Tackling Climate Change: Bridging the Technology Divide – An Indian View

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1. Climate Change: Implications for India

Climate change is increasingly becoming a central topic for debate and strategic decision making by Governments and businesses all over the world. The warming of the climate system is unequivocal, as is now evident from observation of increases in global average air and ocean temperature, widespread melting of snow and ice, and rising global mean sea level. Climate change is undoubtedly one of the greatest environmental, social and economic threats, our planet faces today. It impacts all countries, but is particularly severe for developing countries like India, given their vulnerabilities, inadequate means, and limited capacities to adapt to its effects.

For India, the ramifications of Climate Change are not limited to ecology and environment alone, equally important, it is a serious issue which impacts country's economic and energy security. According to India's Initial National Communication, 2004 (NATCOM I) to UNFCCC, warming trends have already been observed along the west coast, in central India, the interior peninsula, and north-eastern India. Change in rainfall pattern, increased frequency of extreme weather events and rise in sea level has also been observed. The prediction for the future is more severe. There is growing consensus among scientists that India will be one of the worst hit countries of global warming. Consequently, the country would have to incur huge costs to cope up with the effects of climate change.

Some of the developed countries are demanding major developing countries such as India and China to undertake mandatory emission cuts. In the recent G-8 summit held at Toyako, Japan, G-8 members agreed to halve the carbon emission by 2050. India and China faced increasing pressure to sign up to a mandatory limit on greenhouse gas

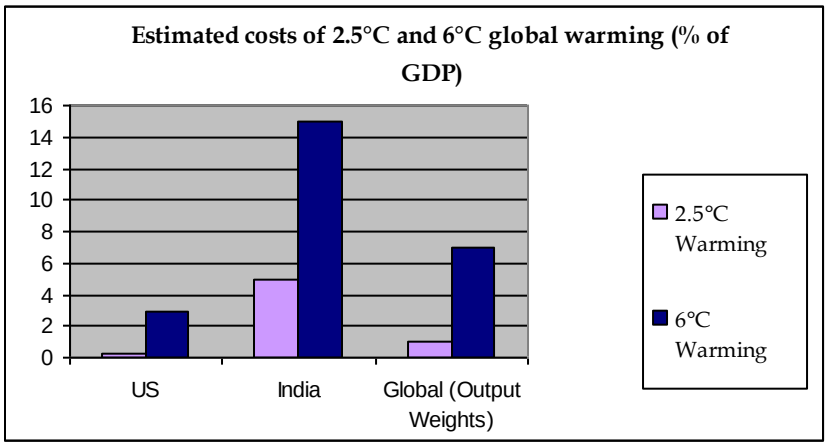
emissions at the summit. Some experts have also called for India's unconditional participation in Global Green House Gas mitigation, while espousing the idea of economic and trade sanctions to force the country into mandatory targets.

India's GDP growth and aspirations to improve quality of life of its people require proportionate increase in energy supply. India's primary energy demand is likely to increase from 537 Mtoe in 2005 to 1299 Mtoe in 2030 (IEA, 2007). Meeting this burgeoning energy demand would require India to embrace all available energy sources ranging from, coal, oil and natural gas to renewables and nuclear. However, it has been estimated that in short to medium term India's energy mix is likely to be dominated by fossil fuels, with coal amounting to 51%, oil-29% and natural gas – 12%. India largely depends upon imports to meet its requirements of oil and natural gas, while, it has significant domestic coal reserves. However, India's ability to use its coal reserves and imported fossil fuels for energy generation might be severely constrained due to climate change imperatives unless the country has access to cutting-edge clean conventional energy technologies.

1.1. Economic Impacts of Climate Change:

The range of climatic changes anticipated in India – from rising sea levels to extreme weather events – will have real impacts on the natural environment as well as human-made infrastructure and their ability to contribute to economic growth and quality of life. These impacts will vary across regions and sectors of the economy, leaving future generations to face a large spectrum of direct and indirect costs accrued from increasing environmental damage and disruption. A rise in temperature in the range of 2.5°C to 6°C could cost India 4-14% of its GDP (figure 1).

