in fertile irrigated lands. To promote bio-fuels, it has been suggested that bio-ethanol and bio-diesel may be brought under the ambit of 'Declared Goods[5] ' under the Central Sales Tax law by the government to ensure unrestricted movement of bio-fuels within and outside the states. The MNRE has proposed to take up focused RD&D projects for biomass conversion; develop

[4] Jaideep Malaviya (2008):"On a Solar Mission: How India Is Becoming a Centre of PV Manufacturing," Renewable Energy World. Also available at http://www.renewableenergyworld.com/rea/news/article/2008/10/on-a-solar-mission-how-india-is-becoming-a-centre-of-pv-manufacturing-53849

[5] A declared good status would force states to peg the sales tax rate at not more than three per cent

technology for production of ethanol from sweet sorghum and sugar beet and also develop 2nd generation bio-ethanol.

Indonesia

Coal

Though the need for clean coal technologies are clearly spelled out in the TNA report, however, as far as clean coal technology is concerned, those that will be implemented in Indonesia are limited to fluidized bed combustion, sub-critical technology (for advance thermal technology), and coal upgrading[6]. This is because the Government of Indonesia's energy plan was developed based on economic objectives and resource availability with respect to energy supply security. The most recent Indonesia's electricity supply plan by the State Power Utility indicates that the clean coal technology to be applied in Indonesia during 2009 – 2018 is limited to fluidized bed combustion, sub-critical technology (for advanced thermal technology), and coal upgrading. According to the State Power Utility plan, expensive advance clean coal technology, such as IGCC and supercritical technologies will not be implemented in Indonesia at least up to 2018.

Solar

The Blueprint National Energy Plan has developed a roadmap for solar energy technology, whereby by 2025, it is targeting the utility sector by designing PV panels. Solar PV will have significant potential to be developed in the near future since the GOI (Government of Indonesia) is targeting to achieve 100% electrification in 2030, while currently the household electrification level is around 60%. Solar thermal in the form of direct heating through sun light is only used for drying the agriculture and fishery products in rural and coastal areas.

Bio-fuels

GOI is very active in the development and utilization of bio-fuel, especially in transportation, industries, and power sectors. The GOI has released various policies and regulations on bio-fuel development, namely Presidential Instruction No. 1/2006 concerning supply and utilization of bio-fuels, Presidential Decree No. 10/2006 concerning the establishment of National Team for Acceleration of Bio-fuel Development, Presidential Decree No. 5/2006, Ministry of Energy and Mineral Resources Regulation No.32/2008, concerning bio-fuel utilization obligation in specific sectors, namely power, industry, and transportation. Indonesia has a large bio-fuel development program that is released as National Bio-fuel Development Blue Print (2006), in which there is a deployment plan of each type of technology.

[6] Since Indonesian coal mostly is low rank coal (brown coal), therefore, to increase its calorific value the coal has to be up-graded primarily to remove high water content.

Malaysia

Coal

The use of clean coal technologies have already been implemented in new coal fired power plants built in Malaysia e.g. Sultan Azlan Shah Power Plant in Janamanjung, Tanjung Bin PowerPlant in Johor and Jimah Power Station in Port Dickson. But these are more to do with pollution control rather than low carbon technologies. Tenaga Nasional Berhad (TNB) is keen to use clean coal technology such as circulating fluidised bed combustion process (CFB) and carbon capture & storage (CCS). However, the problem lies in getting adequate finance since these technologies are in their infancy stage.

Solar

Malaysia have initiated the SURIA 1000 project with the objective to promote and educate the public on the use of solar especially grid connected PV systems. The current public response to these activities is good with the strong support from the government. Apart from that, projects like this have supported setting up of local units to build solar panels with the hope to reduce the cost of installation. Tenaga Nasional Berhad (TNB) has always been supportive to these efforts especially in the use of solar PV and hybrid variants for rural electrification. The Malaysia Building Integrated Photovoltaic (MBIPV) Technology Application Project, MBIPV, is intended to induce the long-term cost reduction of the PV technology via integration of the PV technology within building designs and envelopes.

Bio-fuels

The use of bio-fuel in Malaysia can be subdivided into several categories:

a) Bio-fuel – using waste cooking oil as a source of fuel
Universiti Tenaga Nasional (UNITEN) has spearheaded activities in this area and has already obtained good and viable results. Efforts towards this have been ongoing with local and international companies for commercialization purposes.

b) Bio-fuel – using palm oil husk as a source of energy
Malaysia is known to be a major supplier of palm oil products. Due to this, various palm oil processing plants are set up near the palm oil plantations. Since the locations of these plants are remote to be practically connected to the Malaysian Power Grid, most of these plants utilize the processed palm oil waste (husk) as a source of energy to power up the plant.

c) Bio-fuel – using waste products as a source of energy (Biomass)
A group of Malaysian Universities has already embarked on a joint major research and development to build a power plant that uses

waste products as a bio-fuel source (biomass). In this context, the energy extracted is not via burning of this fuel source but extracting energy using biological reaction processes. The project is currently funded by the Ministry of Science Malaysia under the Fundamental Research Grant Scheme (FRGS).

Thailand

The Thai governmental does not provide any additional support for clean coal technologies. However, there are environmental criteria to be followed, as a result of which the installation of CCT is somehow mandatory for power generators and like Malaysia, this has more to do with pollution control technologies.

Solar

Thai government supports utilization of solar power for power generation. Thailand has a capacity to utilize solar energy for generating electricity more than 50,000 MW and for generating thermal energy more than 100 ktoe. For power sector, the promotion scheme is run under SPP (small power producer) and VSPP (very small power producer) program. The government has provided financial support for installing PV system in the residential sector from time to time. Recently the National Energy Policy Council (NEPC) has approved an increase in special tariffs called the 'adder' tariffs on power generated by renewable energy, to highlight the government's focus on such sources. An adder of 1 baht per unit has been approved for renewable energy that replaces diesel consumption. For the residential sector this programme supports around 50% of installation cost for grid connected PV system. The adders will be in effect for ten years.

Bio-fuels

The total potential of biomass in the country is 7,400 Ktoe, gasohol is 5.4 million liters/day (ethanol production) and biodiesel is 3.3 million liters/day (biodiesel B100 production)[7]. The government supports to utilize biomass for power generation and also for biodiesel and gasohol utilization in the country. The 'adder' rate on biomass and biogas power with less than 1 megawatt in installed capacity has been raised to Bt 0.50 per unit from Bt 0.30. Currently, the government enforced that all gas stations in Thailand should blend biodiesel at least 2% (biodiesel B2). There are also other voluntary choices for biodiesel, which are biodiesel B5 (5% content of biodiesel) and biodiesel B100 (pure biodiesel) for machines in agricultural sector. The government also promotes farmers to grow oil palm in order to have enough supply for the growing demand of biodiesel. Soft loan is an important support provided to farmers.

[7] Ministry of Energy (2009), 15-Year Renewable Energy Development Plan

State of technologies available globally vis-à-vis those available in the countries

Clean coal

As a general rule, clean coal technologies (CCTs) are regarded as 'cleaner' if they offer an environmental improvement over those currently in use, i.e. facilitate the use of coal in an environmentally satisfactory and economically viable manner. However, for the purpose of this study, CCTs are those, which primarily reduce carbon emissions.

The specific CCT available in the countries can be seen from table 2.2, which also gives a snapshot of these technologies available in the global market. It is worth mentioning here that with respect to the specific CCTs that have been discussed here, other than China and India, almost no progress has been made in the other three countries i.e. Thailand, Indonesia and Malaysia. However in Thailand, based upon draft Power Development Plan (PDP) 2007[8], the role of clean coal will be slightly more prominent in years to come. The percentage share of coal (both imported coal and lignite) utilization for power generation is expected to increase from 19% in 2009 to 21% in 2021. In Malaysia, the use of renewables is paid more attention and there clean coal has to do more with pollution control technologies rather than low carbon technologies.

Table 2.2 Status of clean coal technologies

Clean Coal	Global status	Status in countries
Super critical	Commercially mature. One of the most advanced plants - unit 3 at the Aalborg power plant in Denmark - has a thermal efficiency of 47%, a 96% SO_2 removal rate and an 80% NO_X reduction rate.	- China (commercially available) - India (setting up of commercial plants has started) - Other countries (not available)
Ultra-supercritical	Commercially mature. Used in Netherlands, Germany, Denmark and Japan.	- China (commercially available) - India (R&D) - Other countries (not available)
IGCC	Presently there are about 18 IGCC power stations with 4200 MW units in operation. A few more under construction. Commercial plants in U.S., Europe, Japan, China	- China (construction of the first commercial plant has started) - India (R&D) - Other countries (not available)
Carbon capture and storage (CCS)	R&D stage	- China (limited move) - India (not available)

[8] Ministry of Energy, Presentation on "Power Development Plan (2nd Revision)", Available at: http://www.eppo.go.th/power/pdp2007/2.ppt

	- Indonesia (not available) - Malaysia (limited move) - Thailand (not available)

Source Adapted from various sources and country studies

Supercritical and ultra-supercritical technologies

Supercritical (SC) and ultra-supercritical (USC) power plants operate at higher temperatures and greater steam pressures than conventional systems. They require less coal per megawatt-hour, leading to lower emissions per megawatt. Supercritical variants of the pulverized coal-fired technology were first developed in the USA during the 1960s, with the aim to increase plant thermal efficiency. Over 85% of the new coal-fired capacity that was commissioned between 1997 and 2000 used supercritical technology (Department of Trade and Industry, 2003). Within the OECD, supercritical technology, due to its high efficiency, has been primarily installed more in countries with high coal price (Germany, Netherlands, Denmark, Japan, Korea) and less so in countries with low coal prices (United States, Canada, Australia) (Ghosh, 2005). In most of these countries, thermal efficiency over 40% has been achieved. Ultra-supercritical plants operate at higher temperatures and pressures than supercritical units and consequently require the use of special steel alloys. These plants have already been set up in Japan, the European Union and the United States. As costs come down and alloy properties improve, such plants might become fully commercial within the next decade.

In China, advanced coal technologies is constrained by high costs and a lack of policy support. Also though China has started to install supercritical units, most new plants still use subcritical technology. The Chinese average efficiency is affected by the large number of small power plants in use. In 2005, only 333 of China's 6911 coal-fired units had capacities of at least 300MW (Watson et al, 2007). Many of the remainder has capacities of less than 100MW (Zhang and Zhao, 2006). There is therefore pressure from central government in particular, to phase out the use of these smaller, inefficient units. A number of R&D initiatives are underway to improve further on this and move towards ultra-supercritical steam conditions. Supercritical boilers are regularly installed in new power stations in China to replace the outdated small conventional coal-fired power plants. In China, with technology learning from other countries, ultra-supercritical units are being manufactured in China, with more than 80% components domestically produced. Beilun Power Plant is the first ultra-critical unit constructed in 2005.

Presently, concerted efforts are being made in India to adopt super-critical technology for a majority of coal-based power plants.

Six units of 660 MW each, are likely to come up by the year 2012. Further, during 12th Five Year plan period (2012-17), 42,480 MW are likely to be super-critical plants, which is around 67 per cent of the total planned capacity addition during this period. Design and manufacturing facilities are being planned through the various collaborations already in place. Bharat Heavy Electricals Limited (BHEL), a public sector company, has been a pioneer in providing designs and supplying boilers since the 1960s. BHEL used to supply small capacity boilers with technical know-how from Czechoslovakia. It had a technology transfer agreement with Combustion Engineering (now part of Alstom) for about 30 years. BHEL has focused on tying-up with international manufacturers to license supercritical technology for manufacture. However, there is little operating experience in the international market for running supercritical power plants using high-ash-content coal. Recently, Alstom and BHEL have announced an industrial partnership agreement whereby Alstom will license its once-through boiler and pulverizer technologies to BHEL. Using this technology, an NTPC power plant (3x660 MW) is under construction at Sipat. Here, the boilers will be wholly imported from the Korean company Doosan. The other NTPC project at Barh has reached financial closure, with boilers from a Russian firm (Chikkatur and Sagar, 2007).

IGCC

Gasification of coal is an important step for utilizing coal for electricity generation. During the nineties, coal-fired IGCCs were constructed at five sites in the USA and Europe (Watson, 2005). Even today, IGCC technology development is still experimental and a lot of R&D is being done. Coal and petroleum coke based IGCC plants are built in a few countries like USA, Spain, Netherlands, China and Japan. These plants have demonstrated varying degrees of success and requires further experimentation and development to be recognized as reliable operating plants. One of the key issues with this technology is the high capital cost. For example, UK's most recent assessment estimates the difference between an IGCC and supercritical plant of the same size to be between $200 and $400/kW (Department of Trade and Industry, 2006). In Japan, concrete IGCC development plans are underway. A new 250MW demonstration plant is due to begin operating in mid-2007 (Jaeger, 2006). It is being developed by a consortium of Japanese utilities with support from the Japanese government.

