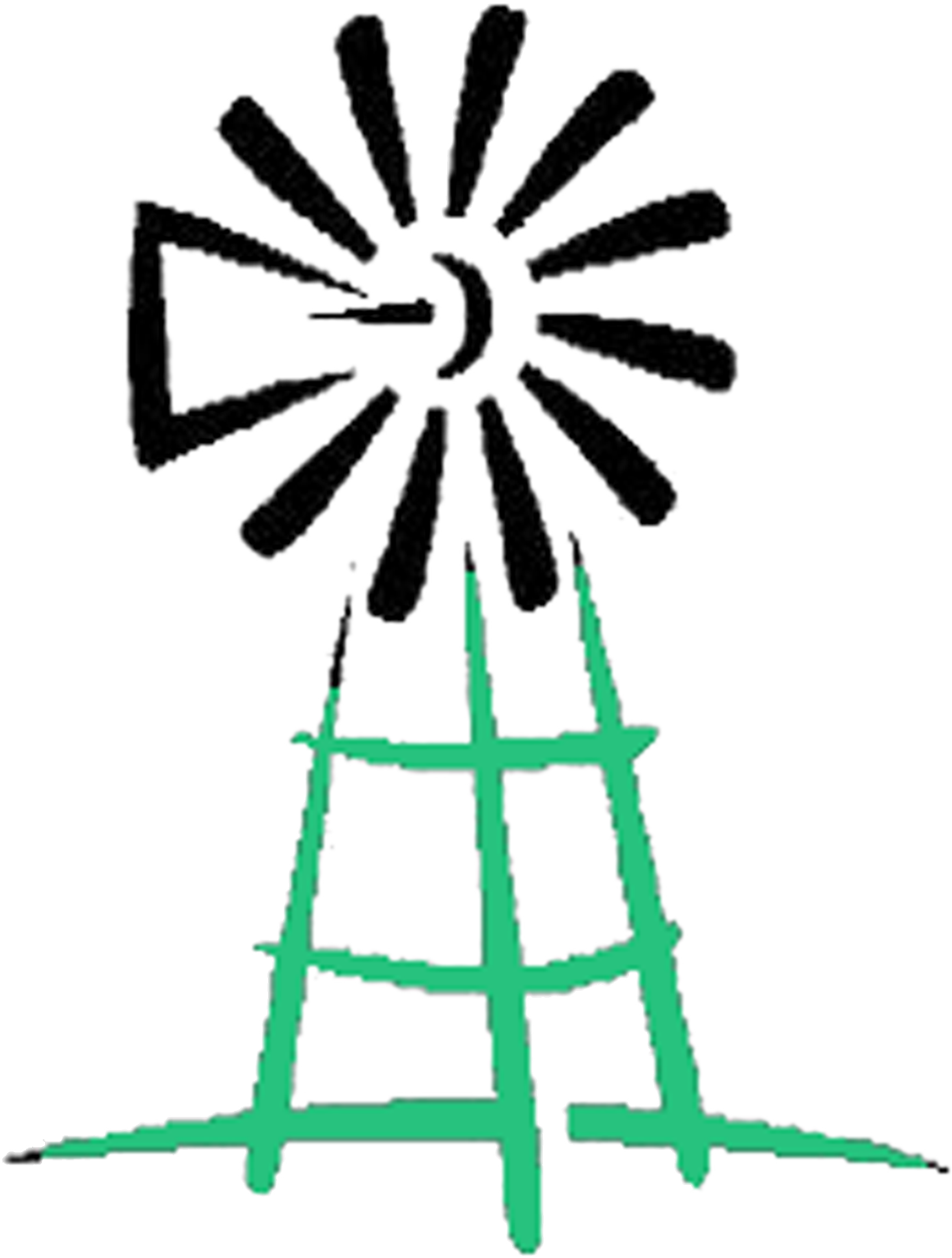

Climate Change and Challenges of Clean Technology Deployment in India's Power Sector

December 2010

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The information contained herein has been obtained from interviews and other secondary sources and are to the best of our knowledge accurate. The opinions expressed herein do not necessarily reflect the views of WWF India and ActionAid. Despite all precautions taken to accurately reflect the information that was gathered for this report, any errors pointed out subsequently by any party cannot lead to any liability on part of the researchers or project partners.

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Contents

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CLIMATE CHANGE is one of the greatest challenges facing humanity and how we choose to respond will to a large extent determine the quality of life for billions in the coming decades. The electricity generation sector in emerging economies like India has a major role to play in enabling a high-growth future – since technology and its transfer is crucial to delivering this economic and social development in a carbon-constrained world, this study has a special significance.

We are grateful to ActionAid India and WWF India for providing the financial support for this study. We believe that civil society and the private sector can play complementary roles to ensure a just and equitable world and we hope this study will further efforts to develop deep and productive engagements between these two sectors.

The content of the report captures the wisdom of many thought leaders and experts from companies, civil society and government who generously shared their time, insights and experiences. Any errors and omissions are ours.

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EXECUTIVE SUMMARY

CLIMATE CHANGE imperatives require developing countries to pursue a completely untested low-carbon path to achieve their development goals. For them to succeed, technology has to play a significant role. Access to low-carbon technology is seen as one of the ways to fulfil the obligations of the developed countries. The developed countries have been responsible for 77 percent of the total cumulative emissions to date. Therefore, as part of the equitable burden sharing efforts by the developed and developing countries, many of the technologies which are owned by the developed world have to be transferred, quickly at an affordable price.

This will inevitably lead to a whole set of challenges as public and private interests conflict. Identifying what these challenges and barriers are – including the issue of intellectual property rights (IPRs) and how these may be addressed – is the focus of this study. To ensure that the recommendations are actionable, the report concentrates on a single critical sector – power generation – and the research methodology centres around interviews with a range of experts to provide the "reality check" to what secondary information sources – few of which were India-focused – were saying on the issue.

India faces significant social and economic development challenges, and providing access to energy and long-term energy security is of paramount importance to enable it to attain its development goals. At the same time, India also needs to provide opportunities through its diverse set of entrepreneurs to develop and propagate solutions which are low carbon in nature to meet them. Therefore, access to technology and knowledge that is currently in the domain of the developed countries becomes extremely critical.

Technology transfer typically refers to a spectrum of activities. At one end is the import, usually of equipment, by developing countries while at the other end are local firms and institutions innovating through their own R&D. Most consider the process as complete only when the latter happens, but practice shows this is rare and takes a very long time. The challenge therefore is to not only reach the last stage but to do it quickly. This process is governed by international agreements and local laws which attempt to protect both the developer of the technology and its beneficiaries. Currently, the ***product*** of the inventors are protected by a patent for a fixed period of time during which he has they have a monopoly over it and the role of the state in technology transfer has reduced from an actor to a facilitator.

Challenges to technology transfer are several and have been grouped into the following four categories for the purpose of this study:

- **Access**, covering availability of these technologies for transfer and the conditions or restrictions that come with this transfer;
- **Local capability**, dealing with the availability of infrastructure, capacity and skills to absorb the technology and subsequently to build on it;
- **Trade and policy**, which is about the legal and policy frameworks relating to IPR protection, acquisition and deployment of technology;
- **Financial and market**, covering all relevant aspects that make such transfers practicable and financially viable.

The headline conclusions were as follows:

Access challenges

- **Technologies are available and there is a willingness to transfer.** Historically, India has always had access to technologies. Hence, there is unlikely to be a physical barrier to transfer of climate change technologies, especially since India's huge and increasingly open market makes it attractive to investors and technology suppliers.
- **Conditions for transfer are a matter of market conditions and negotiating skills.** The route taken by technology transfer – licensing on the one hand and setting up a wholly-owned subsidiary on the other – and the conditions of transfer depend upon global and local market conditions. An important market condition is the competitive landscape though the market for technology in the power sector has always remained competitive.

Local capability challenges

- **Indian capability to absorb and build on technology is not being doubted.** The recent spate of joint ventures in the supercritical thermal power space is evidence enough that India has the capability to absorb, develop and deploy sophisticated power technologies of the present and future.

Trade and policy challenges

- **Fair and equitable policies that facilitate trade in power equipment are important.** Low trade barriers, especially for low-carbon power generation technologies, and balanced and fair IPR protection are critical to boost demand and hence stimulate innovation. This study identifies some policy anomalies that need to be addressed as well as the need to ensure that responses to financial and climate crises do not result in protectionism, especially by the developed world.
- **Low and zero-carbon technologies require strong policy support to deliver value.** Expectedly, there are a whole slew of low-carbon power technologies that are at various stages of development and deployment but costs of deployment and use are high. If they are to realise their potential of "carbon and cost win-win", then scale, innovation and risk mitigation are critical. Public policies – within India and globally – have a crucial role to play.

Finance and market challenges

- **Availability and cost of finance is crucial for development, commercialisation and deployment of new technologies.** Adequate and patient funds at a cost that keeps the final cost of new technology at a reasonable level are crucial at all stages: development, commercialisation and deployment of clean technology. Many experts share the belief that the current global financial crisis has hit the renewable energy sector hardest.
- **Availability and cost of finance is crucial for transferring developed low-carbon technologies from anywhere in the world.** Given the high initial cost of low-carbon technologies and the long pay-back periods involved, availability and cost of finance is critical to procure the best available technologies. Alternative sources of funds are essential to make it more attractive to commercial interests.
- **IPR does increase costs of technology but the impact is hard to assess.** Few doubted that IPR increases the costs of technology but it was very difficult to assess the actual impact. Crucially, none of the companies surveyed reported that the IPR prices were so high as to undermine their economic viability and one reason was the availability of alternatives i.e. competition.