Figure 1: Impact of Global Warming on Indian Economy



Source: Nordhaus, W.D. Boyer, J. (1999)

All sectors of the Indian economy - most notably agriculture, energy, and transportation - will be affected; and ecosystems, on which quality of life for many relies (such as forests, rivers, and aquifers), will suffer. Some of the expected impacts of climate change on India are:

- India's 7600-km long densely populated and low-lying coastline would be worst hit due to rise in sea level
- 20% of the coastal population may need to migrate
- 25% of the country's population would be exposed to increased cyclone and flood risk
- Melting and receding of Himalayan glaciers may lead to reduced flow of water in perennial rivers
- 70% plants may not be able to adapt to new conditions
- More than 20,000 villages may have to be deserted
- Adverse impact on agricultural yield
- Increase in incidences of diseases like malaria

This certainly means that the country would need to invest heavily to minimize the adverse impacts of climate change. Government of India (GOI) is already expending over 2.6% of the GDP on various adaptation measures. Gross expenditure by individuals on adaptation measures is even higher. Government of India, in all international forums has emphasized the critical importance of adaptation for India. The National Action Plan recently announced by GOI has identified a series of additional adaptation measures that would be taken-up in short and medium term. Consequently, expenditure on adaptation measures would substantially increase as percentage of GDP.

At a time when India is grappling with heavy resource requirement for adaptation measures, global pressure is mounting on the country to commit to climate change mitigation targets as well. Capping or reducing emission levels in India without any method of global transfer of technology and financial resources means that India may have to limit its industrial growth and sacrifice its millennium development goals.

2. Business and Climate Change:

For business, global climate change is a source of risk and opportunity to be understood and managed. Though climate predictions vary, the increasing scientific understanding, growing public concern and international treaty activity, and the seriousness of potential consequences are convincing many business leaders to address these concerns in their business plans.

2.1. Business Risk and Climate Change

An actual change in climate could have catastrophic effect upon many industries. It could increase some costs of doing business and in some cases may completely disrupt the supply chain of the company. If environmental change and degradation were to occur on a large scale, suppliers, employees, operations and customers all could be affected, usually adversely. The impact of severe weather storms, droughts, hurricanes or similar weather disturbances suggests that the economic impact of major climate change could be

significant. The business risks associated with climate change have mainly four drivers (Table 1) that must be properly understood by all business leaders.

Table 1: Factors Influencing Business Environment

Drivers	**Effect on Businesses**
Public Concern	Public concern about the environmental consequences could further strengthen the market pressures favouring "green" companies. This may affect ability to market products and ability to mobilize investment for perceived ‘dirty industries’.
Governmental Action	Governmental action to reduce emissions of greenhouse gases, varying in strength, emphasis and from one jurisdiction to another.
Developments in Markets, Knowledge and Technology	Recent and ongoing developments in markets, knowledge and technology, which enable businesses to cut their carbon emissions while increasing productivity.
Climate Change itself	Can cause physical risks such as disruption of supply chain, physical infrastructure and networks.

There are many types of possible risks for business that could emanate from the four drivers mentioned above. Public concern about climate change may translate into consumer preference and market preference that may disfavour brands perceived as dirty. Governmental action may result in regulatory risk for certain companies due to change in

policy and regulation. Due to change in technologies and know-how, new companies may take environmental leadership and may put existing firms in a competitive disadvantageous position. There are many such risks that can hit the bottom-line of existing businesses. An indicative list of these risks is provided below:

- **Regulatory Risk**: frequent changes (tightening of) national/international regulatory structure (provisions).
- **Physical Risk:** possible damage to physical infrastructure, inventories of companies due to drought, flood, cyclone and other extreme events.
- **Competitive Risk**: due to rise in the cost of energy-intensive processes and a decline in demand for energy-intensive products.
- **Reputational Risk:** from customers and investors. Perception of inaction on climate change.
- **Litigation Risk**: threat of lawsuits for units emitting GHG gases.
- **Product & Technology Risk:** various technologies will be at risk due to carbon constraints.
- **Supply-chain Risk**: vulnerability of inputs such as energy and agricultural products.