China is now becoming quite active in the development of IGCC technology, with several demonstration projects under construction or in planning. China Hua Neng Group started working on another 250MW IGCC demonstration project in Tianjin using a design developed by the Thermal Power Research Institute (TPRI) (Watson et al 2007). Yanzhou Coal Mine Group also made plan for IGCC, together with methanol generation system. This project started construction in 2003 and started operation in 2007. The Huaneng Group also planed to construct a pilot IGCC power plant in Tianjing City. This project got approval in 2009 and has now started construction. Presently there are more than 15 IGCC projects in the pipeline waiting for approval.

In India, a key technical barrier to using gasification technology for power generation is the high ash content of Indian coals (Abbi 2009). Feasibility studies by the Council for Scientific and Industrial Research (CSIR), Government of India, determined that bubbling fluidized bed gasification is well suited for IGCC power generation using high ash coals. Considering this, Bharat Heavy Electricals Limited (BHEL) has developed a pressurised fluidised bed gasifier (PFBG) based IGCC pilot plant of, a 6.2 MWe capacity at Trichy. In July 2008, BHEL and APGENCO (Andhra Pradesh Power Generation Corporation Limited) commenced construction of a 125 MWe IGCC commercial demonstration plant at Vijayawada in Andhra Pradesh, with partial funding from the Indian government. However, the industrial sector has expressed frustration on the lack of international information sharing on IGCC which restricts domestic technology development and application (Ockwell, Watson et al., 2006). This implies that there is a need for indigenous R&D and possibly full-scale demonstration before IGCC commercial plants become viable.

CCS

Various studies on implementing carbon capture and storage (CCS) technologies point to a considerable cost premium. Recent figures from an IPCC special report on CCS show that carbon capture would increase the costs of a coal plant between of 35-60%, depending on the technology being used. A number of industrialized countries, particularly Australia, U.S. and the European Union are already exploring various facets of CCS. Presently there is a limited move to explore the potential of CCS technologies in China. CCS technology is integrated into the National Medium- and Long-term Science and Technology Development Plan towards 2020 (Watson et al, 2007). In China, work is underway on China's first clean coal-based power plant in the northern city of Tianjin. The $1bn project, called GreenGen, will be the country's first commercial-scale plant to use carbon capture and storage. However costs for CCS are prohibitively high and recent estimates have shown that costs will total as much as $400 billion over 30 years to install systems to capture carbon dioxide from power plant smokestacks in China and bury it underground[9]. CCS represents a long term potential consideration in India. At present there is limited interest for CCS in the country.

[9] http://www.bloomberg.com/apps/news?pid=20601087&sid=av__wX90MZIQ last accessed on 7 September 2009.

Solar

Sunlight can be converted directly into electricity using photovoltaics (PV), or indirectly with concentrating solar power (CSP). CSP systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. The concentrated heat is then used as a heat source for a conventional power plant. This is also known as the solar thermal technology. Within this, a wide range of concentrating technologies exists; the most developed are the parabolic trough, the concentrating linear fresnel reflector, the Stirling dish and the solar power tower. Since the 1980s and 1990s, nine CSP plants were built (the first of which in 1984) and operated in the California Mojave desert. Their capacity ranged from 14 to 80 MWe and their combined capacity was 354 MWe. Presently another 400 MWe is under construction in this region. The global solar thermal market is dominated by USA, Spain, Germany and Israel. Some of the leading companies in this field are Skyfuel, SolarReserve in USA; Solar Millennium and Schott Solar in Germany; Abengoa Solar in Spain; Solel in Israel etc. Solel's parabolic trough technology has been around for decades and has been used in test plants for 20 years.

On the other hand, a solar cell, or photovoltaic (PV) cell, is a device that converts light into electric current using the photoelectric effect. Since the mid-1990s, leadership in the PV sector has shifted from the US to Japan and Europe. Between 1992 and 1994 Japan has increased R&D funding, and introduced a subsidy program to encourage the installation of residential PV systems. Germany became the leading PV market worldwide since revising its feed-in-tariff system as part of the Renewable Energy Sources Act. Installed PV capacity has risen from 100 MW in 2000 to approximately 4,150 MW at the end of 2007[10]. After 2007, Spain became the largest PV market after adopting a similar feed-in tariff structure in 2004, installing almost half of the photovoltaics (45%) in the world, in 2008, while France, Italy, South Korea, China and the U.S. have seen rapid growth recently due to various incentive programs and local market conditions.

Chinese research institutes are conducting research on solar energy utilization technology development in a massive way. It is the biggest solar water heater producer and consumer in the world. Both her output and consumption of solar water heaters account for over a half of the world total. In 2008, China overtook Japan to become the new world leader in PV cell production[11]. Suntech of China tripled cell production from 160 MW in 2006 to

[10] "Renewable energy sources in figures - national and international development" Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germany). Available at http://www.bmu.de/files/english/renewable_energy/downloads/application/pdf/broschuere_ee_zahlen_en.pdf. Retrieved on 2008-05-29
[11] Renewables Global Status Report, 2009 Upodate

500 MW in 2008 (By the end of 2008, Suntech claimed to have reached 1 GW production capacity in both modules and cells, the highest cell capacity of any PV company). As an expansion of solar PV promotion programmes, China has also opened up a grid-connected solar PV market with a new policy for building-integrated PV (solar panels used as architectural components), which also applies to off-grid applications. The policy provides initial subsidies in 2009 of 20 RMB perwatt ($3 per watt) for installations larger than 50 kW.

In India, in the last three decades, a lot of developmental work has been done in the field of solar photovoltaic and solar thermal technologies. Presently, the country has a basket of technologies/products that are at various stages of commercialization or R&D. Table 2.3 provides an overview of the current state of solar technologies available in India and globally. In March 2007, the Indian government announced a policy under its Special Incentive Package Scheme (SIPS)[12]. According to this policy, the government or its agencies will provide 20% of the capital expenditure during the first 10 years for semiconductor industries, including manufacturing activities related to solar PV technology located in Special Economic Zones (SEZ) and 25% for industries not located in an SEZ. This has attracted a tremendous response, so far receiving nine proposals pertaining to solar PV related manufacturing worth US$18 billion. In 2009, rural applications of solar PV in India has increased to more than 435,000 home lighting systems, 700,000 solar lanterns, and 7,000 solar-power water pumps[13].

Table 2.3 Solar technologies – state of the technologies available globally vis-à-vis the state of art technologies available in India

	India	Global
Solar photovoltaic		
Single crystalline silicon	R&D and commercial production	R&D and commercial production
Multi crystalline silicon	R&D and commercial production	R&D and commercial production
Thin silicon film (Amorphous, microcrystalline etc.)	Technology developed indigenously; production not started	R&D and commercially produced
New types of solar cells (organic and polymer cells)	Not started	Intensive R&D; production not started
Balance of systems (batteries)	No systematic work on technology up gradation	Commercially produced

[12] Jaideep Malaviya (2008), "On a Solar Mission: How India Is Becoming a Centre of PV Manufacturing,"Renewable Energy World. Also available at http://www.renewableenergyworld.com/rea/news/article/2008/10/on-a-solar-mission-how-india-is-becoming-a-centre-of-pv-manufacturing-53849

[13] Renewables Global Status Report update, 2009

	India	Global
Solar thermal		
Solar water heating using flat plate collector	R&D and commercial production	R&D and commercial production
Solar process heating using evacuated tube collectors	Still at a conceptual stage	R&D and commercial production
Solar cooker	R&D on various types of solar cookers, Box type solar cookers at commercialisation stage	R&D and commercial production
Solar desalination	R&D on single effect as well as multiple effect solar stills	R&D and commercial production

In Indonesia, utilization of solar PV is slowly developing, mostly through government-funded promotion projects, especially for rural electrification. Various photovoltaic systems ranging from solar home systems, photovoltaic pumping systems for drinking water, TV repeaters, public health centers, and more recently, solar boat systems have been installed in Indonesia.

In Thailand, PV technologies using amorphous and crystalline silicon (also called 1st generation PV) are commercially available. Founded in 1986, Solartron Public Company Limited has been providing Thailand and neighboring countries with alternative clean energy sources of photovoltaic for more than 20 years. At present, the company has designed and installed more than 80,000 solar electricity systems in the Southeast Asia region.

PV technology is being used in Malaysia and most of it is being acquired from the global market. Research in this area has been ongoing thus looking into various ways to improve the performance of PV panels and at the same time reduce the cost of producing it. Some of these technologies are applied to the building sector. The key Malaysian company viz. Solarplus Technologies (M) Sdn. Bhd., is engaged exclusively in the design, manufacture and marketing of solar power hot water system for domestic, commercial and industrial purposes.

Bio-fuels

The technological options for producing bio-fuels can largely be divided into two categories depending upon the biomass used for their production. One source is conventional agricultural products which include sugar-rich crops, starch-rich crops and oilseeds. As far as technologies on bio-ethanol are concerned, ethanol can be produced from sugar or compounds such as starch or cellulose that can be broken into sugar. About 60% of the world's ethanol production comes from sugar crops and molasses, mainly from sugar cane (IEA, 2004). The other source is lignocellulosic products and residues which include wood, energy plantations, and agri-based residues.

As compared to conventional agricultural products, lingnocellulosic biofuel feedstocks are in abundance and cheaper for they do not compete with food crops directly. This is also popularly known as second generation biomass ethanol technology. To date, only a few small demonstration bio-refineries are producing ethanol from cellulosic feedstock. Iogen[14] is operating a facility in Ottawa, Canada, The company has announced plans for a commercial-scale facility in western Canada, the U.S or Germany. BC International[15] is applying a proprietary acid hydrolysis technology to agricultural residues and forest thinning feed-stocks to produce ethanol. The company is developing facilities in Louisiana, California and Asia and claims their process produces ethanol at costs lower than conventional ethanol plants. Arkenol and Masada Corporation are also developing bio-refineries in the U.S. utilizing acid hydrolysis process to convert cellulosic wastes into ethanol. A Japanese company, licensing Arkenol's acid hydrolysis technology, is already producing ethanol in a plant in Izumi, Japan from waste. Broin[16] has received a $5.4 million grant from DOE to investigate employing fiber and corn stover in the production of ethanol. A $17.7 million grant from DOE is funding Abengoa's research on processes to pretreat a blend of distillers' grain and corn stover to produce ethanol. The project calls for the building of a pilot-scale facility in York, Nebraska.

As far as bio-diesel is concerned, it is generally produced through catalytic trans-estrification of the oil (extracted from sunflower, palm, jatropha or pongamia pinnata) with methanol. In this process oil molecules are broken apart and reformed into esters and glycerol, which are then separated from each other and purified. The most promising route of producing bio-diesel, however, is through gasification followed by syngas conversion of lignocellulosic products (Bharadwaj et al, 2007). In this process, through Fischer-Tropsch (FT) synthesis methanol, diesel and petrol can be obtained from biomass. The general scheme of this process is known as biomass-to-liquid (BTL) route and is still subject to R&D needs.

In China, recently, biomass ethanol projects have attracted great enthusiasm. In 2005, China promoted the National Key R&D

[14] Iogen is a world leading biotechnology firm specializing in cellulosic ethanol - a fully renewable and advanced bio-fuel that can be used in today's cars.
[15] BC International Corporation (BCI), formed in 1992 was originally BIONOL Corp. and developed a paper mill sludge to ethanol project in New York state. It has now acquired the exclusive license rights to the technology from the courts. It is headquartered in Dedham, Massachusetts and is a privately held company.
[16] Broin Companies is US's largest dry mill ethanol producer

Program (863) for cellulosic ethanol as a step to promote the ethanol industry in the country. China needs to make a major effort to carry on basic and applied work on domestic technology development to convert lignocellulosic biomass to ethanol. In addition, China needs to carry out an economic evaluation of a whole bioconversion process on a commercial scale and a comprehensive analysis of the national availability of biomass.

Table 2.4 gives a snapshot of the technological status in India, vis-a-vis the world. At present the technology for producing bio-diesel from cellulosic products is not commercially available in the country, and there is no commercial plant in operation. For bio-diesel, India's current choice of technology is transesterification of vegetable oil. There are two demonstration projects under process currently. Naturol Bioenrgy Limited, a joint venture between Energea Gmbh and Fe Clean Energy, has set up a 90,000 t/year bio-diesel plant near Kaknada, Andhra Pradesh. The other plant of 9,000 t/year capacity is set up by Southern Online Biotechnologies.