The study clearly shows that competition amongst suppliers is the most effective way of ensuring access to technology at reasonable prices. To achieve this, a combination of policy interventions, market forces and availability of finance is required. The following steps are recommended to enable this:

- **Increase domestic demand for clean technologies through policy interventions.** High demand for appropriate technologies leads to a virtuous cycle of reducing costs, stimulating innovation and keeping global technology suppliers ready and willing to transfer technology. For this to happen, public policy is crucial to overcome the initial financial hump. The building blocks of such policy signals are the setting of long-term and ambitious targets and strategies; feed-in tariffs that incentivise capacity expansion and performance; binding obligations on the proportion of low-carbon technologies in the power mix: and favouring energy efficient and low emission technology.
- **Increase access to global markets.** Establishing an equitable trading system that ensures access to clean technologies, especially renewables, will also contribute to this virtuous cycle. International negotiations must resist attempts at protectionism, especially by the developed world, in line with global covenants.
- **Increase supply of clean technologies.** Experience has shown that increased competition or availability of clean technology is crucial to enable its free transfer at reasonable prices and minimising the impact of IPR premiums. While demand provides an important signal to innovate and increase supply, it is not sufficient. Fiscal incentives like capital subsidies and tax breaks encourage innovation in development, manufacturing and deployment. Availability of public funds for technology development and commercialisation (along with setting up of long-term goals and strategies by governments) is important in itself and because it helps leverage private investment in this high-risk space. The setting up of publicly-supported global, regional and national innovation centres that bring together the best minds from across the world – designers, developers, manufacturers and investors – will also play a key role.
- **Facilitating technology cooperation.** While the supply of clean technologies catches up with demand, it would be important to create an enabling framework for technology cooperation, ensuring that technology is shared and deployed from the developed world (which currently owns most of the advanced technologies) to developing countries like India at prices that enable these countries to meet their development goals. A global fund, equitably managed and governed, has been mooted and this fund would be crucial both to cover high licensing costs of technologies as well as setting up of the global innovation centres. Using flexibilities under TRIPS (Trade Related Property rights System) – such as compulsory licensing, exceptions to patent rights etc. – is also possible, but this study indicated that the trajectory of technology development and demand may make this unnecessary ■

Notes:

1 It may be noted that there are subsidies – overt and hidden – associated with conventional power sector that keep their costs artificially low.

2 It is not surprising that industries view competitiveness as the driver for accessing and lowering the cost of low-carbon technology and does not view IPR as a major challenge. However, from a regulatory perspective, given past and current experiences of reluctance to create an unimpeded framework for technology cooperation, IPR remains a challenge.

1 INTRODUCTION

1.1 Context

The United Nations Framework Convention on Climate Change (UNFCCC)[3], the Kyoto Protocol, the Bali Action Plan (BAP) and more recently the Copenhagen Accord, all envisage enhanced long-term global cooperation on issues of reducing greenhouse gas emissions – Mitigation – and increasing capacity to meet the consequences of climate change that are already unavoidable – Adaptation. To meet these objectives, financial and technical support to developing countries is important.\

As a follow-up to the BAP, several countries submitted proposals on technology transfer for discussion at the UN Climate Conference held at Poznan, Poland in December, 2008 and a major point of debate was Intellectual Property Rights (IPR). Developing countries in general felt that IPR was a major barrier to transfer of technology, a position which was contested by developed countries.

1.2 Why technology transfer is important to climate change

As developing countries pursue their own development agendas to bring prosperity to their people, it is clear that following the same path used by the developed economies will inevitably conflict with the low-carbon path that the world will have to pursue for its own survival. For instance, India will have to invest heavily in infrastructure like power generation and provide them at a price that its people can afford; however, the currently available technologies will inevitably either lead to huge carbon emissions (if the fossil fuel route is followed, resulting in carbon lock-in) or high up front costs of renewable electricity (especially if solar-PV or concentrated solar thermal or offshore wind is the technology of choice), neither of which is acceptable.

So, how do we break this logjam? Technology is believed to hold the key to a high-growth, low-carbon future. However, with many of the climate-friendly technologies believed to be owned by companies in the developed countries, the availability of these technologies to the developing world is critical if they are to make the necessary changes in the modes of production. Therefore, unimpeded transfer and absorption of low-carbon technologies to the developing country economies will be the key to attain low-carbon or even zero-carbon trajectories[4].

1.3 Need for the study

If rapid technology transfer to the developing world is important to address climate change, what are the challenges to be addressed to ensure that this happens? There are some concerns that IPR could be a challenge but there appears to be little empirical evidence – at least from India – to support this position or indicate how important it is.

Given India's diversified economy, industrial and research capabilities and its growth trajectory, identifying the challenges to technology transfer with a specific focus on IPR would provide interesting points of learning and inputs to the process.

1.4 Methodology

The key research question that this study addresses is: What are the challenges to transferring climate change related technologies to India in the power sector? A sub-question that arises from this was: How much of a barrier is IPR to technology transfer? In order to answer these questions, evidence was gathered from a range of sources on:

- What are the technology gaps as seen in India?
- Where do these technologies reside – countries, companies?
- What are the various challenges in transferring these technologies?
- How significant a challenge is IPR?
- What would be the enablers – policy, regulatory, financial etc. – to faster and better transfer of technologies?

The study is based on information gathered from both primary and secondary sources. A range of secondary sources like research reports, submissions to the UNFCCC and so on have been drawn upon. A key source of information was interviews with five policy and technical experts and senior executives from ten companies – equipment manufacturers in India and overseas, as well as domestic power utility companies. Many of the respondents shared their thoughts, opinions and data in confidence and so not everything could be attributed to specific sources.

1.5 Note for readers

It may be noted that the study focused on getting perspectives of actual users and providers of power sector technology i.e. Indian industry and select global equipment manufacturers on the challenges to technology transfer and cooperation. Industry experiences of the challenges relating to deployment of new and emerging technologies is limited; hence the perspectives presented here also draw upon experiences gained through deployment of existing technologies.

The report does not reflect the experience of the developing countries as a whole on technology deployment and diffusion which has not been positive. Further, this study was designed as an input to policy makers and negotiators and hence does not reflect their views and concerns.

The interviews were all conducted in the third quarter of 2009. Developments subsequent to this that might have a bearing on the funding have been factored in to the extent possible ■

Notes:

[3] In the Convention itself, Article 4 addresses technology development, cooperation and diffusion between the developed and the developing countries. Article 3 of the Kyoto Protocol and Paragraph 11 of the Copenhagen Accord both address technology cooperation through a technology mechanism.

[4] Ockwell,D (2008):Intellectual Property Rights and Low Carbon Technology Transfer to Developing Countries—a Review of Evidence to Date,Sussex Energy Group,TERI,IDS

2 TECHNOLOGY TRANSFER FRAMEWORKS AND CLIMATE CHANGE

International forums have recognised the need for frameworks governing technology transfer especially to the developing countries, since the early 1960s. Over eighty international instruments and numerous sub-regional and bilateral agreements contain measures related to transfer of technology and capacity building has been promoted since the 1960s. The set of technology-related arrangements within the purview of the UN system has been categorized by UNCTAD into (a) legally binding arrangements and (b) non-legally binding ones. The various regional level agreements are also part of these broad divisions.

2.1 Stages of technology transfer

A sustainable model of technology transfer requires the receivers of technologies (in this case, the developing countries) to undergo three stages based on the learning-by-doing model[5]:

- Initiation stage, essentially means technology is being imported;
- Internalization stage; local firms learn through imitation under flexible Intellectual Property Rights (IPR) regime;
- Generation stage, wherein local firms and institutions innovate through their own R&D.

Technology transfer as espoused in the literature, and borne out in practice, necessarily means climbing up the ladder through all the stages mentioned above.

However, to date the most prominent type of technology transfer has been in the form of import of capital goods and equipment[6]. A study by Evans[7] has shown that eighty percent of the aid to China's energy sector was focused on funding construction of new thermal and hydro power plants, wherein the aid was in the form of finance directed to importing the technology. Developing countries predominantly receive plant and equipment from their developed counterparts on a "turnkey" or "product in hand" basis and the terms and conditions of such transfers often tend to be so restrictive that there is little scope of fostering innovation further in the developing countries[8].

2.2 International agreements on technology transfer

The interesting journey of technology transfer agreements began with the Paris Convention (1883), which established the underpinnings of technology transfer and securing the intellectual property through the provisions of patents on the process. This allowed developing countries to adopt, adapt, and modify the technologies required for the customized needs of the countries without violating the ownership criterion of the technology developer. This protocol held till the product-based patent system came into force during the 1990s through Trade Related Intellectual Property Rights System, or TRIPS (1995). Between the Paris Convention and TRIPS, a series of developments took place and the regulations on protection of IPR became stricter in favour of the technology developer. The technology transfer debate centred on a very basic principle, i.e. technology as an economic agent and hence the classification of technology as a private or a public good, which shaped the policy regime and the agreements that were put in force.

During the 1970s and 1980s, the State played a central role in technology transfer agreements through direct intervention, and not as merely a facilitator. In almost all the major international treaties – the Berne Convention (1971), the Law of the Sea (1981), and the Vienna Convention of the Ozone Layer (1985) – the State identified the need for developing the capabilities and know-how on one hand as well as the need for physical transfer on the other.

In many ways, the Montreal Protocol (1987) signalled an important landmark in such frameworks in that the developing countries (other than the Least Developed Countries, or LDCs) were given a special status regarding the technology transfer arrangements[9]. Furthermore, the Montreal Protocol was the first to identify the need for international financial support to developing countries for the development, deployment, and diffusion of ozone layer friendly technologies[10]. The set of covenants put into force from the 1990s onwards, emerging from the Convention on Biodiversity (CBD 1992), International Union for the protection of New Varieties of Seeds (UPOV 1991), and UN Conference on Environment and Development (UNCED 1992) identified the need for additional financial resources and the development of an international technology transfer framework.

The discourse on environmental agreements recognised technology as (i) a tool for conservation of the nature, and (ii) a tool for identifying alternative pathways to economic activities that reduce irreversible exploitation of nature. To meet these requirements, the agreements acknowledge the need for developing alternative frameworks for patent protection which – without impeding transfer of technologies and know-how – were aligned with the international agreements of the IPR regime[11].