Businesses all over the world and in India have responded to mitigate the threat of climate change. There are several examples of such efforts including formation of Business Council of Sustainable Development, voluntary emission reduction targets by many companies (primarily traded in CCX) and corporate investment in R&D for clean technologies. In India, industry has been the prime investor in energy efficiency, renewable energy and green building projects. Companies are competing to improve efficiency of their business processes and reduce energy and material consumption by utilising instruments like supply-chain management, ERP, automation, etc.

3. India Poised

3.1 The New Economy of India: Leapfrogging to a Low-Carbon Future

Efforts to mitigate climate change and global warming offer new opportunities for Indian industry and business to leapfrog the energy and resource intensive development process witnessed in the developed world. India can lead the newly industrialising countries in developing and adopting technologies and processes, and demonstrate a growth path and low-energy consumption pattern that would be far more sustainable than that of the industrial countries.

Technologies and practices affecting durable long-lasting systems are difficult to penetrate once assets have been constructed. Typically, power plants and industrial facilities last for 50 years or more. Buildings, once constructed, can stand for many decades. An automobile or truck has a life span of 15-20 years. Indian economy and infrastructure is relatively new compared to most of the large industrialising economies. The country is likely to add massive industrial and capital assets, and create huge infrastructure in the near future.

Developed countries have to retire old assets, created over the years, before they can build new assets based on cleaner technologies. India, on the other hand, can opt for efficient, clean technologies, and low-intensity resource efficient infrastructure. It is clear that environmentally conscious investment decisions can allow the county to leapfrog into an era of carbon-efficient advanced technologies.

There is abundant proof and a large number of examples wherein foreign direct investment in India has yielded high benefits for the investor, while simultaneously leading to a strong development surge locally. These investments need to be channelled in a direction which promotes low energy development.

Indian industry is determined to adopt the more energy efficient and cost-effective technologies and processes available in the world. It is also able to suitably adapt these to local conditions and environment. Some of the technologies that can help leapfrog the

conventional energy intensive growth path are LEDs and solar lighting, and a wide array of energy efficient systems and processes.

For instance, Cosmos Ignite Innovations, a spin-off from Stanford University that is now based in New Delhi, has developed the Mighty Light, a solar-powered LED-based lamp that is waterproof, portable and runs for up to 12 hours. So far, Cosmos has sold nearly 5,000 of its $50 lamps to various charities. The lamp is potentially a very attractive and appropriate solution for kerosene replacement.

Box 1: Case Study - ITC

ITC presents an interesting case of a company responding in numerous ways to make their systems and processes environment–friendly, energy-efficient and responsive to climate change. Various initiatives taken by ITC include the following:

ITC (tobacco, hotels, paper, food) has charted out a quiet but ambitious move to become the only corporation on earth to achieve triple green rating - it is already *water positive*, and is now moving to become both *carbon positive* and have *zero solid waste.*

Carbon positive: Implies a company, through afforestation programmes and efficient use of energy, eliminates more carbon dioxide from the atmosphere than the sum of the carbon emitted by the company through areas like the generation of electricity, running A-C plants and so on. *Water positive:* This implies that an organization generates more volume of fresh water through various water harvesting methods than it consumes in its factories. *Zero solid waste:* A company that achieves this is either able to utilize its entire waste as raw material for some other industry, or recycle it for use again in the factory.

- In all its hotels, high-tech water treatment plants (that cost Rs 40 lakh each) ensure that the water used in the rooms, the kitchen and by the laundry department is recycled back for use in the hotel gardens, in the cooling towers for the A-Cs, and even for flushing toilets.
- It has succeeded in registering as many as seven CDM (clean development mechanism) projects (three large-scale and four small), accounting for nearly one million CERs (certified emission returns).
- In 2004, the company created a total rainwater harvesting potential of 16.1 million kilolitres with the company consuming only half of this.
- The carbon sequestered during 2003-04 at 1,74,000 tonnes, offsetting carbon dioxide to the tune of 6,36,000 tonnes. The wood production during 2003-04 is put at 3,48,000 tonnes. As per current pulp requirements, the company needs only 4,000 ha of plantations annually, but is actually covering more than 10,000 ha, delivering bumper yields.