Table 2.4 Technological status of bio-fuels in India and world

Technology	Status in India	Status in world
Bioethanol		
Fermentation of Sugar	Available and commercially deployed	Available and commercially deployed
Hydrolysis of Starch followed by fermentation	Available but not used as large scale	Available and commercially deployed
Enzymatic hydrolysis of cellulose followed by fermentation	Not available	Under R&D
Dilute acid hydrolysis of cellulose followed by fermentation	Available but not preferred due to environmental and process consideration	Available but not preferred due to environmental and process consideration
Bio-diesel		
Catalytic trans-estrification of the oil	Available but commercial viability with non-edible oil is subject to debate	Available and commercially used with edible oils
Gasification followed by syngas conversion of lignocellulosic products (Fischer-Tropsch (FT) synthesis)	Not available	Available but not commercially viable. Under R&D
Biofuel-Cells	Not available	Under research

In Indonesia, biodiesel technology is available but bio-ethanol is not available. However the Indonesian government has developed a bio-fuel development programme for the country, in which the technology used of the production system will be also developed domestically. The Thai government has set up strategic plans on renewable energy, which also includes bio-fuels. Bio-fuel is set to be produced and utilized as a power generation resource, heat energy source and fuel for vehicle-used purpose. In Thailand, second generation bio-ethanol technologies and biomass gasification technologies are available. In Malaysia, the Malaysia Palm Oil Board (MPOB) has developed its own in-house biodiesel technology in 1982. Apart from that, the Biogen Full Scale Model (Biogen FSM) Demonstration Project was initiated in 2002. Its main aim is to catalyse the development of RE projects through effective demonstration of the techno-economic viability of biomass and biogas grid connected power generation projects.

Thus it can be said that other than China and India, clean coal technologies (in this case low carbon technologies) has not made much progress in the other three countries. Most of the clean coal technologies in China have more or less developed at the commercial scale whereas in India these are largely at the R&D level. For solar, again China has achieved substantial progress. Already solar companies in China are benefiting from the government's push for clean technology. China also plans to install more than 500 megawatts of solar pilot projects in two to three years. In India too, a lot of developmental work has been done in the field of solar technologies thus leading to a number of technologies at various stages of commercialization or R&D. For bio-fuels, systematic studies and research has started in all the countries. However, the point to be noted is that in some of these cases, technologies have been developed indigenously backed by strong Government support. In most of the other instances, technologies have been developed through some technical collaboration. A lot of these technical collaborations are already in place and a lot many are coming up. For instance, Q-Cells (Germany) and Solar LDK (China's solar wafer manufacturer) announced a joint venture partnership in May 2009 to develop large-scale solar power plants in Europe and China.[17] American solar developer, First Solar, signed a pact with Chinese government officials to build a 2 gigawatt photovoltaic farm to go up in the Mongolian desert. On bio-fuels, India has recently signed an pre-agreement with the USA to establish a framework of cooperation dealing with scientific, technical and policy aspects of production, utilization, distribution and marketing of bio-fuels. The point that deserves mention is that technical collaboration cannot be equated to technology transfer in any way, as these occur purely on commercial terms. On the other hand from the definition of technology transfer it follows that there has to be some elements of non-commercial transactions to specially address the needs of the developing countries.

[17] http://www.renewableenergyworld.com/rea/news/article/2009/05/chinas-new-focus-on-solar?cmpid=WNL-Wednesday-May27-2009

Barriers to technology development

Barriers to developing technologies indigenously were addressed, and approaches to the identification of the barriers varied from country to country. The types of barriers that the countries have faced have been broadly divided into six categories as shown in the table 2.5. The breakup of these barriers has been provided in table 2.6.

Table 2.5 Types of barriers faced by countries

Countries	Economic and market	Lack of favourable environment	Institutional	Social acceptance	Technical	Lack of adequate skills and training
India	▪	▪	▪		▪	▪
China	▪		▪	▪	▪	▪
Thailand	▪	▪		▪	▪	▪
Indonesia	▪	▪		▪		▪
Malaysia	▪	▪			▪	

Table 2.6 Specific barriers faced by countries

Economic and market - Lack of financial resources - High capital costs - Low income among consumers - Well-established competitive/cheaper alternatives - Subsidies for conventional energy sources - Lack of knowledge or expertise amongst financial institutions to evaluate RE projects - Lack of financial incentives	**Lack of favourable environment** - No incentive for energy efficiency - No emission norms - Inappropriate pricing - Absence of incentives to develop renewable energy technology (RET), owing to small profit compared with invested capital
Institutional - Lack of demonstration projects - Lack of adequate codes and standards - Lack of institutional capacity to solicit ideas and encourage potential entrepreneurs	**Social acceptance** - Lack of confidence - Rigid traditions - Lack of awareness - Food vs fuel dilemma (for bio-fuels) - Land use conflict and its availability (for bio-fuels)
Technical - Operation and maintenance - Lack of adequate R&D - Technological reliability and performance - Low capacity utilization - Little operating flexibility - Complexity of new technology - Limited scientific data	**Lack of adequate skills and training** - Local adaptation - Lack of skilled personnel

It is important to note that all the countries have reported about economic and market barriers and mostly in terms of high investment cost of the technology. Also though renewable energies are high priorities of the countries, some of them (for instance Thailand, Malaysia and China) have indicated their lack of capacity to adequately exploit the available renewable energy options.

India and China mostly faces economic and technical barriers. In terms of economic and market barriers, high capital costs for super-critical, ultra-supercritical and solar technologies are the main barriers. India also faces several technical barriers in terms of inadequate operation and maintenance, technological reliability, lack of appropriate and timely R&D, no systematic efforts on technology up-gradation, low capacity utilization for solar thermal and PV technologies. The other critical barriers involve lack of sufficient demonstration projects, inappropriate pricing mechanism and lack of adequate skills locally. As far as bio-ethanol is concerned, availability of sugarcane is another challenge that constrains the expansion of bio-ethanol from sugarcane. The Indian average sugarcane yield is 65 tonnes/ha (GoI, 2004). It is suggested that drip irrigation with fertigation (adding fertilizers during irrigation) may increase the yield upto 150 tonnes/ha. If 25% of the present area is deployed under sugarcane cultivation, then ethanol production can go up to 2920 million tones per annum which is adequate for 10-15% petrol blend, without compromising with the supply of sugar. However, one time cost for building drip irrigation network is about Rs 7000 crores (Bhardadwaj et al, 2007).

In China, the technical barrier pertaining to IGCC is the problem of integration and localization of the technology. Moreover, the specific fixed unit investment cost (cost/MW) is 20% higher than that of the conventional coal-fired power plant. Nowadays, the average cost in the world of IGCC power plant is around 1200~1600 US$/kW, and the investment on gasification, gas cleaning and dynamic subsystem account for 39%, 16% and 45% respectively. More over, if the carbon capture and storage device is added, the cost will rise further. Research has shown that in China, high cost is still an issue for second generation biomass ethanol production, which is around double the cost than corn based ethanol production process. And it is difficult to decrease the cost much, even though after large scale utilization. Long-term development trend is not very clear. Even though many people think there are plenty of biomass available in China, there are some views that total biomass available for modern energy use is less than 200 million ton. Hence public acceptance is also a major barrier. As far as solar technology is concerned, China faces technical barriers. There are some pilot projects on solar thermal power generation in the world, but it is still new for China. China has to develop the technology in collaboration with other countries. Apart from the high capital cost, the other barriers include inadequate skills and training, lack of adequate codes, standards, and net-metering guidelines.

The root of barriers of all advanced clean energy technologies development in Indonesia is related to energy pricing policy, which tends to keep energy prices low, lower than their market prices. The low energy price has made renewable energy uncompetitive with conventional energy system. In the other hand, efforts in the area of clean energy technology development (R & D) are still limited. The overall national budget for R & D in all sectors is only around 2%, which is mostly prioritized for the development of agriculture (non-energy) sector.

In Thailand, the key economic barrier to the utilization of CCTs is the high capital cost. Costs are even higher, when the import cost of coal and high transportation cost is considered. Other regulatory barriers include lack of supporting measures and lack of R&D. For biodiesel and bio-ethanol, the main barrier emerges from the food vs fuel issue. As far as 2nd generation bio-ethanol is concerned the key barriers are high capital cost and lack of R&D. There are some technical problems like low efficiency and low storage capacity with the solar PV, and this requires intensive R&D. For solar thermal, the high capital cost and the lack of awareness seems to be the major obstacles.

Under the Ninth Malaysia Plan (NMP), 2006-2010, clean technology development in Malaysia revolves around renewable energy (RE). The fuel diversification policy which includes oil, gas, hydro and coal will be extended to include renewable energy as the fifth fuel, particularly bio-fuel (e.g. biomass, biogas, biodiesel), municipal waste, solar and mini-hydro. The government has set a non-mandatory target of 350 MW electricity to be generated through renewable energy resources by 2010 of which about 300 MW is expected to be generated and connected to the TNB Grid in Peninsular Malaysia and 50 MW to the Sabah Electricity Sdn. Bhd. (SESB) Grid in Sabah. However, due to several barriers, the success rate of the programme is quite low. The absence of a strong and favourable environment prevents proper and legal action taken for RE implementation, particularly in the power sector. The existing Electricity Supply Act, 1990 which is to provide for the regulation of the electricity supply industry, is inadequate to be used as the legal basis to support the growth of RE business.

The act covers only for the licensing and control of any electrical installation plant and equipment with respect to matters relating to the safety of persons and the efficient use of electricity. Since RE related issues are not covered adequately under the particular act (or any other act), and RE governance principle is not embedded into the regulatory framework, the participation of stakeholders and legality of actions has subsequently been affected. The current tariff for RE electricity of RM0.21/kWh (for biomass and biogas fuelled electricity generation) does not also take into consideration duration for full recovery cost and sound economic principles. In addition, the tariff does not provide enough rate of return to attract investors or project developers. Apart from that, the unattractive mechanism of utility payment to the RE developers compared to the Independent Power Producers (IPPs) has also discouraged RE project implementation in the country. There is no performance based incentive (rebates) for the amount of electricity fed into grid. Furthermore there are penalties in REPPA (Renewable Energy Power Purchase Agreement) that may hinder the development of RE since there are much smaller projects as compared to the IPPs. As far as economic barriers are concerned, there have been direct and indirect subsidies for conventional energy sources, which tend to skew the playing field against RE in the country. In addition to high risk of developing RE projects, the cost of electricity utilizing RE technologies are highly sensitive to financing terms due to their high capital requirements and small project size. Financial institutions are skeptical in investing into RE business due to the risk involved compounded with the lack of clear policy and direction from the government. Technologically also, majority of the palm oil refineries in Malaysia are using fossil fuels to generate steam. Introducing new technology that is not fully developed in Malaysia is a limiting factor for project development. This is because the capacity to design and manufacture some of the parts do not exist, and this may lead to higher risk and higher costs for the project.

Thus it is seen that despite the huge potential of these countries in utilizing the specific technologies, there are a whole lot of domestic barriers that hinders their successful implementation. The major barrier is the huge upfront cost of these technologies and limited R&D investment in most cases. Commercialisation of any technology is encouraged through the generation of market demand or by guaranteeing the existence of a future market. A stable and consistent policy and a favourable environment, which is conducive to strategic deployment programs, ensuring that quality standards are adopted, designing appropriate tariffs, improving the technical adaptability of countries, greater absorption capacity and incentivizing large scale R&D and demonstration projects needs to be in place, to sufficiently address the environmental and developmental objectives of a country.

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CHAPTER 3 Perspectives on IPR and technology transfer

In Chapter 2, the domestic technology needs of the countries, their availability and barriers to development have been studied. Access and ability to use certain advanced technologies have however been a cause of concern though there have been some attempts to develop these technologies indigenously in these countries. Countries have reported about the several domestic barriers along with the high cost of technologies that have hindered development and deployment of technologies across different sectors. Moving away from the domestic issue, this chapter will focus on the larger international issue of intellectual property rights (IPRs) and discuss the role of IPRs towards technology transfer mechanism and whether IPRs have been acting as a barrier in such cases. This chapter also discusses certain mechanisms that can be explored to address the challenges emanating from IPR issues for smooth and effective technology transfer.

Intellectual Property Rights and technology transfer: Whether a barrier or not?

The impact of IPR on technology transfer cannot be generalised, as it is context specific and complex. However, the importance of IPRs in smooth and effective transfer of technology for promoting actions directed towards mitigation of climate change has been too contentious a subject of debate to ignore. Whether IPRs are indeed a barrier is an issue that elicits different responses from different stakeholders. At the climate change forum, these can be clearly divided into two kinds of responses – Annex I position and Non-annex I position (See table 1 in the annexure).