2.3 Role of IPR in technology transfer

There are two distinct and opposing views on the issue of protecting IPR. One view is that IPR protection is essential to incentivise innovation by awarding a monopoly right over the know-how developed so that economic returns can accrue to the inventor. Under the TRIPS agreement, it has been noted that a protected regime of IPR will facilitate the increased flow of FDI and also transfer and dissemination of technology[12]. Further, it has been argued that the IPR regime has established the necessary legal clarity and certainty, and has stopped others from blocking the use of a technology by follow-on derivative inventions; this protection is important for a private player to invest in risky ventures like the development of low-carbon technologies and their deployment[13].

The alternative view is that the TRIPS regime is an important barrier to technology transfer, especially in an environment where the private sector plays an increasingly pivotal role in technology development. This is because IPR protection means that the patent holder can control the use of the specific technology, and decide when, where and how to use it, whether to transfer it and at what price. Further, there have been cases when the fear (real and imagined) of patent proliferations has led to the closure of the manufacturing facilities in some developing countries, resulting in reduced access to these products due to the resultant higher prices. This was particularly apparent in the Latin American countries after the introduction of the product patent protection for pharmaceuticals.

2.4 The challenges of technology transfer

Developing countries are faced with a number of practical difficulties that impede the effective and timely transfer of technology. Literature reviews identify several issues and challenges that inhibit (or promote) successful transfer of technology, including:

- Access challenges
- Availability of technologies globally
- Conditions on use of technologies – products, geographic restrictions etc.
- Local capability challenges
- Infrastructure for local manufacture
- Absorptive capacity[14]
- Availability of skilled personnel[15]
- Trade and Policy Challenges
- Laws and regulations that protect technology owners/IPRs
- Regulations covering acquisition and deployment of technology – import tariffs, incentives/disincentives for competing technologies etc.
- Financial and Market Challenges
- Availability and cost of funds to acquire technologies
- Price and costs deployment of certain technologies
- Lack of market for the relevant technologies which makes local manufacture viable

A central factor identified from the variety of challenges described above is the lack of a system of obligations and incentives for the technology owner to transfer the same to developing countries, such as: (a) mechanisms for going beyond export of the products to the other two stages of transfer of technology mentioned above; (b) mitigating the risk of the licensee becoming a potential competitor to the licensor in the global market; (c) addressing the perception of insufficient profits to compensate the licensor for his risks and transaction costs[16].

2.5 Current positions at UNFCCC on technology transfer

Based on the successful experience of process patent regimes in countries like India, Philippines and others in Asia, the G77 has been pushing for a similar regime for climate change technologies that would enable easy and inexpensive transfer of these technologies to the developing world. The developed countries have so far refused to concede to the demand, but have in principle agreed to concessional terms of transfer of environment-friendly technologies. However, it was clearly stated by the developed countries that IPR be applied and that an exception should not be made on such technologies[17]. Their position is summarised in Appendix I.

The emerging discussions indicate that the Nationally Appropriate Mitigation Actions – or NAMAs[18] – will be an important vehicle for diffusion and deployment of climate friendly technologies. The so-called MRV criteria – measurable, reportable, and verifiable – of the supported actions by the Non-Annex I Parties[19] ensure the accountability of both developers of the climate friendly technologies (principally Annex I Parties) and the technology recipients. Annex I Parties have proposed the need for linking national policies with the NAMAs for developing countries, on which the G77 and China disagree on the grounds that this contradicts the Bali Action Plan agreements (which require that only full incremental costs have to be supported and can be put under international scrutiny)[20]. They further argue that the process may lead to dilution of national interest and sovereignty, because the international criteria may sometimes overlook the domestic policy priorities and policymaking[21].

Differences of opinion also exist between Annex I and Non-Annex I Parties around issues related to the methodology of implementation. The developed countries acknowledge and promote the fact that there is a huge amount of private investment involved in technology development and therefore proper incentive mechanisms are necessary to sustain the pace of innovation in climate change solutions. Thus, they argue for the strengthening of the current IPR regime, while the developing countries mainly advocate for a relaxed regime and the need for public investments in the development, diffusion, and deployment of technology, irrespective of geographical location. Further with regards to the requirement of finance for technology development, the G77 and China have proposed a framework of new finance mechanism under the Conference of the Parties (COP) that would be guided by an Executive Body on Technology Transfer. Annex I Parties – led by the EU – support the idea of enhancing the capabilities of the existing mechanism ■

Notes:

5 Khor, M (2008): IPRs, Technology Transfer and Climate Change, Third World Network

6 Ockwell, D (2008): ibid

7 Evans, P.C (1999): Cleaner Coal Combustion in China: The Role of International Aid and Export Credit Agencies for Energy Development and Environment Protection 1997-1998, Centre for International Studies, MIT

8 Saad M and G. Zawdie (2005): From Technology Transfer to Emergence of Triple Helix Culture: The Experience of Algeria in Innovation and Technology Capability Development, Technology Analysis and Strategic Management, 17 (1)

9 Note that the LDCs were always exempted from meeting the strict requirements of the technology transfer because of their relatively low base of socio-economic performance and also because of their capabilities.

10 Art.10,10A of the Montreal Protocol,1987.

11 Art 16,paragraph 5,CBD (1992),Art 9 of Montreal Protocol (1987),Art 15,17 of the UPOV.

12 Ockwell,D 2008:ibid

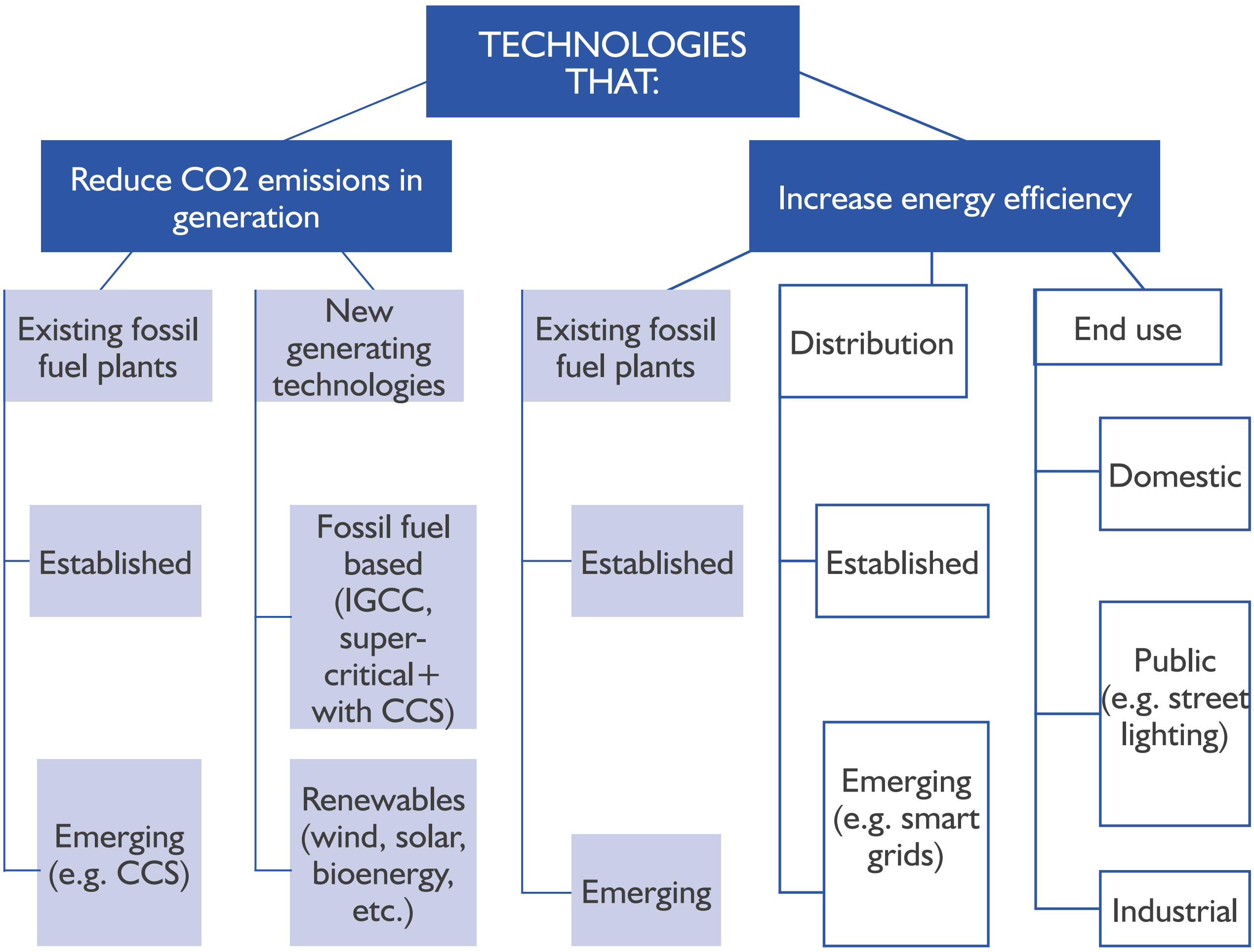
13 Correa,C (2005) Can TRIPS Agreement Foster Technology Transfer to Developing Countries? in International Public Goods and Transfer of Technology: Under a Globalised Intellectual Property Regime, edited by Keith E. Maskus and Jerome H. Reichman, Cambridge

3 TECHNOLOGY TRANSFER AND THE POWER SECTOR

3.1 Frame-working the issues

If there is anything that symbolizes the key challenge of addressing both climate change and development, it is electrical power generation. It is almost inconceivable for any development process to be successful without using electricity. However, with the mix of technologies currently in use, the power sector is the world's largest source of CO2 emissions. For this to change in a cost-effective manner, technological developments and rapid deployment and diffusion are critical. Besides this, the power sector also has the potential to replace oil and gas from transport (especially surface) and buildings sectors. Therefore, on the supply side, the only way that the negative climate change impacts of power generation can be mitigated is by reducing the amount of CO2 emitted per unit of electricity produced, ultimately to zero. And, in a developing country context, especially where nearly 1.6 billion people have no access to electricity, all this must happen at a cost that the poor can afford, while providing an acceptable return to power utilities and their investors. Implicit in this is the notion of power security – the need for developing countries to ensure that they have control over the supply of raw material to produce electricity.

