HEINRICH BÖLL FOUNDATION
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The Contribution of the Commercial Transfer of Technology to Climate Change Mitigation

Evaluating the Trend of the Post-Kyoto Negotiations on Technology Transfer

Project Supported by Heinrich Böll Foundation, the Climate Group and Worldwatch Institute

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Contents

1. Overview ... 1
1.1 Basic Concepts of Technology Transfer ... 1
1.2 Key Issues of Climate Negotiations ... 2
1.3 Successful commercial Transfer of Technology ... 3
1.4 Technology Transfer and CDM ... 6

2. Official Development Assistance (ODA) ... 8
2.1 Background of Technology Transfer through ODA ... 8
2.2 Process of Technology Transfer ... 8
2.3 The Distribution of Interests ... 8
2.4 The Role of the Government ... 9
2.5 Achievement ... 9
2.6 Analysis on typical Industries ... 9
2.7 Experience and Lessons ... 10
2.8 Conclusion ... 12

3. Commercial Transfer of Technology ... 13
3.1 The Market for Technology mode ... 13
3.1.1 Case Study: Tianwei Group ... 14
3.1.2 Case Study: Supercritical Coal-fired Power Generation Technology ... 16
3.1.3 The Role of the Government ... 20
3.1.4 Conclusion ... 20
3.2 Technology transfer through purchase ... 21
3.2.1 Case Study: Goldwind - a Leader in Wind Turbine Manufacturing through the direct Purchase of Technologies ... 22
3.2.2 Case Study: The Cement Equipment Manufacturing Industry ... 23
3.2.3 Conclusion ... 26
3.3 Joint-Venture and Cooperation: the Future Direction of Technology Transfer ... 27
3.3.1 Case Study: Linuo-Paradigma - a Successful Technology Transfer Case Based on Joint-venture ... 27
3.3.2 Conclusion ... 29

4. Final Conclusion and Recommendation ... 30
4.1 Conclusion ... 30
4.2 Policy Recommendations ... 31

Initiated by the "Kyoto Protocol" in 1997, the international climate negotiations began to follow a formal track. The global response to climate change moved from rhetoric to action. However, the United States and several other countries have not ratified the "Kyoto Protocol". The Kyoto Protocol, with carbon emissions trading at its core, has been effectively implemented in other participating countries. Emissions trading have not only been carried out in the Annex 1 countries, but they were also utilized in developed and developing countries through the clean development mechanism. This mechanism helps to reduce global greenhouse gas emissions. Technology transfer designed by the "United Nations Framework Convention on Climate Change" (UNFCCC), had a great effect on addressing climate change in developing countries. Progress has been slow in related negotiations, and the parties involved have not reached any binding agreements. This inhibits the progress of global GHG emissions reduction, and greatly reduces building capacity in developing countries struggling to address climate change.

There have been no breakthroughs in negotiations for more than a decade over the ownership of intellectual property rights, financial resources, or the objects of technology transfer. Despite this slow political process, low-carbon economy and related industries have become increasingly popular. Furthermore, related technologies have advanced in various countries. Technology cooperation and transfer under commercial conditions, or with certain government involvement, continues to gain further experience. Energy efficiency and renewable energy technologies improved and made a considerable contribution to GHG emissions reduction due to the encouragement of active climate mitigation policies.

Case studies of commercial transfer of technologies in Chinese enterprises in the fields of energy efficiency and renewable energy, examine other ways to accelerate technology transfer through commercial mechanisms. This can be done through public and private sector funding and future global climate policy framework. This allows the establishment of new mechanisms for joint research and development, and encourages concerted efforts in GHG reduction and global climate agreements. This report offers recommendations for policy makers and other relevant experts.

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1. Overview

1.1 Basic Concepts of Technology Transfer

Current technology transfer under UNFCCC has the potential to evolve into a unique mode of technology transfer. Traditional international technology transfer methods, such as international commodity trade, international technology trade, and foreign direct investment (FDI), are direct paths for global technology sharing. Controversies over the definition and methods of technology transfer under the climate change regime, delayed negotiations on technology transfer and have yet to produce the desired effects.