The Bali negotiations in 2007 were fraught with considerable disagreement between the United States and G77/ China over IPRs and clean technology transfer. While the G 77 group argued that IPRs need to be addressed as a barrier within the technology transfer discussion; Australia and the US maintained that IPRs serve as catalysts, rather than barriers to technology transfer (South Centre and CIEL, 2008). This divergence among Member States over IPRs in clean technology transfer became even more pronounced in the last COP held in Poznan in December 2008. Developing countries argued for a fundamental paradigm shift in the treatment of IPRs in addressing the climate change emergency, as done in the case of access to affordable medicines. On the other hand, developed countries continued to maintain that IPRs are indispensable to ensure innovation for technology development and deployment (TWN, 2008). The recently held climate talks in Bonn in April 2009 concluded with developing countries (including Bolivia, China, India, Philippines for G77 and China, supported by Saudi Arabia, Uganda, Pakistan) arguing for a departure from a 'business as usual' approach and putting forward a range of proposals for relaxation of IPRs on climate friendly technologies (TWN, 2009).

The central premise of the developing country position is that a strong IPR regime can hinder access of developing countries to technology, and transfer to developing countries of ESTs or clean technologies in a number of ways (Khor, 2007). First, where most patents in a developing country are held by foreign inventors or corporations, monopoly rights conferred by patents could stifle R&D by local researchers. Secondly, a strict IPR regime makes it difficult for local firms or individual researchers to develop and make use of the patented technology, as this could be prohibited or expensive. Also, should a local firm wish to 'legally' make use of patented technology; it would usually have to pay significant amounts in royalty or license fees. Again, even if a local firm is willing to pay the commercial rate for the use of patented technology, the patent holder can withhold permission to the firm or impose onerous conditions, thus making it extremely difficult for the firm to use the technology.

According to Ockwell et.al. (2008), the North-South divide on the relationship between IPRs and clean technology transfer is basically rooted in the existence of two conflicting political discourses of economic development and clean technology diffusion that underpin developing and developed countries' respective motivations for engaging in such technology transfer. In their opinion, while developing countries see clean technology transfer as a means of enhancing their technological capacity and contributing to their economic development, developed nations' motivation is to achieve rapid and widespread diffusion of these technologies to reduce emissions. They further stress that a positive post-2012 agreement on clean technology transfer relies on both developed and developing countries taking time to reflect on their positioning at opposite ends of the development-diffusion polarity, directing efforts towards rectifying the deficiencies in their understanding of processes of development and diffusion and confronting the political and economic power dynamics that continue to play out between north and south in this area.

In view of the polarization as mentioned above, there is a merit in analysing the empirical evidence in this regard. Despite a growing number of discussions and opinions on the subject, most of the research has been in the nature of rhetoric, with very little reliable empirical evidence on the impact of IPRs on technology transfer. There have been studies pointing out evidence of IPRs as a barrier to clean technology transfer. Much of this impact varies from sector to sector and from country to country with different levels of economic development. A study on wind power manufacturers, Suzlon and Golwind in India and China respectively. brings out, albeit indirectly, how developing country firms are likely to encounter barriers to international technology, owing to the 'unlikeliness' of leading companies in the industry to license information to companies that could become competitors (Lewis, 2008). The two firms had to obtain technology from smaller companies that had less to lose in terms of international competition, and more to gain in terms of license fees.

In the case of meeting commitments under the Montreal Protocol[18], developing countries have faced a similar problem. Phasing out ozone depleting substances (ODS) requires sophisticated technologies, most of them patent protected, making it a heavy financial outflow for developing countries. Hence, transfer of technology becomes a crucial issue therein. Watal (1998) identifies two trends in difficulties faced in the acquisition of new ODS substituting technology. First, transition has been smooth where alternative technology exists, that is commercially viable and not covered by IPRs; Second, technology switchovers and phase out have been difficult in sectors where the required technology or processes are under IPRs and dominated by a few owners. While transition was smooth in foam and aerosol industries, both characterised by availability of low cost options not covered by IPRs, difficulties were faced in finding substitutes for CFCs in refrigerators and air-conditioners and ODS in fire-extinguishers, all of which had a few companies in developed countries controlling the related patents and trade secrets. High costs, export restrictions, demands of high shares in joint ventures were some of the problems associated with the latter.

There are other factors as well and the stage of development and maturity of a technology is also integral in determining the extent to which IPRs pose a barrier (Ockwell et.al. 2008). The study reports that more than the IPR issue, the prime barrier of IGCC commercial plants in India is the limited amount of testing of IGCC that has been done with Indian grade coal and also the absence of large-scale demonstration and commercialization of this technology. Barton (2007) notes that IPRs would not pose a significant barrier in the photovoltaic sector and if developing country firms wish to enter the field as producers, they are likely to obtain licenses on reasonable terms because of the large number of firms in the sector. A UNIDO study (2006), based on country-specific evidence noted that strong IPRs particularly at initial stages of development hamper transfer and adoption of technology.

[18] Montreal Protocol on Substances that Deplete the Ozone Layer, in force since 1989

Box 3.1 Factual Overview from Country Studies

The country studies conducted as part of this report (viz., China, India, Indonesia, Malaysia and Thailand), also provide some interesting insights with regard to the factual status on technology transfer in these countries –

- All the countries under the study have IPR regimes that are in compliance with the TRIPS Agreement.
- The IPR laws in all the countries also provide for compulsory licensing on grounds of non-implementation of the patent by the patent holder, and in the event public interest is impacted. Compulsory licensing has however not been used so far in the context of proprietary technology intended for climate change mitigation.
- The legal regimes in all the countries are conducive to technology transfer through both: (a) licensing arrangements and (b) foreign direct investment.
- Several instances have been cited in the studies from China, Indonesia, Malaysia and Thailand, regarding technical collaboration and technology licensing agreements in the context of environmentally sound technologies, in each of the sectors covered under the study: clean coal, solar and biofuels.
- In some cases, the implementation of indigenous technologies can be enhanced through products or technology sourced from other countries through purchase and licensing or other collaborative arrangements.
- While studies reveal that access to proprietary technology in itself is not a problem, but the manner in which this access is transferred may pose difficulties. Studies from Malaysia and China show that the prohibitive costs of such technology often act as a barrier to access. Malaysian examples also show how unreasonable restrictions and conditions in technology transfer agreements make the arrangement onerous for recipient countries.

The Stern Review (2006) has emphasised strong IPR regimes as a means to ensure better technology transfer, suggesting that governments can take measures to create a "*suitable investment climate for energy investment and the adoption of new technologies, such as .... strengthening intellectual property rights*". This is also an oft-repeated suggestion by the developed countries, implying that strong IPR regimes promote technology transfer and the present lack of transfer is due to *inter alia* weak IPR regimes. Nanda and Srivastava (2009), however contests this view. They argue that, it is not easy to infringe on IPR of sophisticated technology that requires huge scientific and technical knowledge. The basic scientific knowledge of patented technologies is not inaccessible, what is not available is the right to use such knowledge. Even in alleged absence of strong IP regimes, the fact that developing country companies are not using such technologies shows that it has little to do with strong or weak IP regimes but the fact that they are either respecting the patent rights or they simply do not have the technical capacity.

Thus there are not only varying impacts of IPRs on technology transfer, there are differences in approaches and perceptions of the companies vis-à-vis these barriers as well. For example, even within India, different companies have had different experiences and opinions with respect to IPRs acting as a barrier to technology transfer. While big companies have been able to access technologies except in cases where the technology owner has direct presence in the Indian market or where the technology holder perceives a threat from the recipient in outside markets, there have been instances where negotiations have broken down due to high price for the required proprietary technology. Even with respect to the same technology, while one company perceived IPRs as a hindrance, the other did not.

IPR as a barrier: Is cost an issue at all?

Like other aspects of the technology transfer and IPRs debate, the issue of cost and its relevance is also disputed and somewhat polarised. Developing countries have repeatedly raised concerns about the financial burden in accessing technologies protected by IPRs. One of the causes given for restricted access to patented technologies by developing countries is high price given as license fees to the patent holders, usually in the developed countries. Strong IPRs usually lead to licensing, thereby leading to higher production and usage costs on account of payments made to obtain licences.

The situation gets worse in technologies where the important patents are in the hands of a few dominant players, creating a monopolistic situation where dissemination of knowledge is restricted on account of limited access and higher prices for climate friendly technologies. There have been instances in the Indian solar power sector, where negotiations for technology transfer from abroad have broken down due to high costs involved. In the Chinese Yantai IGCC demonstration power plant, Chinese companies failed to get technology from foreign companies due to high cost and reluctance to transfer the key technologies on the part of patent holders and after a long round of negotiations, the project finally had to be stopped.

IPR costs become a bigger issue in technologies such as clean coal etc., because these require access to a number of technologies along the process. Thus even if one considers of one technological process, in order to be able to adapt it at a domestic level, getting access to multiple technologies and linked patents raises the overall cost.

There is a counter view to the above concern with respect to high costs of accessing IPR protected technologies. Studies and even some companies point out that given the small share of R&D in the overall budget of a company, there is only in a small way that licence fees can impact the balance sheets. Moreover, IPR protection is further assured by specific clauses contained in the TTAs (technology transfer agreements) between the buyers and suppliers of technology (Abbi 2009). The TTA has various clauses covering designs of products/systems to be transferred for commercial exploitation by the receiving party, IPRs, period of agreement, limits of market/countries for manufacture and sale of product/system, terms for termination, rights after expiry of agreement etc. These TTAs are very meticulously negotiated to satisfy the commercial interests of both the parties, i.e the buyer and supplier. The supplier has to specify the patents and know-how used in the design of the product/system, and it should also represent that it has not infringed others patents. This helps in suitably defending any claim or litigation in future by a third party for IPR infringement. Generally, the party receiving the technology gives an undertaking that it will protect the rights of all patents specified in the TTA, thus protecting the technology supplier. In such a situation, IPR costs alone do not constitute a large percentage of the total cost.

This view however, takes a very narrow approach and ignores the larger picture. Licence fee is only one of the many ways in which IPRs lead to increased cost of a technology transfer. A technology in most cases is a package that involves several IPRs. But only few of the IPRs can be transferred while for other IPRs, the technology transfer project might involve imports of goods and components, which might bring embodied technologies. These costs do not get reflected as a part of IPR costs, since these are not royalties or licence fees, but are nevertheless associated with them. Besides, there are cases where the patent holder has simply refused to license a technology[19], which would force purchase rather than manufacture. A Malaysian company for solar power, on breakdown of the negotiation with a foreign supplier, had to acquire the technology indirectly through purchase of machinery. Moreover, a barrier due to intellectual property rights may not be present only in terms of direct cost but lead to increased spending by the company willing to be the recipient, either due to refusal of technology transfer or unreasonable conditions put in the technology transfer agreements.

In another case, the Malaysian company, Solartif after initial difficulties managed to gain access to a foreign technology but on a condition of buying machines from the same company. There have also been instances, for instance, in LED, where countries have gone for import of technologies, as it is a cheaper and easier option than manufacturing domestically due to IPR issues involved therein.[20]

The above discussion leads to the conclusion that the link between IPRs and access to clean technology is a very complex issue, which

[19] Dupont case
[20] Prof. N Narendran, Director of Research, Lighting research center, New York, quoted in David Ockwell, Jim Watson, Gordon MacKerron, Prosanto Pal, Farhana Yamin, N Vasudevan and Parimita Mohanty. 2007, UK–India collaboration to identify the barriers to the transfer of low carbon energy technology, Sussex Energy Group, TERI and IDS

varies from country to country, technology to technology and the stage of development or maturity of the technology. There is no doubt that IPRs are a premium that the developing countries have to pay in order to acquire the ESTs. But the serious issue is how big is the premium and also the time horizon over which the technology will have its impact, i.e basically the expected time between investment in development of a new technology and the payoff. If the technology is expected to yield good results over the long-term, it makes economic sense to acquire the technology even by paying a high premium and in that case the real IPR cost will be less as calculated by the net present discounted value. On the other hand if the technology is expected to yield returns only in the short run, but a country has to meet stringent environmental regulations, for which the technology has to be acquired, in those cases the real IPR cost is high. But again such an assumption is true only in the perfect information scenario.

However, the importance of technology transfer in terms of actions aimed at mitigating climate change is widely accepted now. The differences lie in (i) who/what is responsible for the lack of it (ii) the role that IPRs can play in restricting or facilitating it, and (iii) what measures should be taken to promote transfer of climate relevant technologies. Following section discusses some of the options within the existing regime that can be explored in this regard.

Mechanisms to facilitate technology transfer: TRIPS or beyond?

Developing countries were convinced to sign the (Agreement on Trade Related Aspects of Intellectual Property Rights) TRIPS Agreement because they were promised that IPRs would stimulate local innovation in the developing world, and lead to increased investment and technology transfer from the developed to the developing world (Correa, 2003). However, there is no indication that such transfer of technology has been faster in the post-TRIPS period. Since TRIPS has mandated minimum standards for IPR in WTO member countries, in most developing countries, it enhanced the standards of IPR protection. Domestic IP laws in all the five countries of this study too are TRIPs compliant but technology transfer remains an unresolved issue. Therefore, one cannot assume technology transfer being facilitated through strengthening of IPRs. In fact the above discussion and the status of countries' commitments at the WTO with respect to intellectual property shows that TRIPS has not really helped technology transfer in the area of climate-friendly technologies.