Sonar Bangla, Kolkata (Hotel)

- Energy Reduction is 20% by using solar heaters, condensed steam to generate hot water and using variable frequency valves in fans.
- In the process of getting certification for a reduction of 3,000 tonnes of carbon dioxide emission achieved by energy reduction.

Bhadrachalam Paperboard Plant

- Fly ash generated from the boilers in the mill is used to make bricks.
- Promoted 74,427 hectares of plantations (both Eucalyptus and Subabul trees) by distributing 313 million saplings in Andhra Pradesh in a bid to achieve ‘greening of wastelands’ through its ongoing social forestry programme.
- This unit which accounts for 60% of the carbon dioxide emitted by ITC Units has significantly enhanced the use of black liquor, a biomass waste generated in the pulping process, as fuel.

3.2. Lead by Example

India has been an early mover in increasing the use of renewable energy through the formulation of appropriate policies and in number cases has effectively addressed major barriers to developments.

For instance, scarcity of food, malnutrition and diseases, poor availability of modern and convenient forms of energy, the lack of technology in several key sectors, low level of telecommunications infrastructure, have all been addressed in effective ways. India's experience in dealing with these problems provides valuable lessons and practical models for turning liabilities into assets, and climate change could well be another area in which the country can show how barriers can be overcome effectively.

Supplying energy to remote rural areas: Energy shortages in rural and remote areas were a major drag on bringing the poor and isolated population groups into the mainstream of development. Through a dedicated Ministry for New and Renewable Energy (formerly Non-conventional Energy Sources), and through a combination of support based on subsidies and grants, as well market-oriented policies Renewable energy technologies (RETs) have played a key role in supplying energy to areas where conventional grid power cannot reach. There is a wealth of experience in a wide range of RE technologies and their applicability to different regions. This includes extensive R&D efforts in development, innovation, customization and maintenance of RETs and their deployment in varied and niche areas.

India is now a world leader in the application of certain RETs. Approximately 10,000 MW of RE based installed capacity[1] is already in place. Financial Institutions such as the Indian Renewable Energy Development Agency Ltd (IREDA), dedicated to financing and developing renewable energy and energy efficiency in India, are in place. IREDA has played a key role in channelling private finance and entrepreneurship into developing the RETs. R&D and technological support for RETs has also been addressed through

[1] This figure does not include large hydro, which is another significant energy source.

institutions such as Centre for Wind Energy Technology (C-WET). The Indian company Suzlon Energy Ltd. is now the world's 4th largest wind energy company. The country is emerging as an export hub in wind, solar and biomass equipment.

Addressing lack of technology: To address the issue to lack of technology, Indian companies have made rapid strides in shopping for the best technologies world-wide. In recent years several global acquisitions have taken place. A key objective of these acquisitions has been to access to cutting-edge technology. For instance, Tata Steel acquired Corus, Suzlon acquired RE Power and Hansen Transmission while Hindalco acquired Novelis. Multinationals are setting up R&D facilities in India (GE, AREVA, etc.) and Indian companies are increasingly investing in R&D in India and abroad.

Improving poor telecommunications infrastructure and low tele-density: Today India is one of the fastest growing telecom markets with one of the cheapest call rates in the world. Indian telecom companies now offer a variety of world class services and service providers.

Combating climate change and related natural disasters: Since the early years of development planning, India has had to contend with climate-related impacts and natural disasters affecting economic development. These have been in the form of droughts and floods, tidal waves and cyclonic storms, earthquakes and epidemics, localized scarcity of food and water. Over the years the economy has built up resilience to cope with these crises and reduce their overall impact. Even though the frequency and intensity of these calamities has increased, there are many cases where effective policy and local response has helped in cushioning the impact and in assisting the local population to return to normal life, and in the restoration of their livelihoods.

Technical departments and organizations of the government, R&D institutions, industry and civil society organizations have also actively supported efforts to minimize the impact of natural calamities on the population. Industry and business too have complemented government efforts to rebuild lives, incomes and infrastructure.

Global recognition to Indian pioneers: Due to its size and the fast pace of economic growth in recent years, India is crucial to the global response in countering the challenge of climate change. India's lead in promoting renewables and in achieving low energy intensity at a much earlier stage of development is a significant model for other developing countries.

