Proposal on Innovative Mechanism for Development and Transfer of Environmentally Sound Technologies (ESTs)

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Content

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The Authors

1 Introduction

1.1 The importance of ESTs in response to climate change

The innovation and diffusion of environmentally sound technologies (ESTs) is critical to meet the challenges of climate change. The cost and pace of any response to climate change concerns will also depend critically on the cost, performance and availability of ESTs that can lower emissions in the future (IPCC, 2007).

The “mitigation cost curves” of McKinsey (McKinsey, 2008) has illustrated the abatement cost of many kinds of technologies. It concluded that there is potential to reduce emissions by 27 gigatons CO2e by 2030. More than 70 percent of the potential can be achieved through the application of currently available technologies and the remaining can be achieved through the diffusion and deployment of technologies that are at present near commercialization. In addition, the abatement costs of 7 gigatons CO2e reduction through the application of energy conservation measures are negative, which means positive investment returns.

In “Energy Technology Perspectives 2008”, IEA conduct an in-depth assessment for the current situation and prospects of existing and advanced clean energy technologies such as low-carbon technology, providing a scenario analysis for the different outcomes resulted from theses technology combinations and calculating mitigation potential of each technology. In this report, IEA pointed that the sustainable development of energy system is possible and the technological factors will play an important role for the evolution of the current energy system. In addition, energy efficient, carbon capture and sequestration, low-carbon technologies such as renewable energy and nuclear power are also very important.

According to the following well-known Kaya equation (Kaya, 1990), reducing the energy consumption intensity (energy consumption per GDP) and the CO2e emission intensity (CO2e emission per energy consumption) , given the precondition that population and GDP per capita keep growing in the future , are the basic way to control total emissions. To realize the former target, we need to improve energy efficient, enhance the value added of industries and upgrade economic structure; and for the latter, we need to adjust energy structure and increase carbon sinks.

$$\mathrm{CO_2}\,Emission = \frac{\mathrm{CO_2}\,Emission}{EnergyConsumption} \times \frac{EnergyConsumption}{\mathrm{GDP}} \times \frac{\mathrm{GDP}}{Population} \times Population$$

（Kaya equation）

1.2 The necessity and urgency of development and transfer of ESTs

Currently, most of the advanced ESTs, including energy efficient technologies, low carbon technologies, adaptation technologies and so on, are owned by companies and governments of developed countries. Because of their low level of economic development, backward scientific and technological levels and limited investment in R&D, developing countries are always far behind in the field of energy efficiency, renewable energy and adaptation technologies, etc. There are great technology gaps between developed and developing countries. For example, average energy efficiency of China was about 36% in 2005, which is 8 percent lower than the world's advanced level, the same as the level of Europe in 1990s and Japan in 1975. The timely promotion of the development and transfer of ESTs will help to not only more rapidly narrow the technology gap but also achieve significant global climate benefits. It will benefit developed countries, who can keep enjoying global public goods without needing to replace current infrastructure and spend more on mitigation.

It is especially urgent to facilitate the availability, installation and operation of low carbon technologies in developing countries to avoid lock-in effects and control rapidly increasing GHGs emission. Developing countries, e.g. China, are deploying massive construction of infrastructure with available but low-efficient technologies. These developing countries will face the risks of lock-in effects of a high carbon economy and lose a historic opportunity to transfer to a low-carbon economy because of the long lifespan for infrastructure operation and the high replacement cost of existing infrastructure with high emission features. This will not only put a serious restriction on the global efforts in mitigating climate change, but also goes against the sustainable development of economic society in developing countries.

Take the power sector as an example; lock-in effects in the power sector are obvious when comparing the emission scenarios between high carbon technology and low carbon technology. Figure 1-1shows that, although the costs of initial investment in a low carbon technology scenario is higher than that in high carbon technology scenario, the reduction of GHG emissions will also continuously increase over the coming decades because of the advanced generation technology used under a low carbon technology scenario.

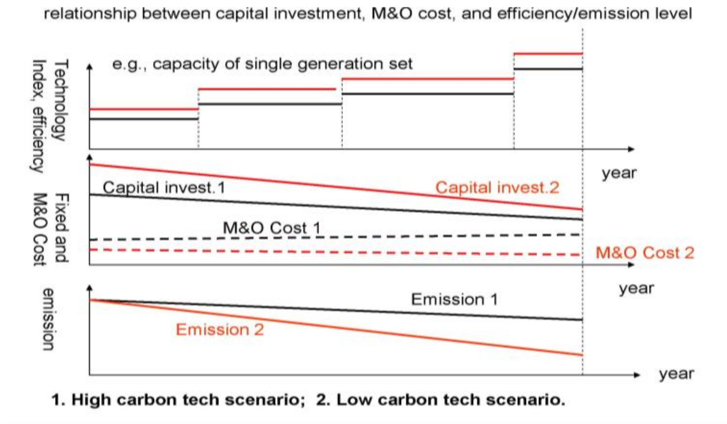


Figure 1-1 Example of lock-in effects in power sector

Source: Zou Ji, 2007

The quantitative relationship between the different power generation technologies and corresponding CO2 emissions is shown in table 1-1. The total installed capacity of coal fired power generation units was 368GW in 2005. The installed capacity in 2010, 2020 and 2030 is respectively assumed as 687GW, 1010GW and 1291GW. Two scenarios are established as follows:

Baseline scenario: suppose that sub critical technology (600 MW) is selected as the main technology option.

Technology progress scenario: suppose that Ultra Super-Critical technology (600 MW and above) is selected as the dominant technology, while accelerating the process for removing small-sized generation plants and the process for demonstration of IGCC.

The specific installed capacities for each kind of generation technology are shown as follows:

Table 1-1 Estimation of CO_2 emission reductions in the coal-fired power generation sector

		small scale sets	Normal	Sub-critical	Sub-critical	SC	USC	IGCC(Multi-Nozzle Gasifier)	IGCC (dry pulverized coal gasifier)
Unit capacity,MW		<100MW	100～300MW	300～600MW	600MW	600MW	≥600MW	≥200MW	≥200MW
Unit coal use, gce/kwh		394	346	322	306	298	267	304	299
Capacity volume in 2005, MW		102	99	120	33	14	0	0	0
Installed Capactiy under BAU Scenario （GW）	2010	70	110	140	277	64	20	4	2
	2020	35	95	130	500	134	100	10	6
	2030	0	70	120	652	164	230	30	25
Installed Capactiy under Technology progress Scenario （GW）	2010	55	100	140	128	74	180	6	4
	2020	20	70	100	109	94	581	26	10
	2030	0	35	60	85	114	897	60	40
Accumulative CO2 reduction （Mt-CO2）	2006—2020	2313							
	2006—2030	5813							

Note: Here the assumption is made that technology substitution during the three periods:2006—2010，2011—2020，2021—2030 is linear.

Source: Working paper of the Renmin University—Harvard University Joint Project"Economics of Win-Win Energy Policy in China"，2008.

Compared with the BAU scenario, the cumulative CO2 emission reduction will reach 2.313 billion tons from 2005 to 2020 and 5.813 billion tons from 2005 to 2030 in the technology progress scenario. In other words, if there is no technology transfer to help China equip its coal-fired power generation plants in a timely and effective manner, the extra accumulative CO2 emission up to 2030, representing the lock-in effect, would reach as much as 6 billion tons.

Overall, there are great gaps between developed countries and developing countries in major technology fields of mitigation and adaptation. To close over these gaps as faster as possible is favorable to help developing countries overcome lock-in effects and create historic opportunity for mitigation in the future. R&D institutes and companies in developing countries should enhance their technical innovation, introduction, digestion and absorption capacity, so as to obtain advanced ESTs. Only by this way can they fasten technology diffusion speed, broaden application scale, and then contribute more to climate protection and go onto the road of sustainable development. Currently, developed countries have most of the advanced technologies, and developing countries have a lot of mitigation potentials, this is just where the significance of international ESTs transfer lays.

1.3 Technology development and transfer – the key issue of The Copenhagen conference

As mentioned above, The innovation and diffusion of environmentally sounded technologies (ESTs) is fundamental and critical in addressing the challenges of climate change. International cooperation in the development and transfer (D&T) of ESTs is an important way for technology to play its role. According to the United Nations Framework Convention on Climate Change (UNFCCC) and Kyoto Protocol (KP), developed countries have responsibilities and obligations to transfer ESTs to developing countries on preferential terms. Articles regarding to technology transfer in the convention are as follows:

Article 4.5 of the Convention states, “The developed country Parties and other developed Parties included in Annex II shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention …”

Article 4.7 of the Convention further states: “The extent to which developing country Parties will effectively implement their commitments under the Convention will depend on the effective implementation by developed country Parties of their commitments under the Convention related to financial resources (Article 3.1) and transfer of technology (Article 4.5) …”

Article 4.1(c) of the Convention extended D&T of ESTs to the level of sectors. It commits all Parties to the Convention to promote and cooperate in the development, application and diffusion, including transfer, of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol in all relevant sectors, including the energy, transport, industry, agriculture, forestry and waste management sectors.

Article 10.6 (c) of KP commits Parties to “cooperate in the promotion of effective modalities for the development, application and diffusion of, and take all practicable steps to promote, facilitate and finance practices and processes pertinent to climate change, in particular those impacting on developing countries, including the formulation of policies and programmes for the effective transfer of environmentally sound technologies that are publicly owned or in the public domain, and the creation of an enabling environment for the private sector to promote and enhance the transfer of access to environmentally sound technologies.

Furthermore, Article 11.1 (b) of the KP commits developed countries Parties and other developed Parties in Annex II to the Convention to “provide financial resources, including the transfer of technology, needed by developing countries to meet the determined full incremental costs of advancing the implementation of existing commitments under Article 4.1 of the Convention.”

However, since the Convention entered into force 14 years ago, the issuing of technology under the Convention and KP has made little progress and cannot meet the challenge of climate change.

Technology development and transfer is also a key issue in the negotiations for an international climate regime post 2012, as well as one of the important elements in the discussion of the second commitment period of the KP and the future long-term cooperative actions (LCA). The Bali Action Plan (BAP) is a milestone for technology transfer. Under the Bali Action Plan, the development and transfer of ESTs makes up one of the four building blocks to be discussed and agreed upon in Copenhagen (the other three being mitigation, adaptation and financing). Enhanced actions on technology development and transfer to support actions on mitigation and adaptation requested in the Bali Action Plan include:

- Removal of barriers to promoting technology transfer, including financing, tariffs and non-tariffs, intellectual property rights (IPRs), and capacity, etc;
- Ways to accelerate the deployment, diffusion and transfer of affordable ESTs;
- Cooperation on research and development of current, new and innovative technology, including win-win solutions; and
- Effectiveness of mechanisms and tools for technology cooperation.

The progress of technology development and transfer is an important indicator within the effectiveness assessment of the implementation of the Bali Action Plan.

In order to promote progress on technology issue, the key is to set up a relevant mechanism for technology development and transfer including an adequate and stable level of fund resources.

The aim of the international cooperation mechanism for technology development and transfer is to help developing countries to understand technology information, to put ESTs at affordable and achievable prices, to allow ESTs to be adopted as an aid to limiting their greenhouse gas emissions and adapting to the impacts of climate change. It can be summarized as “knowable, available, affordable, and effective”.

Table 1-2 Major parties’ proposals on the mechanism of technology development and transfer

China+G77	Propose to establish an Executive Body (EB), functioning as a subsidiary body under the Convention, made up of government representatives and experts on technology transfer, with balanced regional representation. The EB would be supported by a Strategic Planning Committee, Technical Panels, a Verification Group and a Secretariat. One of the EB’s tasks would be to develop a Technology Action Plan to accelerate research and invention. The plan would include “the establishment of national and regional technology excellence centers and will reinforce north-south, south-south and triangular cooperation, including joint research and development”. The Technical panels would compile information on policies and measures; intellectual property rights and intellectual property cooperation; assessment, monitoring and compliance. The G77 proposes to create a Multilateral Clean Technology Fund (MCTF) under the UNFCCC that would provide technology-related financial support as determined by the Executive Body. The fund could partly act in a similar way to a venture capital fund, with public investment leveraging private capital for emerging technologies. The fund would also cover the incremental costs of new installations as well as capacity building, including costs of research, development and demonstration as well as enhancing human and institutional capacity.
China	China calls for the establishment of a Subsidiary Body for Development and Transfer of Technologies under the COP with a strategic planning committee and panels for technology needs assessment, dialogue and coordination for enabling policies and measures and IPR, management of financial resources, capacity building, and monitoring and assessment of performance. China also provides more details on the fund, which it calls the Multilateral Technology Acquisition Fund (MTAF). The MTAF should cover the full cost of capacity building and R&D and support deployment through public-private partnerships by linking public finance with the carbon market, the capital market and the technology market. Mechanisms to leverage private capital with public

	funds include insurance, loan guarantees, or investments via stocks, bonds and other financial products. China expects the fund to cover the incremental costs of low-carbon technologies, measured against a baseline of technological change in given technology areas.
India	Call for establishing a“ new, multilateral financial architecture for climate change” that treats financing as “entitlement not aid.”Call for a “balanced governance structure ”that takes decisions with” concurrence of the “beneficiary Party ”and has “no scope for unilateral determination by the assesses (developed country Parties)of which developing country Parties may be funded, or the extent(quantum)of funding required, or the funding modality(project, program, budgetary contribution).” This governance structure would enable “procurement norms ”that are “competitive in terms of technical capability and cost.” Request annual contributions equal to 0.5%of the total GDP of the developed world for funding adaptation and mitigation through resource transfers or grants.
EU	The EU proposal emphasizes the role of existing institutions. The EU would like to discuss how these institutions, including the Global Environment Facility and international and regional technology initiatives, such as the Carbon Sequestration Leadership Forum, could be improved and reinforced. The EU suggests that support for technology development and transfer through different channels, including for example the World Bank and regional development banks, should be recognized under the UNFCCC. The European Union has also proposed some mechanisms under the UNFCCC. For instance, it proposes a general coordinating mechanism to assess Low Carbon Development Strategies and Nationally Appropriate Mitigation Actions, match support to actions, and validate both. This would apply to actions and support in general, including those related to technology.
USA	The Conference of the Parties should consider whether there is a need for additional institutional arrangements, noting that any new arrangements should be consistent with: • the need for effectiveness, efficiency, and transparency; • cooperation, where appropriate, on a regional basis to coordinate efforts; • making use of existing national platforms, such as those for the Hyogo

	Framework; • flexibility in addressing adaptation and encourage a learning-by-doing approach; and • Encouragement of international organizations and institutions to support (through their programs on, inter alia, financial cooperation, capacity-building and institution-strengthening mechanisms) the integration of adapta- tion into development plans, programs, and priorities.

Source：Institutional Options to Enhance Technology Development and Transfer in the UNFCCC Context. Pelin Zorlu, Shane Tomlinson, E3G；Deborah Seligsohn, Lutz Weischer, WRI

From comparison of these proposals above, we can see that there is a discrepancy between developing countries and developed countries on how to promote technology transfer. The developing countries reached a common understanding that the current institutional arrangement is ineffective in promoting technology transfer, hence strongly recommend reestablishing a new technology transfer mechanism(e.g. China and G77 proposed to establish an subsidiary Executive Body under the Convention or COP , which is specially responsible for all the issues involved in technology transfer) and a fund which support this mechanism to operate(e.g. G77 proposed to create a Multilateral Clean Technology Fund (MCTF), China proposed to create a Multilateral Technology Acquisition Fund (MTAF)). Moreover, India calls for a “balanced governance structure” to make the developing countries have the same negotiation and decision rights as developed countries in the process of technology transfer. EU and USA , however, hold a different point of view as the representatives of developed countries, they insisted on making improvements on existing mechanism, but not rebuilding a new one),.In addition, EU proposed a general coordinating mechanism to assess Low Carbon Development Strategies and Nationally Appropriate Mitigation Actions, match support to actions, and validate both.

This not only reflects an obvious discrepancy between developing countries and developed countries, but also reveals that the two sides do not have faith in each other. As a result, it is very important to establish an international cooperation mechanism which could coordinate the benefit of each side and promote technology development and transfer simultaneously.

1.4 Study target

The objective of our study is to provide technology support to promote the formation of the international mechanism of development and transfer of ESTs and to promote the compliance and enforcement of the actions under the Convention and Bali Action Plan. The priority of the project is to conduct deep analysis of some key problems in the policy suggestions about an international technology cooperation mechanism and to facilitate communication among stakeholders.

The structure of this study is arranged as follows: the second part makes a brief introduction of concept framework, including global public goods and externality, ETSs, technology development and transfer, role of market mechanism, roles of government and analytical framework; the third part gives a description of Current technology status and TNA; the forth part discusses the barriers to current technology development and transfer; the fifth part makes a review of the existing mechanism under UNFCCC & KP and Other mechanisms implemented by International Organizations and Partnerships, then raises the conclusion that there is no effective mechanism to promote technology transfer; the sixth part elaborates on the framework of the International Mechanism for the D&T of ESTs; the seventh part is policy recommendation.

2. Concept Framework

This study focuses on the international cooperation mechanism for development and transfer of ESTs with the ultimate purpose of promoting the development, transfer, diffusion and deployment of ESTs around the world, in particular within developing countries, to solve the problem of global public goods of climate change.

Therefore, this report begins with the elaboration of global public goods and externality theory. Then it defines two basic concepts of the study: the concept of ESTs and technology development and transfer to resolve the controversy, so that the research is more focused. Due to the global public goods attribute of climate change and the existence of externalities, the solution to the problem cannot simply relies on the market mechanisms. Consequently, the latter part of this chapter analyzes the roles of market mechanism and government in the development, transfer, diffusion and deployment of ESTs respectively. Finally, the chapter explains the basic principles and analytical framework of this report.

2.1 Global Public Goods and Externality

Public goods are non-competitive and non-exclusive goods that are contrary to private goods, without clear property rights characteristics and difficult to separate in physical fragmentation. Public goods have two distinct features: non-competitive and non-exclusive for consumption. The theory of global public goods further expands the traditional theory of public goods. The global public goods refer to the ones that their benefits generally cover all countries (including more than one group of countries), groups (involving multiple population groups, in an ideal state across all population groups) as well as different generations of people (involved today's population and future generations, or at least meeting today's generation’s needs without compromising future generations’) (Inge Karl, 2006). According to the definition above, climate change is a typical problem of global public goods. It is consistent with the two remarkable features of pure public goods and its influence scale goes beyond the borders of a country, across different generations. All economies have to consume, willing or not since it once formed and thus it can be called "mandatory public goods."

As public goods, stable climate, safe concentrations of GHG and the corresponding volume of global GHG emissions are global public wealth. To maintain this safe concentration of GHG and to control GHG emissions not to exceed its global capacity, are consistent with global public interests and thus every country has its own responsibility. Due to the long-term existing attribute of GHG in atmosphere, we need to take the cumulative emissions into account when considering the allocation of public goods and responsibilities.

Climate change is also a typical issue of environmental externalities. Externality problem was first introduced by Marshall in his work "Principles of Economics," and was enriched and improved later by Pigou in his work "welfare economics", forming the theory of external. Externalities are free transfers of values (Zou Ji, 2000). From the perspective of welfare economics, externalities refer to that a person's or vendor's behavior has affected the welfare of other people or companies, but without a effective mechanism to restrain or provide incentive to consider the impacts in decision-making.

In terms of cumulative emissions, developed countries have created an enormous negative externalities, of which the consequences mainly are born by developing countries nowadays. First of all, the developed countries morally have inescapable historical responsibility concerning the climate change. Today's developed countries shall set targets and take measures to fully reflect their historical responsibility. However, undisputable, developed countries have not fully fulfill their historical responsibilities.

People in developing countries have the right to develop and to achieve safe, dignified standard of living. They also enjoy the right of their own basic energy consumption as well as the share of GHG emission volume. The basic fact is that current per capita GHG emissions in developed countries have massively exceeded the counterparts in developing countries, which indicates the greatly uneven distribution of global public wealth. In this context, if the developing countries take the responsibility of emission reduction, which they are not supposed to, they are creating a positive externality, benefiting the whole world.

Generally, the general public goods problem can be solved with involvement of government. However, as for the climate, such a global public good, there is no "global government" to manage, let alone using public policy to address this global problem of "market failure". Advanced ESTs are owned by the enterprises in developed countries while the development and transfer of ESTs cannot be achieved due to IPR issues, which result from the private sectors' purpose to maximize its own interests. It is warranted to protect IPR while it makes a paradox of solving the global public goods and IPR protection. Therefore, in the field of climate, we cannot simply focus on the role of market mechanism and leave all the tasks to market. The international technology cooperation needs the involvement of government to solve the problems caused by market failures - poor technology transfer and cooperation.

However, today's international order is still dominated by the developed countries, generally favoring the developed countries with irrational international political and economic order. Therefore, the international community should minimize the adverse impact on developing countries caused by the irrational international political and economic order when establishing international institution to address the climate change. It should also emphasize the protection of the rights and interests of developing countries, seek a new institution to overcome "market failure" and maintain a stable climate -global public goods.