International technology transfer refers to technology exchange and communications among countries, exemplifying itself mainly as technology distribution and transfer from developed countries to developing countries. Generally speaking, the modern international technology transfer consists of non-commercial technology transfer and commercial technology transfer. In a sense, international technology transfer refers only to commercial technology transfer. Non-commercial technology transfer is not for profit.This includes technical assistance from both international organizations and inter-governmental agencies. An example of this would be scientific, technical, and academic exchanges of information. This method is generally free of charge or with preferential conditions. Commercial technology transfer is for profit. It is carried out through international technology trade or economic cooperation. Generally, foreign partners in a joint venture who own the technology use technology as investment capital, price it, and then transfer it to the joint venture in host countries. Local and foreign partners work together in the technical cooperation including researching, developing, and producing new products. This transfer mode includes joint ventures, cooperative ventures, compensation trade, and international engineering contracting.

In order to achieve a stable atmospheric GHG concentration level and avoid dangerous human interference in the climate system, the UNFCCC established the "common but differentiated" principle. Article 4.5 under 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." The ultimate goal is to protect the atmosphere as global public goods, and to achieve a sustainable level of development by human beings. This is a strategic initiative whose purpose is to achieve a "win-win" situation for developed and developing countries, as well as a global "win-win-win" situation. It is important that this initiative includes general international technology transfer, not merely commercial technology transfer.

In addition, the IPCC report "Technology Transfer Methodologies and Technical Issues" defines technology transfer as a series of steps including the transfer of knowledge, experience and equipment. This is also the outcome of years of discussions by various interest groups. Successful transfer depends on consumer and business awareness, access to information, existing technology, business, managerial skills, standardized skills, and the policy and regulatory framework in recipient localities. The recipients understand, utilize, and then replicate the technology. It also requires the recipients to choose and adapt technology to fit local conditions, as well as introduce new technologies and bridge the gap with old technologies. This distinguishes technology transfer under UNFCCC from technology diffusion, or "purchase of advanced equipment" and "technology and equipment localization" which only emphasize technology penetration and utilization.

No matter how controversial it may be, let us make a comparison of the conventional international technology transfer and technology transfer under UNFCCC. The common international technology transfer emphasizes only technology distribution and defusion. Its evaluation focuses mostly on effects, and its purpose is to develop an economy based on cost-benefits analysis. However, technology transfer under the UNFCCC does not only emphasize technology flow, but also the technological capabilities of the recipient in international technology transfer. The evaluation focuses on the capability and effectiveness of technology transfer, and its purpose is to achieve GHG reductions, protect the earth's climate, and technologically improve the recipient's capability to adapt to and mitigate climate change. The difference in the goals of technology transfer under UNFCCC and conventional methods determines their differences in supporting theories and content, as well as major driving forces.

1.2 Key Issues of Climate Negotiations

Developed countries and developing countries have different points of views when dealing with "common visions" and the "common but differentiated responsibilities" principle. As a consequence, negotiations over the past several years have made little substantial progress, including the COP 14/MOP4 Conference in Poznan in 2008.

For many years, technology transfer and financing have been the most divisive issues in negotiations between developing and developed countries. Countries which started early in the field of low carbon technologies will undoubtedly regard this as their future core national competitiveness. As active players to encourage global climate agreements, those countries have to balance the contradiction between environment protection and economic development, which is the key to solve the issues with technology transfer. Developed countries have not made clear responses on how to effectively transfer mitigation technologies and provide financial assistance. Therefore, negotiations are less than productive. Developed countries have stressed that low carbon technologies are in the hands of the private sector and issues of intellectual property rights need to be addressed. At the Poznan climate conference, developed countries also pointed out that the main channels for fund raising and technology transfer should be based on market mechanisms, private sector investment, and carbon market trading. They stressed that they had already set up other channels for financial mechanisms and technology transfer in addressing climate change such as The Global Environment Facility and the Special Climate Change Fund, in order to circumvent financial and technical obligations under the UNFCCC. Developing countries expect the international community to distinguish technology transfer under the UNFCCC from traditional profit seeking technology transfer. This consensus will force the international community to set up a technology transfer mechanism led by governments and businesses that will follow market principles. This will enable developed countries to honor their commitment to technology transfer and financing and encourage the transfer of climate-friendly technologies to developing countries on preferential and concessional terms. Furthermore, it will allow developing countries to pay a lower price to acquire new technology. It must be recognized that it is in the interests of all parties that developing countries are allowed to acquire affordable and applicable advanced technologies to improve their capability of addressing climate change. Developing countries also require that government funding from developed countries to be the major funding source to address this issue.