India's leadership in meeting the challenge of climate change has been further highlighted by the recent global recognition awarded to a number of Indian pioneers. The recently announced Nobel Peace Prize was shared by the R. K. Pachauri[2]-led IPCC while Time magazine has included the entrepreneur Tulsi Tanti of Suzlon Energy and the glaciologist Dr Dwarika Prasad Dobhal of the Wadia Institute of Himalayan Geology in its 2007 list of environmental heroes around the world. Tanti has been recognised for his work on promoting wind energy while Dr Dobhal has been recognised for his work on studying glaciers.

4. Technology

Innovation and technology are crucial for achieving low-carbon development. A new approach to R&D and technology transfer is required in order to develop and deploy clean technologies within a given timeframe to avoid carbon lock-in. Along with harnessing the power of markets, actions should also be centred on developing international cooperation in order to capture the global public good aspects of low carbon innovation and enhance the diffusion of low-carbon technologies in developing countries. Governments must also accelerate the development of critical technologies, such as carbon capture and storage, Integrated Gas Combined Cycle, concentrated solar power , hydrogen/fuel cell etc.

4.1. Technology Access

[2] Dr. R. K. Pachauri is also the founder Director General of The Energy and Resource Institute (TERI), India

The vast majority of technology investments will be made by the private sector and the critical factor for stimulating those investments will be a robust carbon price. Many studies indicate that at a carbon price above $30, a number of low-emissions technologies would start to become cost competitive. But carbon markets will not automatically ensure transfer of low-emission technologies to developing countries (refer to sec 4.2). A package of complementary policies and international cooperation should be devised to further accelerate technology development and diffusion by allowing developing countries equitable access to advanced low-emission technologies.

4.2. Technology Transfer and UNFCCC Framework:

Technology development and transfer, together with finance, is the key component of a fair agreement under the UNFCCC. The Convention recognizes this in several provisions, including article 4.3 (developed countries shall provide financial resources including for technology transfer needed by developing countries to meet their agreed full incremental costs of implementing measures), art. 4.5 (developed countries shall take all practicable steps to facilitate and finance transfer of and access to environmentally sound technologies and know how particularly to developing countries; and shall support the development and enhancement of endogenous capacities and technologies of developing countries).

Despite the central role of technology transfer, there has been very little practical transfer of climate-friendly technology under the UNFCCC. The operationalisation of the principles, the establishment of mechanisms, and the actual transfer of technologies have yet to be put into effect. Table 2 below shows that only a handful of countries have been able to gain in terms of technology under the Clean Development Mechanism (CDM) in the year 2006. Notably, only 7.3% of the Indian CDM projects had component of technology transfer.

Table 2: Technology transfer for CDM projects in selected host countries

Host Country	Number of projects	Estimated emission reductions (ktCO2e/yr)	Average project size (ktCO2e/yr)	Technology claims as number of projects	Transfer percent of annual emissions reductions
Argentina	9	3,579	398	77.8%	99.4%
Brazil	160	20,471	128	33.1%	74.1%
Chile	23	3,720	162	17.4%	44.8%
China	69	52,996	768	55.1%	75.9%
Honduras	19	446	23	57.9%	57.5%
India	329	26,595	81	7.3%	34.4%
South Korea	12	12,556	1,046	50.0%	88.2%
Malaysia	18	2,343	130	83.3%	94.8%
Mexico	54	7,305	135	85.2%	91.4%
Nigeria	2	4,044	2,022	0%	0%
Philippines	22	388	18	63.6%	72.8%
Other host Countries	137	14,930	109	49.6%	50.9%
Total	**854**	**149,369**	**175**	**33.5%**	**65.5%**

Source: Haites et al. (2006)

4.3. Collaborative R&D and Technology Development:

Focused Research and Development is critical for improving the understanding of drivers of climate change and finding options to reduce its impact. Developing countries such as India, having a large pool of research professionals, is expected to contribute significantly to the R&D efforts pertaining to climate change. These R&D activities in developing countries should be carried out in sync with global R&D efforts of similar nature.