2.2 Definition of ESTs

In the context of the Convention, ESTs are regarded as the technologies which can "protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residual wastes in a more acceptable manner than the technologies for which they were substitutes" (Agenda 21). According to such a definition, ESTs are supposed to solve the problem of environmental protection as a kind of global public good. The core returns of ESTs are climate benefits which, because of the existence of externalities, do not usually coincide with commercial interests. In addition, there other different viewpoints and understandings of the concept of ESTs (See further Blakeney, 1989, pp. 1-2; Santikarn, 1981, pp. 3-6; and Ubezonu, 1990, pp. 24-39). Although these definitions display that they have discerned various features of ESTs, they are too abstract, occasionally incomplete, and lack operational and practical considerations. Policy makers also find it difficult to use them directly to support their decision-making. According to the long term practice of technology application, ESTs can only become effective when they work as a system/package functioning with elements including hardware, software, know-how, infrastructure and complementary technologies or products, human and financial resources, and an institutional and policy enabling environment:

- Hardware: devices, equipment, processes, etc.;
- Software: IPRs, designs, know-how, principles and implementation of technical designs, etc.;
- Human resources: well trained and qualified workers;
- Financial resources: to make development, diffusion and deployment of technology happen; and
- Enabling environment: mechanism, policies, appropriate institutional arrangement, and infrastructure.

ESTs are not just related to equipment or "hardware", but also systems which include know-how, experiences, goods and services, equipment, human-resources, financial resources and organizational and managerial procedures.

ESTs may be distinguished by their stage of development, ownership, sector in which they are applied, et al. Furthermore, different technologies may involve different stakeholders, policy instruments and financial resources.

2.3 Definition of Technology Development and Transfer

As noted above, in the Convention context, technology development and transfer refers to promoting the transfer of technology(including know-how and skills) from developed countries to developing countries, in order to make ESTs "knowable, available, affordable, and effective" for developing countries.

"Knowable" means improving the conditions of the technology market and helping developing countries understand their technology needs, potential available technology and ways to acquire technology; "affordable" means making the prices of ESTs become affordable for developing countries; "available" and "effective" means developing countries can obtain the ESTs that they really need, and enabling these technologies to take true effect through the transfer of not simply the equipment but also abilities related to their operation, maintenance and improvement. If action is taken in accordance with the above criteria, the capacities for addressing climate change of developing countries can be improved and a sustainable development process in developing countries can be supported through the development and transfer of ESTs.

In order to make the D&T of ESTs effective, international cooperation in technology development and transfer should range across all stages of the ESTs' cycles, including invention, innovation, and diffusion. Efforts should be made at all stages of the technological cycle, including R&D for making inventions and undertaking the demonstration, diffusion, deployment, and operation of technologies. Different types of policy instruments and measures, cooperative models/patterns, may apply to different stage of these ESTs' cycles, also when addressing their corresponding challenges, issues, and objectives.

Barriers might exist at each stage, especially so in the stage of research and development. It is of great significance to enhance the independent endogenous innovation ability of developing countries and to promote their sustainable and endogenous technical ability through cooperative R&D etc.

2.4 Role of Market: spillover effects int'l trade and investment

Technology spillovers refers to the unconsciously transfer or dissemination of technologies during the process of trade or other economic activities. The technological spillover effects of International trade and foreign direct investment (FDI) are the primary means of technology transfer based on market mechanism.

International trade can bring cross-border technology flows, benefiting both developed and developing countries and leading technological progress and labor productivity improvements of their counterparts. Import trade is a more important means to absorb the foreign innovation compared to export trade.

On the other hand, FDI is also considered as an important means of international technology transfer, because multinational corporations in developed countries are the main source for R&D while technology of multinational corporations in developing countries are more advanced than the ones in the corresponding sectors. According to "World Investment Report" analysis by World Bank in 2008, global FDI inflows increased by a further 30 percent after four years of consecutive growth, reaching 1.833 trillion U.S. dollars, far higher than record level in 2000. All the flows in developed countries, developing countries and transition countries are continuing to grow. In the past 15 years, the growth rate of FDI in developing countries is about twice the growth rate of GDP, which significantly promotes the diffusion and transfer of technology. 40% R & D in developing countries is financed by foreign companies (World Bank, 2008).

However, technology transfer under the Convention, which merely depends on the traditional market mechanisms are not enough. On one hand, more advanced ESTs are owned by the private sectors in the developed world. In order to maintain market competitiveness and compensate for the cost of technology development, and even to form technological monopoly, they want to carry out the technology transfer through the market mechanism in accordance with commercial prices. They made the expensive intellectual property claims one of the substantial barriers to the technology transfer. On the other hand, due to the global climate public goods attribute, the private sector in developed countries do not have enough incentives to invest in the public sectors, which have almost no profit or a small profit with the universal existence of “free rider" phenomenon. They may also lack the incentives to make efforts for the technologies with slight possibility to gain profits in the future.

Compared with developed countries, developing countries can only obtain weaker technology transfer from trade and FDI because the intra-industry trade between developed countries can absorb technologies much easier than the one between the inter-industry trade between developed countries and developing countries. PECE researcher has evaluated the role of international trade in promoting climate technology diffusion from developed regions to developing ones, for instance China. Technology Spillover effect was quantitatively analyzed within the framework of Global Trade Analysis Project Model (GTAP), and spillover equation was specified as the function of trade volume and the effectiveness of foreign knowledge, the latter one was combined with human capital index and structural similarity index. The simulation results show that trade does not play a satisfactory role in promoting North-South technology flow, though it works more effectively in the case of North-North technology diffusion. Given a certain technological innovation in one developed region, other developed regions enjoy much more technological spillover benefit than China does. One extreme case is that when 3% of TFP shock is introduced in chemical sector in Europe, Japan reaps most of this innovation and gets as much as 2.9% of TFP shock in the domestic chemical sector via bilateral trade with Europe, while China only reaps 0.7% of TFP shock in the corresponding sector. This mainly results from the lower absorptive capacity in China and the lower structural similarity between China and Europe. The simulation results also show that China obtains more technological spillover which comes from the goods imported from Japan than that from North America and Europe, and Japan is the most important source for China's technological progress while North America is the least one.

FDI flow to developing countries in 2007 is nearly 500 billion U.S. dollars, rising 21% from 2006, however only accounting for 27% of the total global FDI inflows. The ability to attract FDI in developed countries is much higher than the one in developing countries, which indicates the limited technology transfer achieved by FDI. As a result, the technology spillover effects could only reduce the GHG emissions in developing countries to a limited extend. In addition, many multinational corporations only transfer the less efficient technology instead of the cutting-edge technology, fearing losing the control of the most advanced technologies (World Bank, 2008).

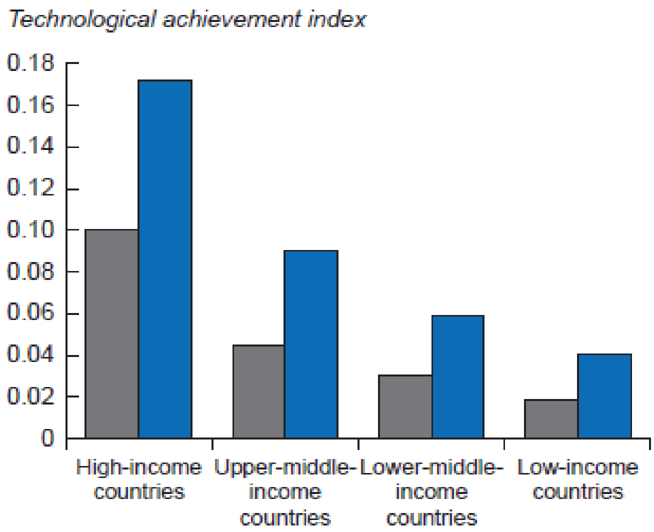


Figure 2-1 Technological achievement: converging, but the gap remains large

Sources: World Bank, 2008

As mentioned above, the development and transfer of ESTs aimed at protecting the global cannot focus only on the market mechanism based on the private cost information. From Figure 2-1, it is clear that the rates of technological progress in low-income countries and middle-income countries are slightly higher than the ones in high-income countries since 1990. However, , technological advances in developing countries over the past 15 years reflect large improvements in technological achievement by some, but much more modest advances by the majority. As a consequence, many are only maintaining pace with, or even losing ground to , high countries

(World Bank, 2008). As shown in Figure 1.3, the technology gap between the developed and developing countries has not narrowed significantly. To a certain extent, it proves that the international trade and investment regimes cannot effectively reduce the technology gap between developed and the developing countries.

On the other hand, technology diffusion and transfer to a large extent depends on the domestic capacity building, including technical infrastructure, skilled people, per capita income and so on. Although the absorption rate of the technology in developing countries has reduced from 100 years in 1800 to the present 20 years, only about 25% of developing countries reached 5% -25% of the absorption of many technologies that were invented in the high-income developing countries during the period of 1950-1975 (World Bank, 2008). Therefore, a sustentative improvement of the receiving countries' capacity building is also very important.

The Stern report (Stern, 2007) has pointed out that climate change will be the largest market failure encountered by human beings so far. In other words, the development, transfer and diffusion of ESTs achieved through the traditional market-based mechanisms of international trade and investment, are still far from being able to meet the challenge of climate change in terms of size, scope and speed. In addition, the inherent problems of monopoly and improper control (such as technology export restrictions) in the traditional market mechanism have also become the barriers to transfer the technology cross-border. According to EG3 studies, Current low carbon innovation programs are not adequate to manage the risk of policy failures and higher ranges of climate sensitivity (Thomlinson et al. 2008). For one thing, there is a huge financial gap. Stern also said that the public energy R & D funds should be doubled with an annual increase of 10 billion U.S. dollars; for another, a lot of energy efficiency measures to remains uncertainty in terms of emissions reduction. Consequently, the establishment of new and effective international mechanism for technology development and transfer is very necessary to combat climate change, reduce risk and uncertainty and speed up technology transfer.

2.5 Roles of Government: way-out to address externality and public goods

The traditional international technology transfer is based on micro-enterprise, and therefore depends on the function of the market, emphasizing achieving technology transfer through market channels. However, the technology transfer under the Convention will emphasize more on the government intervention due to the externality and global public goods characteristics of climate change. In the "Methodology and technical issues in technology transfer, it also clearly put forward that the government's role is extremely important in facilitating and promoting technology flows cross-border to reduce GHG emission (IPCC, 2000).

If entirely relied on the price mechanism for technology transfer, companies will not consider the environmental benefits brought by the technology transfer and annul the environment protection under the convention due to their mere pursuit of profit-maximizing. At the same time the purchasing power of developing countries is not enough to purchase the expensive advanced technology. Continuous use of backward technologies in developing countries will definitely lead to backward technology "lock-in effect."

As the main driving force of international cooperation of ESTs, the Government should build a platform for technology transfer, where still micro agents conduct the technology transfer between the two countries. It is only a market with government intervention. The Government's public service function determines it will play a leading role in enterprise guidance and supervision of the market. Specifically, the Government can play a role in two aspects: the "supply push" and "demand pull", respectively.

On the supply side, the government needs to remove barriers on the business innovation chain. Fundamentally, companies will invest in low carbon innovation and accelerate diffusion into new markets if the risk/reward balance is right. While policy discussion often focuses on issues of R&D funding and intellectual property rights (IPR) protection, issues of market creation and regulation at least as important in driving change in many areas and delivering the right balance of incentives (Thomlinson et al. 2008). A major shift in strategic innovation priorities and approaches will be needed at the national level to make international collaboration on low carbon innovation work at the scale and pace needed. Incentives for enhanced collaboration could include through co-financing support for collaborative RD&D with developing countries, agreements on reciprocity of knowledge sharing in national R&D programs, and MRV criteria on collaboration and knowledge sharing for making national innovation support eligible to count against international obligations (Thomlinson et al. 2008).

On the demand side, the Government should state a clear policy signals to guide the private sector to make a useful guide in climate beneficial decision, use public financial means to lower transaction costs, reduce risks in market development and adoption of new technology, compensate for the incremental cost and create favorable conditions for enterprise to development, transfer and deployment of ESTs. Public finance in developed countries should take the lead role.

In terms of cumulative emissions per capita distribution, the developed countries bear the inescapable historical responsibility for climate change. Besides, developed countries dominate the current world political and economic system and are the leaders in international trade and international investment and the main owner of the technology. They should take the lead in technology development and transfer, and take concrete initiatives to address climate change.

In particular, the developed countries may take the following policies incentives to push their enterprises and R & D institutions to transfer technology to developing countries, from economic and policy instruments:

- offer tax exemptions for enterprises in developed countries that export the ESTs
- provide subsidies to stimulate the development and transfer of technology of ESTs
- preferential export credit conditions for ESTs: such as the provision of trade guarantees, export subsidies, etc.
- lifting of restrictions on the export of ESTs
- technology joint research and development
- Other policies and measures

These policy measures will give a positive signal to the private sectors in developed countries to actively involved in technology transfer to developing countries and to provide incentives so as to promote and expand international technology cooperation.

On the other hand, government can also remove all obstacles on the way for private sector participation in international technology cooperation and provide positive incentives. Developed countries can help developing countries to eliminate the obstacles to improve the appropriateness of the environment in developing countries, including enhanced environmental regulations, strengthen the legislative system, protecting intellectual property rights for the private sector to facilitate technology transfer. Ultimately, through all these means, developed countries can promote the technology transfer to developing countries.

2.6 Analytical Framework

2.6.1 Analytical framework

The general analytical framework (see figure 2-2) is based on the logistic chain of the structure-behavior-performance model (Bain, 1951). As shown in figure 4, a technology transfer mechanism will first affect the behavior of different stakeholders and finally contribute to the performance of technology transfer.

In this analytical framework, the technology transfer mechanism will include many building blocks such as an innovative financing mechanism, institutional arrangements, an IPRs mechanism, a mechanism for promoting technology transactions and a mechanism for promoting the realization of social responsibility and the capacity building of enterprises. In order to assess the effectiveness of this mechanism, a performance monitoring and evaluating system is necessary which includes a set of performance indicators as well as modality and steps.

The direct role of the technology transfer mechanism is to adjust all stakeholders' behaviors (including governments of developed and developing countries, R&D institutions, technology owners, brokers, financial institutions, etc.) through a series of policy arrangements, then to change the speed, range and scale of technology and finance flow, and finally to change the trend of technology development.

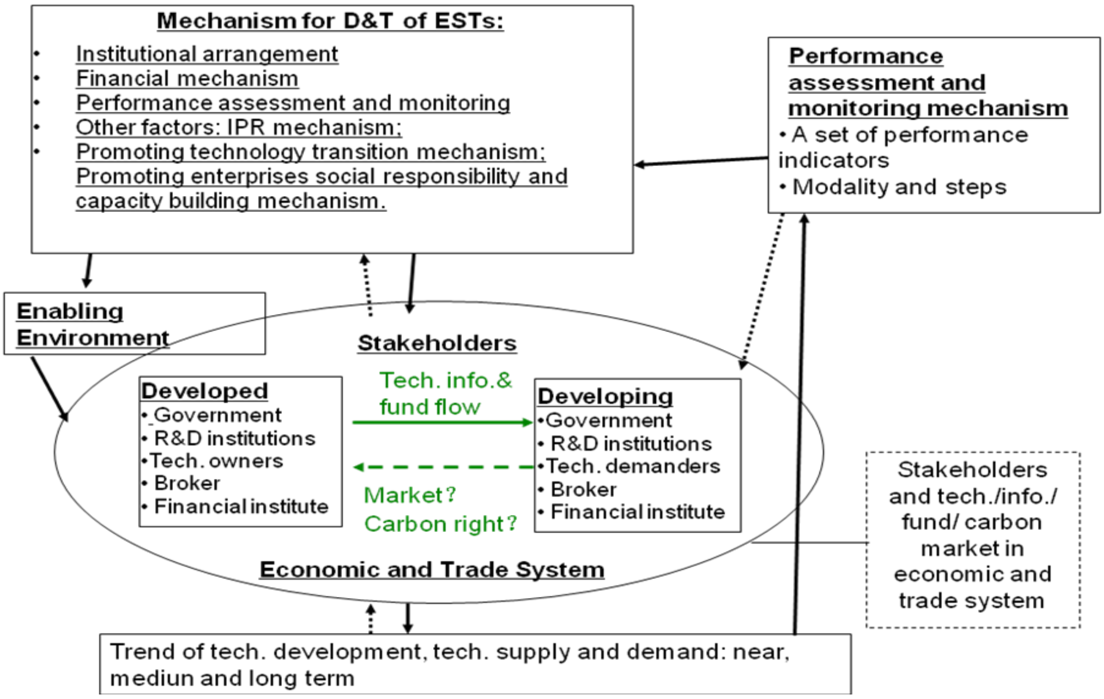


Figure 2-2 Structure-Conduct-Performance analytical frameworks

Source: Zou Ji, 2008a

2.6.2 Conceptual model

Performance assessment (including examining the exact speed, range, scale of technologies really transferred, and their corresponding effect, such as the effect of emission reductions and so on) is of great importance to judge whether the design and implementation of the mechanism is appropriate or not. Technology transferred should be available, affordable, and effective for developing countries.

Based on the above analytical framework, the identified major building blocks of an innovative mechanism for the D&T of ESTs need to be integrated in a conceptual model. This conceptual model has established a series of relations between independent variables and induced variables and made all major components of the innovative mechanism for the D&T of ESTs an organic whole. The following equation is the preliminary conceptual model:

$$TP_{s,p,o} = f_{s,p,o}(If, Fina, Inst, Hum, Infra, X)$$

Here：

f: technology transfer concept model

s: sectors

p: phases of technology life cycle

o: owner of technology

TP: Technology Transfer Performance

If : Technology information

Fina: Finance

Inst: Institution

Hum: Human resources

Infra: Infrastructure

X: Other factors

According to this equation, the induced variable is the effectiveness factor of technology transfer and independent variables are different constraint factors which affect the results of technology transfer. Independent variables include technology information, finance, institutions, human resources and infrastructure. The innovative financing mechanism is one of the most important parts of the technology transfer mechanism.

In addition, because of the disparities between regions and sectors, there is no unified technology transfer mode. The technology transfer conceptual model for different sectors in different regions and at different technology development stages will differ from each other. So the above equation has had a three dimensional subscript added to it to show the importance of empirical studies into specific technology in specific sectors, technology development stages and specific regions.

3．Status of Technological Level in China and Technology Needs Assessment

3.1 Current Status of Technological Level in China

3.1.1 The situation that the overall technological level of china lags behind that of developed countries has not changed

As a developing country, china started late on the development of climate-friendly technology, and lags behind developed countries on the whole. Even though China has achieved rapid development on climate-friendly technology through introducing, digesting and absorbing technology in recent years, the situation that the overall technological level of china lags behind that of developed countries has not changed.

The “National Guideline on Medium and Long-term Program for Science and Technology Development (2006-2020)” which is published in 2006 pointed out that, “compared with developed countries, the overall technological level of our country still falls behind, which manifests in several aspects: low self-sufficiency rate of key technologies and small number of invention patents; …scientific research quality is not high enough, being short of top-notch talents; meanwhile, there are not enough investment in science and technology, and the current mechanism has a lot of shortcomings.”

The gaps between China and developed countries in terms of energy efficiency are particularly obvious. Through the comparison of china’s energy intensity and international correspond level in 2000 and 2005, we can see that china’s energy intensity is higher than all the major countries. The gaps between china and developed countries such as EU, Japan are especially significant, for instance, china’s energy efficiency in 2005 is more than 7 times that of Japan. Furthermore, china’s energy efficiency level even lags behind India, which is also a developing country.

Table 3-1 International Comparison of Energy Intensity in 2000 and 2005

tce/million US dollars

	2000	2005
China	743	790
USA	236	212
Japan	113	106
EU	204	197
India	664	579
OECD	208	195
Non-OECD	603	598
World Average	284	284

Note: U.S. dollars at 2000 values

Source: Institute of Energy Economics, Japan, 2008

The gaps between China and developed countries in terms of energy efficiency is not only reflected in overall energy intensity, but also reflected in energy consumption of major energy-intensive products.

Table 3-2 International Comparison of energy consumption of energy intensive products (2007)

Indicators of energy consumption	China			International advanced level	Gap in 2007	
	2000	2005	2007		Energy consumption	%
Coal consumption of thermal power generation (Grams of coal equivalent/kWh)	363	343	333	299	34	11.4
Comparable energy consumption of steel (Kilograms of coal equivalent/ton)	784	714	668	610	58	9.5
Electricity consumption of electrolytic aluminum (kWh/ton)	15480	14680	14488	14100	388	2.8
Integrated energy consumption of copper smelting (Kilograms of coal equivalent/ton)	1277	780	610	500	110	22.0
Integrated energy consumption of cement (Kilograms of coal equivalent/ton)	181	167	158	127	31	24.4
Integrated energy consumption of flat glass (Kilograms of coal equivalent/Weight Box)	25	22	17	15	2	13.3
Integrated energy consumption of crude oil	118	114	110	73	37	50.7

processing (Kilograms of coal equivalent/ton)						
Integrated energy consumption of ethylene (Kilograms of coal equivalent/ton)	1125	1073	984	629	355	56.4
Integrated energy consumption of ammonia (Kilograms of coal equivalent/ton)	1699	1650	1553	1000	553	55.3
Integrated energy consumption of diaphragm caustic soda (Kilograms of coal equivalent/ton)	1435	1297	1203	910	293	32.2
Integrated energy consumption of soda ash (Kilograms of coal equivalent/ton)	406	396	363	310	53	17.1
Integrated energy consumption of Calcium Carbide (Kilograms of coal equivalent/ton)	NA	3450	3418	3030	388	12.8
Integrated energy consumption of paper and paper board (Kilograms of coal equivalent/ton)	1540	1380	NA	640	650*	115.0*

Source: Eerngy Data of 2008, Wang Qingyi, 2008

Note: 1. * is the data for 2006

2. "International advanced level" is indicated by the average level of advanced countries in the world

3. energy consumption data of steel, building materials, petrochemicals, paper and cardboard in 2006 to 2007 is estimated

As illustrated in the figure above, energy consumption of all the listed energy-intensive products in China are higher than advanced international standards, though these gaps are narrowing constantly. Except the "Electricity consumption of electrolytic aluminum" and "Comparable energy consumption of steel" have minor gaps compared with advanced international standards, all the other products' energy consumptions are more than 10% higher than advanced international standards.