The diagram below outlines the technology challenges facing this sector in order to achieve the transformation that is needed to meet the climate and development challenge:



Note: This study covers all the technology types in the shaded boxes as shown in the diagram above

3.2 Some trends and challenges

Transfer or sharing of relevant technologies in the power sector involves a combination of direct sales of equipment and services, technical assistance contracts, turnkey projects, wholly owned subsidiaries, joint ventures, licensing agreements, cooperation in research and development agreements, and personnel exchanges. In the power sector, as Martinot et al[22] , Maskus[23] and Copenhagen Economics[24] observe, there has been spurt in joint ventures since 1980s, due to: (i) changes in the policy regime in favour of joint venture based cooperation rather than turnkey projects; (ii) big power companies preferring to involve local partners who are well informed about the complex nature of the business and risks involved with it; and (iii) a growing trend to be cost-effective, irrespective of the costs involved due to geographical variations. The barriers to technology transfer in the power sector are likely to arise if any of the above conditions are not being met.

Section 2.4 detailed the barriers that typically inhibit transfers of technology. These are examined in greater detail with reference to the power sector under four broad headings:

- Access challenges
- Local capability challenges
- Trade and policy challenges
- Financial challenges

3.3 Access challenges

The most extreme form of a technology access challenge is when the technology supplier refuses to part with the technology at all because it sees huge financial benefit from it. This has been observed in sectors like pharmaceuticals but not in the power sector.

A second type access challenge relates to the conditions that the technology supplier imposes on its partner to source a percentage of equipment directly from itself and not transferring some key elements of the technology. In a study by TERI in 2007 on the traditional energy sector in India[25], it has been reported that foreign companies entering into collaborations with Bharat Heavy Electricals Limited (BHEL) have not allowed BHEL to take on the design and manufacture of the most advanced, high-tech parts (such as the first row of blades, incorporating advanced materials, cooling technologies and manufacturing techniques) in order to maintain the comparative advantage in the sector. This acts as an impediment to the recipient country absorption of technology and also hinders their ability to further develop the technology.

Lack of an adequate market to justify transfer and local manufacture of new technologies is a third type of access challenge. For instance, until 2006 when the Indian market was restricted and small, technology transfer was of a limited nature and only to the State-owned sector BHEL. After power sector expansion was given priority and opened up to private power producers, the Indian market has become more attractive to super critical thermal power plant equipment majors like Alstom and Mitsubishi, which have established joint ventures, clearly signalling their interest in local manufacture, if not wider dissemination of technology.

Sometimes the patenting of innovations is used for strategic reasons to prevent market entry, or delay the entry of competitors in that particular area in order to protect the market share of the existing player. According to Sovacool , the intentional use of these activities will result in blocking rather than slowing the entry of other firms into an area of business. These will then act as fences rather than thickets. It has been observed by the Federal Trade Commission that "such fences can introduce licensing difficulties, especially when royalties are stacked one on top of the other, increasing uncertainty about the patent landscape, frustrating competition for both current manufacturers as well as potential entrants".

USE OF IP TO PROTECT/DELAY THE TECHNOLOGY ENTRY

In 1982, Philips Engineering began a residential gas-fired absorption heat pump project. By the early 1990s, Philips developed number of laboratory prototypes of the same, but neither licensed its technology to anyone, including its R&D partner, the Gas Research Institute (GRI) nor did it commercialise it itself and it therefore did not reach the market. However, by 1995, Philips did license the technology to an entirely new company, Carrier, who made significant investment in developing the technology further but abandoned it in 1996. Italian company Robur convinced Philips to grant a license in late 1990s, which finally brought the technology to the EU market. Thus, a technology that was developed in the early 1990s took ten years to reach the consumer.

The complicated licensing situation delayed the introduction of the new technology to market, raising costs substantially. Further, the manufacturing units are in Italy, and they are exported to US, incurring huge costs to the US consumers.

Source: Placing a Glove on the Invisible Hand: How Intellectual Property Rights May Impede Innovation in Energy Research and Development, written by Dr. Benjamin K. Sovacool, Albany Law Journal of Science and Technology, 18, 2008.

3.4 Local capability challenges

Conditions and capacities in the countries and companies on the receiving end of the technology transfer to understand, absorb, and then replicate can be a significant challenge to technology transfer; it is a combination of availability of local infrastructure and skills (technical and managerial). Though not reported in India, it is not unknown. In the renewable energy sector, Barton[27] has highlighted the importance of the industrial structure for the successful transfer of renewable energy technologies. The industrial structure is characterized by a small number of technology-developing firms and a large number of buyers across the world. This sometimes creates impediments to successful technology transfer. Therefore, it has been observed by Tomlinson et al[28] that some developing country firms are increasingly investing in developed countries to access the technology. According to the study, developing countries' activities around development and acquisition of renewable technologies have increased in recent years. As part of the strategy, developing country firms are increasingly entering into acquisitions and mergers of their developed country counterparts. Also they are

EXPERIENCE OF COMPANY-LEVEL IMPEDIMENTS TO TECHNOLOGY ABSORPTION

A review of the energy industry found that hosts of greenhouse gas reducing technologies – such as combined heat and power (CHP) systems, resource efficiency, substitution of materials, changes in design etc. – remain impeded by high transaction costs for obtaining reliable information and capacity building. According to Chris Russel of Alliance to Save Energy, "facilities are thinly staffed, running flat out every day to meet production goals. So proposing changes will mean absorption in the way they operate. You have people in the operations, finance, procurement, and engineering – all of whom are going to be impacted. The company employees may also be reluctant to invest time in learning as well."

Source: Placing a Glove on the Invisible Hand: How Intellectual Property Rights May Impede Innovation in Energy Research and Development, written by Dr. Benjamin K. Sovacool, Albany Law Journal of Science and Technology, 18, 2008.

developing R&D units abroad for accessing the technological and institutional capacities in the parent countries. As the study iterates, "Chinese firms alone have set up 37 R&D units abroad, of which 26 are based in developed countries (11 in the USA and 11 in the EU). Emerging economy firms have also acquired developed country firms in order to gain access to their intellectual property and markets. A leading Indian wind turbine manufacturer, Suzlon Energy, recently acquired majority control of several wind turbine technology and components suppliers, including Hansen and REpower".

3.5 Trade and Policy challenges

In order to incentivise trade in environmental goods and services (EGS) through concessional tariffs and other means, these goods were classified and listed by OECD in the early 1990s. The list has since been expanded to include renewable energy technologies and related services as well. However, there are some anomalies in the list: for example, Shah[29] observes that the list includes wind energy equipments of 250 kW which therefore qualify for concessional tariffs, while equipment of higher capacities such as 2000 kW are excluded. Furthermore, the current EGS list does not include many key equipment required for generation of electricity from sustainable sources like solar, wind, tidal and geothermal components[30].

Since economies of scale play a significant role in lowering the cost of technologies, unrestricted access to markets is critical. This means the developed world needs to also provide ample market access conditions in their own countries. This is simply not happening for the Indian wind power manufacturers who have encountered barriers in the form of tariffs, standards and also movement of professionals in the developed countries.

Inadequate laws and regulation in the developing countries that protect IPR is often quoted as a significant barrier to transfer of technology. The owners of technologies fear their IPR will be copied in India while they are engaged in collaboration which covers the operation and maintenance of the power generation plants and the moment they sense this, technology sharing simply ceases. Even though India's patent regime now recognizes product patents and the country has a well established rule of law, many point to the slow pace of this legal system as a reason for their reluctance to transfer technologies to Indian companies.

Indian regulations for renewables too are sometimes contradictory and confusing. For instance, subsidies are available for solar-PV but only for capacities below 50 MW. Subsidies are available for installing wind turbines but not for their operations, resulting in low generation compared to installed capacities.

3.6 Financial and market challenges

Since power utilities in developing countries have to balance tariffs (dictated by market conditions and regulations) with adequate returns to investors, the cost at which they can procure equipment holds the key to profitability.

In a perfectly competitive market, the market mechanisms ensure that equipment is available at the lowest possible price and many argue that power sector equipment markets are competitive, with several suppliers. While it is true that there are no real monopolies, especially for coal-based power plant technologies, the fact is that suppliers are still small in number and have in the past known to form cartels. This oligopoly, combined with the fact that equipment manufacture is typically located in high-cost developed countries, has meant that price is likely to remain a barrier as long as these technologies and manufacturing remain closely guarded. Section 5 deals specifically with IPR issues and discusses this aspect in greater detail.

Balancing the need for low-cost power with ensuring adequate returns to the technology owner necessarily means addressing this financial barrier. The BAP did acknowledge the need for financing mechanisms that enable technology transfer. The challenge though lies in achieving a balance where everyone benefits – not just the equipment manufacturer but also the power utility (and hence the consumer).