4.3.1. Participation in Global R&D Consortia

For example, India can combine its strength of abundant scientific manpower and low-cost innovation with the already existing research infrastructure and resources of the world to bring about optimum results. Several opportunities exist where Indian R&D stakeholders can be part of Global R&D consortia. Some work has been done in this direction. India is already participating in several global R&D consortia project for example;

- **International Thermonuclear Experimental Reactor (ITER):** ITER is a joint international research and development project that aims to demonstrate the scientific and technical feasibility of fusion power. The long-term objective of fusion research is to harness nuclear energy for mankind's future energy needs. ITER is the first fusion experiment to produce net power and will test a number of key technologies, including the heating, control, diagnostic and remote maintenance that will be needed for a real fusion power station.

- **International Partnership for the Hydrogen Economy (IPHE):** IPHE is a global partnership to help organize and implement effective, efficient, and focused international research, development, demonstration and commercial utilization activities related to hydrogen and fuel cell technologies. It also provides a forum for advancing policies, and common codes and standards that can accelerate the cost-effective transition to a global hydrogen economy to enhance energy security and environmental protection.

- **FuturGen:** This is an initiative to build the world's first integrated sequestration and hydrogen production research power plant. The $1.5 billion project is intended to create the world's first zero-emissions fossil fuel plant. When operational, the prototype will be the cleanest fossil fuel fired power plant in the world. The prototype plant will establish the technical and economic feasibility of producing electricity and

hydrogen from coal, while capturing and sequestering the carbon dioxide generated in the process.

– **Carbon Sequestration Leadership Forum (CSLF):** CSLF is a framework for international cooperation in research and development for the separation, capture, transportation and storage of carbon dioxide. The CSLF seek to realize the promise of carbon capture and storage over the coming decades, making it commercially competitive and environmentally safe.

4.3.2. Public-private partnership (PPP) approach for R&D

An effective R&D strategy for climate change would require combining government financing, social responsibility and public accountability of the public sector, with the finance, technology, managerial efficiency and entrepreneurial spirit of the private sector. Various R&D projects with the objective of finding-out effective solutions for climate change can be taken up under Public-Private Partnership (PPP) mode. To enable the same, a dedicated fund on 'Climate-Friendly Technologies' may be created by the governments that could be further leveraged with both international and private funds to promote research, development, demonstration and deployment of clean technologies. Various projects can be started for commercialisation and use depending upon time frame. Short-term and medium-term projects may be taken up mainly with the view of improving existing technologies. However, many promising solutions can be worked out in long run. Some of these options for R&D are summarised in the table below (table 3):

Table 3: Options for Emissions Reductions beyond 2030

Power generation	• Solar PV and concentrating solar power in combination with long distance electricity transportation • Ocean energy

	• Deep water wind turbines • Hot dry rock geothermal • Generation IV nuclear reactors • Large scale storage systems for intermittent power sources • Advanced network design • Low cost CCS for gas fired power plants • Distributed generation • Low cost unconventional gas
Transport	• Hydrogen fuel cell vehicles • Plug in hybrids • Trans modal transportation systems • Intermodal shifts
Industry	• CCS • Biomass feedstocks /bio refineries
Buildings	• Advanced urban planning • Zero energy buildings

Source: World Energy Outlook, 2006

4.4. Intellectual Property Rights (IPR) Issues:

Some of the clean technologies are in the public domain, or are not subjected to patents. But most of the key technologies are patented. Few generic technologies that are not strictly IPR protected does not necessarily mean that developing countries are able to deploy them. There are many additional barriers such as lack of capacity, poor infrastructure, inadequate laws and regulation and shortage of skill personnel, which needs to be addressed through international co-operation and framework.

For technologies that are patented, there must be an understanding that patents should not be an obstacle for developing countries to have access to them at affordable prices. According to the TRIPS agreement, if there is a patent on a product, a process or a technology, a firm or agency in a country in which the patent is operating can request for a voluntary license from the patent holder, in order for the firm to make or import generic versions of the patented product or technology. The patent holder will normally charge a price (royalty or license fee) for granting the license. If the patent holder refuses to give a license, or if the price charged is too high, the firm or agency can apply to the government to grant it a "compulsory license". Alternatively, a government that wants to have access to generic versions of a product or technology can itself take the initiative to issue a compulsory license.