3.1.2 The Gap of Key Technologies Is Significant

Through rapid development in recent years, China has achieved great progress in localization of low-carbon technology such as ultra-supercritical power generation, solar photovoltaic technology and onshore wind turbine technology, etc. However, what the china enterprises could manufacture are basically low-tech components, China still have obvious gaps in terms of fundamental and key technologies compared with developed countries. Even for those technologies with localization rate surpassing 80%, their key components still heavily rely on imports.

China lacks production capacity of rotor and high-temperature thermal components, which are key components of gas turbine. The production of rotor requires dedicated processing and testing equipment with high precision. Nevertheless, China has not yet mastered the production technology of special gauge and the processing technology of advanced rotor. The technical content of gas turbine embodied mainly in the high-temperature thermal components, particularly the first-stage compressor blades, nozzle of combustion chamber and combustion components. But China lacks both high-temperature materials technologies and manufacturing technologies , such as leaf punch and spraying.

China's wind power industry has been developing rapidly. It is predicted that in 2009, China’s additional wind power installed capacity will rank first in the world. By 2012, China's total installed capacity of wind power will also become the largest in the world (GWEC, 2009). At the same time, China's domestic manufacturers of wind turbine are thriving, with their share in China’s wind turbine market accounting for more than 70%. Moreover, Gold Wind and Huarui among these domestic companies have entered the world's ten largest wind turbine manufacturers. Nevertheless, very few enterprises in China are able to manufacture core components of the turbines , such as control systems, bearings and so on, due to the lack of technologies of materials, systems integration, control technology and other aspects, not to mention the most critical and difficult technology of wind turbine designing.

Programme of Energy and Climate Economics (PECE) of Renmin University of China has conducted a research on energy industry, iron and steel industry, transportation industry, construction industry and other important sectors of the national economy, identifying more than 10 important low-carbon technologies which include ultra-supercritical power generation technology, renewable technology, and high-performance pure electric vehicle technology and so on. Through a comparison of the status of these technologies development at home and abroad (see the details in table3-2), it comes to a conclusion that China still lags behind developed countries in core technologies at present.

Table 3-3 Comparsion of key technology between China and developed countries

Sector	Technology	Development Status in China and Abroad
Energy (mainly power sector)	Ultra-super Critical Power Generation Technology	The technology is developing rapidly in China, with an import substitution rate of more than 80%. There is still room for efficiency improvement on ultra-super critical power generation. R&D of a new generation of high power ultra-super critical unit, with the efficiency rate of 55% is going on in the world, while key technologies on high-temperature materials, casting and forging are still restricted to developed countries.
	IGCC Power Generation Technology	New generation of IGCC has a high efficiency rate (more than 50%), and low pollution emission rate, and is a new type cost-effective clean coal technology. Meanwhile, there has not been any project experience in China yet. China is leg behind in the integrated design control, large scale coal gasification and gas turbine technologies. These technologies are of strategic importance to China and China must acquire them. However, taking into consideration the lessons learned from failed import of gasifier and gas turbine, and the fact that there has not been operation experience of high efficient, large scale IGCC power generation project abroad, it is important to do both joint-research and independent research in China, in order to avoid being experimental lab to foreign enterprises.
	Large-scale Onshore and Offshore Wind Power Generation Technology	So far, China has the production capacity of MW- level turbine and some components, but the key technologies of control system, turbine and blade design are still rely on foreign imports.
	High efficient thin film solar cell	China is lack of thin-film cell production technology, and is blank in the commercialization of technology (flexible solar energy production process) and the whole set of production equipments and key equipments such as vacuum pumps. Countries like Switzerland, the United Kingdom, Italy and Germany have these key technologies.
	Solar Photovoltaic Technology	High cost of solar cell is the major constraint of development of solar photovoltaic power generation. More than 90% of the high-purity raw materials used in the solar cell are imported from other countries. These imported raw materials are expensive and countries who own the technologies blockade them, which caused the high cost of solar cell. Besides, China is lack of key materials and manufacturing equipments, and needs to further improve the conversion efficiency.
	Smart grid	At present, China does not have the key manufacturing technology of inverter, does not have much large-scale on-grid power plant experience, nor commercial operation model. The United States, Germany and Japan are the main possessors of these technologies in the world.
	Second-generation bio-energy technologies	The second generation of using cellulosic ethanol as liquid fuel, should have wider application. There have been many years of R&D experiences abroad, and many enterprises is planning/constructing demonstration plants, although not widely commercialized. The cellulose enzyme technology is one of the most critical technologies.
	Energy Storage Technology	Wind and solar are intermittent energy sources, and affect the stability of power grid. Hence, power grid has a limited capacity for such kind of energy. Therefore, efficient storage technology needs to be developed. At present, this technology is in the hands of European countries and the United States. The technology is still in the R&D stage.
	CCS Technology	Taking into account China's coal-based resource endowment, CCS technology will be of great significance to the mitigation. Currently, there has not been a commercial demonstration of CCS technology.

		The research is still in the preliminary stage, and is still a long way from large-scale commercial implementation. China needs to do joint R&D and to keep tack of the latest development. In addition, China needs to study both pre-combustion carbon capture and post-combustion carbon capture technologies.
Steel	Coke Dry Quenching（CDQ）	By the end of May 2008, 57 units of CDQ devices have been put into operation in China, accounting for 13.5% of total coke production capacity (360 million ton). Most of the CDQ techniques in China were imported. Domestic metallurgical coke design institutes such as Capital Steel & Iron Design Institute and Anshan Coking & Refractory Engineering Institute have the capacity of CDQ process design, and some are able to manufacture CDQ equipments, but are still lacking the capacity to design and manufacture high-pressure CDQ technology, which is in the hands of Japanese companies.
	Residual heat and pressure recovery technologies	Including sintering waste heat recovery technology, converter gas recovery (LT), converter of low pressure steam for power generation, hydrogen production from coke oven gas technology, and so on. The residual heat and energy recovery in China's iron and steel sector is low (only 45.6%), while international advanced enterprises, such as Japan's Nippon Steel can have a recovery rate of more than 92%. So there is great potential for China's iron and steel industry to improve its waste recovery rate.
	Coal Moisture Control（CMC）	CMC has great mitigation potential and have been developed by leaps and bounds in Japan, which has widespread use of third-generation technology of CMC. In China, however, only second-generation of CMC is widely used.
	CCPP (Combined Cycle Power Plant) Technology with Low- calorific Value Gas in Iron & Steel Plants	Low-calorific value gas turbine and some core components need to be imported, because they only have 10-20 years of service life and cost high. There are joint-ventures, such as NAC and GE are making the gas turbine and core components, but they can only make 50,000 kilowatts. Anything more than 150,000 kilowatts needs to be imported.
	Smelting Reduction Technologies	Smelting reduction technology is based on direct coal coke and iron ore powder technology. Since there is no coke, or sintering, or pelletizing plant involved, the technology simplifies iron-making process. There are dozens of technologies, but only COREX and FINEX have been tested and implemented in industries. Baosteel has successfully introduced COREX technology, but no breakthrough has been achieved. Smelting reduction technology has very little value in reducing CO2 emissions, but they are of significant importance to environment protection.
Cement	NSP Technology	Although the proportion of NSP kiln is raised continuously, the proportions of old production processes such as shaft kiln are still high. There is still a wide gap between technologies used in China and advanced technologies in the world, especially in some key technologies, such as the automatic control device and the level of integrated operation.
	Eco-Cement Technology	The substitution rate of secondary fuel in cement industry is more than50% in the Netherland, Germany and Switzerland. Although some academic institutions and some cement enterprises in Beijing, Shanghai, Guangzhou and Sichuan have made numerous experiments and pilot productions, it has not been promoted nationally. Hence, the utilization rate of alternative fuels in cement industry is close to zero.
Transport	The motorcycle engine technology, power-train technology and lightweight vehicle technology to improve fuel	Traditional technologies in vehicle energy saving and fuel economy improving have high market proportions. There is huge gap between

	economy	these domestic technologies and advanced technologies in the world.
	Hybrid Electric Vehicle Technology	The R&D of hybrid electric vehicle started 30 ago in the world. Now hybrid vehicle has been industrialized and commercialized. China's auto industry has begun to research, development and manufacture hybrid vehicles, but is still lagging behind in the recovery efficiency and matching technology of full hybrid vehicles.
	High-performance pure electric vehicle technology	Developed countries have developed series of pure electric cars, high-speed pure electric vehicles, pure electric bus, and electric touring bus. China needs to improve the technology integration and wire transport technology in the pure electric vehicle area.
Building and residential	LED Technology	The United States, Japan, Germany and Taiwan are most advanced in LED technology. The majority of patented technologies are in the hands of a small number of large companies, and the core technology has been securely protected. China is currently doing packaging and heat sink, and does not acquire core technologies.
	New building envelope materials and parts	China has induced and learned a number of technologies in the external wall and roof insulation. Major breakthrough has been made in the technology advancement in external windows and glass curtain walls but the level of technology diffusion is low; huge gap with foreign advanced companies in the outdoor sunshade.
	Regional Combined Heat and Power (BCHP) technologies	The BCHP offers a solution to the energy supply of large public buildings. Compared with direct access to grid electricity, the technology can save primary energy by 20% ~ 30%. Major technical obstacles include: high-power efficiency, low-emission gas-fired power plant, and high-density, high-conversion efficiency thermal-driven air-conditioning.
General Technology	High-power electronic devices, especially power semiconductor component technology	There is still a gap between the level of China's high-power electronics products and foreign advanced level. Represented by Siemens and ABB, the European Union is in the leading position in the high-power electronics products and technologies. IGBT and IGCT devices have been the constraints of China's electric and electronics industry, especially the high-power electronics industry.
	Permanent Magnet DC Brushless Motor	Micro, small areas implication of this technology is relatively mature. Japan is in the leading position. Taking into account China's rare earth resources, technology provider from developed countries continue to make troubles in this area.

3.1.3 Unbalanced distribution of advanced technology

The technology development level of Chinese enterprises is not balanced. With the development of market economy, a number of modern enterprises have gradually integrated with the advanced international level in terms of governance structure, financial strength and technological level. But at the same time, there still exists a larger number of collective enterprises, private enterprises and even family workshops, whose business concepts, management level, financial strength and technological capabilities lag far behind the advanced level. Moreover, the "dual structure" of this industrial sector also determines the "dual structure" of its distribution of technological level: on the one hand, the technology level of some advanced enterprises ,especially the large state-owned enterprises, have already been closed to or even exceeded the level of developed countries; On the other hand, there are still a large number of SMEs which use outdated equipment and technology for production, hence have energy efficiency far below international level, which results in a large waste of resources and serious environmental pollution. According to the technical capacity distribution, outdated and high-energy-intensive technologies often account for the majority of total capacity, while the adoption rate of advanced technologies is still very low.

Zhejiang Huaneng Yuhuan Power Plant had two sets of 1000MW Ultra-supercritical generators with coal consumption rate of 282.6g/kWh put into operation in 2006, which are the largest capacity and the most efficient Ultra-supercritical units internationally up to now (Lin yin, 2008). Since 2003, the total number of ultra-supercritical generators made in China is already more than 4 times that of foreign-made. However, while China has the ultra-supercritical units most advanced in the world, there are still a large number of backward thermal power units in the country. As of July 2009, there are about 80 million kilowatts of high-energy-consumption and heavy–pollution pure condensate thermal power units with capacity below 200 thousand kilowatts, hence eliminating small and backward thermal power still has a long way to go (Xinhua Net, 2009).

In the iron and steel industry，Shanghai Baosteel Group purchased a direct smelting reduction iron (Corex) equipment from Austria equipment supplier VAI in 2005, and put it into operation at Luo Jing Project base of Pudong Iron and Steel Group Company of Baosteel in November 2007. This means that Pudong Iron and Steel Group Company will become the world’ s largest factory using the new technology of direct smelting reduction ironmaking, thus leads the world in this green energy-efficient smelting reduction iron-making technology. However, there are still a large number of blast furnaces with 300 cubic meters and below production capacity, and converters, electric furnaces with 20 tons and below production capacities at the same time. “Steel industry restructuring and revitalization plan" published in 2009 points that, 300 cubic meters and below blast furnace production capacities of 53.4 million tons, along with 20 tons and below converter and electric furnace production capacities of 3.2 million tons should be eliminated by the end of

2010; by the end of 2011, eliminate blast furnace production capacities of 400 cubic meters and below, converter and electric furnace production capacities of 30 tons and below, which is equivalent to the corresponding elimination of backward iron smelting capacity of 72 million tons and steelmaking capacity of 25 million tons (State Council, 2009).

3.1.4 The increase in the number of patented technologies is inconsistent with the rise of technology level of domestic enterprises

In recent years, the number of energy technology patents registered in China shows an upward trend, which gives an illusion that the level of low-carbon technologies in China has achieved a great progress, for example, the number of wind power technology patents registered in China has ranked 4 globally, second only to the United States, Japan and the World Intellectual Property Organization, and more than European Patent Office.

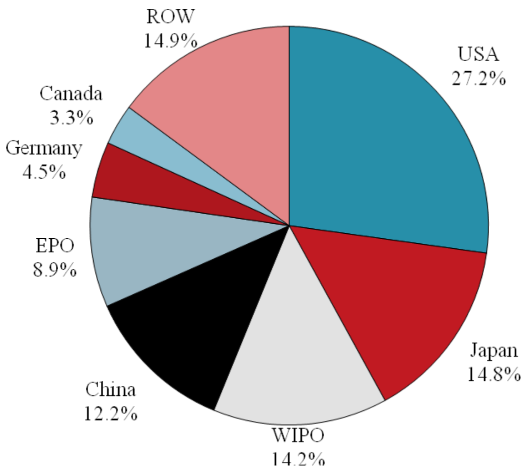


Figure 3-1 Comparision of Wind Power Patents Filing in Different Countries

Data Source: Chatham House, 2009

In fact, if we make a careful analysis toward the actual applicants of these patents, we will find that the most of these patents are actually applied by the subsidiaries of multinational corporations in China. As is shown in Figure 3-2, the top three applicants for wind power patent are all companies from developed countries, there are only three Chinese applicants among the top ten. It is thus clear that, the actual owners of the vast majority of those patents are foreign companies, even though they are registered in China.

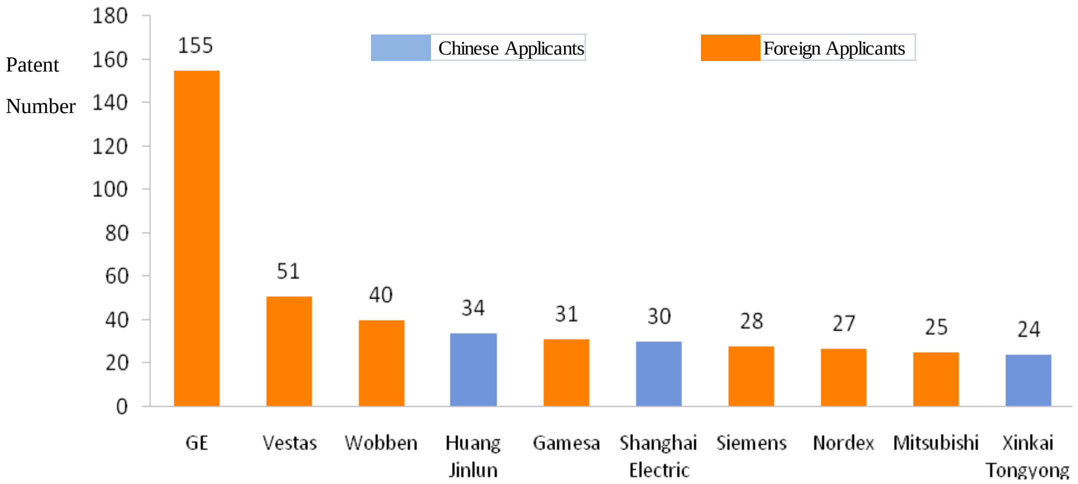


Figure 3-2 Top 10 Wind Power Patent Applicant in China

Data Source：Patent Database, State Intellectual Property Office of PRC

Up to November 20, 2009

Moreover, in the patents applied by Chinese enterprises, the proportion of Utility Model Patents is much higher than the proportion of invention patents, which contrasts with foreign enterprises: almost 100% of the patents applied by foreign enterprises are invention patents. The following figure selects five domestic leading fan manufacturers and four foreign fan manufacturers and then makes a comparison between the two groups in terms of the proportion of invention patents to total patents applications. It is thus clear that even for these companies like golden wind and Huarui, which are able to rank among the world's top ten wind turbine manufacturers, the proportions of invention patents to the total patents they have ever applied do not exceed 60%. In contrast, the proportion of invention patents has reached 100% in all the four foreign companies selected.

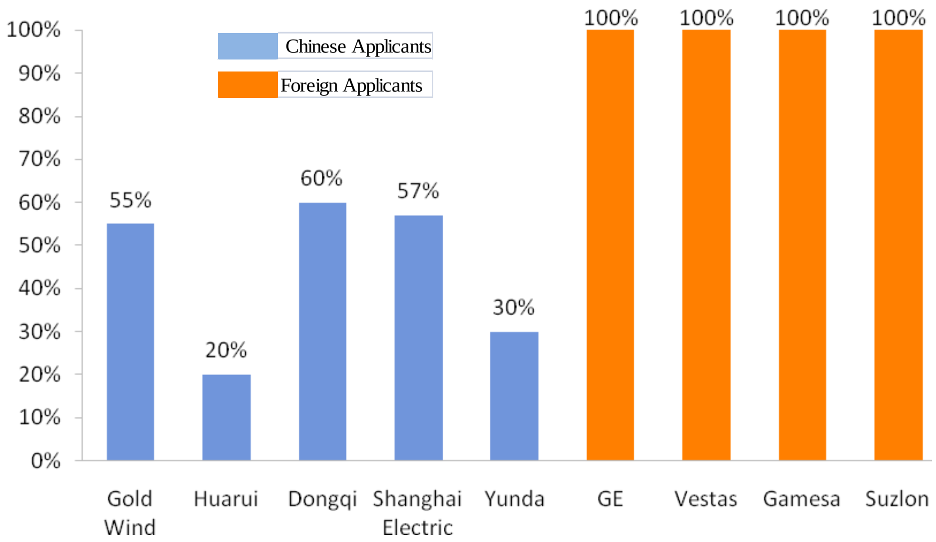


Figure 3-3 Comparision of the proportion of invention patents of Chinese and foreign wind turbine manufacturers

Data Source：Patent Database, State Intellectual Property Office of PRC

Up to November 20, 2009

Intuitively, hrough comparison of the gap between Chinese and foreign enterprises in the development of low-carbon technology, it will be find that with the rise of the number of patents registered in China, the technological level of Chinese enterprises has not been simultaneously increased, and the gap between China and advanced international standards does not get shortened substantially.

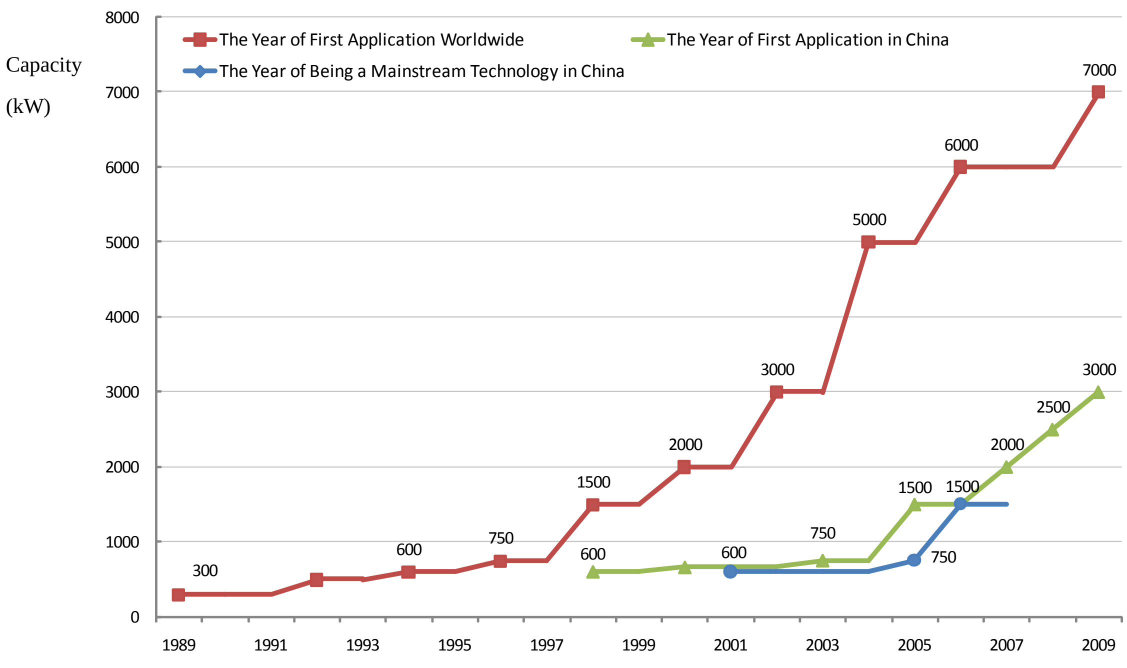


Figure 3-4 The gap of wind turbine manufacturing technology between Chinese and foreign Companies

Source: CUI Xuiqin, 2009

The first time for Chinese enterprises gain the ability to produce 600kW wind turbine was in 1996, by purchasing patent license from the German manufacturer Repower. Since then, Chinese companies gradually gained manufacturing technology of 50kW, 1.5MW and even 2.0MW, 2.5MW and 3MW wind turbine through various ways, such as technology acquisition, purchase of the design, establishment of joint ventures, joint R&D, etc. At the same time, wind turbine manufacturing technology is developing worldwide, turbines with larger capacity emerging. Currently the largest wind turbine manufactured in China is 3MW, while the most advanced wind turbine in the world, with a stand-alone capacity of 7MW has started mass production. There remains a technology gap of abut 7 years between China and developed countries. The gap just maintained, rather than narrowed.