In addition to technology transfer and financial mechanisms, the current negotiations also hinge on several other issues. One such issue is that developed countries are reluctant to shoulder any GHG reduction commitments for the second phase of the "Kyoto Protocol" (2012 to 2020). This level of cooperation falls short of the objectives that UN scientists were expecting developed countries to meet in the second phase. Furthermore, developed countries are trying to shift responsibility by setting up emission reduction targets for developing countries. Many developing countries expressed concern that “this is not acceptable” because they would not receive any financial and technical support.

So far, China, India, Brazil, Mexico, South Africa, and many other developing countries have developed and enacted important climate change strategies. This shows that developing countries are not waiting for developed countries to act first. Despite this change, their efforts have not gained sufficient recognition and support. Developing countries have unanimously expressed their desire to take actions that will reduce emissions which are commensurate to their national conditions. However, a prerequisite is that developed countries should clearly define responsibilities, including specific emission reduction targets, as well as increase technology transfer and financial assistance to developing countries.

Negotiations in 2009 still hinge around these key issues, and it is still uncertain if there will be a successful outcome from the Copenhagen conference. The US government has shown a consistent and positive attitude in negotiations, which is a positive sign for future summits.

1.3 Successful commercial Transfer of Technology

As politicians debate over technology transfer mechanisms and financing in protracted negotiations, China and other developing countries have been quietly and successfully conducting commercial transfers of technologies. These countries are making direct contributions to GHG reduction, but are also exerting influence on the climate negotiation process.

Since the early 1980s, China has organized technology transfer to improve energy efficiency and develop renewable energy through the method of “import, digestion, assimilation and re-innovation”. This has improved the country’s energy efficiency level in energy intensive industries and renewable energy equipment manufacturing.

China has seen an annual economic growth rate of roughly 10% since 1980, while its energy consumption growth rate hovered around 5%. This means that the GNP per capita quadrupled while the countries energy consumption doubled. The country has seen technological advances across a wide range of sectors. For example, the thermal efficiency of China's thermal power plants increased from 34.85% to 40.36% between 1992 and 2002, registering a 5.51% increase. In comparison, South Korea's thermal efficiency increased from 36.7% to 40.0%, a 3.3% rise over the same period of time. The United State's thermal efficiency increased from 32.5% to 33.1%, registering only 0.6% rise. The PRC is the fastest growing country in thermal efficiency over this time period. Furthermore, China is a world leader in energy efficiency improvement in the iron, steel, and cement industries.

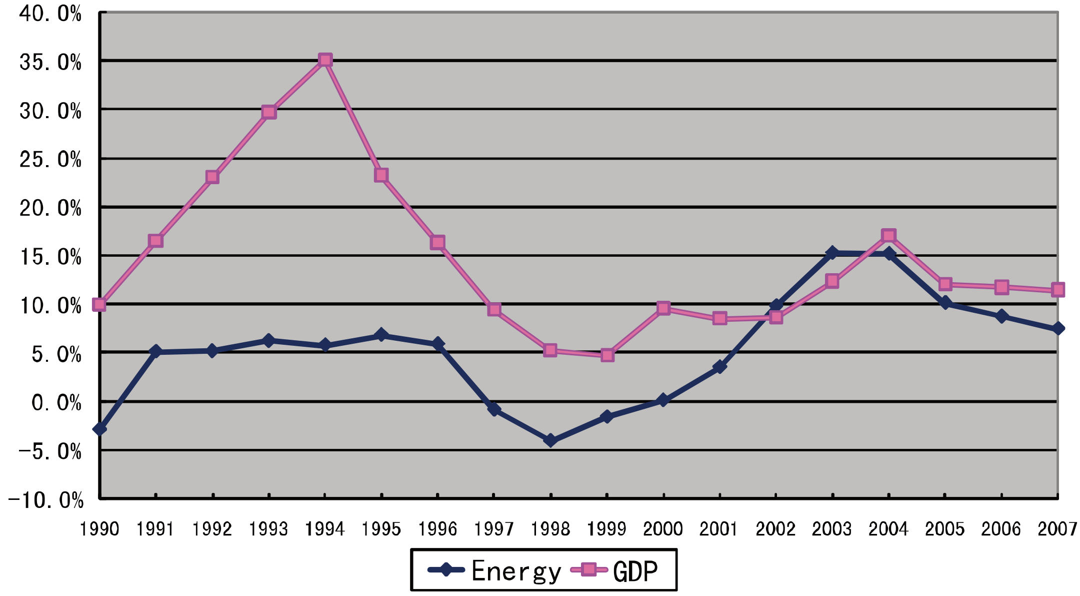
Renewable energy technologies have made remarkable progress too. Prior to 1990, China only produced small wind turbines of 50-100 watts. At the end of 2008 China installed over 12,000 additional megawatts of wind turbines, and also had the manufacturing capacity to build 3 MW large-scale turbines. China's total production capacity exceeded 10,000 MW at the end of 2008. Additional gains have been made in China's solar cell manufacturing sector. For example, in 2000, China's solar cell manufacturing capacity was only 4 MW. At the end of 2008, China had 2,500 MW of solar cell production and a 4,000 MW production capacity. In addition, China is now able to produce various solar technologies including polycrystalline silicon, monocrystalline silicon, and thin-film solar cells.[1]