However, there are some mechanisms, both within and outside the WTO- TRIPS, that can be made use of to promote technology transfer to advance actions on climate change mitigation. Within TRIPS, although there is not much in the text of the agreement directly with respect to technology transfer, there are indeed some principles and provisions that can be used to transfer climate relevant technologies to developing countries.

Article 27.1 of the TRIPS Agreement, for instance, requires WTO Members to grant patents for all types of inventions in all fields of technology, as long as these inventions meet certain basic criteria. Article 7 of the Agreement states that the objective of the protection and enforcement of IPRs should be to contribute "to the promotion of technological innovation and to the transfer and dissemination of technology, to the mutual advantage of producers and users of technological knowledge and in a manner conducive to social and economic welfare..." Article 8 also recognizes that measures "may be needed to prevent the abuse of intellectual property rights by right holders or the resort to practices which ... adversely affect the international transfer of technology."

TRIPs and compulsory licence

One of the tools used by countries to access patented technologies is through an old concept of compulsory licensing. Compulsory Licence (CL) refers to a statutorily created licence that allows certain entities to pay a royalty and use an invention without the patentee's authorization or permission.[21] The term does not appear in the TRIPs text, but can be read into its clauses on other use (of the patented subject matter) without authorization of the right-holder. The TRIPS Agreement allows countries to grant non-voluntary licences to a third party, allowing the exploitation of the patented invention without consent of the patent owner. Exceptions to rights of patent holders[22] and principles on measures for preventing the abuse of intellectual property rights by right-holders or the resort to practices, which unreasonably restrain trade or adversely affect the international transfer of technology[23] also provide reasonable flexibility for resorting to the provision of compulsory licence.

Drawing from TRIPs and Doha Development Declaration, a compulsory licence can be granted in cases such as meeting government requirements, abuse of patent rights, national emergency, public non-commercial use and technical advance of considerable economic significance over the existing patent (Keayla, 2007). Rights of the member countries to make use of compulsory licence in the interest of public health have been explicitly recognized in the Doha Declaration on Public health. Thus, treating health as one of the public goods, the scope of compulsory licence has been extended to health. Consequently, a

[21] Black's Law Dictionary (Seventh Edition) pp 938
[22] Article 30 allows members to provide limited reasonable exceptions to the exclusive rights conferred by a patent, if it does not unreasonably prejudice the legitimate interests of the patent-owner and takes into account the legitimate interest of third parties.
[23] Article 8, TRIPS

few CLs have been issued by developing countries as well. Till now, most of these examples have related to health. On November 29, 2006, Thailand announced a compulsory license to import and locally produce Effavirenz under stipulated conditions. In 2007, Indonesia issued a CL for Efavirenz (KEI, 2007). In April 2007, the Brazillian Ministry of Health declared that Efavirenz is in the public interest. Therefore, the developing countries have to be more forthcoming in the case of climate change mitigation technologies like they have done in the case of pharmaceuticals in the past.

Developing countries, including India have made submissions at the UNFCCC that demand a paradigm shift in the way climate mitigation technologies are subject to intellectual property rights protection, and have an approach similar to affordable medicines. This has included pushing for a mechanism that would ensure that privately owned technologies are available on an affordable basis, including through measures to resolve the barriers posed by IPRs and addressing compulsory licensing of patented technologies (Government of India, 2008).

Although the application of CL can be made by both individuals and governments, in the past it is the governments who have initiated the action for CL. It is a part of domestic IP laws of several nations, including China, India, Indonesia, Malaysia and Thailand to meet national emergency. TRIPs recognizes its members' freedom to determine and defines national emergency in their specific country context to issue a CL. The flexibility rests with the countries, thus giving an opportunity to treat climate change mitigation as a public good. Some national laws have inserted specific clauses for environmental protection, such as Thailand, where the Patents Act permits the Thai government to issue a CL to carry out any activity for preservation or realization of natural resources or the environment or for any other public service.[24]

The main innovation of the Doha Declaration was to allow CL for exports. This was incorporated in the Indian patents law by way of 2005 amendment vide section 92A, which allows CL to be issued not only for manufacture for domestic needs but export also to countries 'having insufficient or no manufacturing capacity in the pharmaceutical sector.' While India has explicit export related provisions vis-à-vis CL, not all countries have incorporated this approach. Even in the Indian context, the provisions allowing CL for export have been restricted to pharmaceutical sector only, while the concept of CL and grounds for the same can be applied to *any* 'reasonable requirement of the public' or 'national emergency' both under the TRIPs regime and the domestic IP regime.

[24] Section 51, Patent Act B.E. 2522

However, the issue of compulsory licence is much more complex than it may seem. This is reflected in the fact that there have been only few instances, particularly in developing countries, where a CL has been issued. The instances of issuing of CL by a national authority where the IPR-owner is a foreign national or domiciliary are even fewer if not rare. Most developing countries may not have domestic capabilities and such capabilities are concentrated only in a few countries like US, UK, France, Germany and Japan (Nanda 2009). As per the country study reports from China, Indonesia, Malaysia and Thailand, they have not had any experience so far in using compulsory licensing in respect of clean technologies. Moreover the case of climate technologies would be slightly different than health due to the fact that Doha Declaration on the TRIPS Agreement and Public Health clarified the rights of member countries with regard to the compulsory licensing system by recognizing that each member has the right to grant compulsory licences and the freedom to determine the grounds upon which such licences are granted.

No such clear declaration exists for climate change, but that makes the task of issuing CL for climate change mitigation technologies difficult, and not impossible. Nevertheless, issue of compulsory licence for pharmaceutical products where IPR is held by a foreign company has been done by Brazil and Thailand. Use of compulsory licensing for imported pharmaceutical products has occurred only once. It is politically very difficult to issue a compulsory license as the experiences of Brazil and Thailand shows. In multilateral discussion on the TRIPS Agreement, specific focus has been placed by WTO Members on the use of compulsory licensing as a means by which to promote access to medicines. In fact WTO Members have put in place a mechanism in order to ensure use of compulsory licensing provisions in respect of export of pharmaceutical drugs to least developed countries.[25] Thus in order to use the CL provision to access climate change relevant technologies first and foremost, climate has to be treated as public good in domestic and international regimes. A specific declaration in line with TRIPS and public health this regard at the WTO as well as allowing even non-LDC developing countries to uses compulsory licensing for climate-friendly goods could also be useful in this context. In this regard, one element that can be considered at the WTO is a waiver in respect of use of compulsory licensing to supply EST to export markets.

While there are several lessons to draw from the CL for public health model, the case of climate relevant technologies will be slightly different on account of its nature and scale of manufacture and operation. The use of compulsory licensing in respect of

[25] WTO General Council, Implementation of Para 6 of the Doha Declaration on the TRIPS Agreemeent and Public Health (2003)

transfer of technology would have different characteristics as compared to compulsory licensing in respect of pharmaceutical drugs primarily because compulsory licensing of technology, in the absence of access to equipment, know-how and human skills to adapt and implement the technology, would not be able to translate to effective transfer.

It has been observed that often the situations in which IPRs negatively impact technology transfer are the ones where the technology is owned by a handful of patent holders. Thus, it is also linked to market monopoly and anti competitive practices. Some of the hurdles in technology transfer of climate relevant technologies can also be addressed through tackling anti-competitive practices. Article 31 (c) of TRIPS provides that a country can use such a measure "to remedy a practice determined after judicial or administrative process to be anti-competitive". Hence, countries can invoke their competition law where "abuse of dominance" is included as one of the anti-competitive practices and the source of dominance is an IPR.

Similarly, Article 40 of TRIPS dealing with control of anti-competitive practices in contractual licences provides, "Nothing in this Agreement shall prevent Members from specifying in their legislation licensing practices or conditions that may in particular cases constitute an abuse of intellectual property rights having an adverse effect on competition in the relevant market". Hence, refusal to give licence can also be included as an anti-competitive practice.

Looking beyond TRIPs

Since the members are bound by WTO-TRIPs, it is important to ensure that all the flexibilities within the TRIPS regime are explored for mitigating climate change. However, beside TRIPS flexibilities, other measures beyond the TRIPs regime, such as cooperative R& D and technology acquisition funds could be tried to reduce the high costs resulting from strong IPR protection.

Technology acquisition or repository fund

Creation of a Technology Acquisition Fund as an option has been proposed at certain fora.[26] The inspiration for such a fund comes from the financial mechanism under the Montreal Protocol for inter alia licensing fees of alternative technologies and which has been hailed as being fairly successful (Anderson et.al., 2007, Sarma, 2008).

Such a fund could be managed by a multilateral organization or a trust, which serves to acquire or buy out patented technologies that

[26] Srinivasan, Ancha [Ed.] 2006, op. cit

are climate friendly and make them available to the intended users, often the developing countries in want of technology to reduce or mitigate the green house gas emissions.

However, in cases where few dominant players exist and conditions other than high price (e.g., restrictions, and mandatory purchase etc.), technology acquisition fund may not go very far. Watal's case study makes it amply clear that despite a multilateral fund, developing countries may face difficulties in accessing technologies due to unwillingness on the part of the technology holders to license the technology. A patent buy-out mechanism is something that can circumvent compulsory licences keeping in mind the patent owners' concerns as well, therefore can be the 'most diplomatic alternative' to compulsory licence (Kim Do Hyung, 2007). Outterson (2006) has outlined a detailed process for a suitable buy-out mechanism, where compensation is calculated at the net present value of expected future profits.

Mandatory price negotiations

Another mechanism could be the mandatory price negotiations for patented products. This is very common in many countries, both developed and developing in pharmaceutical products. However, it could be more difficult as climate-friendly technologies are often complex in nature and involves several IPRs in a technology. Price regulation can be imposed even as a competition-remedy measure. Since countries are empowered to act under their competition regimes such a mechanism is legally possible. However, for many developing countries, it would not be easy to enforce when the companies in question could be big trans-national companies from a powerful country (Nanda and Srivastava 2009). Even though companies are paid a royalty in compulsory licensing, companies oppose any move of issuing a CL. In the case of antiretroviral drug nelfinavir in Brazil, when the decision to issue a CL was opposed by Roche, the Brazilian government and Roche entered into an agreement. Accordingly, Roche agreed to sell the drug in Brazil at an additional 40% discount, and Brazil would not issue the compulsory licence.

WIPO recommendations

The interest of the WIPO on environmentally sound technologies is relatively recent. The thirteenth session of the WIPO Standing Committee on the Law of Patents (SCP), held in March 2009 has decided to tackle the issue of "patents and the environment, with a particular attention to climate change and alternative sources of energy" in greater detail in the next patent committee meeting scheduled for November, 2009 (Knowledge Ecology Notes, 2009).

Although climate change and clean technology transfer are yet to figure directly in the WIPO development agenda, there is a view that the WIPO agenda would be an appropriate forum to promote technology transfer and take advantage of the various flexibilities that exist internationally (Nanda, 2008). Till now WIPO has been taking a cautious approach without an attempt to advocate or advance any position.[27] However, it observes that neither the simple existence of a patent serves as a barrier in itself to the transfer of a technology nor does the absence of an enforceable patent right in a certain country provide any guarantee of technology transfer.

Besides 'direct regulatory interventions', WIPO has also been promoting voluntary arrangements for sharing of technologies by technology holders who realize that the benefits of pooling technologies from several sources outweigh any immediate advantage of closely restricting access to their technology. Some such technology sharing models include:

- Patent pools, where patent holders agree to license their technologies to one another.
- Patent commons, broader in scope than patent pools, with technology holders pledging their patented technology for widespread use for no royalty payment, subject to certain general conditions.
- License of right, which provides for a reduction in official fees for patent holders who agree to make their patented technology available to anyone requesting a license, subject to terms that can be negotiated or determined by the authorities.
- Non-assertion pledge or covenant, whereby patent holders may choose to make their technology widely available by legally pledging not to assert their patent rights against anyone using the technology, which may be restricted to specific uses of the technology.
- Humanitarian or preferential licensing, which provides highly favourable or free terms to certain beneficiaries like developing country recipients, social marketing programs or public sector/ philanthropic initiatives.
- Placing technologies directly in the public domain
- Open innovation, open source, commons-based peer production and distributed innovation, all of which emphasize a collaborative or shared technological platform for innovation (WIPO, 2008)

Patent pools, patent commons, technology competition and prize funds, a differentiated patent system (the EPO's Blue Skies proposal) and a host of other innovative approaches and ideas have also been advanced by the United Nations Department of Economic and Social Affairs (2008) for enabling the transfer of ESTs particularly to developing countries.

[27] WIPO Briefing paper 2008

Conclusion

The role of technology transfer in promoting actions that mitigate climate change is now recognized and agreed by various actors and at different fora. However, the role of IPRs in facilitating or restricting technology transfer has been at the centre of much debate. The differences lie in (i) who/what is responsible for the lack of it and, (ii) the role that IPRs can play in restricting or facilitating it, (iii) what measures should be taken to promote transfer of climate relevant technologies. Following are the key observations and recommendations.