3.1.5 Major Producer, But Minor User

Currently, China has achieved a comparative high level of production capacity in some low-carbon products, and has realized a great export amount of these products. At present, however, these low-carbon products manufactured in China are mainly for export to international market. The relative high cost often couldn’t be afforded in domestic market. As a result, low-carbon products haven’t got widely applied in the domestic market of China and thus have little substantial effect on its energy-saving and emission-reduction process. China’s becoming the major producer of low-carbon products should be attributed to its advantages of low-cost labor and energy rather than technical advantages.

Solar photovoltaic industry, for example, has achieved great development in China. The solar cell output in 2000 was only 3 MW, by the end of 2007 this number had reached 1088 megawatts, ranking first in the world. However, there exists serious problem in China’s solar PV industry: on the one hand , the high purity crystalline silicon as the raw material of solar PV production mainly relys on imports; on the other hand, because the domestic application market of solar power generation is so small that the PV products are mainly sold abroad.

The reason for this phenomenon is exactly that China's current technological capabilities are backward and its renewable energy markets are immature. Refining high-purity crystalline silicon technology is currently only held by a few core companies from United States, Japan and Germany, what china could do is to export large amount of industrial silicon at a price of one U.S. dollar per kg and then import purified silicon crystals at a much higher price of 46-80 U.S. dollars per kg. currently, 97% of high-purity silicon required by China PV industry relies on imports. Due to the current high solar PV costs in China, it is only applied in China's northwest border region , islands and deserted villages, the remaining 95% of products are all exported (Li Junfeng, Wang Sicheng, et al., 2008). As a result, China is now only a major producer of solar PV products, rather than a major user of solar PV products. Environmental and social benefits which should be generated from PV industry have not been reflected in China.

In order to produce these solar PV products for foreign use, China has to consume large amount of resources and bear the expense of pollution. Polysilicon, as the basic material of information industry and photovoltaic industry, belongs to high energy consumption and high pollution products. The integrated power consumption of the whole process from the production of industrial silicon to solar cells is about 2.2 million kWh / MW (State Council, 2009). The current improved Siemens method which is widely adopted by Chinese enterprises will generate silicon tetrachloride and other exhaust gases, the recycling of which is very difficult. So, it can be said that china’s mass production of solar PV products and large amount exports brings “low-carbon” to foreign countries and has energy consumption and pollution left to itself.

3.2 Technology Needs Assessment

It has become the consensus of the international community that developing countries require technological support from developed countries to address climate change, as a result of their limited technological capacity. To determine the real needs of technologies for a country, and benefits that these technologies can bring in terms of GHGs emission reduction and adaptation to climate change, technology needs assessment is needed. Technology needs assessment is the common requirement for both international technical cooperation and energy conservation domestically.

3.2.1 Definition and Background of Technology Needs Assessment

Technology needs assessment (TNA) is an approach that entails the identification and evaluation of technical means for achieving specified ends (Robert Gross, et al, 2004).

In the context of climate change, technologies referred here are those reduce GHGs emissions to achieve emission reduction targets, as well as enhancing the ability to adapt to climate change in various countries and different sectors. From a climate change and developmental perspective, TNA prioritises technologies, practices, and policy reforms that can be implemented in different sectors of a country to reduce greenhouse gas emissions and/or to adapt to the impacts of climate change by enhancing resilience and/or contributing to sustainable development goals. Therefore, TNA is an integration of sustainable development and climate change technologies.

Technology needs assessment is the initial stage of the technology transfer process. At the most general level, the criteria for selecting sectors and technologies for TNA will depend upon three factors, which are not necessarily mutually exclusive (Robert Gross, et al, 2004):

- Contribution to development goals. How much overlap exists between the technology and the already identified technology needs?
- Contribution to climate change mitigation or adaptation. How effective is the technology in reducing GHG emissions and/or increasing resilience to the impacts of climate change?
- Market potential. Is there a ready niche for the technology?

In determining applicable criteria, technology needs assessment will help to select appropriate technologies through the assessment of a country's requirement in industrial and technological development, evaluation of technological capacities of enterprises as technology recipients, and cost-benefit analysis of climate-friendly technologies. Technology needs assessment can effectively improve the performance of technology transfer of climate-friendly technologies. Technology needs assessment is a dynamic process evolving with the development of new technologies.

Technology needs assessment is a key element in the international climate negotiation and issues of technology development and transfer. In “The Marrakech Accord” adopted in COP 7 in 2001, it is propsed that technology needs assessment should be included as one of key themes and areas in the framework for meaningful and effective actions to enhance the implementation of Article 4, paragraph 5, of the Convention. In 2007, Parties to the Convention reached to an agreement on the implementation of results identified by technology needs assessment and network of technology information centers.

In 2009, UNFCCC Secretariat and UNDP jointly published the latest “Handbook for Conducting Technology Needs Assessment for Climate Change” on the basis of the earlier edition released in 2004. This TNA handbook provided a more detailed framework for the development and implementation of technology needs assessments and in particular in the development of technology programmes and strategies in developing countries. It also seeks to support capacity building and to help with the establishment of the enabling environments for technology transfer.

In May 2009, UNFCCC Secretariat released “Second synthesis report on technology needs identified by Parties not included in Annex I to the Convention”. Based on 70 technology needs assessments and 39 national communications submitted by Parties not included in Annex I to the Convention, this report highlights priority technology needs identified, both in mitigation and adapation field. It draws attention to specific barriers to technology transfer and suggests measures to address them, as well as highlights various ways used to involve stakeholders in a consultative process to conduct TNAs, including the methodologies and criteria used to prioritize technology needs.

Nevertheless, technology needs assessment is just the preliminary stage of a a successful technology transfer process. Well-conducted technology needs assessment by developing countries itself is not sufficient enough to guarantee the validity of technology transfer. Whether developed countries can provide substantial technical support and promote technology transfer according to technology needs assessment, is the most significant factor that may determine the real performance of technology tranfer.

3.2.2 Key Activities of Technology Needs Assessment

The TNA process directly need to addresses the question: “What are the key actions, priorities, and criteria with respect to GHG mitigation and adaptation to climate risks?” Generally, technology needs assessment is comprised of six key activities, which are illustrated in Figure 3-5.

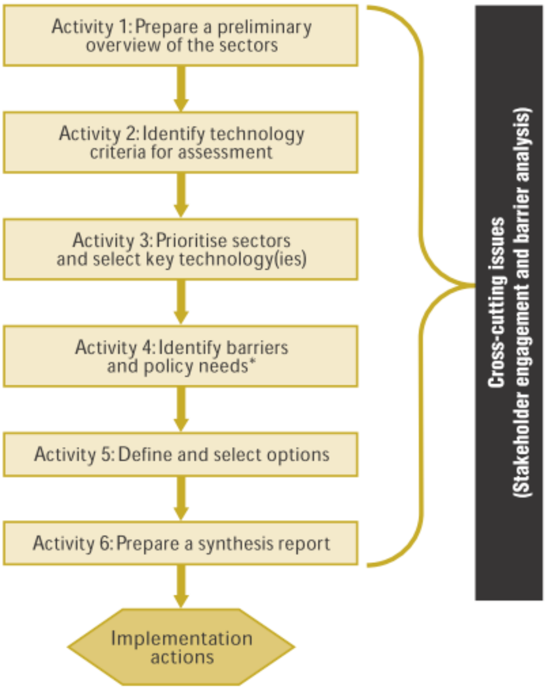


Figure 3-5 Key Activities in the Technology Needs Assessment Process

Source：Robert Gross, et al, 2004

Activity 1: Prepare a Preliminary Overview of Sectors. Preliminarily identify those major departments which have abatement potential on account of macro background and their abatement capacity according to the GHGs inventory; meanwhile, identify the characteristics of these departments based on the national planning.

Activity 2: Identify Technology Criteria for Assessment. When selecting sectors and technologies for TNA, three factors which are mentioned above should be followed.

Activity 3: Prioritise Sectors and Select Key Technology (ies). The identification of priority sectors will be based upon the importance of the sector in terms of the criteria as outlined in the previous activity. Priority sectors and technologies in different countries may vary, depending upon individual country circumstances.

Activity 4: Identify Barriers and Policy Needs. Through the assessment of abatement technology, indentify barriers for RD&D, as well as further policy required.

Activity 5: Define and Select Options. Once technology and sector priorities have been identified, barriers assessed, and stakeholders assembled, technology options can be selected for the short and long terms.

Activity 6: Prepare a Synthesis Report. Each of the previous activities needs to be combined into a coherent whole that allows actions to be pursued and provides an overview of the basis upon which decisions have been made. This will require the compilation of a synthesis report. The synthesis report should contain a summary of the issues of concern to the technology transfer process – issues such as the key sectors affected, the types of criteria applied, the ranking and selection process applied, and the list of technologies that emerged as an output of the process.

3.2.3 Technology needs List on Key Mitigation Technology

Technology needs assessment should combine goals of addressing climate change and promoting sustainable development in the selection of appropriate technologies. In the practice of technology needs assessment in China, the following criteria were often used (Zou Ji, 2002; Zou Ji, et al. 2008):

- Environmental: including GHGs (e.g. CO2), local pollutant abatement and the impact of mitigation of climate change
- Technological: including the reliability, easiness, diffused extent and duplicability of technology (in demand of specific index of certain technology)
- Economic: including financial analysis like internal cost-benefit/effectiveness and economic analysis like external cost-benefit/effectiveness
- Social: whether it is good for employment, public health, to narrow the income gap and reduce poverty

Following the main activities the criteria of technology needs assessment, Programme of Energy and Climate Economics (PECE), Renmin University of China developed a bottom-up non-linear technology optimization model. Analyzing cost data of 388 technologies and taking into account the stage of technology development, the model indentified the technological support system for China to develop low carbon economy. Further, in the objective of meeting the energy service demand and minimising the mission reduction cost, the model calculated out the technology needs list in China, which is illustrated in Annex 3-1.

Table 3-4 Technological Support System for China to Develop Low Carbon Economy

	Deployment &Diffusion (Near term)	Demonstration (Mid-term)	R&D (long term)
Power	USC; On-shore Wind power technology; 3rd generation large-scale Advanced pressurized water reactor; Geothermal- Conventional; High-efficiency natural gas fired power generation;	Coal Integrated Gasification Combined Cycle (IGCC); Off shore wind power; Solar Photovoltaic; Geothermal–Enhanced; 2nd Biomass;	Low cost CO2 capture and storage; Nuclear fusion; CSP; Power storage; Smart grid; 4th nuclear generation; Solar nanotechnology photovoltaic; Hydrogen production, storage and distribution; Fuel Cell
Steel	CDQ; CCPP; CMC; Power, heat and fuel recovery; Coal Injection of Blast Furnace; Energy management center;	COREX; FINEX; Advance EF; Smelting reduction technology; Waste Plastic Injection;	Direct Casting; CO2 capture and storage;
Transport	Enhance fuel economy of vehicles by improved engine/ transmission/ matching technology; Develop advanced diesel vehicles; Improve railway electrification; Aviate fuel economy management;	Hybrid vehicles; Enhance fuel economy of transport system by information & intelligent systems Improved road network;	Fuel cell vehicles; Electric-motor vehicles; Optimizing the construction and integration of transport capacity;
Cement	NSP cement kiln technology, especially the automatic control device and the overall operation level; Low-temperature cogeneration technology;	Eco-cement Alternative fuels and cement clinkers;	CCS;
Chemical	New type catalyst; Large-scaled Synthetic Ammonia equipment; Optimize structure of raw material for Ethylene;	Alternative fuels and raw materials;	CCS;
Buildings	Green Lighting; Technologies and materials of heat-insulation of external walls and roofs; Advanced efficiency electric devices;	District energy system; Heat pump system; supervising and Monitoring of building energy consumption technologies; Heat-electricity-coal gas triple co-supply system	Energy storage technology ; Zero-emission buildings Building integrated photovoltaic solar power system; Advanced city plan;

3.2.4 Technology needs List on Key Adapation Technology

Due to a large population, poor weather conditions, fragile ecological environment and other reasons, China is one of the most vulnerable countries to the adverse effects of climate change. Meanwhile, relatively low level of economic development, poor infrastructure and weak public health system undermine the ability to adapt to climate change for China. Climate change has brought serious negative impacts on public health, agriculture, forests and other ecosystems, water resources, coastal environment and biological diversity, etc. in China.

To reduce adverse impact of climate change on people's livelihood and socio-economic sustainable development, it is necessary to take measures to enhance the ability of adaptation. A broad range of sectors and regions may adopt appropriate adaptation measures and technologies. There are key adaptation technologies in areas such as climate change monitoring, agricultural production, water resoures management, coastal zone protection, etc.

Adaptation to climate change is an integral and important part of addressing climate change. China also has technology needs in the field of adaptation to climate change.

Programme of Energy and Climate Economics (PECE) identified a list of technology needs for adaptation through expert interviews and case studies, including key technologies from areas of integrated meteorological observation, climate change monitoring, agricultural production, coastal zone protection and biodiversity conservation.

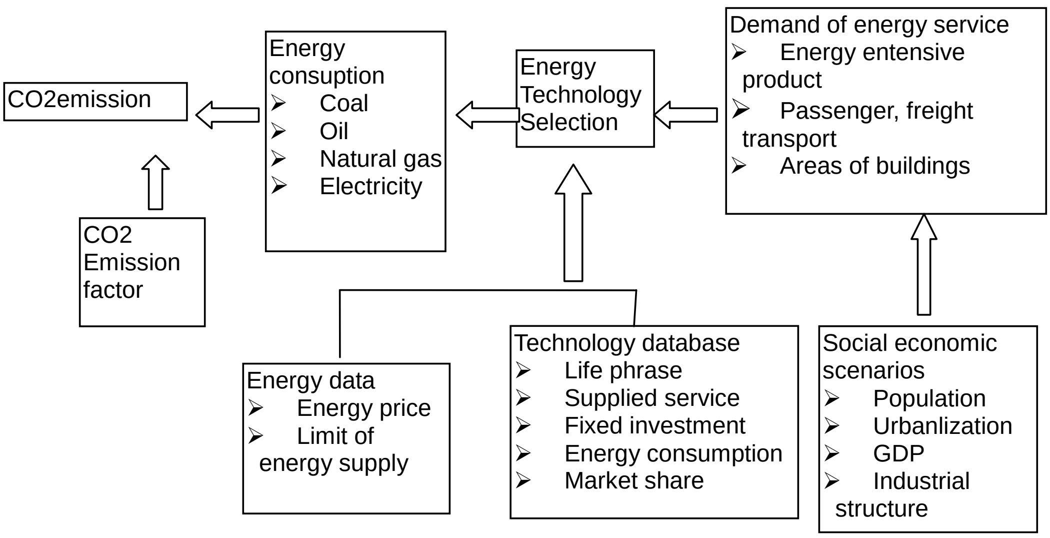
BOX：Technology Optimization Model of PECE

Technology Optimization Model of PECE is a bottom-up non-linear technology optimization model. The model calculates the technology option meeting the objective of minimising cost, under a series of constraints, such as energy service demand, limitation on energy supply and technological feasibility, etc. Costs contained in the model including fixed investment on technology, operation cost, energy cost, tax and subsidies, and so on. Analytical framework of the model is illustrated in the figure below.

The main features and functions of the model are as follows:

- The model can reflect results of scenario analysis under different assumption of driving forces.
- The model can provide optimal mitigation technology portfolio with minimum cost.
- The model can provide optimized technology needs, investment on emission control and reduction, total and unit cost of emission control and reduction corresponding to a certain amount of emission (scenario). Further, technology road map can be drawn based on the model results.
- The model can be extended from national level to regional and provincial level.
- The model can integrate different policy variables into it. For example, the model can simulate the impacts of carbon taxes and energy taxes of different levels on abatement cost and investment, and so on. At the same time, information of cost on emission control and reduction provided by the model will help to determine the appropriate rate of carbon or energy tax, while providing useful reference to the pricing in carbon market.

Figure Analytical Framework of Technology Optimization Model of PECE



Annex 3-1 Technology needs List on Mitigation Technology

Sector	Technology	Development Stage	Mitigation Potential[1]	Accumulative incremental investment[2]
Energy (mainly power sector)	Ultra-super Critical Power Generation Technology (mainly new generation of efficient ultra-super critical power generation technology, high-temperature materials, and casting and forging technology)	Diffusion/ Demonstration	4.8	4128
	IGCC Power Generation Technology (mainly integrated design control technology, large-scale efficient coal gasification technology, and high efficient gas turbine technology)	Diffusion/ R&D	5.9	5233
	Advanced Nuclear Technology (mainly the 4th generation nuclear technology, i.e. new generation of fast reactor technology)	R&D	7.6	9705
	Nuclear Fusion Technology	R&D	N/A	N/A
	Large-scale Onshore and Offshore Wind Power Generation Technology (mainly control system, turbine and blade design, new material for blade making (carbon fiber), blade detection and bearing technology)	Diffusion/ Demonstration	5.7	6765
	High efficient thin film solar cell (mainly manufacturing equipment, vacuum technology, and advanced technology)	Diffusion/ Demonstration	0.6	696
	Core technology of solar thermal power (including the Stirling machine, medium and low temperature solar heat conversion technology, etc.)	Demonstration/ R&D	1.3	1729
	Solar Photovoltaic Technology (mainly high-purity silicon production technology, key materials such as steel wire, and complete industrial chain of equipments manufacture, and high-conversional efficiency of photovoltaic power generation technology)	Diffusion/ Demonstration/ R&D	2.1	2993
	Smart grid (mainly the key on-grid technology and the inverter technology)	Diffusion	N/A	N/A
	Advanced geothermal power generation technology	Diffusion/ Demonstration	0.3	219
	Second-generation bio-energy technologies (including production of fuel ethanol from lignocelluloses, such as the technology of cellulose production and biomass technology)	Diffusion/ R&D	1.5	5030

[1] 100 million ton of CO2, under the EA in 2050
[2] 100 million USD, 2005 Price, under the EA scenario in 2050

	Energy Storage Technology	R&D	N/A	N/A
	Hydrogen Fuel Cell Technology	R&D	N/A	N/A
	CCS Technology (including pre-combustion carbon capture technology and post-combustion carbon capture technology, and carbon storage technology)	R&D	13.1	15576
Steel	Coke Dry Quenching（CDQ）	Promotion	0.3	240
	Residual heat and pressure recovery technologies (such as sintering waste heat recovery technology, converter gas recovery (LT), converter of low pressure steam for power generation, hydrogen production from coke oven gas technology)	Promotion	0.95	943
	Steel Production Energy Management Center	Promotion	0.16	110
	Coal Moisture Control（CMC）	Promotion	0.2	166
	CCPP (Combined Cycle Power Plant) Technology with Low- calorific Value Gas in Iron & Steel Plants	Promotion	0.1	138
	New-generation of Coking technologies (such as SCOP21)	R&D/ Demonstration	0.48	1479
	Technology of Injecting Waste Plastics into Blast Furnace	Demonstration/ Promotion	0.16	318
	Smelting Reduction Technologies (including COREX, FINEX Technology)	Demonstration/ Promotion	0.1	244
	The use of microwave, electric arc and exothermal heating of direct steel-making technology	Demonstration/ Promotion	0.1	445
	Advanced Electric Arc Furnace Steelmaking (EAF)	Demonstration/ Promotion	0.9	2253
	Itmk3 Iron-making Technology	R&D/ Demonstration	0.1	371
	Technology of Thin Strip Continuous Casting (Castrip)	Demonstration/ Promotion	0.6	2417
	CCS Technology	R&D	1.1	1250
Cement	NSP Technology (mainly automatic control device and level of integrated operation)	Promotion	2.6	1968
	Eco-Cement Technology (taking combustible waste as an alternative fuel)	Demonstration/ Promotion	0.6	615
	Precalcining pure low temperature waste heat power generation technology	Promotion	0.9	831
	Efficient grinding technologies (such as	Promotion	0.3	305

	advanced vertical centrifugal mill)			
	CCS Technology	R&D	1.3	1574
Transport	The motorcycle engine technology, power-train technology and lightweight vehicle technology to improve fuel economy	R&D	8.4	13440
	Advanced low-emission diesel engine technology and high-quality automotive diesel technology	Promotion	1.8	3366
	Hybrid Electric Vehicle Technology (mainly the energy recovery efficiency improvement technology and matching control technology)	R&D/ Demonstration/ Promotion	3.3	7194
	High-performance pure electric vehicle technology (mainly the integration of technology and technology-wire)	R&D/ Demonstration/ Promotion	2.2	7040
Building and residential	LED Technology	R&D/ Demonstration/ Promotion	1.9	1234
	New building envelope materials and parts	R&D/ Demonstration/ Promotion	8.9	8583
	Regional Combined Heat and Power (BCHP) technologies (such as heat, electricity and gas combined-cycle technology)	Demonstration/ Promotion	1.7	2952
	Ground Heat Pump Technology	R&D/ Demonstration/ Promotion	1.9	7480
	Advanced ventilation and air conditioning systems (such as independent temperature/humidity control systems)	R&D/ Demonstration/ Promotion	2.6	2105
General Technology	High-power electronic devices, especially power semiconductor component technology	Demonstration/ Promotion	1.5	2340
	Permanent Magnet DC Brushless Motor	Demonstration/ Promotion	N/A	N/A