The improvement of energy efficiency technologies and the development of renewable energy industries have not only enhanced China's economic competitiveness, but also slowed the growth of China's energy consumption dramatically and reduced GHG emissions. According to China's National Statistics Bureau, the annual GDP growth rate averaged 10% between 1980 and 2008. The corresponding average annual energy consumption increased by only 4.5%, this is well below the rate of economic growth over the same period. The energy consumption elasticity coefficient was only 0.44, and over the past 28 years, China has saved 2 billion tons of Standard coal. The PRC is now capable of producing half of its energy needed for its economic growth from developed energy sources. In addition, more efficient energy production has allowed China to cut their energy consumption in half. The energy that China saved over this period is equivalent to a reduction of 3.04 billion tons of carbon dioxide emissions.[2]

Low energy consumption elasticity coefficients are rare in developed countries, but they are extremely rare in developing countries such as China.

[1] Li Junjfeng et al, China Renewable Energy Development Prospects，*China Technology Investment*，2009 Issue 3

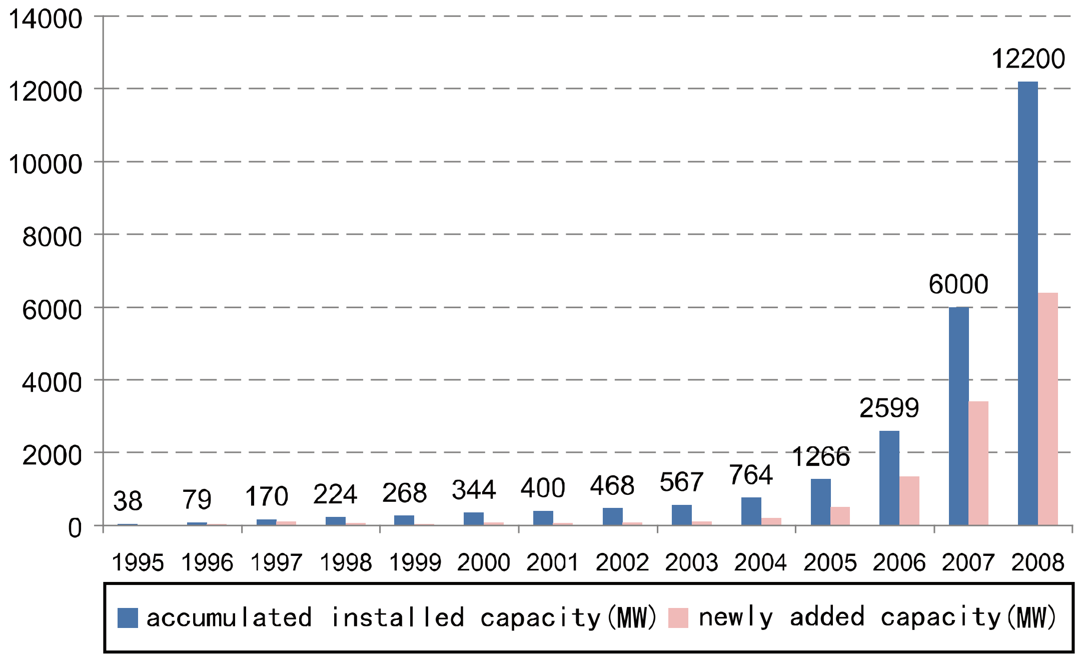
[2] Zhu Yuezhong, Efforts and Contributions of China's Energy Saving and Emissions Reduction, *Research Paper, Energy Research Institute*, 2009



Trends of China's Energy Consumption and GDP Growth

(Source: China Statistical Yearbook 2008)