Key observations

- Reviewing the debate in literature and negotiations, one can easily distinguish concerns of the Annex I and non-Annex I positions. While annex I countries allege, inter alia, that absence of strong IPR regimes in developing and least developed countries act as a disincentive for technology transfer to take place, developing countries hold that their regimes are TRIPs compliant and technologies protected by strong IPRs are making access to technology even more difficult.
- The legal mandate for technology transfer as part of the UNFCCC and Kyoto Protocol, is worded as soft obligations, and not as a legally binding and enforceable commitments.
- The actual impact of IPRs on technology transfer and also the issue of IPR costs acting as a barrier is often context specific depending upon the maturity of the technology, region, the time horizon, number of patent holders etc.
- IPR access is necessary in some cases, but not sufficient on its own to enable access to ESTs. However, even where it does not stop access per se, it does slow down rate of diffusion of technologies considerably.
- Intellectual property costs in technology transfer are contentious. While one of the ways in which IPRs are believed restrict technology transfer is through high license costs, it is also alleged that IP costs are very small in a project to act as a real barrier in technology transfer. However, the issue of IP cost in a technology transfer project is itself debatable, as often IPR influences not just in the form of licence fees and royalties but leads to purchases, import of associated equipment, losing stake in joint ventures etc., all of which do not get reflected as IP costs.
- All the countries studied (China, India, Indonesia, Malaysia, Thailand) have TRIPS-compliant IPR regimes domestically and have even legislated on some of the flexibilities available under TRIPs.

Key recommendations

In order to promote technology transfer of climate relevant technologies, countries and multilateral fora would have to explore existing and innovative mechanisms to facilitate technology transfer. These can be both within the flexibilities provided by TRIPs and outside the TRIPs framework. Some of the measures recommended below are voluntary in nature, while others would have to be made mandatory by the state.

- There is a need for clearer binding and enforceable commitments for developed countries at the UNFCCC to live up to the promise of transfer of clean technology, including new proprietary technology. In this regard, specific commitments and work programmes would need to be evolved which focus on obligations from developed countries to ensure transfer of climate relevant technology to the developing countries. As a part of their commitments, developed nations could set aside a part of their R&D budget for developing climate change mitigation technologies and make them available and deployable in developing countries too.

- Beside commitments at the level of government action, companies in the developed countries, who own and control a majority of the climate relevant technologies, also will need to be bound by some kind of codes of conduct, directives and incentives by their country governments to check anti-competitive practices and restricting practices like refusal to licence, exorbitant licence fees and unreasonable conditions in technology transfer agreements.

- Another way of tackling the issue of refusal of licence, unreasonable exercise of IPRs for technology transfer, is compulsory licensing. It is one of the most talked about flexibilities within TRIPs and although possible, is fraught with complexities and political difficulties. In the past, instances of issuing compulsory licence by a developing country authority where the IPR-owner is a foreign national or domiciliary has been rare, therefore, it is difficult to issue a compulsory license for imported products and technologies. In such a circumstance, a more feasible option can be exploring a mechanism whereby, the developed country can compulsorily license and facilitate access to the technology. However, compulsory licensing in the context of high-end clean technologies, may have limited usage because of the deep linkages with transfer of know-how and human resources to ensure understanding and working of the technology. Interventions from developed countries to address this aspect would therefore also need to be worked as part of any such mechanism.

- Given that TRIPs leaves it to countries to decide what constitutes emergency and public good for the purposes of CL, it would be worthwhile to have a declaration or agreement (like the Doha Declaration on public health) recognizing climate change as a national emergency and climate change mitigation as a public good.

- Adequate financial commitments are also essential from developed countries, to fund incremental costs of sourcing proprietary technology through licensing and other mechanisms. In this regard it should be noted that Article 4.3 of the UNFCCC convention clearly points *out "The developed country Parties and other developed Parties included in Annex II shall provide new and additional financial resources to meet the agreed full costs incurred by developing country Parties…They shall also provide such financial resources, including for the transfer of technology, needed by the developing country Parties to meet the agreed full incremental costs of implementing measures"*. Financing mechanisms need to be examined both in the context of technologies that are protected by IPRs and those that are in the public domain.

- Monitoring mechanisms and performance indicators in respect of monitoring and evaluating the effectiveness of implementation of a technology transfer framework is of critical importance to ensure implementation of such provisions. In this regard, the recommendations of the EGTT in relation to the following needs to be kept in view: (a) ensuring a common technology typology between the UNFCCC secretariat and IGOs (intergovernmental organisations) and international organizations engaged in technology transfer; (b) as part of the post-2012 arrangement, the guidelines for national communications may need to be specified to guide reporting in national communications in order to obtain the data needed for specific key performance indicators.[28]

- Other options include voluntary actions and technology-sharing models as proposed by WIPO, such as patent commons and patent pools. However, as the initial experience with the Eco-Patent Commons indicate, the success of such models is severely constrained unless more players come on board, willing to share a greater number of 'valuable' patents.

[28] See, "Performance indicators to monitor and evaluate effectiveness of the implementation of the technology transfer framework", FCCC/SB/2009/1 dated May 22, 2009

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CHAPTER 4 Linking an appropriate financial mechanism with technology transfer

In Chapter 3 it has been seen that IPRs is a complex issue as far as technology transfer is concerned. There is no clear-cut relationship between the two. Much depends on the maturity of the technology, region, the time horizon, number of patent holders etc. In this chapter we have looked at financial resources required as a means to facilitate technology transfer. The financing resources and vehicles needed too, depend on the stage of technological maturity, research, development, deployment and diffusion of the technology. Unfortunately, available data provided by UNFCCC (2009) presents very disturbing trends on the financial availability catering to technology transfer, particularly for the developing countries.

- The financing resources for technologies for mitigation and adaptation make up only a small share (probably less than 3.5 per cent) of the resources devoted globally to all technology development and transfer.
- Only about 10–20 per cent of these resources are used for development and transfer of technologies to developing countries
- Most of the financing resources (probably over 60 per cent) for the development and transfer of climate technologies are provided by businesses, and most of the remaining resources (about 35 per cent of the total) are provided by national governments
- Technology development is concentrated (about 90 per cent) in a few countries or regions – the United States, the European Union, Japan and China

Existing arrangements and gaps

Research, development, deployment and diffusion of climate mitigation technologies (and also for technologies on adaptation) are funded mainly by the private sector and most of the remaining funding comes from national governments. International public funding covers only a very small share of the total (UNFCCC, 2009). The principal international funding mechanisms available for financing climate change mitigation activities and technology transfer under the UNFCCC are the Clean Development Mechanism (CDM)[29] and the Global Environment Facility (GEF)[30].

[29] Clean Development Mechanism (CDM) (defined in Article 12 of the Kyoto Protocol) allows Annex I parties (or industrialized countries with binding targets) to implement projects that reduce emissions or sequester carbon through afforestation/ reforestation activities in non-Annex I parties, in exchange for Certified Emission Reductions (CERs) and assist the host parties

Even though the overall flow of finance is inadequate, India and China have benefitted more from both the mechanisms compared to other developing countries, but whether these mechanisms have been the prime driver of the mitigation activities is somewhat uncertain. Nonetheless, the two mechanisms have played a complementary role. While CDM finance has generally flowed to non-CO2 reductions, renewable energy projects and industrial efficiency projects, GEF finance has supported early stage development and efficiency improvements in small-scale industries that are not easily captured by the carbon market. Several other types of international financial flows support technology transfer, including ODA (Official Development Assistance), FDI (Foreign Direct Investment), venture capital, commercial loans, and ECAs (Export Credit Agencies). However, none of these financial flows provide a direct measure of technology transfer. Most of these financial flows support private-sector technology transfer.

Rough estimates of the sources of current financing for climate mitigation technologies are provided in table 4.1. The sources are being classified as being under or out of the convention. From table 4.1, it can be seen that the dominant source of financing under the Convention is the sale of certified emission reductions (CERs). Convention sources account for USD 5–10 billion, or about 7 per cent of the total. However, this amount is probably an overestimation owing to gaps in estimates for the private financing for deployment and diffusion.

Table 4.1 Estimates of current sources of financing for development and diffusion of climate technologies, by source (billions of United States dollars per year)

Developing Countries		
Source under the Convention		
Deployment and diffusion	The GEF	0.19
	The CDM	4 to 8
Sources outside the Convention		
Diffusion and commercial	Export credit agencies	<1
Deployment and diffusion and commercial	Bilateral ODA	2
	Multilateral ODA	1 to 3
Deployment and diffusion	Philanthropic private source	1
Deployment, diffusion and commercially mature	Private investment including FDI of USD 1 billion	1.5 to 4
Developed Countries		
Source under the Convention		

in achieving sustainable development, thereby contributing to the ultimate objective of the Convention.

[30] Other mechanisms under the Convention include the Special Climate Change Fund (SCCF) and the Adaptation Fund, which focus on adaptation activities. The SCCF also funds technology transfer activities under its Programme for Transfer of Technology but has seen very limited activity to date. Of the $74 million received by March 2008, $14 million was allocated to technology transfer globally.

Deployment and diffusion	Joint implementation	<0.5
Sources outside the Convention		
Deployment and diffusion	FDI	
	Domestic private	1.5 to 2.2
	Investment	9 to 16.5
Deployment and diffusion	Government funding	30 to 45

Source: Adapted from UNFCCC (2009)

Sources within the Convention

GEF

Since the time of the first meeting of the COP, GEF has served as an entity operating the financial mechanism of the convention. Since the creation of the GEF in 1991, about $2.4 billion has been allocated to projects in the climate change focal area, funding which has leveraged an estimated additional $14 billion in financing and resulted in the reduction of over one billion tons of GHG emissions (UNFCCC, 2008a). According to GEF records, it has supported more than 30 technologies in the years of its existence and more of its focus has been on mitigation technologies. From 1991 to 2007, the GEF has approved grants totalling more than $800m for approximately 150 projects that promote the transfer of renewable energy technologies in developing countries. However, it does not mean that all of these technologies have been successfully transferred, but rather this gives an indication of the GEF portfolio.

In terms of the 3 specific mitigation technologies covered in the study, the status can be observed from table 4.2. For instance, in India out of the total 44 national projects on climate change, GEF has supported only four projects, which covers renewable energy technologies and one on coal bed methane. If calculated percentage wise, it can be seen that out of the total GEF grant in these 44 projects, only 16 per cent involved clean technologies. In China, out of the 82 national projects, only 2 of such projects involved renewable energy development, thus catering to 10 per cent of the total grant. In Thailand, out of the 11 projects, none involved clean technologies. Also from annexure table 2, which shows the country-wise details of the projects involving the specific three technologies, it can be seen that leaving two or three projects, GEF has supported very little. For example, in the Indian project on alternate energy, the fundamental objective of which was to popularize renewable technologies through public education programs that explain their functions and capacity, GEF covered around 6 per cent of the total project cost. This holds true for most of the other projects, where GEF has contributed a nominal part of the project cost, and the rest has been raised through co-financing. It is often argued that GEF only provides for the incremental cost of the project, which can be broadly defined as the cost of additional measures necessary to provide global environmental benefits. However, the methodology for determining incremental cost is very complex and there is much confusion about the procedure of calculating it. Also the GEF procedure of calculating incremental cost is not always transparent. On the evaluation of incremental cost assessment, one of the key findings of applying such a practise to GEF projects is confusion on whether incremental cost is a (primarily qualitative) form of logic or reasoning, or a quantitative, numerical calculation (GEF, 2007). Also, most project documents register low quality and compliance when measured against GEF requirements for incremental cost assessment and reporting. The G77 and China proposal on innovative financing mechanism have clearly pointed out as to how the co-financing requirements are making it burdensome to obtain funds through the GEF.

Table 4.2 Total disbursement of GEF on climate change projects (country-wise)

	No of approved national projects on climate change	Total GEF grant (in US$)	% of funds utilised for clean technologies
India	44	305722257	16.54
China	82	741655729	10.32
Indonesia	28	111800042	21.74
Malaysia	12	36991550	13.06
Thailand	11	30136590	0.00

Source: Adapted from GEF (http://www.gefonline.org/Country/CountryProfile.cfm)

A mechanism for funding technology transfer under the Convention has not yet been implemented; however, at the fourteenth session of the COP in Poznan, the GEF announced a USD 50 million strategic programme to scale up funding for technology transfer[31]. By its decision 2/CP.14, the COP requested GEF to promptly initiate and expeditiously facilitate the preparation of projects for approval and implementation under the strategic programme, collaborate with its implementing agencies in order to provide technical support to developing countries in preparing or updating their technology needs assessments, and consider the long-term implementation of the strategic programme.