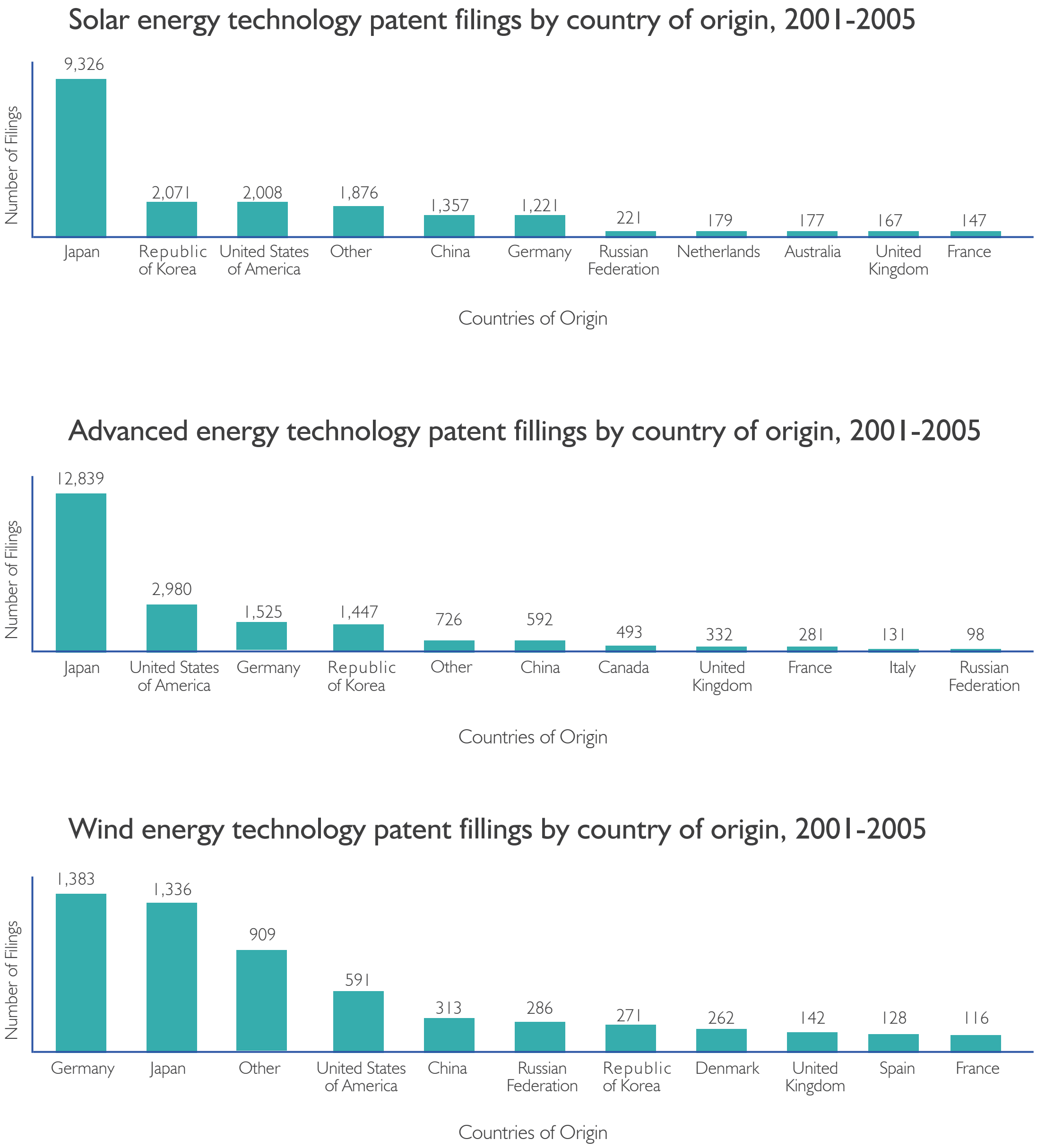
3.7 IPR as an inhibitor to technology transfer: intuitive and empirical evidence

The analysis of the challenges discussed above suggests that as the ownership of clean technologies moves into the private domain, IPR issues can potentially inhibit transfer of technology – whether the transfer can happen at all – impose restrictions on what technologies are transferred and influence the equipment price.

There is little empirical evidence on how significant a challenge IPR has been. However, some interesting observations can be made from the diagrams below.

Figure 1 shows that around 80-90 percent of the patents in three important advanced energy technologies – solar, advanced energy technologies, and wind – are owned by a small group of countries, most of which are the developed Annex I Parties. This certainly suggests that the developing countries will need to depend on these countries for low-carbon technologies, at least in the short to medium term, putting them at a disadvantage at the negotiating table.

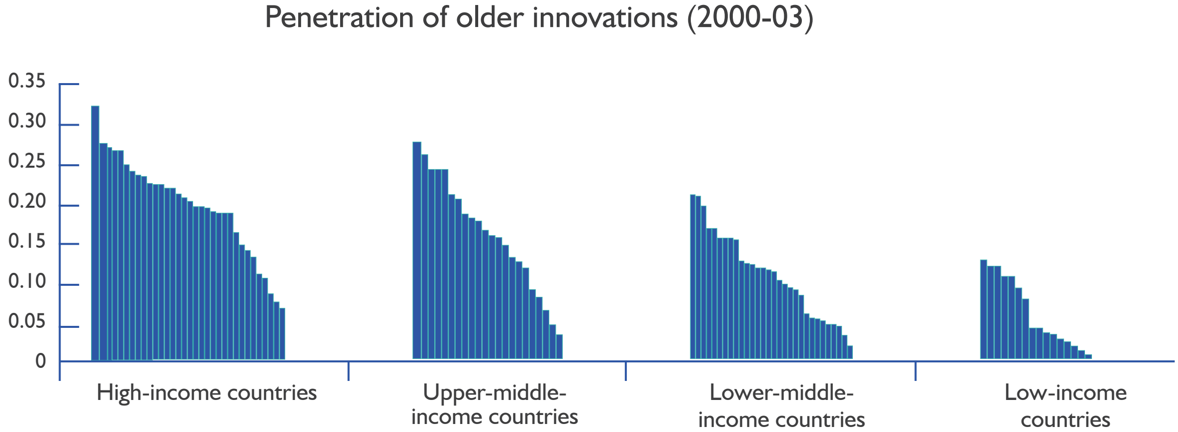
Figure 1: Distribution of Patent ownership by Country

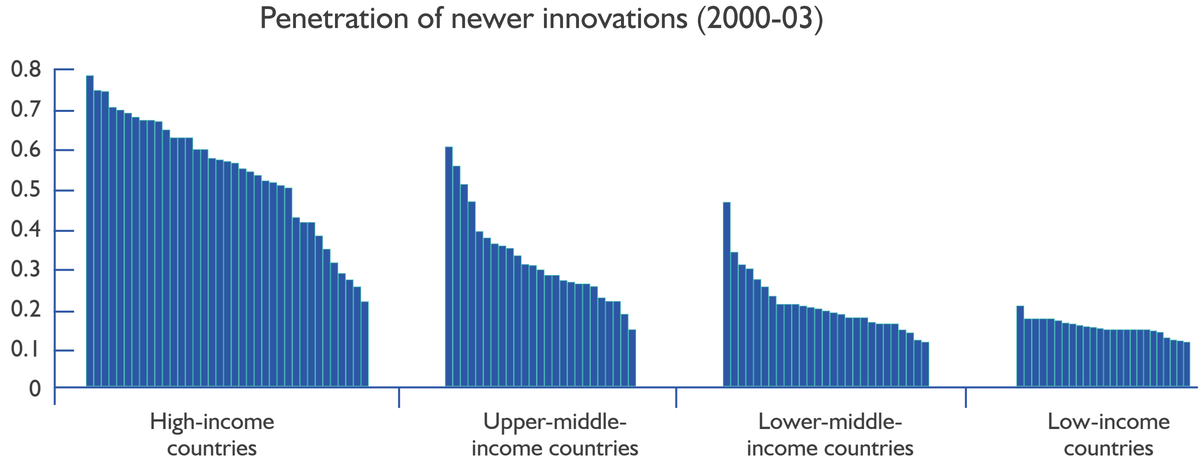


Source: WIPO Patent Statistics, 2008.

According to a World Bank report in 2007[31] , the diffusion of technology into developing countries – irrespective of the type of technology – is low relative to developed countries. This can be seen from Figure 2. What is indeed a positive sign is that low income countries seem to absorb newer technologies faster than older technologies but penetration is still significantly lower than high income countries.

Figure 2 : Penetration of Innovation





Source : World Bank

There are also counter claims regarding IPR as an inhibitor and various studies, including Copenhagen Economics[32] , Barton[33] , and World Bank[34] argue against this claim. They assert that most of the carbon abatement technologies are owned by the emerging economies and therefore the technology does not need to be transferred from advanced to emerging countries. Here, the classification of the countries as 'emerging economies' has to be carefully considered: according to accepted definitions, countries like South Korea, Poland, and Singapore cannot strictly be classified as 'developing'. The patent filing in the WIPO[35] clearly shows that patent ownerships by a country like Korea far exceeds patents owned by the countries like India, China, and Brazil ■

4 COAL BASED POWER GENERATION – EVIDENCE FROM THE GROUND

About 52 percent of India's installed power capacity of 151 GW is coal-based (large hydroelectric plants account for 24 percent, natural gas for 11 percent with other renewables totalling about 9 percent), according to the Central Electricity Authority. Thus, any significant improvements in efficiency or emissions have to essentially focus on the dominant coal-based plants. Coal is also important from India's energy security point of view, given its vast coal reserves (of about 220 billion MT, albeit with high ash content of about 40 percent which reduces its calorific value) and the Indian Government's assertion that coal will remain a significant fuel of choice for the next 15-20 years.

4.1 Technology options

So, what are the specific technologies that would be relevant for coal-based plants? The literature review as well as discussions during the study suggested the following:

TECHNOLOGY	OBSERVATIONS
Existing coal-based plants	
Reducing moisture from coal.	Technology not commercialised.
Reheat cycles, variable frequency drives etc.	Limited benefits.
Fitting Carbon Capture and Sequestration (CCS) systems.	Not economical (can consume 10-20 percent of power generated) and can double electricity costs; Safe sequestration options not resolved; Technology not fully proven; No space in existing plants to retrofit them.
New coal-based plants	
Supercritical technology	Widely accepted in India; Constraint has been supply due to lack of capacity but will ease as new joint ventures and technology transfers happened in India in the recent past.
CCS (with or without oxyfuel boilers that reduce NOx)	More possible in new plants but sequestration risks remain.
Integrated Gasification Combined Cycle (IGCC)	Still experimental but needs significant research for it to work with India's high ash-content coal; Gas available only for 80-90 percent of time thereby underutilising the turbine.
Ultra supercritical technologies	Science known, technology yet to be developed but expected to improve efficiencies significantly.
Chemically converting carbon dioxide to chemicals like methanol.	Unproven. Methanol requires free hydrogen which itself is power and water intensive.