The Chinese government also strengthened the development and utilization of hydropower, nuclear, oil, gas and coal-bed methane production through legislation, policy guidance, and capital investment. It supported the development and utilization of new renewable energy sources in rural remote areas and locations with suitable conditions that include biomass, solar, geothermal, and wind power. This increased the share of clean energy in the country's total energy mix, reduced carbon intensity per unit of energy consumption, and made contributions to global GHG emission reductions. China's installed hydropower capacity increased from 20.29 million kW in 1980 to 170 million kW at the end of 2008. Household biogas digesters exceeded 30 million, with an annual production of roughly 12 billion cubic meters of methane. The installed biomass power generation capacity was roughly 3 million kW, and the annual bio-ethanol production capacity with grain as feedstock was about 1.56 million tons. Additionally, more than 260 wind farms were built and connected to the grid with a total installed capacity of 12,000 MW. The total collector area of solar water heaters reached 135 million square meters. It is estimated that China has utilized 250 million tons of Standard coal renewable energy (including large sized hydropower), and this amounts to a reduction of 600 million tons of carbon dioxide emissions. These developments have benefited from the commercial transfer of technology. China has made substantial progress in the wind power and solar photovoltaic industries.



Trends of China's wind power market's development

(Source: Annual Report of China Renewable Energy Industries Association. March 2009)

1.4 Technology Transfer and CDM

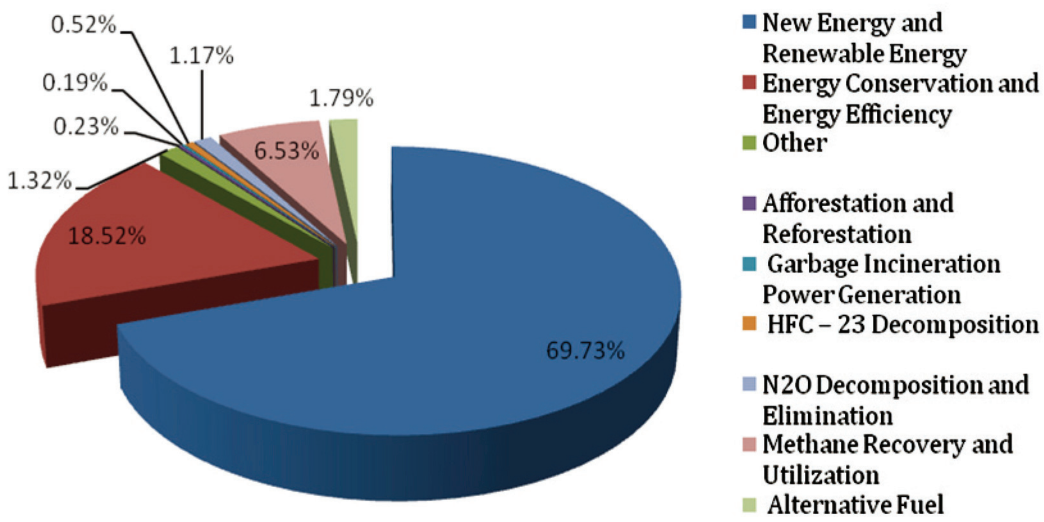
At the moment, little progress is being made on climate negotiations and technology transfer. However, the CDM has seen vigorous growth and development. By July, 21 2009, 1,732 CDM projects were successfully registered, with China ranking first among the recipient countries hosting a total of 589. By June, 22 2009, China's National Development and Reform Commission approved 2,092 projects. Successful global projects have the potential to reduce 300 million tons of carbon dioxide emissions annually, and China has the ability to reduce 180 million tons which would account for 58.79% of total emissions[3].

In China's case, among the projects developed to date, renewable energy, energy conservation, energy efficiency, and methane recovery are the top three in terms of total number of projects. The CDM has played a key role in the wind power field. In other words, the CDM stimulated demand for China's renewable energy legislative framework, and has thereby contributed to technological progress and encouraged commercial transfer of technology. However, this form of transfer is far from what is expected under UNFCCC in terms of principle and scale.

The current rules of the CDM is one of the major bottle necks. For example, sellers of emission reductions could only receive the payment in one or two years after the starting of the project. Furthermore, they have to assume the risk of being rejected by the CDM Executive Board. As

[3] Li Junfeng, Speech at the Seminar on Energy Conservation and Emission Reduction at Hangzhou Environment Exchange, July 2009

such analysis of the revenue is the base for decision making on whether or not to launch projects, few investors purchase technologies and equipment in advance. Thus only few technology projects have been triggered by CDM funds. Such barriers must be overcome in order for the carbon market to play a key role in the post-Kyoto technology transfer mechanism.