Although the GEF is supposed to be the key player in providing public financing for the transfer of ESTs to developing countries, its function as a technology transfer mechanism can be improved and strengthened. The gaps identified have been the following.

[31] Document no. FCCC/SBI/2008/16

a. Weak link between GEF project development, TNAs and national communications

To date about 50 TNAs are available at the UNFCCC website. Only a handful of countries have developed project concepts and proposals based on their TNAs, and hardly any of those proposals have been submitted to the GEF for funding. Enabling activities such as national communications are primarily designed to assist countries in fulfilling their requirements under the UNFCCC; they seldom lead to the development of projects. Also the guidelines for preparing TNAs do not cover project development.

b. Lack of adequate reporting

There has been limited reporting by the GEF on its activities on technology transfer. No efforts have been made to draw on the experiences and lessons learnt and to disseminate them. Despite all the financing that the GEF has provided and the results that have been achieved from the completed and ongoing projects, there has been no comprehensive, in-depth analysis of the GEF portfolio from the technology transfer perspective.

c. Limited synergy with the carbon market

The GEF has limited interaction and synergy with the CDM mechanism. Although the mandate and the modality of the GEF and carbon finance are different, there is tremendous potential for synergy between the two mechanisms that needs to be explored.

CDM

The CDM is intended not to promote technology innovation, but the deployment (including international transfer) of existing low-carbon technologies in developing countries. It incentivises the private sector to finance emissions-reduction projects and thereby potentially contributes to the transfer of technologies previously unavailable in developing countries. It is likely that the CDM in its current or a modified form will play an important role in post-Kyoto negotiations because it is able to provide the side-payments necessary to engage developing countries (Frankel, 2007).

The literature on technology transfers through CDM is more recent but it is growing fast. A good review can be found in Schneider et al (2008), with a detailed analysis of the CDM contribution to the alleviation of various barriers to technology transfer. Several papers use a quantitative approach. Based on a sample of 63 registered projects, DeConinck et al. (2007) show that imported technologies originate mostly from the European Union and that the investments from industrialized countries associated with the CDM are small when compared to total foreign direct investments. Seres (2007) and Dechezlepretre et al. (2008) analyze technology transfers, in 2293 projects in the CDM pipeline and 644 registered projects. They find transfers in respectively 39% and 43% of these projects (accounting for 64% and 84% of emission reduction claims). Using regression analysis, both papers find that larger projects and projects with foreign participants involve more technology transfer. The credibility of these studies is questionable as they have treated separate components of technology transfer as pure technology transfer e.g. knowledge transfer, know how experience, turn-key transfer etc.

As far as clean coal, solar and bio-fuels are concerned, the total number of CDM projects registered as on 1 July 2009 is negligible. There are only 32 projects in the pipeline, involving solar technology, accounting for 0.7% of total the projects in pipeline and 0.1% of accumulated CERs till 2012, of which 58% is in India, China and Indonesia. Transport, which is expected to use most of bio-fuels, has only 10 projects (0.2%) in pipeline accounting for 0.2% of accumulated CERs till 2012.

There are many projects planned in India and China using supercritical technology and some of them have also submitted their project design documents (PDD) for CDM status. But these projects face difficulties in terms of proving investments additionality or calculations of GHG reductions[32]. However, China is the largest producers of CERs. As the most important supplier of CERs, both the current status and future development of the CDM market in China are of great interest and have significant potential impact for the international carbon market. Out of the total 2159 projects at the validation stage in the Asia Pacific region, China and India together account for 1757 CDM projects. While China claims more than 60 per cent of CERs till 2012, India's share will be a little above 20 per cent. Though CDM appears to be a success in India and China, not much has been achieved in case of the specific advanced technologies that we are talking about in this study. According to the FICCI climate change report (2008), the limited technology sharing, that has taken place so far in the context of CDM is project specific and does not enhance the technology capacity of the industry as a whole and nor does it lead to broader spillover effects.

Malaysia has reported that the number of CDM applications in the country has increased tremendously since 2002. One of the successful technology transfer can be seen is the collaborations between United Plantations Berhad, Malaysia and Royal Danish Ministry of Foreign Affairs, Denmark on replacing the existing low efficient biomass fired, fire-tube boilers with a more efficient water-tube biomass reciprocating grade boiler in the palm oil mill. Thailand has a very small number of CDM projects comparing its potential. There are numbers of issues that hold back CDM in Thailand, At the international level, complicated procedure, time-

[32] For example see the objections on Sasan Power Project in India at <http://cdm.unfccc.int/Projects/Validation/DB/JB9AVH5IAWF0MDFULY3P4678XR05JN/view.html>

consuming processes and high investment cost (may not be financially feasible for small projects) discouraged interested parties to apply for CDM projects. At the national level, knowledge and understanding the concept and applicability of CDM is still limited, and have thus resulted in delayed implementation of CDM projects.

The potential of mechanisms like CDM in promoting penetration of cleaner technologies is evident. However, in certain cases, particularly in the instances of dispersed end-users, CDM is inadequately designed. As a financing mechanism, CDM is also limited by its dependence on issued CERs and their prices that too realizes only after the project becomes operational while the main financing obstacle for many energy efficiency and renewable energy projects remains the high upfront cost. Since the consumption of solar energy and bio-fuels is largely dispersed, where the revenues generated through the sale of CERs, particularly with low carbon prices, is not adequate to compensate for the high upfront costs. Also, since bio-fuel blending is required as per regulations in many countries, it does not satisfy the additionality criteria[33] of a CDM project. Therefore, it is suggested that following provisions should be incorporated in functioning of CDM in order for it to become a proactive mechanism:

- An internationally agreed higher floor price of CERs
- A fast track clearing mechanism for projects which are certain to reduce emissions.
- In cases where emission reduction promises are high but technologies are not fully developed, such as bio-fuels, relaxation in additionality clause is required.
- In cases where end-users are dispersed, a clear methodology to group the emission reduction achieved at one transaction point. For instance, in case of bio-fuels, the manufacturer may be awarded CERs for producing bio-fuels. This will also make bio-fuels more competitive with petrol and diesel, and promote R&D in second generation bio-fuels technology.
- Programmatic CDM should be proactively encouraged. It may be considered to have a relaxed set of conditions for programmatic CDM projects so that the transaction costs can be minimized.
- CDM may also be linked with other financing mechanism such as GEF, proposed technology transfer funds under UNFCCC (particularly the G77 proposal on technology transfer and development). The projects which require additional funding but the additional costs cannot be met through CER revenues, may be given preference in providing financial support by other

[33] Technically speaking a CDM project is additional if "anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the registered CDM project activity." However, if the developer has to undertake the project activity because of any law, such a project is generally not eligible for CDM benefits

international mechanisms. To begin with, certain types of projects or technologies can be identified where the funding under GEF's operation-5 (OP 5)and operation-6 (OP 6), targeting removal of barriers to energy efficiency and renewable energy adoption respectively can be linked with CDM.

Sources outside the convention

From table 4.1, it is seen that as far as sources outside the convention is concerned, the financing support for deployment and diffusion of mitigation technologies in developing countries per year is less than USD 1 billion for ECAs, USD 1 to 2 billion each for bilateral ODA and philanthropic sources, USD 1 to 3 billion for multilateral ODA, and almost USD 1.5 to 4 billion for FDI, thus giving a total of around 8-12 USD billion per year. No information is available on the share of this amount that supports technology transfer, but it is likely to be small. New venture capital (VC) funds, entirely focused on ESTs, are expanding rapidly throughout the world. Venture capital is a type of private equity capital typically provided to early-stage, high-potential, growth companies in the interest of generating a return through an eventual realization event such as an IPO (initial public offering) or trade sale of the company. While it is recognized that VC funds cannot supply all the ESTs that will be needed by developing countries, these funds utilize a variety of innovative financial instruments. Data in table 4.3 shows a mix of different types of investments across the financing spectrum, from R&D funding and venture capital for early-stage companies to public market financing for projects and mature companies, and asset financing for increasing installed generation capacity.

Table 4.3 Global new investment in clean energy, 2004–2007 (billions of US dollars)

Year	VC/PE	Public markets	Government/corporate R&D & demonstration	Asset finance	Small scale project[a]
2004	1.7	0.7	10.3	12.4	8.2
2005	3.0	4.1	12.3	27.5	11.6
2006	7.3	10.5	14.3	48.0	12.5
2007	9.8	23.4	16.9	79.2[b]	19.0

Source UNFCCC, 2008b

VC- venture capital; PE- private equity

[a] Small-scale projects relate mainly to financing of distributed or off-grid installations such as solar water heaters, biogas digesters, and micro wind turbines.

[b] This figure differs from the estimate of "asset financing" in 2007 of USD 84.5 billion as it has been adjusted to exclude USD 5.7 billion of asset refinancing

Venture capital and private equity investments, which support technologies at the deployment and diffusion stages, amounted to almost USD 10 billion in 2007. A major share of this funding was for solar technologies. Asset financing accounts for most of the investment in clean energy, reaching USD 79.2 billion in 2007, largely composed of investments in wind power and bio-fuels. Investment raised through public markets has become the second largest component (USD 23.4 billion in 2007). This form of finance, which is mainly raised from the sale of shares, is used for technologies for which there is a growing market. Small-scale projects are the third largest component reaching almost USD 20 billion in 2007.

Although private investment in clean energy is only a small part of total private investment, it is growing rapidly and already contributes a reasonable share of total energy infrastructure investment (UNFCCC, 2008b). Projecting the additional capital costs for technology development, the IEA in its Energy Technology Perspectives (2008) report investment needs in the diffusion phase of up to USD 1,100 billion annually, as an average over the years 2010–2050. For diffusion in developing countries, USD 660 per year would be required based on an investment share of 60 per cent for developing countries and 40 per cent for developed countries. Furthermore, the IEA estimates that USD 100–200 billion per year is required globally in early deployment costs, 60 per cent of which would be required in developing countries. In summary, the additional financing needs for climate change mitigation technologies span a range of USD 262–670 billion per year. This suggests future financing three to four times greater than the current level. Of this increase, 40–60 per cent, or an additional USD 105–402 billion per year, is projected to be needed in the developing countries.

Key country positions on financial provisions

A number of innovative financing proposals have been advanced by various countries (or groups of countries) in the climate change negotiations to address financing gaps for mitigation and adaptation. These are summarized in table 3 in the annexure. It is to be remembered that a combination of commercial and concessional flows will only leverage the scale of operation to address the climate change challenge. A number of proposals call for the establishment of global technology funds. The main differences are in the methods of financing and replenishing such funds and also in the methods of governance. Most of the developing countries have advocated a new technology fund under the Convention, which should focus only on financing technology development and transfer initiatives under a post-2012 agreement. The proposals often incorporate specific funds and financing instruments including a renewable energy technology fund; an international public venture capital fund; an international public equity fund and investment risk mitigation incentives for emerging technologies and markets.

The specific recommendations that have come from the select partner countries are as follows

China

Technology transfer and the provisions of financial support and capacity building by developed country Parties for national mitigation actions in developing country Parties shall be measurable, reportable and verifiable, and be new and additional to ODA. The basic idea of the financial mechanism supporting of ESTs is to develop public private partnership by linking public finance with carbon market, capital market and technology market and, leveraging larger amount of private finance. A Multilateral Technology Acquisition Fund (MTAF) shall be established with sources mainly from public finance from developed countries. The sources for the MTAF may be from parts of the regular fiscal budget for R&D, fiscal revenues from taxation on carbon transaction and/or auction of emission permit in carbon market, as well as fiscal revenues from energy or environmental taxation. China is also in favour of bilateral or multi-literal collaboration for technology development and transfer. Joint research on technology R&D is an important factor for technology development and transfer for climate change collaboration.

India

The Multilateral Climate Technology Fund (MCTF) should provide technology-related financial requirements as determined by the Executive Body on technology. The fund will operate under the COP, as part of the enhanced multilateral financial mechanism. The Executive Body on Technology should be established as a subsidiary body of the Convention in accordance with Article 7(2)(i) to enable implementing the Convention by enhancing action on technology development and transfer to support both mitigation and adaptation. There should be a Verification Group to verify the financial and technological contributions made to the mechanism in accordance with the overall “measurable, reportable, verifiable” requirement of Decision 1/CP.13. A Technology Action Plan shall serve as the starting point for the work of the executive body. The Action Plan shall support all stages of the technology cycle, including research, development, diffusion, establishment of national and regional technology excellence centers as well as issues related to patented technologies.

Indonesia

TNA should become a priority in the working program and there should be greater synergy of GEF with the market-based flexibility mechanisms such as the CDM under the Kyoto Protocol. Indonesia also feels that a whole lot of demonstration projects need to be arranged and that there should be a clear link between the technology providers and the demander to mobilize the potential funds available word-wide.