Annex 3-2 Technology needs List on Adaptation Technology

Sector	Technology	Development Status (China)	Development Status (Overseas)	Detailed Requests
Integrated Meteorological Observation	Regular sounding technology	The update work for upper air sounding equipment is very slow and there is no obvious improvement in the upper air sounding ability.	In the world, air detection equipment has been developed relatively fast. The balloons floating sounding technology has been rapidly developed in the United States.	The application of Wind Profile Radar; the implementation of GPS in the upper air meteorological sounding.
	Irregular sounding technology	China's meteorological satellite remote sensing instruments has limited features, are less accurate and less stable. The existing radar technology can not meet the demand of economic construction and social development.	The meteorological satellite observing system in the United States, European Union, Russia and Japan has entered a phase of microwave remote sensing, and initiative remote sensing.	The technology is developing towards "high-time resolution, high spatial resolution, high spectral resolution and high accuracy of radiation measurements, as well as towards the implication of global, all-weather, multi-band observations; based on Doppler weather radar, and new technologies of foundation remote sensing.
Numerical Weather Prediction	Data analysis and assimilation	Currently, China has only the three-dimension variational data assimilation technology, using satellite and radar remote sensing.	In the world, four-dimension variational data assimilation technology has been developed and widely implemented.	The development of four-dimension variational data assimilation technology; A large number of satellite data direct assimilation and near-surface density data rapid assimilation; Parallel computing of high-resolution high-performance four-dimensionl variational assimilation, as well as a strong supporting business environment for high-performance computing platform.
	Numerical forecast models	China has successfully developed a new generation of independent numerical prediction system GRAPES. The basic testing system has been established, and some of the core results can have business applications. However, in general, the present numerical prediction model is not very well tailored to China's weather and climate issues.	In the next 3 to 5 years, almost all major countries will improve the horizontal resolution in the global numerical prediction model to 10 to 20 kilometers, reaching world medium level.	the coordination between physical process parameters, optimization program, dynamic models, and system-wide assimilation; perturbation method of initial singular vector; improvement of typhoon vortex initialization method
Agriculture	Crops Molecular Design Breeding Technology	China is lag behind in the research of this technology.	American Pioneer, University of Queensland, Australia and the International Maize Wheat Improvement Center have carried out studies on the genotype and environment interaction analysis, such as breeding simulation.	To strengthen the application of crop molecular breeding; to carry out large-scale germplasm innovation and cultivate new varieties using molecular breeding technology;
	Efficient allocation of water resources and limited	China's agricultural water-saving hardware construction project is 30-50 years behind the level of developed countries.	Germany, the United States, Israel have advanced technologies and successful experiences.	To learn advanced foreign technology; to strengthen the infrastructure construction of water-saving agriculture

	irrigation technology	China is lack of advanced technology with intellectual property rights.		
	Recycling of agricultural technology	In China, research and application of high-techs in the food industry is still in its infancy stage.	Materials technology, highly efficient separation technology, drying technology, micro-capsule technology and other modern technologies in food industry have been widely applied in foreign countries.	Technologies of common platform for new food manufacturing; technology of comprehensive utilization of agricultural and livestock; critical technologies of agricultural storage, packing and logistics chanel; key technologies of functional food research and development.
Protection of the Coastal Zone	Marine monitoring and observation	There is a large gap between the level of China's marine monitoring equipments and those in the world.	Foreign countries lead the technology	Imported: tension-type mooring buoys, mooring buoys profiling; Joint-research: air-sea flux measurement system, and carbon dioxide measurement system
	Evaluation of sea level rise forecast	China is almost 10-20 years lag behind developed countries in sea level rise monitoring and analysis.	Advanced sea level rise analysis and forecasting system has been built up in developed countries.	Aerial remote sensing image processing techniques; numerical sea level prediction; world sea - air - ice land - vegetation coupling technology
Climate Change Adaptation Technology for Ecosystems		China has just started the research on climate change adaptation technology for ecosystems.		Forest fires, pest and disease monitoring and early warning and rapid post-disaster fighting technology; the prevention and treatment technologies for extreme weather events (including drought, high temperature, ice and snow), including scientific forest ecosystem management, the accuracy of extreme weather events forecasting, disaster recovery technology; and forest ecosystem adaptive management techniques.
Climate Change Adaptation Technology for Bio-diversity Protection		China is very rich in species diversity. Climate change may change species distribution, pattern distribution and the level of richness, and even cause extinction of some species. So it is critical to help these species to adapt to climate change. China is just beginning to work in this area.		In situ conservation, ex situ conservation, habitat restoration techniques, as well as the nature reserve planning and management, botanical gardens, zoos, breeding species, ecologically fragile areas (arid areas, alpine regions, coastal zones, high-altitude and high latitude region) of species diversity to adapt to technology; species adaptive management techniques; help to carry out the technical migration of species; the establishment of large migratory species corridors and networks; the degradation of habitat restoration techniques (such as climate change, the arid zone aquatic habitat restoration); broken habitat connectivity technology. Rare and endangered species monitoring and forecasting technology and breeding of early-warning technology, as well as the protection of genetic technology. Pest control technologies, including biological control, chemical control and physical control of the integrated technology, as well as pest monitoring and forecasting early warning technology.

4. Barriers to Technology Development and Transfer

The transfer of ESTs is significant to address climate change. However, the current development, transfer and diffusion of ESTs are far from being able to meet the challenge of climate change in terms of size, scale and speed.

The current barriers for transfer of ESTs is from different levels, not only from the technical level, but also related to social, economic, political and cultural factors. Market-based incentives, management system, science, education, social values and preferences will greatly affect the transfer of technology and diffusion.

In order to improve the effectiveness of transfer of ESTs, it is necessary to identify the barriers and accordingly take measures to remove them, facilitating the transfer of ESTs.

4.1 Classification of barriers for technology development and transfer

Domestic and foreign scholars have already conducted a large number of research on the barriers for transfer of ESTs. IPCC have categories the general barriers into financial barriers, political barriers, information barriers, institutional barriers and barriers to an Enabling Environment (IPCC, 2000). Specifically，barriers includes：lack of data and information, insufficient human and institutional capabilities, high transaction costs, poor understanding of local needs, lack of adequate codes and standards for EST's and low, subsidized conventional energy prices, absence of full-cost pricing.

Sussex (2007) summed up the barriers for technology transfer process for different technologies.

Table 4-1 Barriers for different technologies

Different	Barriers May Existing
Transfer of capital goods and equipment	Financial barriers; Political barriers
Transfer of skills and know-how	Management of projects
Transfer of knowledge and expertise	Degree of integration of transfer activities:

	Absorptive capacity; National systems of innovation; Micro-level management of transfer projects; Intellectual property rights (IPRs):
Demand for technology transfer	Preference for conventional technologies:High costs of new technologies:Cultural barriers: Information barriers;
Status of technology development	Risks and uncertainties related to stage of commercialisation
Government intervention in technology transfer	Markets for carbon; Need for private sector involvement;
The role of interests and power	Interests and power

Source：Sussex Energy Group, 2007

Programme of Energy and Climate Economics (PECE) in Renmin University of China has conducted various case studies on diverse ESTs. The research scale covers the traditional power generation technologies, such as gas turbines, ultra-supercritical(USC), circulating fluidized bed, IGCC and so on, and renewable energy technologies, such as wind power technologies, solar photovoltaic power generation technologies. Based on these case studies of ESTs and summarization of previous studies, PECE initially identified the main barriers for technology transfer and divided into the following categories:

- Supplier of technologies: political barriers, technology blockade, improper protection of intellectual property ect.
- Recipient of technologies: lack of technology infrastructure and weak absorption ability, lack of human capital and financial resources ect.

4.2 Barriers from the supplier of technologies

Most owners of ESTs are enterprises in developed countries due to their financial, technology and R & D strength. These enterprises played the leading roles as the supplier in the process of technology transfer. However the technology monopoly could bring significant profits to them and thus they always set varied barriers to technology transfer.

4.2.1 Political barriers

Political barriers are the main factors, hindering the technology transfer. The developed countries represented by the United States have strictly controlled the high-tech export to China, and this degree of control changes as the bilateral diplomatic relations and international political situation fluctuate (Sun Ying-chen, 2000).

In June 2007 U.S. Department of Commerce announced the new policy for the U.S. high-tech export control to China. According to the this new policy, only those Chinese enterprises with "authorization Validated End-User (VEU)" have been able to import the items in the regulated list. The newly announced list includes 20 categories of 31 kinds of technology products, with the 20th the "aero gas turbine engines" (Du Yuan-Qing, 2007). The gas turbine technology, as an energy-efficient, low-emission power technology, is included in the list of restricted technologies.

In the list of gas turbine technologies transferred from United States to China, first-class blade and nozzle and other key technologies are not included largely due to technical restrictions of the U.S. government's policy. GE's technical staff said that without U.S. government restrictions, GE will consider transfer these technologies considering the cost and competitiveness (PECE, 2005). U.S. The one of gas turbine technology transfer restrictions is only one example of the restrictions, which usually resulted from the political barriers and greatly hindered the technology transfer process.

4.2.2 Technology blockade

In the context of market mechanism, in order to seek maximum profits, technology transfer is the worst choice for the enterprises comparing to the export trade, direct investment. Consequently, enterprises in the developed countries tend to adopt a technology blockade. Yet even the technologies transferred are only the over-mature ones. According to the technology life cycle theory, these technologies will be phased out and replaced by new technologies after research, development and maturing in the countries. The company in the developed world then transferred the technology, which near to death, to developing countries at high prices and obtained a significant amount of money. For the developing countries, they can only obtain the relatively backward and outdated technologies with a expensive transfer fee.

The technology blockade of the suppliers also reflects in the transfer forms. Since the high protection of technologies, the wholly-owned factories, the sale of equipment technology rather than the establishment of joint ventures, technology licensing are frequently adopted, in order to deploy the technologies in the companies and limit the technologies within the companies even aboard. This is essentially a form of technology blockade. This phenomenon is particularly evident in wind fan manufacturing. Technology transfer through such a manner can only obtain relatively low-level technologies rather than those high level technologies directly related to labs and innovation, which has a negative impact for companies in the developing world to improve their R&D ability (Cui Xueqin, 2009).

At present, advanced fan manufacturer represented by Vestas un Denmark, Gamesa in Spain and GE in the United States all adopted the strategy to establish wholly-owned enterprises None of them established joint ventures with Chinese companies, let alone to sell technology patents. Therefore, Chinese enterprises usually could only purchase wind power production technology permits from those smaller companies which already have a comparative disadvantage in the international competition (Lewis J. 2005).

In the case of gas turbine technology transfer, the technology blockade was also a common phenomenon. The gas turbine technologies transferred from United States GE company, Japan's Mitsubishi Corporation and Siemens AG of Germany, to Harbin Power, Dongfang Electric Group and Shanghai Electric Group respectively does not include the core fuel nozzles, turbine blades and combustion chamber technologies. The three foreign companies set up a joint venture, respectively, to produce these turbine core components in order to block Chinese companies access to these core technologies approach.

In August 2005, PECE research group in Qinhuangdao investigated the technology transfer of F-class gas turbines from GE in US to Harbin Electric Group, and were informed that foreign technical staff prohibited Chinese officials to approach the gas turbine assembly when any technical difficulties and technological content of high link during the process to assemble the gas turbine assisted by the foreign staff (PECE, 2005).

4.2.3 Improper protection of intellectual property

Technology transfer would affect the interest of owners of this technology and its alternative technologies. Intellectual property protection can prevent the technology recipient through access to technology to enhance research and development capabilities, and therefore can protect technology owner’s interests. Enterprises in developed countries always stressed the protection of intellectual property rights due to their ownership of the majority of low-carbon technologies.

According to some studies, it is shown that: the existing international IPR rules are setting obstacles to the development of developing countries, making developing countries to pay the high IPR royalties for the product urgently-needed. The existing IPR increase the cost of developing countries to upgrade their technology level (Carlos Maria et al, 2005). This is a unfavorable factor for reducing greenhouse gas emissions and combating climate change.

On the one hand, excessive protection of intellectual property rights has the unaffordable high cost for many developing countries. For example, in the field of wind power, China's fan manufacturing enterprises need to pay a high patent royalties to buy a patent license from foreign companies. In 1997, Gold Wind bought a 600KW wind turbine production licenses from a small German manufacturer of fan Jacobs Company (German Repower has been acquired, while the Repower by Suzlon acquired in 2007). According to technology transfer agreements, Gold Wind need to pay a concession fee of 10,000 marks (5,000 euros) for producing a machine. However, the technology transfer only includes which includes only the components of technology transfer and the contents of the technical requirements and fan assembly, excluding fan design (Lewis J., 2005).

On the other hand, intellectual property protection has become a way for the enterprises in developed countries to limit the technological progress of firms in developing countries. The patent litigation occurred in 2005 -2,007 years between Denmark, LM Glass Fiber Co., Ltd. and Shanghai FRP Research Institute of fan blades is a good example.

Danish LM is one of largest global manufacturers of wind turbine blades, which has settled in China and established wholly foreign-owned factories. In September 1998, LM companies applied to China's State Intellectual Property Office for a patent of pre-curved blade wind turbine invention. In April 2004 it was awarded the invention patent. The technical content of the patent is to bend fan blade shape in order to meet the tip and the tower design requirements under the condition of reducing the stiffness and weight of leaves. The wind fans above 37 meters long, 1.5 MW should all be applied to the patent. If the LM patent is effective, then China's fan blades need to pay high royalties to LM enterprises and will ultimately lead to withdraw of Chinese blade manufacturing enterprises from the field.

In the end, after the State Intellectual Property Office of Patent Reexamination Board review, the Beijing First Intermediate People's Court and the Beijing Municipal Higher People's Court of Final maintained the patent reexamination Committee’s decision of LM's invalidation of the patent review by stating that "This technology is public knowledge and do not have the innovation". It is worth noting that, LM Company had applied for the patent in Germany, but in 2003 the German Patent and Trademark Office invalidated its application.

Enterprises in developed countries maintain its technological monopoly position through intellectual property protection system to which is not conducive to technological progress, impeding the transfer and diffusion of ESTs.

4.3 Barriers from technology recipient

Barriers to international technology transfer, are not only from the supplier, such as technology blockade, improper intellectual property protection, but also from the recipient, mainly lack of technical infrastructure and technical absorptive capacity lack of human resources and financial resources.

4.3.1 Weak technical infrastructure and technical absorptive capacity

The weak China's existing technology infrastructure and technical status of the weak absorptive capacity have created obstacles for transfer of ESTs.

In the gas turbine technology transfer process, the Dongfang Electric Group, Harbin Electric Group and Shanghai Electric Group, were initially impossible to absorb the foreign and the rotor blade processing technology, not only due to foreign-blockade on these core technologies, abut also resulted from China’s weak technology infrastructure. The production of blades relates to high-precision technologies, such as material technology, spraying technology and welding technology while the production of rotor requires a huge investment in processing equipment. The Chinese equipment and personnel of technology infrastructure are very weak, making the domestic enterprises are unable to produce these core components.

The Introduction of a kind of technology through purchasing business license does not necessarily mean that businesses will be able to absorb this into their own. Enterprises’ capabilities of integrating new technology into its own technology are the technology absorptive capacity.

From the microscopic point of view, an enterprise's technical absorptive capacity relates to the accumulation of its technology. Technological absorptive capacity is an enterprise’s capabilities of digestion and absorption of new technologies and integrating them into their own. The size of the absorptive capacity will affect the transfer of technology. The Stronger the absorption capacity is, the more enterprises can obtained from the technology transfer and improve their technological ability. Chinese enterprises’ generally technology accumulation are relatively weak, and thus technological absorptive capacity is also weak. This phenomenon is particularly prominent in the renewable energy sector. For example, the solar photovoltaic industry is a high-tech industries, but at present many of China's solar energy industry investors do not have the professional background, and even enterprises producing garments, fabrics, bags, glass, bearing are investing in solar PV industries (Li Junfeng, Wang Si Cheng, etc., 2008).

From the macro point of view, the absorptive capacity of an industry closely linked with the strength of the whole country’ s R & D and innovation system. National Innovation System is a situation of national service on the R & D infrastructure and R & D capacity-building. Such as universities, research institution-building, international cooperation and public-private partnership in research and development sector. According to the OECD report, "China's Innovation System Assessment Report", it is pointed out that China need to go a long way to establish a sound and mature national innovation system.

4.3.2 Lack of human capital

Adequate human capital - including professional and technical personnel and experienced labor force - is essential to the diffusion of ESTs in China. However, both of them are relatively scarce in China because the Chinese late start and early development stage in the field of ESTs. On the one hand, energy technology R & D team are "too big" with lack of talents for high-quality research, management, personnel management, making lack of innovative capacity, advanced technologies fragmentary and low level of systematic, engineering-oriented and industrialization (Xiao Han, 2008). On the other hand, the lack of an integrated energy university, the lack of training system for strategic planning for the energy sector, industry management, auditing, management and business expertise. In subfield of the energy sector, such as renewable energy, biomass energy areas also exist the lack of specialized personnel training system.

In the case of gas turbine technology transfer, Siemens promised to transfer the gas turbine blade manufacturing technology to Siemens and Shanghai Electric Group, but because China has no capacity to receive the first-class blade manufacturing technology, until survey time (May 29, 2007) the transfer of this technology has not been achieved yet (PECE, 2007). The reason for this phenomenon, on the one hand is that the quality control of China's equipment manufacturing process cannot reach the requirement. On the other hand, very few people that understand the principle of first-class production of blades in China, in other words, lacking the professional and technical personnel. Similarly, the fan manufacturing technology as an important ESTs, has been taught in very few number of universities in China. Serious shortage of professional and technical personnel, further restricted the R & D.

In addition to the professional and technical personnel, experienced workforce is also able to promote the rapid development of low-carbon industries. Fans industries need the experienced manufacturing labor force. Currently only Denmark, Germany, the United States and other countries have mature experienced labor market of fans production. China is still lacking experienced labor force. Therefore, in fan manufacturing technology development, China is still lagging behind these advanced countries. However, as also from the enterprises in developing countries, India's Suzlon companies built their overseas R & D center in the Denmark, where the wind power development started earliest with the most abundant of the Danish labor market and therefore has made significant technological advances.

4.3.3 Lack of financial resources

The R&D of ESTs often needs to be invested intensively. Insufficient capital investment will slow down the process of technological progress. Especially for emerging low-carbon technologies that have not yet commercialized, large amounts of public money will be required to compensate the high additional cost.

Due to the stage of economic development and other reasons, the Chinese R & D investment on energy technology lags far behind the developed countries. China R & D investment in 2006 reached 300.3 billion yuan, accounting for 1.4% of GDP, among which the energy R & D is about 12.9 billion, accounting for only 0.06% of GDP (Dai Yande, 2008). In 2005, Japan's energy R & D investment reached 3.905 billion U.S. dollars, about twice of China's 2006 energy R & D.

In the gas turbine technology research and development, the gap between the Government expenditure becomes more apparent. The budget of "863 Gas Turbine Project" to complete the development objectives of heavy-duty gas turbines is 5 billion yuan, while for completion of the development of micro-gas turbine target, the budget is 3000 million, funded by the State, local and enterprise (CAI Ning-sheng, etc., 2006) . However, the total investment of a ongoing project called "raising the overall performance turbine engine program" (IHPTET) implemented by the U.S. Department of Defense and Department of Energy in a period of 15 years, reached 4.5 billion; from 1991, the U.S. Department of Energy has presided a project called "Advanced Turbine System (ATS) Program" over a period of 10 years with the investment of 700 million U.S. dollars. Its technical objective is to improve turbine efficiency, reduce emissions pollution, reduce costs, to study the coal-gas fuel. In this program, the United States GE company developed a steam cooling technology MS9001H gas-steam combined cycle generating units at the beginning of the 21st century, improving the thermal efficiency of 60%. Currently, the United States again implemented a project called "the prospects for the 21st Century Development Plan", including the development a fuel gas steam combined cycle to adapt to a diversified integrated gasification. Europe and Japan are also implementing similar development plans.

Besides a wide gap remained between the Chinese government’s input for energy technology R & D and the counterpart for the developed countries, Chinese enterprises’ input for R & D investment is also inadequate. Siemens research and development investment per year have accounted for about 10% of the sales revenue, while the investment of Chinese power equipment manufacturing enterprises in research and development accounted for only 2% to 3% of the sales revenue (sales have been on a very small base), which is also mainly cost of technology design sectors in the enterprises. The true number of funds invested in research and development are much smaller.

4.4 From barriers to the mechanism to address the barriers

Identification of the barriers for technology transfer is only a means to promote the international transfer of ESTs to play a greater role in coping with global climate change. Therefore, we need to design specific mechanisms and measures to address the identified barriers. The methods to address barriers include institutional arrangements, financial mechanisms, performance assessment system and several aspects of the intellectual property system.

Through a rational institutional arrangements, establishing permanent intergovernmental subsidiary body in charge of international cooperation in ESTs within the framework of the UNFCCC can facilitate the diffusion of technology between developed and developing countries and eliminate the current widespread barrier (PECE, 2008).