What seems apparent is that little can be done with existing sub-critical plants other than to decommission them and use the land for building supercritical ones. But this requires huge investments and the economics do not suggest it to be viable under the current conditions.

Thus, the future of coal seems to be largely around what can be done with new plants. Supercritical and ultra supercritical technologies and beyond seem to be the most promising route. CCS is an essential part of the equation but the issue of safe sequestration remains. IGCC is an option either with imported coal (which could impact energy security) or if the technology is adapted to high ash-content Indian coal.

4.2 Supercritical and beyond – availability of technology and challenges

Although supercritical technology has been around for sometime now, it is only recently that these have been introduced in India. The leading suppliers are summarised below:

GLOBAL SUPPLIER'S	INDIA MANUFACTURING PRESENCE
Alstom, France – boilers and turbines	Boiler licensed to Bharat Heavy Electricals Ltd. (BHEL) Joint venture with Bharat Forge Ltd. for turbines.
Siemens, Germany – turbines	Licensed to BHEL
Mitsubishi, Japan – boilers and turbines	Joint venture with Larsen and Toubro
Toshiba, Japan – boilers and turbines	Joint venture with JSW Ltd. for turbines
Doosan, Korea – boilers and turbines	No presence
Chinese companies – Dongfang, Shanghai Electric	No presence

Though widely used globally, supercritical technology is relatively new to India. Discussions suggest that there have been two tipping points that created a market for this technology. The first was the recognition that power generation capacity was a constraint to India's economic growth, resulting in the enactment of the Electricity Act of 2003 which removed state monopoly on generation, transmission and distribution of electricity and opened it up to private sector. Planned capacity additions more than doubled and the advent of ultra mega power plants of 4 GW capacity meant that supercritical technologies, that were typically only economically viable for unit sizes of 600 MW and above, suddenly became attractive. Clean Development Mechanism (CDM) credits further improved the economics. However, supply was a big constraint as most leading manufacturers had large order books and were not able or willing to commit time lines that suited the power producers. It was not clear whether this resulted in price inflation.

The other tipping point perhaps was the availability of Chinese supercritical technology. The Chinese had begun using supercritical technology long before India did and through joint ventures and other means, Chinese manufacturers had developed this technology and were willing to offer it at cheaper prices and also for lower unit sizes (300 MW and lower). This deepened the interest of Japanese and European suppliers who realised that if they wanted to compete, they not only have to maintain the price line but would also need to establish manufacturing bases in India to reduce cost of manufacture. This resulted in a spate of joint ventures (see table above), most of which have happened post 2008.

What clearly emerged was that the default for any technology holder was to not part with it, if no obligation exists. So, the most preferred option for the technology holder was to simply supply equipment from its works (as this provides maximum profits) and least preferred was to license it, with a wholly-owned subsidiary and a joint venture being somewhere in between these two options. A licensing agreement would typically consist of a fixed lump sum fee (for providing drawings, training etc.), royalty (based on turnover or quantity of units despatched) and a business share (proportion of equipment supplied by the licensor which progressively declines to zero). Experts contacted during the study indicated that for supercritical technologies, these three components can add anywhere from 5-10 percent on the price depending upon the negotiation.

What does this say about the challenges to technology transfer and the role of IPR? Expert interviews indicate the following:

Access challenges

- There appear to be no challenges to physically accessing supercritical technology and to the next generation of ultra supercritical technologies which are owned by much the same players. Even when the Indian market was small prior to the Electricity Act, the technology was available globally and two global majors had licensed it to BHEL.
- It is not clear what restrictions – marketing or component – will be imposed on these new manufacturers in India. As stated above, it was reported that BHEL was not given access to the full range of technologies in turbine manufacture in the past. It was also mentioned by experts that most licensing arrangements require the licensee to buy a certain proportion of finished components from the licensor. Nevertheless, local manufacture provides the potential for rapid diffusion and local innovation.

Local capability challenges

- Subsequently, as the market became more attractive, equipment suppliers were willing to establish a presence in India and make the technology available. This suggested both a willingness to invest as well as a belief that India had the infrastructure, skill and absorptive capacities.

Trade and policy barriers

- None of the suppliers expressed any reservations about the legal and other safeguards available in India to protect technology/IPR holders. Proliferation, they said, was not an issue at all.
- No one commented on any of the regulations that impact supercritical technology.

Financial and market barriers

- None of the experts contacted felt that availability of finance was a barrier.
- There is a view that the price premium for supercritical technology[36] over sub-critical cannot be explained by material cost alone and so IPR must have a role to play. While the IPR premium amount is hard to determine, what is significant is that none of the power companies considered that they had to pay an unreasonably high price for procuring supercritical equipment.
- However, some of the experts felt that the advent of cheaper Chinese suppliers would certainly have reduced the premium.

There is an interesting policy dilemma that one of the respondents mentioned: currently, India does not mandate the use of supercritical technology and therefore these plants are eligible for CDM credit, thereby improving their economics. The moment it becomes subject to a mandate, CDM credits vanish as the additionally test is no longer satisfied. So, should the Government of India mandate what seems to be a better technology or will that run the risk of increasing electricity price? Alternatively, should it mandate this because the resulting energy savings (which can be used to gain tradable energy savings credits) offset the loss of CDM credits for a greater energy saving gain?

4.3 CCS and IGCC – availability of technology and barriers

As far as CCS is concerned, most people contacted in this study agreed that it would make coal-based plants a far more attractive proposition from an emissions and long-term sustainability point of view. However, significant concerns remain and these are the familiar ones. One is the carbon-stripping technology: all indications were that the capital costs remain high (estimated increase in the capital cost of a supercritical plant range from 50-80 percent), the process requires a lot of land and consumes far too much energy (an estimated 25 percent of the energy generated by the plant) to be economical. The second area of concern is sequestration: one view was that given India's seismic vulnerability, underground sequestration may carry risks. This notwithstanding, people who were interviewed do see promise.

There appears to be relatively greater interest in IGCC as many feel that this technology is somewhat closer to commercialisation. GE, Siemens, Mitsubishi and Chevron are all understood to be the leading technology holders. However, doubts remain about the viability of IGCC with the high ash content of Indian coal, though BHEL claims that it is very close to commercialising this technology.

What Barriers did the experts and company representatives see for transfer of these two technologies?

Access challenges

- Without doubt, the availability of commercially viable technologies will remain the challenge. However, given that India will be a dominant market for these technologies, there is no reason to believe that physical access will be an issue.
- Whether these technologies will be transferred or locally manufactured remains to be seen. Since there are multiple developers of IGCC technology including BHEL, the chances of its early transfer are more likely than CCS.

Local capability challenges

- Neither the users nor the suppliers of equipment saw local capability to absorb and manufacture as a significant challenge to transfer of these two technologies. Of course this to some extent depends upon how and when they get commercialised.
- Going by past experience, technology holders would prefer to supply the equipment rather than set up joint ventures or license the technology but given that India is a major market for coal-based power plants and has the capability, local manufacture remains a possibility.

Trade and policy challenges

- Discussions suggested that there is sufficient comfort with India's IPR regime and legal system for technology owners to not be concerned about imitation and proliferation.
- Some of the respondents felt that a favourable policy regime – tax on emissions for instance – would be important to incentivise use of CCS and IGCC, given the high capital costs.

Financial and marketing barriers

- Given the high capital costs of these two technologies, both availability of funds and its costs would be critical for their acquisition and deployment.
- The costs of these two technologies remain uncertain and given that they are relatively new, there is a sense that they will come at a high price. To what extent this price would be reflective of IPR is hard to say but some of the respondents did feel that IPR would significantly add to price in the initial stages. Early availability of low-cost alternatives from emerging economies such as China could overcome this.

4.4 Conclusions

Given the primacy of coal in India's power mix, the long lead times to build power plants and the life cycle of these assets, the big challenge for India will be deployment of technologies that mitigate the negative impacts of coal. What is clear is that the established state-of-the-art technology – supercritical – is physically accessible (as manufacturers are willing to set up production facilities in India) and the next generation – ultra supercritical – is unlikely to represent a problem. The prices too seem reasonable as users of these technologies like Tata Power and Reliance Power seem to be able to meet their contracted feed-in tariffs.

CCS and IGCC technologies likewise seem accessible and while it is too early to predict when they will be transferred to India, the conditions seem to suggest that this will happen eventually[37] . The price of these technologies – and this is indeed related to IPR – is uncertain but availability of the technology and willingness of technology suppliers to supply it may not be a challenge; it would require significant policy and financial support to make them attractive to users and investors.

All this notwithstanding, what is clear is that coal-based power generation will be dominant in India for the next few decades and will remain significant thereafter. India will therefore have to reconcile the seemingly irreconcilable – energy security, low cost electricity and low-to-zero emissions. To achieve this, Indian policymakers and regulators must play a proactive role in creating an enabling environment in which coal-based technologies that can deliver these outcomes are continuously developed and made available ■

Notes:

[14] This relates to firms'capacity to respond to the new technology. If the firm cannot respond quickly,they are less able per se to take the advantage of collaborations with their counterparts who have developed the technology.

[15] This issue refers to the lack of knowledge of the personnel of the particular sector. It is different from the absorptive capacity;a study undertaken by TERI on LED lighting in India has concluded that individual capacities exist in India with regard to manufacture of LEDs at the theoretical level,but the capacity does not exist at the firm level in harnessing these skills to actually manufacture the LEDs.