Table 4: Typical Patents in Climate – friendly Technologies

Biofuels	Catalysts, processes (Novozymes) Standards
Renewable Electricity Sources	Technical improvements
Carbon-based electricity sources	Processes, catalysts
Industrial conservation	Processes
Housing	Devices, products
Transportation	Technical improvements

Quite clearly, IPR regime under WTO provide enough flexibility for crucial technologies like low-emission technologies to flow to developing countries on reasonable terms. However, these flexibility mechanisms should not become deterrent to private research and innovation. Methods need to be devised to accelerate deployment of clean technologies to developing countries, while safeguarding reasonable commercial interests of companies engaged in technology development and R&D.

5. Way Forward:

Technology transfer is not merely import or purchase of machines. A crucial aspect of technology transfer is the building of local capacity so that local stakeholders can design, modify and diffuse the technology within the country. Some of the steps that could create enabling conditions bridging the technology gap between developed and developing countries without jeopardizing genuine commercial interest of private parties are as follows:

1. **Climate-friendly technologies fund**: an international fund, with grants from developed countries and equity participation from both developing and developed countries should be created that would buy patents of key climate-friendly technologies from various companies and agencies and provide these technologies to developing countries at reasonable terms. The fund should also focus on capacity building aspect of developing countries so that these countries can evolve as low-cost technology innovation centres. This would have long-term benefits as technologies developed in these countries are likely to be relatively affordable for other countries.

2. **Removing barriers through institutional co-operation**: as indicated earlier, developing countries suffers from many barriers for technology transfer such as ignorance of technology issues, shortage of skilled personnel, poor infrastructure, improper legal framework etc. These barriers can not be tackled with financial intermediation alone. Institutional co-operation in areas such as assistance in infrastructure development, development of skills, training etc. would be required to effect the accelerated transfer of clean technologies to the developing countries.

3. **Cost reduction through Market Expansion**: for many technologies including solar photovoltaics, concentrated solar power and several energy efficiency technologies, cost comes down significantly if '**economies of scale'** can be achieved in production and deployment. In these cases, market expansion would allow attainment of economies of scale and reduce the cost to an affordable level.

4. **Promotion of Collaborative R&D**: inclusion of developing countries at the R&D stage for key technologies can be the most effective approach to engage these countries at the first place and build their capacity. Technologies developed through collaborative R&D involving both developed and developing countries are likely to be deployed in shorter span of time.

6. Conclusion:

Climate change poses several challenges and opportunities. Catastrophes, which are anticipated due to inaction, can be obviated with global co-operation and timely action. Both developed and developing countries have to play important role in tackling the challenge of climate change. Some of the developing countries viz. several Asian economies are growing at an astonishing pace – adding huge asset base every year. Therefore, it is in the common interest of the entire world to provide them equitable access to climate-friendly technologies to minimize adverse impact on global environment. Technology transfer to the developing world should be accelerated in a manner that does not sabotage reasonable private interests so that incentive to innovate and develop new technologies remains strong. This calls for the larger action by governments of developed countries in terms of assisting developing countries through financial intermediation and institutional support to facilitate transfer of technology. This would be in global interest and would help in Bridging the Technology Divide.

Bibliography:

Haites, E., M. Duan, and S. Seres. 2006, Technology Transfer by CDM Projects. Margaree Consultants Inc., Toronto, Canada

International Energy Agency, World Energy Outlook 2006, International Energy Agency Publications, 2006

International Energy Agency, Energy Technology at the Cutting Edge, International Energy Agency Publications, 2007

International Energy Agency, World Energy Outlook 2007, International Energy Agency Publications, 2007

Llewellyn John, 'The Business of Climate Change', Lehman Brothers, 2007

Ministry of Environment & Forest Government of India, India: Addressing Energy Security and Climate Change, Published by Ministry of Environment & Forest Government of India, 2007

Nordhaus, W.D. and Boyer, J., 'Role of DICE again: the Economics of Global Warming', Yale University, 1999

Planning Commission, Integrated Energy Policy: Report of the Expert Committee, Government of India, August 2006

Raghuraman V. and Kumar Suman, Building a Low-Carbon Indian Economy, Confederation of Indian Industry, January 2008