Innovative financing mechanisms through the promotion of public-private partnership, can attract private capital into low-carbon technology research and provide adequate, guaranteed financial resources to international technology development and transfer and thus help developing countries better bear costs of the development of low-carbon technologies.

Scientific and rational performance assessment index system for technology transfer can effectively measure the real effect of technology transfer, and can be useful for climate policy formulation to promote the transfer of technology and provide more specific guidelines. Although the Expert Group on Technology Transfer (EGTT) has initially completed the development of a series of key indicators of effectiveness to monitor and evaluate the implementation the technology transfer, the present set of indicators focus exclusively on assessment of the technology transfer process, not close related to the ultimate goal of the Convention 4.1C and 4.5. As a result, it is impossible to measure the actual effect of technology transfer.

Intellectual property issues are increasingly becoming an intransigent divergence between.both developed and developing countries in the field of climate negotiations. Solution to the problem of intellectual property rights must satisfy two needs: the need to enhance intellectual property protection of low-carbon technology by the patent holders; developing countries' need to access to critical and essential low-carbon technology. A number of flexible mechanisms will help to break the current deadlock on the issue of intellectual property rights, such as joint research and development, the parallel market, compulsory licensing (E3G, Chatham House, 2008).

Of course, it is a complex process to overcome the barriers to technology transfer and promote the international transfer of technology. A innovative mechanism for removing the barriers will be further elaborated in details in the following chapters (Chapter 5 and Chapter 6).

5 Existing mechanism under UNFCCC & KP and Other mechanisms implemented by International Organizations and Partnerships

5.1 Currently operational mechanisms for development and transfer of ESTs under the UNFCCC and KP

The existing operational mechanism under the UNFCCC and KP that is designed to address the market failure of the conventional commercial mechanism has considered some aspects of the development and transfer of ESTs such as institutional arrangement and information sharing. However, there are still some problems:

First of all, the Expert Group on Technology Transfer (EGTT) was established as an institutional arrangement at COP7, with the objective of enhancing the implementation of Article 4, paragraph 5, of the Convention, including, inter alia, by analyzing and identifying ways to facilitate and advance technology transfer activities and making recommendations to the Subsidiary Body for Scientific and Technological Advice (SBSTA). As an advisory body under SBSTA, EGTT has failed to address the implementation of D&T actions because of the institutional limitations of the SBSAT itself. At COP 13 in Bali, an agreement was reached to renew the mandate of the EGTT by placing it under both the SBSTA and the Subsidiary Body for Implementation (SBI). The strengthened EGTT will provide support both to SBI and SBSTA and they all will provide input into the implementation of the BAP through enhanced action on the D&T of ESTs. This is an important process for making institutional arrangements for the development and transfer of technology because the SBI has the function to give advice to the COP on all matters concerning the implementation of the Convention. Nevertheless, the strengthened EGTT is still an advisory body rather than an enforcement agency. The SBI can hardly promote the D&T of ESTs effectively. It cannot play a critical role like the Executive Broad (EB) under the CDM.

Secondly, as an information sharing network, TT: Clear (technology information clearing house) is not used widely enough. It is also divorced from practice and the private sector. Moreover, information is updated slowly. TT: Clear does not work with other mechanisms. It has not promoted technology transaction effectively.

Thirdly, since COP1, the Global Environment Facility (GEF) has served as a key multilaterally operating financial institution for the D&T of ESTs under UNFCCC. Since the creation of the GEF, about US$ 2.4 billion have been allocated to projects in the climate change focal area and resulted in the reduction of over one billion tons of GHG emissions (GEF 2008a). The GEF reported to the COP at its twelfth session that almost all climate change projects funded from the GEF Trust Fund are concerned with either the initial introduction of modern technologies in developing countries or the dissemination and broadening of their application. It estimates that 80-100 per cent of GEF climate change mitigation funding fits the technology transfer definitions used by the Convention (GEF 2006). A specific programme for the transfer of technologies was set up under the Special Climate Change Fund (SCCF), which follows a technology- or sector-specific approach. As of April 2007, US$ 10.7 million was available from the SCCF for a programme on technology transfer (GEF 2008b). Moreover, the GEF was requested by the COP at its thirteenth session to elaborate a strategic programme to scale up the level of investment in technology transfer to help developing countries address their needs for ESTs. In COP14, GEF strategic program was renamed as Poznan strategic program, under which executing programs are still examined and approved and supported by GEF. The aim of Poznan strategic program is to enhance investment level of technology transfer, help developing countries address their needs of ETSs and promote the development of technology transfer activities. However, the existing financing mechanisms are widely considered to be inadequate for the task of mobilizing resources and effecting technology transfer on the scale required to address the climate change challenge. The existing available funds includes $4.3billion from GEF(including $1billion from the fourth Replenishment), $172 million from LDCF(as of November 7, 2008), $106.5million from SCCF(as of November 7, 2008) , and the estimated scale of AF from 2008 to 2012 is about $0.4-1.5 billion （FCCC/TP/2008/7）. Compared with the estimates of finance needed for developing countries, about $100 billion (The UNFCCC secretariat cannot specify this with certainty, and the estimates of finance remain in need of being updated.) a year by 2030 estimated by the UNFCCC secretariat (UNFCCC, 2007), there is a huge gap between needs and the available resources. Moreover, the financing mechanism is divorced from the capital market, and there are no integrated criteria to assess the effectiveness of the financing mechanism.

Fourthly, the overall work concerning performance assessment is still in the initial process of being undertaken now, and we must inspect this before focusing on the establishment of an assessment mechanism. The EGTT has conducted a review of the implementation of the technology transfer framework, assessed the progress of work in various areas under each key theme of the framework, and identified gaps and barriers to its implementation. Following this work, COP13 requested that the EGTT develop, as part of its future programme of work, a set of performance indicators that could be used by the Subsidiary Body for Implementation to regularly monitor and evaluate the effectiveness of implementation of a framework established for meaningful and effective actions to enhance the implementation of Article 4.5 of the UNFCCC. The work is divided into three tasks: developing a set of candidate performance indicators, testing the set of performance indicators, and preparing recommendations for their use (EGTT 2008). But now it is still in the initial stage and only focuses on the discussion of the indicators. The implementation of the indicators has not been put on the agenda yet.

Fifth, although CDM does not have an explicit technology transfer mandate, it contributes to technology transfer by financing emission reduction projects that use technologies currently not available in the host countries. There are some empirical analyses examining the propensity for technology transfer in CDM projects by analyzing project design documents (PDDs). One study (Seres, 2007), which examined a comprehensive data set of CDM projects and proposals (about 2293 projects up to September 2007), indicates that roughly 39% of all CDM projects accounting for 64% of the annual emission reductions examined claimed some form of technology transfer (i.e., either a transfer of equipment, knowledge, or both). Technology transfer is more common for larger projects and projects with foreign participants. Technology transfer is very heterogeneous across project types (Seres, 2007). Nevertheless, the effectiveness of technology transfer under the CDM is still very limited. The individual and scattered nature of the projects impedes the accumulation of learning as well as technical and implementation capacity that can drive down costs. There is a need to strengthen, streamline and reduce the transaction costs of the CDM. Even then, the project-oriented focus of the mechanism makes it difficult to mobilize financing for large-scale public investment in low-carbon energy infrastructure and/or public transport infrastructure. Taking china as example, the number of her CDM projects involving technology transfer is almost 0, even defined by the widest definition that the scope of technology transfer includes hardware, software, information and experience value, the project involving technology transfer only accounts for 21% of the total amount. Moreover, among the 21% projects, most of them only involve transfer of hardware equipments, and some involve technical training, just one project involves transfer of technology design rationale, experience and know-how. So CDM is more like a kind of measure that foreign relevant enterprises use to occupy china's market, but has no substantial effect on promoting China's technology development (box 5-1). Hence, if we expect CDM serve the technology transfer virtually, we need to reform existing CDM mechanism, for example, establishing a CDM mechanism especially for technology development and transfer.

Box 5-1　Assessment for the sustainable development of china's CDM

According to the statistical data of CDM pipeline, the registered projects of china have amounted to 433 as of 12th January 2009, accounting for 45.53% of the world's total amount. By the end of 2012, the GHGs emissions reduced by china will reach to 1.5 billion CERs, accounting for 53.9% of the world's total mitigation. In china there are 14 types of CDM projects, among which water power and wind power are most popular, they respectively accounting for 48% and 21% of all the projects in china.

By extracting key words through china's 617 Project Design Documents(PDD) collected from CDM official network of UNFCCC and using analytical methods including quantitative analysis, qualitative analysis and case study , this research makes an assessment for China's CDM projects from four aspects including economy, technology, environment and social impact, and determines that whether CDM has achieved the win-win target as set early in the design: reducing GHGs emissions and promoting china's sustainable development at the same time.

Through the read of 617 Project Design Documents, this research finds that the number of China's CDM projects involving technology transfer is almost 0. Even defined by the widest definition that the scope of technology transfer includes hardware, software, information and experience value, the project involving technology transfer only accounts for 21% of the total amount. Moreover, among the 21% projects, most only involve transfer of hardware equipments, and some involve technical training, just one project involves transfer of technology design rationale, experience and know-how.

Taking wind power project as example, equipment transfer mainly comes from the G52－850kW equipments of Vestas in Denmark and Gamesa Eolica in Spain, however, this kind of equipment can also be bought through other channels, so whether can it be obtained has no direct relation with CDM. The projects involving non-equipment transfer only comes from Germany, Denmark and Spain, but there are just trainings in terms of equipment operation and maintenance in these transfers, from which little information of equipment research and design could be gained.

So this kind of technology transfer is more like a measure that foreign relevant enterprises use to occupy china's market, but has no substantial effect on promoting China's technology.

source：He Xuewei, Zou Ji, Wang Ke, 2009

In sum, the mechanism for development and transfer of ESTs under the UNFCCC and KP is not systematic and comprehensive. It lacks institutional arrangements in some fields, lacks specified content to be implemented, lacks operability, lacks a linkage to the private sector and incentives to the stakeholders. That is, it has not addressed the problem derived from the market failure of conventional commercial and market based mechanisms.

5.2 Other mechanisms implemented by International Organizations and Partnerships

Environmentally sound technologies are also recognized as crucial elements for addressing the climate change challenge by other multilateral international cooperation mechanisms such as the World Bank's technology funds, the Asia and Pacific Partnership on Clean Development and Climate Change (APP), and the IEA's energy technology agreements and initiatives. Other important partnerships include the International Partnership for a Hydrogen Economy, the Carbon Sequestration Leadership Forum and the Renewable Energy and Energy Efficiency Partnership.

The Climate Investment Funds (CIFs) which were created by the World Bank in July 2008 are a collaborative effort among the multilateral development banks (MDBs) and some countries to bridge the financing and learning gap until a post-2012 global climate change agreement comes into effect (World Bank 2008a). The CIFs have two distinct funds related to technology: the Clean Technology Fund (CTF) and the Strategic Climate Fund (SCF). The World Bank's sufficient operational experience and financial expertise may provide very valuable technical support for the establishment and operation of a technology related financial mechanism.

The Asia-Pacific Partnership on Clean Development and Climate (APP) has established eight government and business task forces on cleaner fossil energy, renewable energy and distribution generation, power generation and transmission, steel, aluminum, cement, coal mining, buildings and appliances. The practice of the Partnership in terms of a sectoral approach could provide some meaningful lessons on promoting the cooperation of government and industries.

However, either the APP or the World Bank has only the ability to serve as a complement of the Convention rather than as the alternative and would be under the guidance and governance of the UNFCCC and KP mechanism.

6. Framework of the International Mechanism for the D&T of ESTs

As noted above, the development, transfer, diffusion and deployment of ESTs is crucial to the effectiveness of efforts to address global climate change.

But current international technology transfer mechanisms are inadequate, not effective enough to make meaningful D&T of ESTs to developing countries to avoid the lock-in effects or avoid repeating the conventional path of development. There is the need for strategic innovation of the international technology transfer mechanisms whose objective is to speed up, widen, and enlarge international technology cooperation to catch such historic opportunities, meanwhile ensuring that companies make profits and economies boom.

Specifically, the international mechanism includes the following key components:

- Institutional arrangement under the UNFCCC
- A financial mechanism
- Performance monitoring and an assessment mechanism

In addition, the mechanism has other elements including the IPR mechanism which is dedicated to balancing the benefit between IPR owners and global climate protection; enterprises' social responsibilities and capacity building mechanisms which contribute to promote enterprises from developed countries to fulfill social responsibility and help capacity building in developing countries; and promoting a technology transaction mechanism which is aimed at increasing transparency of technology information and reducing transaction costs.

6.1 Objectives, Nature, and Principles of an International Cooperation Mechanism for the D&T of ESTs

6.1.1 Objectives

The objective of an international cooperation mechanism for the development and transfer of ESTs is to speed up the transfer of ESTs, to broaden transfer coverage, to increase transfer intensity and further deepen international technology cooperation. Through this kind of mechanism, developing countries can understand not only their own technology needs but also information on advanced technologies. They can also obtain needed technologies at affordable prices and acquire their own capacity to apply advanced technologies better (**knowable, available, affordable, and effective**).

6.1.2 Nature

The main differences between the new international cooperation mechanism and the conventional ones are described as following:

The goal of the new mechanism is to protect the climate, the largest global public good, and to fulfill humanity's sustainable development, while the conventional ones are to pursue maximum economic benefits.

The technology transfer proposed in the new mechanism is to transfer technologies from developed countries to developing countries. It requires developed countries, which have much earlier on capitalized on opportunities to exploit GHG emission resources and also have advanced technologies now to take actions forward, to realize the transfer and diffusion of technologies rapidly, broadly and deeply.

In addition, developed countries also need to help developing countries improve their technical capacity through joint R&D.

In order to resolve the externality and market failure problems existing in the process of ESTs' development and transfer and give an incentive to investment from private sectors, the mechanism should look to form public-private partnerships (PPP) which means that the process will be led by the government while obtaining full involvement from private sectors.

6.1.3 Principles

Common but differentiated responsibilities

First of all, the international cooperation mechanism for technology development and transfer should be consistent with the principles that flow from understanding the concept of common but differentiated responsibilities. Developed country Parties should take leadership in developing and transfering ESTs to developing countries This assertion is made given the Parties' legal obligation/liability defined in Article 4.5 of the Convention and the fact that today's climate change is derived from a historic cumulative concentration of GHGs to which developed countries have made the major contribution since their industrial revolutions, combined with the facts that technological gaps remain significant between developed and developing countries and that much ESTs and financial resources have existed in developed countries, which can make an immediate contribution to controlling the growth of GHG emissions in developing countries.

Balance between mitigation and adaptation

The mechanism is not only aiming at the development and transfer of mitigation technologies but also the development and transfer of adaptation technologies which are used to reduce the vulnerability of developing countries. ESTs serving both the mitigation of and adaptation to climate change should be considered to equal degrees.

Public-private partnership

Because of its political service function, governments should play a leading role in guiding companies and monitoring the market, and they have to send out clear policy signals to lead private sectors to make climate friendly decisions, as well as using public financial measures to reduce the transaction cost of technology transfer, diffusion and deployment, create attractive opportunities for reducing the risk of adopting new technologies and compensate the incremental costs. The public finances of developed countries should be the first to bear the responsibility of promoting such issues.

Equal emphasis on both technology R&D and diffusion

The D&T of ESTs should range across all the stages of the ESTs' cycles, including invention, innovation, and diffusion. Efforts should be made at all stages of the technological cycle, including when conducting R&D for invention and demonstration, diffusion, deployment, and operation of technologies. Different types of policy instruments and measures, cooperative models/patterns, may apply to different stages of ESTs' cycles and to their corresponding challenges, issues, and objectives.

Cost effectiveness

The inputs to and outputs from the mechanism should adhere to the principle of being cost effective. Outputs from the mechanism may be assessed by their impact in terms of emission reductions, adaptation and the promotion of sustainable development. Capital from the capital market and carbon market used for ESTs' development and transfer can be used as an evaluation indicator.

Global interest-oriented

The goal of this mechanism is to solve the problem of global climate change as a kind of global public good. The mechanism is public benefit oriented and is quite different from the conventional mechanism which is business benefit oriented.

6.2 Institutional arrangement under the UNFCCC

6.2.1 The necessity of establishing a subsidiary body for technology development and transfer

Considering the externalities of climate change and the multilateral character of the Framework Convention on Climate Change, cooperation between governments is still the main driver of cooperation on ESTs, and it also needs to work together with market mechanisms to promote international cooperation.

According to the above evaluation of the existing mechanism, we can ascertain that the UNFCCC and KP have already made some strategic decisions on the D&T of ESTs. However, the commitments of developed countries under the UNFCCC and the KP on technology development and transfer have not been met and there is a need to urgently address implementation issues concerning the D&T of ESTs.

Hence, in order to strengthen the role of intergovernmental cooperation, it is suggested that a new body be established under UNFCCC that is particularly in charge of planning, implementing, coordination, organizing, assessing and monitoring the D&T of ESTs, as well as promoting technology information and experience exchange between different stakeholders.

6.2.2 Organizational framework

The proposed Subsidiary Body for the D&T of ESTs will be an operational and implementing body. It should be parallel with the SBI and SBSTA, and be accountable directly to the Conference of Parties (COP). The subsidiary Body under the COP shall comprise of and be supported by a strategic planning committee and several technical panels on (1) technology needs assessment and information; (2) dialogue and coordination for enabling policies and measures; (3) IPRs cooperation; (4) management of financial resources targeted at the D&T of ESTs; (5) capacity building; and (6) monitor and evaluate the effectiveness of the implementation of agreed actions on technology development and transfer and verifying the financial and technological contributions made to the mechanism in accordance with the overall “measurable, reportable, verifiable” requirement of Decision 1/CP.13. (Presented in Figure 6-1).

A Strategic Planning Committee must develop strategies, provide regular guidance on matters relating to the Convention’s actions on technology development and transfer, to continuously provide regular performance assessment of the D&T of ESTs and to develop updates for the Technology Action Plan.

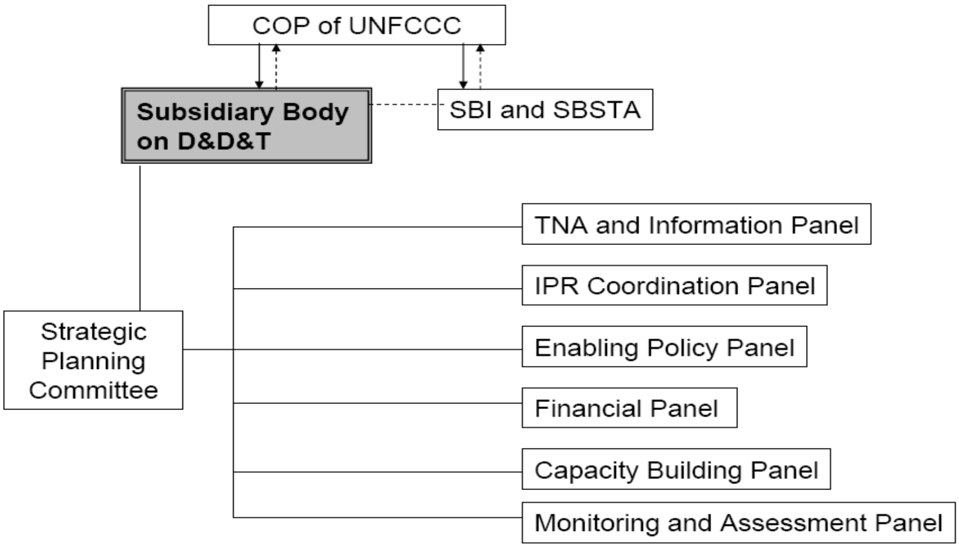


Figure 6-1 Organizational structure of intergovernmental body

Source: Zou Ji & Li liyan, 2008Functions and priorities of the framework

Main functions of the framework include:

- Providing advice, guidance, and recommendations to Parties;
- Coordinating actions by different international stakeholders and governments;
- Promoting communication and sharing of information and knowledge, develop organizational dialogue and communication;

- Organize technology needs assessment;
- Establish international strategy, planning for technology development and transfer;
- Guide and supervise utilization of the Convention's technology fund based on public finance;
- Establish related encouragement, restrictions and punitive policy;
- Provide information and legal services, also guide and promote capacity building activities; and
- Monitor and assess any progress made in ensuring the full implementation of the Convention's provisions relating to technology development and transfer.

And the priorities of the framework include:

- Policy dialogues and coordination to create better incentives for private sectors and markets: Subsidies to encourage R&D and transfer of ESTs; Favorable conditions for EST-related export credits: Guarantee for technology export credits, subsidies, etc.; Removal of technology export bans and other regulations, policies and measures;
- Financing basic research and R&D; and
- Promote transfer and diffusion of publicly owned technologies: Developed nations' governments can play a more important role in publicly owned technologies beyond that of encouraging the private sectors' participants. The framework should encourage developed governments to transfer publicly owned technologies to developing countries more smoothly and effectively.

6.2.3 Governance

The subsidiary body for the D&T of ESTs under the UNFCCC should be open to all parties, membership of the Strategic Planning Committee and Technical Panels allocated observing the UN regional distribution principle, the representatives elected from Annex I, non-Annex I and small island countries. The replacement of members can follow the approach taken by the EGTT. Every government must also appoint a direct administration and contact institution for technology development and transfer.