[16] Correa, C (2005) ibid

[17] Khor, M (2008):ibid

[18] NAMAs (Nationally Appropriate Mitigation Actions): Introduced under the Bali Action Plan (BAP), whereby the developing countries can submit to the Conference of the Parties (COP) a set of actions on which they require support and the developed countries are bound to provide them with the full incremental cost of the mitigation actions.

[19] Annex I Parties or countries refer to the industrialised countries and the list can be obtained from http://unfccc.int/parties_and_observers/parties/annex_i/items/2774.php. Non-Annex I Parties refers to the other countries.

[20] However the international community is divided on the definition of the full incremental cost.

5 RENEWABLES IN POWER GENERATION – EVIDENCE FROM THE GROUND

Amongst the renewables, large hydroelectric power plants (hydros) account for 24 percent of India's current installed capacity and this is one element of the power mix where growth is going to be determined less by technology issues (because it is proven, available and low-carbon) and more by the availability of suitable hydro resources and how associated environmental and social issues are managed.

There are several other options available – solar, wind, bioenergy, geothermal and so on – and both literature reviews and interviews with experts and companies clearly indicated solar (photovoltaic or PV and thermal) and wind power are most relevant to India within the next decade. Many believe that solar is the most promising route for India, given the vast amount of sunlight available and the energy security that it provides. Wind ranks second in terms of promise and companies like Tata Power see significant potential, especially in offshore wind but evacuation of power and coastal zone regulations remain challenges. Bioenergy is also seen to have potential in view of the significant availability of biomass and its widespread use as a fuel for domestic usage at very low efficiencies.

5.1 Solar-PV

In solar-PV the key building block is the cell and module. Two technologies are currently available – crystalline silicon (single and multi-crystalline) which is currently dominant with 80 percent of the market, and thin film, which is significantly cheaper but also less efficient.

There are different views on where the technology is heading. One says that crystalline silicon will be significant for another decade, after which thin films will dominate along with new technologies (like organic cells and nanostructure concentrators) which are now at a nascent research stage. The opposing view is that while thin films and new technologies will grow, the crystalline based technologies will still have a place in stand-alone applications and where aesthetics have a role to play.

Discussions with the two leading Indian players suggest that access to technology to manufacture cells, panels and systems is not an issue at all as it is embedded in the capital equipment which is easily available and fairly uniform. Prices of equipment do vary but this is more a function of supply and demand at a point in time than a reflection of IPR costs as there is little to choose between equipment suppliers. The capabilities and innovation of the equipment user determine the efficiencies achieved and hence cost of the panels and systems.

Availability of PV-grade silicon (which is marginally less pure than semiconductor grade silicon) holds the key to the costs of solar-PV since over 75 percent of the cost of a PV cell is in the bill of materials, of which 60 percent is PV-grade silicon. Interviewees suggested that PV-grade silicon prices were high in part due to an IPR premium because the technology was closely held by a handful of companies globally[38] . With many of these patents expiring, this should no longer hold but whether this will result in lower silicon prices and hence lower PV cell and module costs remains to be seen. Also, there is considerable research work underway using less pure ("dirty") forms of silicon for PV cells without significantly sacrificing efficiencies, which can again reduce prices of silicon and hence PV cells. Whether this will also come with a high IPR price load is unclear but the indications are this will not be the case.

So, what are the technology transfer challenges of solar-PV? There appears a growing convergence of views amongst experts contacted during the study that achievement of grid parity (i.e. when price of electricity from solar-PV equals that available at the grid from the mix of other sources) will happen sooner in India, even with existing technologies, by enabling economies of scale to be achieved. This could be done by:

- Building a supportive policy framework – recognition of the importance of decentralised off-grid power generation (in remote locations) and grid-connected power generation;
- Supporting capital costs through a mix of low cost finance and subsidy;
- Feed-in tariffs without setting limits on size of the installation (as at present).

In some senses, these policy recommendations reflected the need to offset the high PV prices due to IPR and low manufacturing scales. There is also an emerging consensus that IPR would, if at all, be reflected in prices but not on access or local capabilities.

Indian manufacturers see their markets as global and therefore global policies relating to increasing demand for solar in other countries and promoting trade are critical for them to achieve scale. So far, there are apparently no significant policies that inhibit imports of solar equipment from Indian manufacturers (except perhaps in the case of Japan and China) but there is some apprehension that the economic crisis could result in protectionism and therefore impede market access to countries like the US.

An important point that came up during discussions is that India has been slow to respond to the potential and promise of solar-PV, both from a technology development point of view as well as from showing leadership in committing itself to solar in a big way. India's National Mission on Solar Energy and the announcement of a target of 20 GW by 2022 was welcomed by all and both industry and civil society are looking to the Mission to assume the leadership role that it seems to have let slip. The Indian proposal of climate innovation centres is also seen as a progressive step if these could promote development and quick deployment of technologies at reasonable prices.

Notes:

[21] India is opposed to this idea of getting all its activities verified,saying that these actions do not acknowledge the domestic reality of the different Parties per se. For example, if the current system of power distribution to the agriculture sector is being extended under a NAMA, then it might be termed as inefficient. As a result, government might be forced to withdraw the subsidized provisioning of electricity to the small and marginal farmers,thereby inviting serious repercussions domestically

5.2 Solar thermal

Solar thermal, especially Concentrated Solar Thermal Power (CSP), has enjoyed renewed interest recently, evidenced by the large number of installations being planned in Spain. Though India is an attractive location from the point of view of sunlight, there is not much interest shown by the experts surveyed in this study. The main reason is that this technology is applicable to large scale power plants; however where land and ample sunlight is available (e.g. desert regions of western India), transmission of power and availability of water represent major challenges[39] , perhaps insurmountable in the short to medium term. However, if these constraints could be overcome, CSP has potential for large-scale deployment.

5.3 Wind energy

India has an installed wind power capacity of just over 10,000 MW, well below the potential of 65,000 MW estimated by the Indian Wind Energy Association. India currently has only onshore wind power installations and ranks fifth in the world in terms of installed capacity.

According to experts, the design of wind farms is complex but the technology of manufacturing wind turbines is not. Mechanical parts like gear boxes and rotor blades which must be able to withstand high speeds without breaking are critical, but these are widely available. Indications are that the latter is less critical in India (compared to say New Zealand and North America) as the wind speeds are lower, which reduces the requirement for leading-edge technology. Power electronics that determine the efficiency of conversion of wind to electrical energy and enable grid compatibility are also important. Technology developments in the future will focus on designing and building larger turbines (from the 1.5-2 MW ones currently produced) and improving power electronics.

As with other technologies, the Indian wind energy manufacturers range from wholly-owned subsidiaries (like Vestas of Denmark) to those who license technologies, many from Chinese manufacturers. In addition, there are some indigenous manufacturers like Kenersys which have developed their own capabilities based on past experience of operating wind farms and producing components and acquiring design firms. Indications are that licensing costs add about 1-2 percent to the total equipment costs.

Thus, the challenges in India have less to do with technology and more to do with creating a policy environment that encourages greater investment in wind power. Currently, the policy incentivises investment in wind power and not its operations and as a result, experts feel that many non-serious actors have entered the fray. However, it is expected that this would change with greater focus being placed on feed-in tariffs, incentives tied to wind energy produced and not just capacity installed and increased renewable energy obligations to power producers and distributors.

A point of note on wind energy, which seems applicable to renewables as a whole, is how critical both availability and cost of finance – both credit and investment – plays in the growth of this sector. Given the long payback periods of 7-9 years, the growth of the renewables industry is driven by policies that incentivise demand which make it an attractive, low-risk option for bankers and institutional investors. Banks that were comfortable lending to a renewables future in the developed world found themselves in a credit squeeze post October/November 2008 and responded by reducing their renewables portfolio, which significantly reduced the growth of the renewables companies globally. The silver lining to this was that these very companies became more willing to part with technologies at better terms to companies operating in the emerging economies.

5.4 Bioenergy

According to estimates, India produces 600 million MT of biomass from agriculture annually, the bulk of which gets used in low pressure boilers, firewood etc. at very low efficiencies while as much as twenty percent is left unused and degrades and decays to emit greenhouse gases. Perhaps the most efficient use of biomass is by sugar mills that use bagasse – the residue after sugar cane is crushed – as a fuel in their boilers. Thus, biomass represents a significant potential for decentralised production of bioenergy. At the same time, there are indications that this potential is most likely to be realised only in the short and medium term as the price of biomass – the major cost element in bioenergy – is likely to remain relatively constant even as capital costs decrease; on the other hand, cost of electricity from solar and wind are likely to hit grid parity in the medium to long term and therefore will offer a price advantage.

There are two technology options to produce energy from biomass. One which is less attractive is pyrolysis that produces liquid fuel. The other, which is already in use in India albeit in very small quantities, is gasification. The latter can provide efficiencies of 25 percent, which is a great improvement of the 6 percent achieved in stoves and 15 percent in low pressure boilers. Both technologies are well known, proven and widely available and so technology provides little challenge. A policy framework that encourages decentralised power production – helpful for solar and wind as well – holds the key. Policy signals – for example, feed-in tariffs that factor those for diesel generator sets in peak periods, allowing sale of power during off-peak hours to farmers providing biomass without wheeling charges – are among the solutions suggested. Availability of finance, especially at low rates, would also be a factor.

5.5 Conclusions

What emerged from the study is that of the three most promising new renewable energy technologies – solar, wind and bioenergy – India is well placed technologically in bioenergy (specifically gasification) and wind but has performed well below potential in solar. Adoption and widespread use of the former two will be influenced more by policy signals that incentivise demand and less by technology, which is widely available in India.