Malaysia and Thailand

As far as Malaysia and Thailand are concerned, their views on the financial mechanism is very open. The desired level of international funding is not coming and as such private funds and domestic R&D grants needs to be mobilized for this. In Malaysia, since most research is done in public universities, there is ample research funding internally given by the government. With respect to research companies or industries looking for funding, they have access to funds called Technofund given by the government. Malaysia also states that the limited absorptive capacity and the lack of quality research is one of the prime reasons that explains why international research funds are not forthoming This is particularly true in the green technology area.

Finally, it can be said that although the Convention is silent on the appropriate choice of an institution to manage the funds made available, it is quite clear in stating under Article 11.1 that the proposed financial mechanism "shall function under the guidance of and be accountable to the Conference of the Parties, which shall decide on its policies, programme priorities and eligibility criteria". Article 11.2 further states that the "financial mechanism shall have an equitable and balanced representation of all Parties within a transparent system of governance". An Executive Board, with an equitable and balanced representation of all Parties, appointed by COP must manage the proposed financial architecture. According to the view of the Indian government *"Direct access to funding by the developing country parties and their involvement in every stage of the process, through the COP, will make the architecture demand driven*[34].

Key observations and conclusion

In this chapter, we have studied the existing financial mechanisms and tried to analyse the adequacy of such resources in facilitating technology transfer. The key observations are as follows

- UNFCCC reports that while research, development, deployment and diffusion of climate relevant technologies are funded mainly by the private sector; most of the remaining funding comes from national governments, and international public funding covers a nominal share of the total.
- According to GEF records, it has supported more than 30 technologies in the years of its existence and more of its focus has been on mitigation technologies. However, in terms of the 3

[34] Government of India submission on 'Financing Architecture for Meeting Financial Commitments under the UNFCCC

specific mitigation technologies covered in the study, GEF has supported very little. Results show that out of the total GEF grants to the countries, a mere 16 percent was devoted towards clean technologies for India, 10 per cent for China, about 22 percent for Indonesia, 13 percent for Malaysia and none for Thailand. A chunk of this has been devoted towards renewable energy development. Some of the gaps that were highlighted are the weak link between GEF project development and the TNA studies; lack of adequate reporting by GEF on technology transfer projects and its limited interaction with the CDM mechanism.

- CDM is the presently the only market based mechanism which is intended to promote deployment and international transfer of existing low-carbon technologies. As far as clean coal, solar and bio-fuels are concerned, the total number of CDM projects registered as on 1 July 2009 is negligible. There are only 32 projects in the pipeline, involving solar technology, accounting for 0.7% of total the projects in pipeline and 0.1% of accumulated CERs till 2012, of which 58% is in India, China and Indonesia. By looking at the number of projects at the validation stage, it seems that CDM is a success in India and China, but not much has been achieved in case of the specific advanced technologies that we are talking about in this study. As a financing mechanism, CDM is also limited by its dependence on the low carbon prices that too realizes only after the project becomes operational while the main financing obstacle for many of these advanced EST projects remains the high upfront cost.
- Sources outside the convention include ODA, FDI, venture capital, commercial loans, and ECAs. However, none of these financial flows provides a direct measure of technology transfer. Most of these financial flows support private-sector technology transfer. However, UNFCCC reports that private investment in clean energy is growing rapidly and contributes a reasonable share of total energy infrastructure investment.
- Most of the developing countries have advocated a new technology fund under the Convention, which should focus only on financing technology development and transfer initiatives under a post-2012 agreement.

In light of the above discussion it is evident that the existing financial mechanisms are inadequate to mobilize resources and effecting technology transfer on the scale required to address the climate change challenge. There are indications that technology transfer in CDM projects is well correlated with GDP growth and, in key sectors such as energy and chemicals, with the presence of strong technological capabilities (Dechezlepretre et al. 2008). These findings suggest that technology transfer will be more successful in countries that already have a relatively-high technological base. The clearly undermines the special needs of the developing countries in terms of their access to the appropriate technologies for mitigating climate change.

In order to overcome barriers to technology transfer and fill the gaps between the needs for such technologies and the degree to which these technologies are adopted in developing countries, it is important to consider the enhancement or scaling up of existing mechanisms and also creating new mechanisms. For instance, the proposal by the G-77 and China on a multilateral technology fund is an institutional mechanism designed to address all aspects of cooperation on technology research, development, diffusion and transfer in accordance with Articles 4.1(c), 4.3, 4.5 and other relevant articles of the Convention. This new technology mechanism is expected to operate under the guidance and authority of the COP. This fund should also take care of issues like technical expertise, know how in recipient country and the enabling environment factors, cost of technology transfer, including licence costs and deployment costs. Such a fund could be managed by a multilateral organization or a trust, which serves to acquire or buy out patented technologies that are climate friendly and make them available to developing countries on a priority basis. Other modalities including terms and conditions of management, compensation to IP holders, nature or domain of acquired technology would have to be worked out within this mechanism.

It is perhaps also worth considering the setting up of a publicly funded global venture capital fund, which would aim at promoting collaborative R&D in the commercialization of clean technologies.

Finally it is very important to introduce the MRV (measurable verifiable and reportable) indicators to track the flow of climate friendly technologies. Unless the provisions of support in terms of technology transfer, financing and capacity building by developed country Parties to developing countries are measured, reported and verified in a proper manner, it will be very difficult for the developing countries to defend their situation in terms of their technology and financial needs.

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Annexure

Table 1: Annex I and Annex II submissions on technology transfer

	Annex I	Non Annex I
General principles to foster technology transfer and development	Stimulate formation and development of national and international innovation systems and markets for technologies and create investment and enabling environments and engage the private sector (EC) Improve trade and investment flows and use markets (Australia, Canada, Misc. 5) Create effective domestic environments for innovation and dissemination of ESTs (US)	Address all stages of technology development cycle, namely, R&D, demonstration, deployment & diffusion (Brazil, G 77, China) Focus on issues and areas where they make a real impact on overall technology challenges (Rwanda, Brazil, China, G77, Misc. 1) Accessibility, affordability, appropriateness and adaptability of technologies required by developing countries (G 77, China, Misc. 5)
Intellectual Property rights	Strengthen legal and economic institutions to promote the protection and enforcement of IPR, promote competitive and open markets (US) IP licensing models to improve IP protection & reduce project development costs (Australia, Misc. 5) Examine benefits of innovation protection systems & how joint R&D could instill IPR & bring co-benefits such as endogenous technology (Canada, Misc.1)	Mechanisms to promote actions leading to technology development, deployment, diffusion and transfer taking into account intellectual property issues (Argentina) Suitable IPR, regime for accessing technologies owned by private sector in developed countries (India) IPR sharing arrangement for joint development of ESTs (China) Joint patent/ technology pools for technologies at low cost and incentives for owner of technology for differential pricing (China, Pakistan, Bolivia, India, Misc. 5) New approaches that combine IPR protection and facilitate technology sharing, drawing examples from public health (Brazil, Misc. 5) Government licensing of public funded technologies that offer global benefits (Indonesia, Korea) Expansion of public domain for publicly funded technologies and exemptions for climate friendly technologies (Bolivia, Misc. 5)

Source: adapted from UNFCCC/AWGLCA/2008/16/Rev.1* dated January 15th 2009

Table 2. GEF project details

	Projects	Project description	Project duration / implementation	GEF grant (in US$)	Total project cost (in US$)	GEF grant as a % of total project cost
India	Alternate energy	The project promotes and commercializes investment in wind farms and solar photovoltaic power systems through the provision of below-market loans to investors in these systems, primarily from the private sector. Popularizes renewable technologies through public education programs that explain their functions and capacity.	1992-2000	26,000,000	450,000,000	5.78
	Coal Bed Methane Capture and Commercial Utilization	The objectives of this project are to control greenhouse gas emissions and demonstrate the economic viability of harnessing coalbed methane, an important greenhouse gas, in the Indian coal mining sector. The full project is intended to build national capacity in the field of coalbed methane recovery and utilisation	Under implementation. Approval date- 5 June,1998	9,190,000	19,037,000	48.27
	Development of High Rate BioMethanation Processes as Means of Reducing Greenhouse Gas Emissions	Project develops national master plan for generation and utilization of bioenergy, creates commercially viable packages for replication, and promotes and disseminates technology for high-rate biomethanation. Project will introduce, demonstrate, and standardize a wide variety of cost-effective technologies.	1994-2000	5,500,000	10,000,000	55.00
	Biomass energy for rural India	This project aims at developing and implementing a bioenergy technology package to reduce GHG emissions by up to 177 tons of C over the next 25 years, and to promote a sustainable and participatory approach to meeting rural energy needs.	Under implementation. Approval date- 8 May, 2001	4,213,000	8,819,000	47.77
	Removal of Barriers to Biomass Power Generation, Part I	The project aims to increase the use of biomass energy sources for generating electricity for own consumption and export to the grid. It will promote combustion, gasification and cogeneration technologies using different types of captive and distributed biomass resources for electricity generation	Under implementation. Approval date - September 22, 2006	5,650,000	39,150,000	14.43

	Projects	Project description	Project duration / implementation	GEF grant (in US$)	Total project cost (in US$)	GEF grant as a % of total project cost
China	Renewable energy development	The project intends to reduce China's heavy reliance on coal and supply electricity to rural households and institutions that otherwise would not have access to modern energy. The Project will support: (a) installation of windfarms (190 MW at 5 sites); (b) supply of about 200,000 photovoltaic (PV) and PV/wind hybrid systems to households and institutions in remote areas of four Northwestern provinces; (c) technology innovation to reduce cost and improve performance of windfarm and solar PV technologies in China; and (d) strengthening of institutional capacity and market infrastructure for large-scale commercializa-tion of windfarms and solar PV.	Under implementation. Approval date-June 8, 1999	35,000,000	408,000,000	8.58
	Renewable Energy Scale Up Program (CRESP), Phase 1	The main global benefits of the project are (a) the removal of multiple barriers to the introduction of cost-effective renewables in China; (b) the reduction in cost and improvement in performance of small hydro, wind and selected biomass technologies; and (c) an increased market penetration of renewables in China and consequent reduction in greenhouse gas emissions from power generation.	2005-2010	41,570,000	230,170,000	18.06
Indonesia	Solar system homes	The project will catalyze market acceptance of Solar PV Home Systems within the framework of a least-cost rural electrification strategy, relying on private sector delivery/installation systems. The project will support the installation of about 200,000 such systems in up to 4 regional markets	1997-2003	24,300,000	118,100,000	20.58
Malaysia	Building Integrated Photovoltaic (BIPV) Technology Application	Promote building integrated PV (BIPV) applications for new and existing buildings, integrated with building design and energy efficiency. Includes targeted research, capacity building for local manufacturers and architect/engineers, regulatory frameworks, and pilot demonstrations. It dels with both technology innovation and market.	Under implementation. Approval date - May 21, 2004	4,829,420	25,089,160	19.25

Source Adapted from GEF ((http://www.gefonline.org/Country/CountryProfile.cfm)

Table 3. Proposals for funding mechanisms under the UNFCCC for enhancing technology development and transfer (June 2009)

Proposal	Financial means	Parties	Detailed proposal
Streamline existing funding mechanisms	Not applicable	Several	FCCC/AWGLCA/2008/MISC.2 and FCCC/AWGLCA/2008/CRP.2
Scale up support for existing mechanisms	Voluntary contributions from Annex II Parties	EC	To be considered as part of review of the financial mechanism of the Convention
Convention adaptation fund	Not specified	Alliance of Small Island States (AOSIS),China	Dialogue working paper 14 (2007)
Renewable energy technology fund	Not specified	AOSIS	Dialogue working paper 14 (2007)
World climate change fund – mitigation, adaptation, technology cooperation	Through financial contributions from developed and developing countries based on a formula (emissions, population, GDP)	Mexico	FCCC/AWGLCA/2008/MISC.2
Multilateral technology acquisition/cooperation fund under the Convention: • Disseminate existing technologies; • Purchase licences of patented technologies; • Provide incentives to the private sector; • Support international cooperation on research and development; • Support venture capital based on a public–private partnership; Remove barriers	Percentage of GDP from developed countries in addition to ODA	Brazil, China, Ghana, Mexico	http://unfccc.metafusion.com/kongresse/SB28/downl/080603_SB28_China.pdf
Create new financial architecture under the Convention with funds for technology acquisition, technology transfer, venture capital for emerging technologies, and collaborative climate research fund	Not specified	India	Not available
Establish a multilateral fund to provide positive incentives to scale up development and transfer of technology and support innovating funding and incentives to reward development and transfer of technology	Not specified	Summary from the AWG-LCA Chair	FCCC/AWGLCA/2008/CRP.2

Source: UNFCCC (2009), "Recommendations on future financing options for enhancing the development, deployment, diffusion and transfer of technologies under the Convention". Report by the Chair of the Expert Group on Technology Transfer. FCCC/SB/2009/2, 26 May 2009