6.3 Effectiveness: performance assessment

6.3.1 Objectives and tasks related to a monitoring and assessment mechanism

The overall objective of this mechanism is to develop and test a balanced and robust set of performance indicators as well as modalities and steps that could be used by the SBI to monitor and evaluate the effectiveness of the implementation of the technology transfer framework and to verify the financial and technological contributions made to the mechanism in accordance with the overall "measurable, reportable, verifiable" requirement of Decision 1/CP.13; share best practice and lessons from ESTs' development and transfer; provide direction for further reforms and adjustment; and improve the mitigation and adaptation abilities of developing countries.

With those objectives, the mechanism must fulfill tasks as following:

- Evaluate the availability and reliability of data and information through developing a set of indicators, designing procedure and approaches for monitoring and evaluating, creating methodology in accordance with the overall "measurable, reportable, verifiable" requirement to evaluate the effectiveness of ESTs' development and transfer, and developing a database;
- Develop work modes and steps for the implementation of monitoring and evaluation;
- Establish reporting guidance to request Technical Panels under the Subsidiary Body and Parties to regularly report their activities and corresponding effects related to the D&T of ESTs to the COP. The reported content should be linked to the assessment indicators. The detailed content and requirements of this request for reporting should be prescribed clearly in the guidelines. The methodologies used for quantification, acquisition of indicators and setting of a baseline also need to be prescribed in the guideline.
- Use the result of monitoring and assessment as criteria for further fund allocation and guidance for mechanism reconstruction.

6.3.2 Conception of evaluation indicators

3/CP.13 requires the EGTT to include the development of performance indicators to monitor and evaluate the effectiveness of the implementation of the technology transfer into its work plan for the year 2008-2009, and to make and test a set of balanced and effective indicators for regular assessment the implementation of technology transfer framework and enhance the transfer to developing country parties. Up to September 2009, the EGTT has completed an initial set of indicators (Box 6-1)

Box 6-1 EGTT performance indicators to monitor and evaluate the effectiveness of the implementation of the technology transfer framework

The synthesized objectives derived from the technology transfer framework are listed below for each key theme except ‘Mechanisms for technology transfer’.

Technology needs and needs assessments

1. To undertake technology needs assessments (TNAs);
2. To provide resources;
3. To build capacity;
4. To update and to disseminate the TNA handbook;[b]
5. To make available information on the TNAs;
6. To implement the results of technology needs (identified in TNAs);
7. To share lessons learned, success stories, good practices;
8. To consider the synthesis report;
9. To organize a meeting to identify TNA methodologies;
10. (to ensure that) Expert Group on Technology Transfer cooperates with the CGE.

Technology information

1. To establish a technology transfer information clearing house (TT:CLEAR);
2. To maintain, update and further develop TT:CLEAR;
3. To network with technology information centres;
4. To increase the number of users (of TT:CLEAR);
5. To built capacity;
6. To make available information through national communications.

Enabling environments

1. To enhance legal systems (including those related to trade and intellectual property rights;
2. To promote joint research and development;
3. To promote transfer of publicly owned technologies;
4. To strengthen regulatory frameworks;
5. To utilize tax preferences;
6. To integrate technology transfer into national policies;
7. To create an environment conducive for investments;
8. To explore preferential government procurement;
9. To explore transparent and efficient approval procedures;
10. To prepare technical studies for developing enhanced enabling environments;
11. To cooperate closely with public and private partnerships.

Capacity-building

1. To report on capacity-building needs and experiences for the development, deployment, diffusion and transfer of technologies of the developing country Parties;
2. To implement/support capacity-building activities for the development and transfer of technologies (DTT) in developing country Parties;
3. To establish/strengthen capacity for the DTT in institutions of developing country Parties;
4. To increase/enhance/improve awareness/knowledge on environmentally sound technologies (ESTs) in developing country Parties;
5. To provide training on ESTs in developing country Parties;
6. To develop and implement standards and regulations for ESTs.

As pointed out by the EGTT, the development and test of performance indicators will go through a learning curve. However, the indicators designed by the EGTT may have a fundamental shift from what indicated in the Convention. First of all, the evaluation scope defined by the EGTT is made up of 5 parts, which are based on the technology transfer framework. But in fact, the framework will be under discuss in the coming Copenhagen meeting and may be adjusted afterwards. Second, the EGTT indicators monitor and evaluate the process of technology transfer rather than the result of technology transfer, which has a very weak connection with the effectiveness of technology transfer and no direct connection with the ultimate goal set in the Convention, hence can not reflect the mitigation effects of technology transfer.

Article 4.1C in the Convention says that “All parties, taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, shall promote and cooperate in the development, application and diffusion including transfer, of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol in all relevant sectors, including the energy, transport, industry, agriculture, forestry and waste management sectors”, and the Article 4.5 regulates that “The developed country Parties and other developed Parties included in Annex II shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention. In this process, the developed country Parties shall support the development and enhancement of endogenous capacities and technologies of developing country Parties. Other Parties and organizations in a position to do so may also assist in facilitating the transfer of such technologies.” Here, the “development and enhancement of endogenous capacities and technologies of developing country Parties” is one of the key criteria of effective transfer. Namely, whether developing country Parties can truly and fully understand their technology needs and advanced technology information, whether they can afford the technologies needed, and meanwhile whether they have the capabilities to implement the technologies and whether they can use these technologies to mitigate climate change. That is, what we stress a “**knowable, available, affordable, and effective**” technology transfer goals.

To evaluate the technology transfer of ESTs, criteria of successful technology transfer should be set at the first place, specifically:

(1) Should be applicable, the most suitable technology should be the one that fits the recipient country's technological conditions and capabilities, and be cost-effective, and should be of a strategic presence on the recipient country's technology needs, and may not be necessarily the most advanced technology or the most energy-efficient emission mitigation technology;

(2) Should narrow the technology gap, with the transfer of technology, the recipient country can narrow technology gap with advanced countries and improve its technology capacity;

(3) Should have significant emission mitigation effect, the use of technology transferred can increase energy efficiency and reduce greenhouse gases, sulfur and nitrogen oxides emissions;

(4) Should have a suitable objective and method;

(5) Should have appropriate institutions, regulations, and policies that would favor an enabling environment for technology transfer

To this end, research group in the Renmin University has proposed a set of performance indicators to monitor and evaluate the effective implementation of technology transfer. The framework is focused on the real mitigation effects brought by the technology transfer and is consistent with the MRV requirement proposed in the Bali Action Plan and stresses the “knowable, available, affordable, and effective” goals. The framework firstly can be divided into two parts – “the real effects of technology transfer” and “the behavior of stakeholders”, and then be divided into five secondary indicators- “technology capacity”, “environment benefits”, “economic benefits”, “main stakeholders’ behavior” and “government’s regulatory behavior”. Totally, there are four tiers of indicators (Annex 1).

Simply put, in order to conduct the monitoring and assessment, specific criteria, indicators and modality /steps need to be set up. These criteria and indicators should cover, inter alia, the aspects as follows:

Scale of technology flow

- Amount of programs on technology transfer or joint R&D;
- Scale and trend of investment in R&D: amount of capital from public finance, GEF, international organizations and private sectors (including normal investment, venture capital, capital market capital and carbon market capital);

Speed of technology flow

- Speed of reducing the technology gap between developed and developing countries;
- Speed of technology development and transfer: measured in units of scale over time;
- Time needed for equipment to be put in place and take effect: refers to the time needed for the developing countries to push forward the taking in, absorption and re-innovation of transferred technologies.

- Speed of technology diffusion: time need for wide technology diffusion and deployment in developing countries after the effective absorption of technologies

Range of technology flow

- Technology coverage, including range and structure, among sectors;
- Technology or production coverage of specific transferred ESTs within a sector;

Direct effect of technology development and transfer

- Total GHG emission reductions;
- Avoided losses related to climate change: reduced negative influence through the application of adaptation technologies;

Other social and economic influence

- Economic benefits for enterprises;
- Public awareness of protecting the climate;
- Employment rate;
- Influence on governmental decision-making capacity (institutional reform, policy making and implementation);
- Influence on sustainable development capacity;
- Influence on public health and local environment: the improvement of public health conditions and mitigation of environmental pollution;
- Influence on gender and poverty; and
- Influence on education and human resources;

6.3.3 Governance

The monitoring and assessment of the effectiveness of the development and transfer of ESTs should be made a routine business operated by the proposed Subsidiary Body for Technology transfer, supported directly by a panel in charge of monitoring and assessment with agreed terms of reference, steps and modalities.

This panel should report the results of assessment and monitoring to the Subsidiary Body for Technology Transfer on a regular basis.

6.3.4 Case studies

Research team at the Renmin University of China did a case study in 2008-2009 at the Shanghai Electric Group, investigating mainly how the Shanghai Electric Group cooperate with Siemens to introduce, absorb and innovate a 1000MW Ultra-supercritical thermal power unit. The study made surveys in the six aspects - the introduction of technology, the digestion, absorption and innovation of technology, technology diffusion, capital investment, and the barriers in the technology transfer process. With the survey results, a preliminary evaluation of the effectiveness of the technology transfer was also given.

- Speed of technology flow：
  - It takes China about 20 years to introduce and digested the sub-critical technology (1980-2000), 3 years for super-critical (2000-2003), and 4years for ultra super-critical technology (2002-2006， with the first 1000MW ultra super-critical unit put into operation in the Huaneng Group in Yuhuan).
- Scope of technology flow：
  - Up to September 2008, there are 10 units of 1000MW ultra-supercritical units that have been put into operation in China. That is, the total installed capacity of 1000MW ultra-supercritical units has reached 10000MW, accounting for 1.7% of the total installed capacity in China.
  - At present, there are nearly 120 bids for 1000MW ultra-supercritical units in the Chinese market, of which, the Shanghai Electric Group won 58 units, having 50% market occupation rate. There are nearly 100 bids for 600MW ultra-supercritical units, and the Shanghai Electric Group has won a quarter of the amounts.
- Effectiveness of technology flow：
  - Up to the end of September 2008, 10 units of 1000MW ultra-supercritical units that have been put into operation in China. The average coal consumption of 600MW and above units is 349g/kWh in 2008 in China. By using an average coal consumption of 290.4g/kWh ultra-supercritical unit, according to an annual

generation of 6000 hours, as many as 3.516 million tons of coal would be saved and approximately 9.493 million tons of CO_2 emissions would be mitigated.

- Additional conditions to the technology transfer：
    - Siemens stipulated that whenever the Shanghai Electric Group was doing an independent R&D, it needed to consult with Siemens and to obtain their permission beforehand if it was going to raise a parameter by 1%, which brought about strong constraints on the Shanghai Electric Group’s R&D activities. For example, more than 40 units after the seventh unit for Beilungang in Ningbo, do not use the original parameters in Yuhuan or Waigaoqiao project, Siemens demanded the Shanghai Electric Group to pay “technology service fee”.
    - the Shanghai Electric Group can not bid the same project with Siemens.
- Cost of technology transfer：
    - 4 million Euros, according to the contract, for providing materials and offering licence
    - Commission based on the Shanghai Electric Group’s sales invoices: 4% within the first 10 years
    - Annual support: labor cost for modification and improvement of written materials, relatively petty
    - Overseas training cost: per diem
    - Per diem allowance for Siemens to provide service to the Shanghai Electric Group in China or other places
    - Service fee based on a specific service contract signed by Siemens and the Shanghai Electric Group according to the level of services
    - Procurement fee for materials and parts according to localization rate.
- Behavior of technology supplier
    - With regard to the willingness of technology export
    - Control over key technology know-how
    - Constraint terms
- Government of technology supplier
    - There is sill not fully convincing reason for the governments of developed

country Parties to fulfill, "the Convention" , and is negative in transferring technology to the developing country Parties.

6.4 Financial mechanism: demand and supply

Financial sources for the D&T of ESTs have always been a focus of debates; it's also a bottle neck in terms of technology transfer. According to the relevant research into the obstacles to the D&T of ESTs under the UNFCCC, "lack of Capital" has become seen as one of the primary obstacles. The conventional financial flows based on market (via international investment and trade) are neither enough nor guided correctly for addressing climate change. The existing financial mechanism, such as GEF and ODA cannot provide adequate financial support.

Total existing finance sources and vehicles identified and assessed by the UNFCCC is about 140-230 billion USD (Table 6-1).However, the additional cumulative investment cost would be almost 2400 billion USD over 2010－2020 and 8100 billion USD over 2021－2030, while the additional cumulative investment cost would be nearly 400 billion USD over 2010－2020 and 1 700 billion USD over 2021－2030，respectively as 17% and 21% of the global additional investment over the same time (IEA&WEO, 2009). According to the scenario analysis done by the PECE of Renmin University of China, under emission control scenario, the accumulative incremental investment would reach 9.5 trillion US$-2005 from 2010 till 2050, and under emission abatement scenario, the accumulative incremental investment would reach 14.2 trillion US$-2005 from 2010 till 2050. There are huge gaps between existing finance sources and estimated needs.

Finance resources have leveraging effect over climate change though the ratios vary significantly both inside and outside the Convention and by stage of technological maturity. For instance, the MDB has an average leveraging ratio of 1:4-5; while the GEF has much lower levels of leverage (1:0.67 in 2002). The CDM has a leverage ratio of 1:10. If the leverage ratio is supposed to be 1:8, according to IEA's estimation, the annual financial needs in 2030 for public funding would be about 150 billion USD.

Table 6-1 Existing finance sources and vehicles

Stage of technology	Source of Financing	Estimated avergage annual investment（Billion USD）
Sources Outside the Convention		
R&D and demonstration	Pubic Funding	10
	Private Funding	9.8
Deployment and diffusion	Private Investment	148
	Expert Credit Agencies（ECAs)	1-2
	Bilateral and Multilateral Sources	5-10
	Philanthropic Private Sources(including NGOs, foundation and voluntary carbon market finance)	1
Sources Under the Convention		
Deployment and diffusion	The Convention Financial Mechanism（GEF Trust Fund; SCCF; LDCF)	0.22-0.32
	Private sources leveraged by the Convention Financial Mechanism	1.152
	Kyoto Flexibility Mechanism（CDM,JI)	4.5-8.5
	Private sources leveraged by the Kyoto Flexibility Mechanism	45—85
	Total	**140-230**

Source: FCCC/SB/2008/INF.7

According to the above assessment of transitional commercial and transitional mechanisms, we can find out that the existing financial mechanism, basically the GEF, has a significant series of disadvantages: e.g. elements of insufficiency such as fund scale, single-source, decoupling from the capital market, and little impact on technology development and transfer, etc. Hence, it is necessary to build a new financial mechanism for technology development and transfer, which can supply the international cooperation mechanism with sufficient and certain financial insurance.

6.4.1 Main elements of the financial flowchart for the financial mechanism

Figure 6-2 shows the main framework of the financial mechanism for ESTs' development and transfer. The basic idea for the financial mechanism supporting the D&T of ESTs is to develop public private partnerships by linking public finance with the carbon market, capital market, and technology market and leveraging a larger amount of private finance with a smaller amount of public finance. A Multilateral Technology Acquisition Fund (MTAF) should be established with the sources mainly based on public finance from developed countries to create incentives for private sectors through various policy instruments with impacts on the capital market, such as tax exemption, subsidy, and loan guarantee etc. Furthermore, it is also important to connect the MTAF with the capital market to create financial derivative products to attract private investment to promote ESTs' development, transfer and diffusion in developing countries.

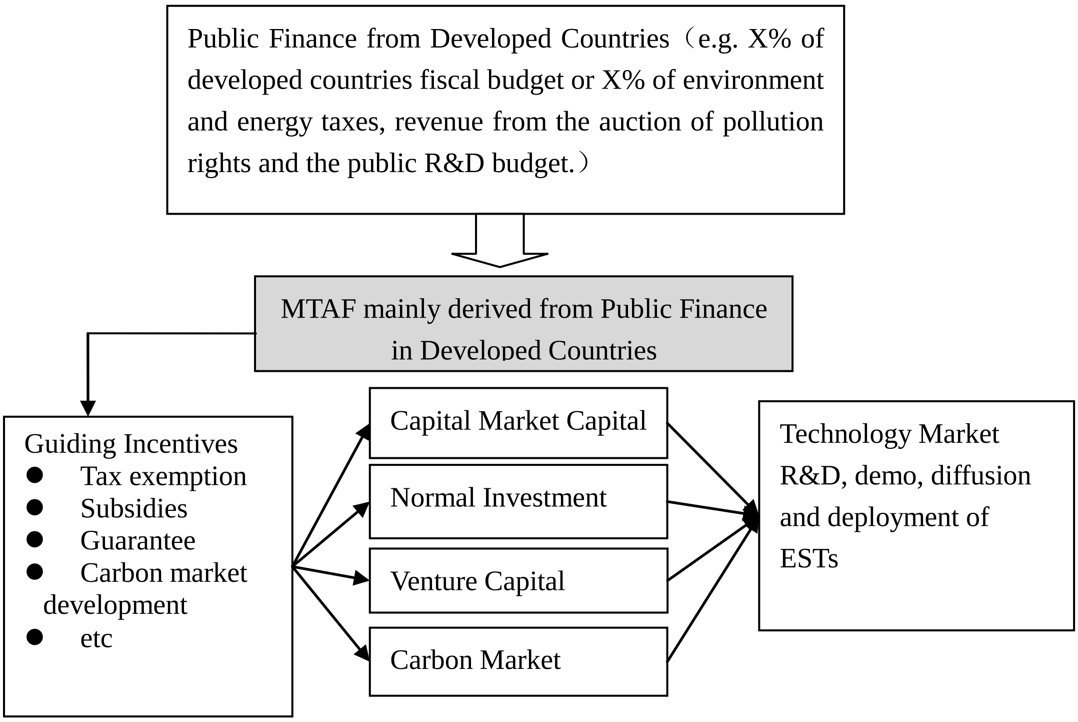


Figure6-2 Financial flowchart for the financial mechanism

Source: Zou Ji & Li liyan, 2008Multilateral Technology Acquisition Fund

As described above, a MTAF which is mainly derived from the public capital of developed countries and specifically targets the promotion of ESTs' development, transfer and diffusion would be a new and additional financial source over and above ODA. And it must follow the following principles:

- Operation under the authority and guidance of and be fully accountable to the COP to the UNFCCC;
- Have an equitable and balanced representation of all parties within a transparent system of governance;
- Enabling direct access to funding by the recipients; and
- Ensuring recipient countries' involvement during the definition, identification and implication of the actions.

6.4.2 Funding Sources and collecting measure

The major sources of the fund would be derived from the public sector of developed countries, and can be an X% of developed countries fiscal budget or X% of environment and energy taxes, revenue from the auction of pollution rights and the public R&D budget.

The goal of this fund is not to cover the overall cost of technology development and transfer, but to make use of public financing as a driving force to promote public-private partnerships (PPPs), encourage the active participation of the private sector including R&D institutions and enterprises, thereby bringing along more private capital and technology and effectively combining the public and private funds.

In addition, the fund should attract resources from international organizations, and search for new financial resources through international negotiations and dialogue, as well as effective international cooperation mechanisms.

Suppose the fund is derived from the fiscal budget and X% is 0.5, take OECD countries as an example, the total amount of the fund in 2005 would reach $61.04billion3 without social donation; far more than GEF's fund for technology development and transfer.

The budgets of R&D in developed countries have been much high than what are in developing countries. In 2007, the average budget of R&D is 2.29% in OECD countries, with 748 USD per capita. In the same year, the budgets of R&D in Brazil, China and India are 1.02%, 1.45%, and 0.71% respectively; i.e. 92 USD per capita, 77USD per capita and 13USD per capita4.

Since the establishment of carbon trading system in 2002, the carbon trading market developed rapidly. In 2006, the total amount of CO2 emission trading reached 28 billion USD, 2.5 times that of 2005; and it is estimated to reach substantially. On January 23rd, the ETS has entered the third stage, namely, in 2020, a more rigid carbon mitigation target will be set for the energy and manufacturing sectors and the auction revenue will be 80 billion USD.

In general, the revenue of environment related tax accounts for 2-2.5% GDP in OECD countries, mainly coming from energy products and vehicles (OECD, 2006). The OECD Environmental Outlook to 2030 also indicates that if the OECD countries tax on CO2 with 25

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[3] source：OECD database.

[4] Source：OECD in Figure 2009, www.oecd.org

USD/ton, the total emission will decrease by 43% in OECD countries (OECD, 2006)

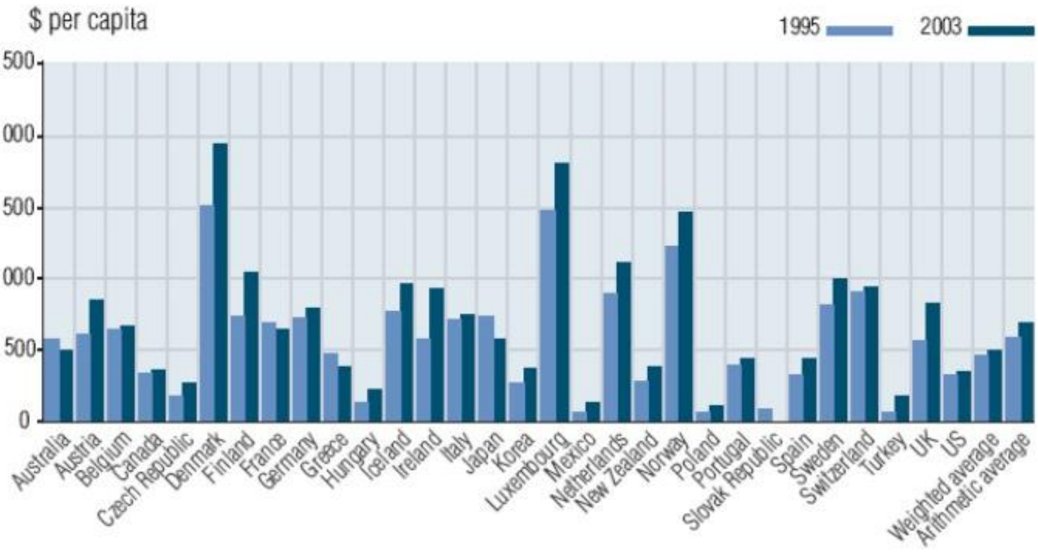

Figure6-3 Revenue from environment related tax in OECD countries

Source:（OECD，2006）

The International Energy Agency (IEA) estimates that in 2005 the subsidies for energy consumption in the 20 largest non-economic Co-operation and Development countries (non-OECD) amounted to 220 billion U.S. dollars, of which fossil fuel subsidies was 170 billion U.S. dollars. The global energy subsidies is about 300 billion U.S. dollars annually, accounting for 0.7%GDP. Subsidies on petroleum products and fossil fuels were up to 90 billion U.S. dollars. According to a report issued by the UNFCCC, based on 2005 data, there are about 180 billion – 200 billion fossil energy subsidies, while only 33 billion dollars were used to subsidize low-carbon energy, of which 10 billion U.S. dollars was for renewable energy and 16 billion USD for nuclear energy, and 6 billion for the biofuels (Lin, 2009).