Solar technologies continue to be developed in the West and while physical access to these technologies is not seen as a challenge, IPR-loaded prices could be. To overcome this, India needs to give strong policy signals not only of magnitude – for instance, 20 GW by 2022 – but also method, i.e. how to achieve these targets, what incentives it will provide and what will be the role of technology developers and suppliers, operations and maintenance companies, investors and others. This would both promote development of technologies by multiple players (including through the proposed innovation centres) and this competition would potentially reduce IPR premiums and create sufficient scales to accelerate the process of achieving grid parity.

For scale to be achieved, it is not only important for the Indian market to grow but also for Indian manufacturers to have free and unfettered access to global markets. Therefore, policy regimes that encourage trade in both goods and services are critical.

Ready availability of finance – both credit and investment – and its cost plays an interesting role. It definitely drives demand and technology development, thus enabling the sector to grow. At the same time, since the build up of production capacities lags demand, the existing producers have full order books and are able to command a better price for their products, thus raising prices.

While low-carbon technologies that renewables represent are a critical component of reducing emissions (the other two being reducing demand and increasing energy efficiency on the supply and demand side), what is clear is that huge technological breakthroughs are necessary to ensure that they have a greater share of the energy mix. Emergent technologies will therefore be critical, and so a regulatory environment that helps overcome the challenges to transfer of these emergent technologies is crucial ■

Notes:

[22] Martinot E, J Sinton, and B.Haddad (1997) International Technology Transfer for Climate Change Mitigation and Case of Russia and China, Annual Review of Energy and Business, 22,357-401.

[23] Maskus K.E (2000) Intellectual Property Rights in the Global Economy, Institute for International Economics

[24] Copenhagen Economics and the IPR Company (2009): Are IPR a Barrier to the Transfer of Climate Change Technology? Retrieved from www.copenhageneconomics.com on July,8 2009

[25] TERI (2007) UK-India Study on Intellectual Property Rights and Low Carbon Technology Transfer to Developing Countries—a Review if Evidence to Date, TERI, in collaboration with Sussex University Energy Study Group, and Institute of Development Studies

[26] Sovacool (2008) Placing a Glove on the Invisible Hand:How Intellectual Property Rights May Impede Innovation in Energy Research and Development, Albany Law School Journal, 18,2008

[27] Barton, J. H (2007) Intellectual Property and Access to Clean Energy Technologies in Developing Countries: An Analysis of Solar Photovoltaic, Biofuels, and Wind Technologies, ICTSD Trade and Sustainable Energy Series, Issue paper no.2, International Centre for Sustainable Development, Geneva, Switzerland

[28] Tomlinson, S. P. Zorlu and C.Langley (2008) Innovation and Technology Transfer: Framework for a Global Climate Deal, published by E3G and Chatham House

6 RECOMMENDATIONS

The study showed that for climate change technologies in the power sector to be adapted and adopted widely and quickly in India, several challenges need to be addressed. These are outlined in this section. It may be noted that the recommendations presented here are based essentially on an analysis of what emerged from meetings with experts, especially from industry – which sets it apart from other similar studies – supplemented by secondary research. It may also be noted that the intention is to provide a framework that will overcome challenges of technology transfer, not to either document or build on specifics that have already been announced or are in place.

While the study focuses on all low-carbon technologies, many of which are new or emergent, most of the experiences – of interviews and reviewed literature – relates to technologies that are now commercially available or incumbent. The recommendations presented here are based on the lessons of these incumbent technologies but look at how they can be applied to the new or emergent ones.

6.1 Overview

The specific recommendations given below are premised on a few very basic, even if obvious, conclusions that came through strongly from the study:

- Increasing the supply of technology developers is the key to ensuring that IPR does not constitute a challenge to physical access to technology or its cost;
- This "democratising" of technology development will be greatly accelerated by growth in demand and the availability of funding that seeks long-term returns;
- In the short to medium term until "democratisation", technology premiums on account of IPR are likely to remain and this needs to be addressed.

6.2 Policy signals to incentivise domestic demand for clean technologies

The rapid availability and adoption of supercritical technology in India in recent years (and China before that) was triggered by one significant factor – demand for power equipment increased due to the expansion plans of the sector and its opening up to private investment. Thus, demand for technology holds the key and this has been echoed by experts familiar with and working in the renewables sector. And given the perverse inverse relationship between the cost of electricity and its carbon intensity, demand for low-carbon technologies will not be driven only by the market but by a policy regime that not only encourages the use of these technologies but is also at least neutral to (if not discouraging of) those based on fossil fuels. The building blocks of this policy (and some are in place or being discussed) are:

- Long-term and ambitious targets for low-carbon power, like the recently announced 20 GW by 2022 target for solar;

- Appropriate feed-in tariffs that are predictable, incentivise performance (and not just installation) and are of a sufficiently long period (ten to twenty years) to make them economically attractive[40] . Experiences in Germany and Spain suggest this is critical;
- Renewable power sourcing obligations to power distributors that compel them to supply an increasing proportion of power annually from renewables. Recent policy changes like Renewable Energy Certificates have attempted to operationalise the obligations;
- Incentive structures – fiscal and non-fiscal – that favour technologies that improve efficiencies and reduce emissions. This is particularly important for carbon-reducing technologies like CCS and supercritical for coal-based plants (which will remain India's mainstay for some time to come) and use of decentralised renewable solutions to replace diesel and kerosene for lighting and stationary applications (like pumpsets).

6.3 Policy signals to incentivise access to global renewable energy technology

Given the infancy of the renewable energy sector and its criticality to a low-carbon world, it is imperative that scale be achieved without national boundaries so that costs can rapidly decline. This is particularly important in the case of renewables as the nature of technologies lends themselves to modularisation. This requires a policy regime in developed countries that enables free and unfettered trade in equipment and services from the developing countries. It also means minimal protectionism in developing countries consistent with their development interests and global covenants.

6.4 Increasing supply of new technologies

What has characterised the currently available technologies in the power sector is that they are easily available as there are several suppliers. The price at which they are available however, varies depending upon demand and supply. For instance, the prices for renewables technology were high through much of 2008 till they were apparently hit by the financial meltdown, after which they dropped because there was no money available to set up plants. Similarly, it has been argued that the despite several manufacturers, supercritical technology suppliers had full order books through most of the early part of the century and could have commanded a high premium but for the availability of inexpensive Chinese technology.

Thus, to ensure that low carbon technologies – both for coal and renewables – remain available at a reasonable price, it is critical to increase the supply of technology which will reduce the premiums on account of IPR. This can be done in a number of ways:

- Increased demand. This automatically encourages more and more technology developers to establish themselves. As was discussed earlier, policy signals are the most powerful tool to stimulate demand for low/zero-carbon technologies;

- Providing fiscal incentives (capital/interest subsidies, tax breaks etc.) that encourage setting up of design/manufacturing facilities for low-carbon technology and equipment, installation of such equipment and their performance. Given that coal will remain an important part of India's energy mix, this should also include technologies that reduce carbon and increase efficiencies of coal-based plants e.g. CCS, IGCC and others that that are emergent or might emerge;
- Increasing availability of credit for clean technologies, either through the traditional banking channels or through funds created for this purpose. This would be required at all stages of the technology development cycle – design and development, commercialisation and deployment. For credit, a mechanism similar to Priority Sector Lending (wherein banks in India are obligated to set aside a certain percentage of their credit to priority sectors like agriculture) could be explored as a possibility. Public funding from both Indian and global sources would be important both to meet the needs as well as to act like a venture fund to leverage private resources;
- Setting up global, regional and even national innovation centres that bring together technology developers, investors and manufacturers from the private and public sectors worldwide together to innovate and create new and appropriate technologies. While there are advantages for the technologies thus developed to be in the public domain, experience seems to suggest that it is more important to keep the pipeline of innovations full so that even if the IPRs are privately owned, competition will ensure that prices are kept reasonable while incentivising innovation. Solar-PV and all technologies that will reduce emissions from fossil fuels (CCS, IGCC etc.) should be the primary focus of these innovation centres.

6.5 Facilitating technology cooperation

There was a general consensus amongst experts contacted during the study that the significant challenge to transfer of climate change technologies to India lay not in access to technology but the price at which it is transferred. In the case of wind power, experts estimated that 1-2 percent of the invoice value is paid as license fee to the technology supplier while in the case of some coal-based technologies, it has been as high as ten percent. This has depended upon the market situation at the time of the negotiation as well as the negotiating capacities of the parties.

Until such time as low-cost technologies are available in India, the country will remain dependent on imports. There is also some merit in the argument that if some countries or regions have a capacity to develop technology, it is probably more advantageous for others to simply acquire the technology rather than develop them from scratch. In either case, the fact is that price at which technologies are transferred to India in the future will be dependent on market conditions on which India will have limited control.

To protect developing countries from paying unreasonably high premiums for technologies, the case for setting up a global mechanism that can fund technology cooperation, especially in adverse conditions, is critical. India should continue to advocate for the setting up of such a fund, especially in the short to medium term, until such time that the process of "democratising" clean technology development is complete. This fund could also be used to develop new technologies in the innovation centres.

Another form of protection available to developing countries is to use the flexibilities under TRIPS – ranging from compulsory licensing to exemption of patent rights. This was used very successfully in the case of HIV/AIDS drugs a few years ago in South Africa. However, the study suggested that the nature of technologies and its demand may make this option unnecessary ■

Notes:

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[38] Besides this, there is a competing demand for silicon from semiconductor industry and telecommunication sector, which also makes difficult for PV industry to get regular supply of silicon.

[39] New technologies can overcome the water penalty by using air cooling process,which will result in low energy penalty.This has been the reason for renewed interest in many parts of world including Europe (International Energy Technology Collaboration and Climate Change Mitigation,IEA, 2004)

[40] While the existing policies enabled through National Tariff Policy (2006) and National Electricity Policy (2005) have resulted in state electricity regulatory commission setting minimum renewable portfolio standards, it is unclear if these guidelines provide longterms policy signals.

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