6.4.3 Main areas supported by the fund

The main areas supported by the fund, among others, may include:

- Supporting joint design, research and development or large-scale commercial application of the CSTs;

- Offering incentives and compensating the incremental cost to developing countries incurred by actions towards addressing climate change;
- To launch a series of capacity building activities that mainly concern the development of human resources, the construction of institutions and the removing of market barriers; and
- Incremental costs for the D&T of ESTs in developing countries should be compensated via appropriate policy instruments among the above-mentioned ones. Agreements should be reached on the methodologies to determine baseline cost of technological change in specific sectors and technological areas, against which incremental costs are estimated.

6.4.4 Policy instruments

The policy instruments, among others, may include:

- Subsidies given to R&D for invention and demonstration of identified ESTs in prioritized areas;
- Insurance to curb risks of investment associated with the design, transfer and diffusion of new ESTs;
- Loan guarantees or subsidies for exporting and diffusing ESTs;
- Direct investment in the D&T of ESTs including by regular modes such as shareholding or via venture capital investment;
- Investment in financial products related to the D&T of ESTs by holding stocks, bonds and other potential financial products.
- Investment in such infrastructure as information, transaction platforms, monitoring and enforcement systems;
- Expenses in capacity building in developing countries with the development of human resources as a priority;
- Government purchases of ESTs;
- Permits, compulsory licensing for patented ESTs, etc; and
- Others.

Appropriate policy tools need to be chosen according to different technology life cycle (Figure 6-4).

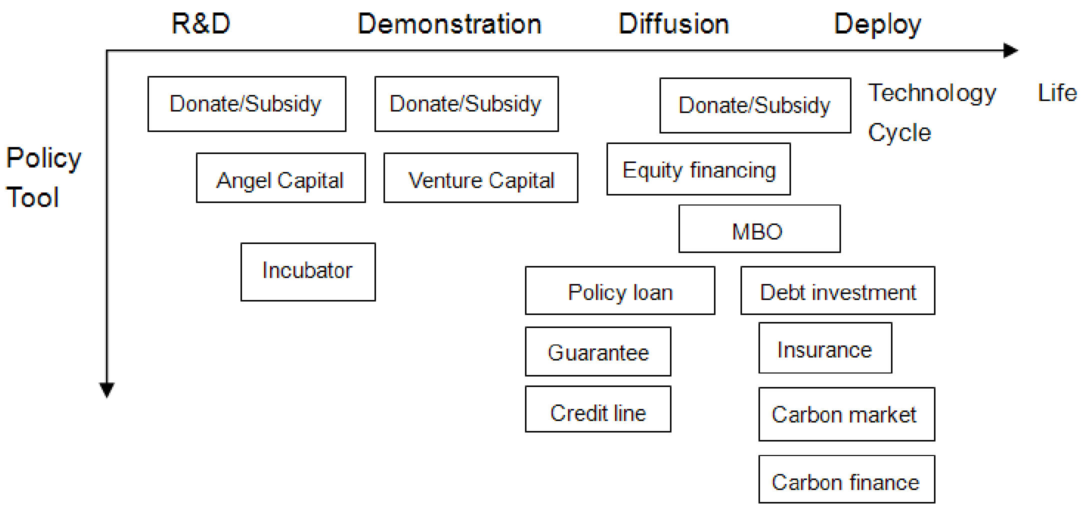

Figure 6-4 Policy tools for technology life cycle

6.4.5 Governance

Fund use must follow these principles: the use of the fund should be decided by developing countries according to the “countries-driven” principle, developing countries having to fully participate in arranging the fund.

Reform must be based on the manner in which the existing GEF fund is managed, simplifying the procedures of approval, improving the efficiency of fund use, and creating a relationship with the capital market.

Policies related to fund use and management should be managed by the SBI, strategic planning committee and technical panels.

The main investment area, focus, direction, principle and strategy of the fund should be decided by the COP, but the decision-making authority for a detailed program may be allocated according to the amount of capital that the developed countries contributed.

A performance monitoring and assessment mechanism can act as a target oriented and incentive tool, and provide a clearer guide for ESTs’ development and transfer policy instruments. In order to assess the effectiveness of the mechanism, a performance monitoring and evaluation system is necessary which includes a set of performance indicators. Hence, the COP by its decision 3/CP.13, annex II, requested that the EGTT develop, as part of its future programme of work during 2008-2009, a set of performance indicators that could be used by the SBI to regularly monitor and evaluate the effectiveness of the implementation of the framework in bringing about meaningful and effective actions that enhance the implementation of Article 4.5 of the Convention.

6.5 Technology Pool: information and tech trade

The purpose of promoting a technology transaction mechanism is to promote the transaction of ESTs through improving transaction convenience, enhancing supply & demand information sharing, improving transaction rules and reducing transaction costs.

Because technology transactions are closely related to technology information, the management of this mechanism should be supervised by technology needs assessment and an information panel under a Subsidiary Body.

In detail, the mechanism should take a role in these areas:

(1) Because of the inadequacy and asymmetry of technology information, an effective information sharing network must be established to eliminate information barriers.

The Secretariat of UNFCCC has already established TT: Clear, but as an information sharing network, the information supplied by TT: Clear is very limited and is neither integrated nor timely enough for the users. Hence, TT:CLEAR needs to be readjusted to establish connection with private sectors and work together with agencies in developing countries to promoting technology transaction.

(2) Conducting capacity building for agencies in developing countries to reduce the cost of technology evaluation and contract establishment.

Highly qualified agencies can effectively reduce the transaction cost of both sides. They can reduce international transaction costs of ESTs through overcoming institutional and cultural differences. Recently on the ESTs market, the number and kinds of these agencies are deficient, especially in developing countries. So technology needs assessment and information panels under the Subsidiary Body should set up a special working group to manage these agencies, to monitor and authenticate these agencies, and to conduct capacity building for agencies in developing countries.

(3) For those costs caused by trade protection and political governance, countries must be

encouraged to strengthen cooperation, to establish preferential policies and a complementary support system, and to create a competitive market so as to reduce additional transaction costs caused by trade protection and administrative management.

6.6 IPR mechanism

Issues related to the IPR will affect the speed of technology innovation and diffusion. IP comes in a variety of forms, only some of which are legally protected. "Patent and trade secrets are the two most important models of IPR protection with regard to environmentally sound technologies" (UNDESA, 2008) According to statistics from the World Intellectual Property Organization (WIPO), most of the ESTs are owned by developed countries. Up to 2007, 17.7%, 17.8% and 44.8% of renewable energy technologies were owned by United States of America, Japan and EU; 5.7%, 28.9% and 50.3% of vehicle abatement technologies belong to United States of America, Japan and EU.[5] So it is very important to trade off between the IPR in developed countries and the technology transfer to developing countries.

While technology transfer is a common feature of all sectors of human activity, there are some features that are unique to the area of climate change (IPCC, 2000). One salient feature is that of scale – both in terms of geography and the number of technologies. Essentially all countries of the world could be involved in the process, and the number of technologies could easily run into the thousands. Another unique feature of technology transfer in the context of global climate change is the number of persons that might benefit from the success of these efforts, since the whole world is expected to be the beneficiary. Historically, IPR practices suggest that the existing IP system does not match the increasing needs for speeding up the D&T of ESTs to meet the challenges of climate change. The contradiction between private technology owners' concerns about violation of IPRs or lower profits/returns from IPRs and potential technological recipients' concerns about high costs and market monopoly of technologies needs to be addressed by innovations in the mechanisms for both patented technologies and those not patented but controlled by monopoly market powers. The proposed measures may include:

- Economic incentives: developed countries use public finance to compensate companies'

[5] Source: OECD, Patent Database, June 2007

losses; developing countries use various approaches including opening up segments of market share, building joint venture factories, building plants producing parts locally, etc. to attract technology transfer;

- Compulsory licensing: developing countries use a legal approach to obtain technologies, but still need special measures to deal with know-how, knowledge and skill;
- Publicly owned patent pool: provide free or cheap technologies to developing countries, these patents can be bought by developed countries, the climate fund, various donors and other sources of funding;
- Differential pricing: provide cheap technologies to developing countries, and use subsidy and risk guarantee to compensate the patent owners;
- Parallel import: make technologies available at a lower price than were they to have been directly traded;
- Package bidding: take charge of competition between a number of companies to lower the royalties (licensing costs) and product prices;
- Joint R&D: improve the R&D ability of developing countries through joint R&D. However, because there is a difference in the ability of developing and developed countries to obtain technology rights and in the abilities of industries to innovate, the allocation of a new IPR should be treated differentially and create an innovational IPR sharing mechanism.

Box 6-2 IPR barriers in the joint R&D in wind power sector in China

Studies have shown that R&D cycle of advanced energy efficiency technologies is long, high risk and heavy investment. The uncertainty of climate change, the investment risk of energy-efficient technologies, as well as cutting-edge energy-efficient technologies makes joint research and development possible in the climate areas. However, due to gaps in technology ownership, industry, technology and innovation capacity, the allocation of the fruits of intellectual property resulting from joint research and development needs to be considered, not only according to the capital, time and human resources inputs. There should be an innovative IPR sharing mechanism for the joint research and development of ESTs.

Technology transfer in wind sector to China from developed countries are mainly through licensing and design, and does not involve a truly transfer of technology. In the joint research and development the IRP issues are:

- 5% commission fees charged by overseas design company for the protection of its IPR, which greatly raises the cost of turbine making company;
- At present, the joint research and development is based on adjustment of original designs owned by foreign companies. These companies charge high licensing fees, which increase the cost of turbine as well;
- Foreign design companies' patents are unknown to Chinese partners. When a Chinese company applies for patent for the result of a joint research and design, it is often found that the result has been applied patent by the foreign partner, so the Chinese company can not have its own patent, which causes huge loss to the Chinese company;
- The foreign design company is not willing to transfer any key technology.
- In order to overcome these barriers and to improve the effectiveness of joint research and development, an innovative IPR sharing mechanism should be created.
- Sharing principle: In general, to allocate the IPR in according with the proportion of inputs, such as capital, technology and human resources, and in favor of developing countries considering their relatively lower capacity of innovation.
- Sharing mechanism: to adopt different modes of cooperation according to different types of patents. Specifically:

Patents owned by two cooperative partners: *None of the partner needs to pay for the licensing fee*， however, the proportion of the patents should be taken into account in the allocation of final results from the joint research and development.

Patents owned by a Third party: The cooperative partners need to pay the licensing fees in proportion, and this ratio should be taken into account in the allocation of final results from joint research and development. Government can subsidize or make compulsory licensing to ensure that the joint research and development can be carried out with a reasonable cost. In this way, the allocation of joint research and development results should refer to the first mode.

In addition, the role of IPRs in ESTs varies from technology sector to technology sector. A technology can be covered by more than one patent and the technology described in one patent might be applicable in more than one technology sector. The choice of specific measures is closely dependant on the sectors which the technology belongs to and the characteristics of its IPRs.

- For such technologies in which a patent constitutes the majority percentage like the case in the pharmaceutical sector, individual patents have a substantial impact, and consequently the patent holder is in an exceptionally strong market position (Barton 2007), compulsory licensing may be a good choice;
- For such technologies which are owned by several companies and the competition between the companies is strong, parallel import and package bidding are better at lower royalties (licensing costs) and product prices than they would be in the case of a monopoly. Economic incentives such as opening up a segment of market share may also be attractive for companies;
- For the transfer of know-how, knowledge and experiences, which only can be transferred with willingness, public finance in the developed countries must make incentives to compensate the R&D recovery and future business opportunity loss for companies;
- In addition, measures to obtain know-how can be differentiated from sector to sector. For example, for power companies whose main sales market is domestic and can be almost seen as not competing internationally, know-how about the operation and maintenance of such companies may be easy to be transferred from developed countries to developing countries. But for manufacturers of power generation units which have strong international competition, the transformation of know-how about manufacturing and construction would be much harder and needs further economic incentives.

The IPR issue related to technology development and transfer need to be managed by the IPR cooperation panel under the Subsidiary Body. And its main tasks include:

- Providing information: provide WTO with technology and other special services;
- Capacity building: provide WTO employees with climate change and mitigation capacity building, including principle guidelines and a professional service;
- Monitoring and evaluation: set up a professional group and monitoring standard to monitor technology transfer under the WTO, helping them to improve.

WTO, as the leading organization on IPR issues, has to play a role in ESTs' development and transfer:

- Creating an effective environment: working closely with the UNFCCC, discerning the mitigation technologies that have the most potential to be traded and transferred. Also, the amending of existing, or setting out of new agreements to deal with the problems surrounding ESTs' transfer;

- Encouragement: providing a special fund for ESTs transfer, reduce the transaction costs;
- Participation: contributing to a technology transfer platform, providing a technology transfer information, standard, monitoring and evaluation system;
- Demonstration: collating so as to record in an organized manner the successful cases of technology transfer, making conclusions on effective experiences and demonstrating them to its members; and
- Promotion: increasing the availability of ESTs; finding out effective measures to deal with technology conflicts.

Annex 6-1 Performance indicators to evaluate and assess the effectiveness of technology transfer on ESTs

1st tier indicator	2nd tier indicator	3rd tier indicator	4th tier indicator
A Results from technology transfer	A-1 Technological capacity	A-1-1 advancement	A-1-1-1comprehensive comparison between transferred technology and other technology in the area
			A-1-1-2 key technology/design or not (yes/no)
		A-1-2 Change in gap	A-1-2-1 change of output quality and quantity
			A-1-2-2 change of input quality and quantity
		A-1-3 Digest, absorption and innovation	A-1-2-1 localization rate of technology transferred
			A-1-2-2 capacity to make the key parts (yes or no)
		A-1-4 diffusion	A-1-3-1 scope of diffusion
			A-1-3-2 market share of localized products
			A-1-3-3 speed of technology transfer
	A-2 Environmental effects	A-2-1 Mitigation effects	A-2-2-1 average annual CO_2 mitigation at the same output level
		A-2-2 Local environment improvement	A-2-3-1 average annual SO_2 mitigation at the same output level
			A-2-3-2 average annual NOx mitigation at the same output level
		A-2-3 Energy saving effects	A-2-3-1 average annual primary energy saving at the same output level
	A-3 Economical effects	A-3-1 Cost reduction	A-3-1-1 average annual power generation cost reduction at the same output level
			A-3-1-2 average annual carbon mitigation cost reduction
B Behavior of major stakeholders	B-1 Behavior of technology transfer stakeholders	B-1-1 Behaviors of both partners	B-1-1-1method of technology transfer
			B-1-1-2 commitment on technology updates
			B-1-1-3 price of technology transfer
		B-1-2 Supplying company's behavior	B-1-2-1 willingness to export the technology
			B-1-2-2 frequency and scale of training to the recipients
			B-1-2-3 resident expert support or not
			B-1-2-4 support to the bid of recipient
			B-1-2-5 support to monitor technology quality
			B-1-2-6 keep key technology confidential for the recipient (yes/no)
			B-1-2-7 unfavorable conditions for the recipients

			(yes/no)
		B-1-3 Recipient company’s behavior	B-1-3-1 Main body of TT: company/government
			B-1-3-2 Objectives of TT: Production use, and "import substitution" / digestion innovation and participation in international competition
			B-1-3-3 the method of introducing digesting, absorbing technologies
			B-1-3-4 finance to introduce technology
			B-1-3-5 finance to digest, absorb and innovate technology
	B-2 Government regulatory behavior	B-2-1 Recipient government behavior	B-2-1-1 policies on demand
			B-2-1-2 policies on supply
			B-2-1-3 cooperation measures
		B-2-2 Supplying government behavior	B-2-2-1 diffusion of technology information
			B-2-2-2 encouragement to multinational companies of TT to developing countries

Source: Lin, 2009

7. Conclusion and Recommendations for Copenhagen's deal on technology development and transfer

To sum up and to promote a successful outcome in the Copenhagen deal, ten elements are proposed here:

Element 1 Legal and Common Sense Basis: Reaffirm Article 4.1 (c), 4.3, 4.5, 4.7… of the Convention, and Agenda 21; Recall Decision 1/CP.13 (Bali Action Plan), 4/CP.7, …; Recognizing the urgency and importance of T&D&T to avoid lock-in effects in developing countries and to achieve a shift of development path to a low carbon world economy; Acknowledging the specific Technology development and transfer (T&D&T) context of protecting climate as global public goods or addressing global externalities; Acknowledging effective T&D&T should address hardware, software, know-how, human and financial resources, and enabling environment in an integrative manner; Noting the different technological nature in different stage of technology lifecycle; Noting the necessity of policy and institutional innovation targeting at the above mentioned technological nature in order to promote T&D&T.

Element 2 Technological Roadmap and TNA: Decide to develop technological roadmap to mitigate and adapt to climate change:

－At global, regional and national level

－Optimized in terms of efficiency and effectiveness (technological potential and cost)

－Taking into account environmental and social impacts

－Country-driven to match local circumstances

－Identify and overcome barriers to fill in the gaps between technological, economic, and market potentials.

－TNA based on the technological roadmap.

Element 3 Technology Information: Decide to enhance technology information service by:

－Develop regional and national information center/clearing house/network

－Implement facilitating policies for better information conditions

－Requirement for both supply side and demand side of information

- Support agents, and
- Others

Element 4 Capacity Building: Develop institutional capacity: define relationships and roles of stakeholders; develop international schemes for development of human resources, e.g., personnel exchanges and training; Development and enhancement of centers of excellence (COEs) and international network of COEs.

Element 5 MRV: Performance Assessment of T&D&T: To define environmentally friendly technologies as an integrative package covering hardware, software, human and financial resources, and enabling environment; To define transfer of technologies as equipment and device in place, Good operation and manufacture, and endogenous capacity to design and R&D ESTs. To develop indicators to present both process and objective performance, covering speed, range, scale of technological flows from developed to developing countries; to develop procedures, modalities, and steps to conduct performance assessment and reporting.

Element 6 Joint International R&D Schemes for Strategic ESTs: To develop principles and to set up mechanism for Joint R&D, which should includes:

- Organizational models, multilateral & bilateral;
- Master plan, Identification of agreed priority areas;
- Decision making process;
- Share of investment and O&M costs;
- Share of IP (via share of license, potential markets;
- Access to the core process of R&D, and
- Others.

Element 7 Institutional Arrangement: A new body is suggested to build under UNFCCC which is particularly in charge of planning, coordination, organizing, assessing and monitoring of D&T of ESTs, to promote technology information and experience exchange between different stakeholders. The position of the subsidiary body is an operational and implemental organization parallel with SBI and SBSTA, and directly reports to COP to provide regular guidance on matters relating to the Convention’s actions on D&T of ESTs, and to provide regular expert assessment of technology-related matters to the COP. Under the subsidiary body, a strategic planning committee and several technical panels are also needed.

Element 8 Policy instruments: to develop policies targeting at different areas and stage of ESTs and stakeholders; to develop policy dialogue mechanisms; and the policy options, among others, may include:

- Adequate commitments by developed countries on targets of emission reduction;
- Fiscal expenditure for subsidies in R&D, loan interest and insurance, and loan guarantee, government procurement;
- Levy on out-of-dated technologies, energy and pollution taxes;
- Tax exemption for development and transfer of mitigation and adaptation technology;
- Create carbon market;
- Regulations: Standards, permits …;
- Removing barriers and bans in technology trade, and
- Others.

Element 9 Multilateral Technology Acquisition Fund (MTAF): The basic idea is to develop public private partnership by linking public finance with carbon market, capital market, and technology market and leveraging larger amount of private finance by smaller amount of public finance. A Multilateral Technology Acquisition Fund (MTAF) should be established with the sources mainly based on public finance from developed countries (e.g. X% of developed countries fiscal budget or X% of environment and energy taxes, revenue from the auction of pollution rights and the public R&D budget.）The MTAF should be used as catalysts to provide stakeholders incentives to implement D&T of ESTs by means of appropriate policy instruments, financial instruments/products, and investment forms.

Element 10 Intellectual Property Right: for publicly owned technologies, to clarify property and made available for favored transfer by Annex I Parties governments or their agents; to develop favored share of IP derived from Joint R&D; Compulsory licensing related to patented ESTs and specific legal and regulatory arrangement should be in place as part of the efforts to implement UNFCCC; Price discrimination of ESTs may be arranged for different regions to support developing countries.

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