China CDM Projects Distribution

(Source：http://cdm.ccchina.gov.cn)

2. Official Development Assistance (ODA)

The Official Development Assistance (ODA) is one of the traditional economic aid transfer mechanisms used to pass information from developed countries to developing countries. The ODA has shifted from general economic aid to the environment and energy field. The "Green Aid Plan" between Japan and China clearly illustrates the ODA in action. Technology transfer is an important component of this project.

2.1 Background of Technology Transfer through ODA

The Japanese Green Aid Plan to China between 1992 and 2003 is a successful case in bilateral intergovernmental cooperation on technology transfer.

The main objective of the plan is for China to learn from Japan in the field of environmental pollution prevention and treatment, to improve the utilization of energy and mineral resources, reduce pollution, protect the environment and encourage cleaner production in Chinese industrial enterprises through technology transfer, diffusion and dissemination in the environment and energy field. Demonstration projects cover the three major areas of energy efficiency, clean coal, and power plant desulfurization. After the implementation of pilot projects, many sectors made progress on technology distribution, promotion through staff training, technical tours and encouraging the transfer of environmentally friendly technologies between Japan and China.

2.2 Process of Technology Transfer

The main mode of technology transfer operation between Japan and China is as follows: During the establishment of pilot projects, Japan supplies Chinese enterprises with design, core technologies, and key equipment. Other equipment is procured in China and much of the production is completed using Chinese labor in order to reduce costs and enhance the competitive value of the final products. In addition, participating Chinese organizations engage in in-depth technical exchanges in cooperation with their Japanese counterparts. The evolvement of pilot projects allowed participating enterprises to systematically organize studies and training for related Chinese managers, R&D personnel, equipment operators, and maintenance personnel in accordance with the project agreement. This improved the trained personnel's work capability, technical skills, and raised their environmental awareness. During this time, Chinese managers and technical staff participated in researching local conditions and working with their Japanese partners to solve issues that arose from the demonstration process. Chinese companies took advantage of their own technological specialties to adapt and improve introduced equipment and technologies.

2.3 The Distribution of Interests

During the demonstration process, Japanese equipment suppliers found new markets that made it possible for further development. In addition, China's environmental industries gained the opportunity to learn from Japan and improve through additional training. These projects allowed the Chinese environmental industry to develop over a rather short period of time.

2.4 The Role of the Government

At the beginning of the demonstration projects, the Japanese Ministry of Economy, Trade, and Industry helped Chinese organizations buy technology and equipment from Japanese companies through grants and low-interest loans. The Chinese government prioritized the localization of mature technologies and equipment and asked governments at various levels and industry authorities to render those projects effectively through policy and institutional investment tools. Specifically, the government was responsible for formulating policy mechanisms and the overall arrangements of the projects, and the companies financed, equipped and trained the personnel during the process. The former China State Planning Commission called for several national working meetings on the Green Aid Plan, summarizing implemented projects, doing research, and gathering recommendations on how to successfully disseminate the demonstration projects.

In addition, China further improved laws and regulations related to the economy and environment, and raised the discharge levy standard in order to encourage the utilization and distribution of energy-saving and environment friendly technology and equipment.

2.5 Achievement

Overall, demonstrated projects were successful. Currently, there are 36 finished and ongoing projects that include blast furnace top pressure power generation, water saving coal preparation, circulating fluidized bed boiler, desulfurization, and bio-coal. These projects contribute to China's energy conservation, clean energy application, and environmental protection. Many key technologies have the potential for wider applications. The establishment of demonstration projects improved China's industrial policy making, industrial restructuring, product quality, energy and raw material conservation, environmental protection and labor productivity enhancement. Chinese enterprises in construction materials, metallurgy, coal, chemicals, machinery and petrochemical industries has improved resources and energy efficiency by applying successful technologies such as blast furnace TRT, simple flue gas desulfurization, cement kiln waste heat recovery power generation and circulating fluidized bed boiler.

2.6 Analysis on typical Industries

Iron and Steel: The blast furnace hot stove waste heat recovery project at Shandong Laiwu Steel Corporation adopted technologies and equipment from the Nippon Steel Corporation. These new technologies effectively reduced approximately 10% of energy intensity of iron production; the blast furnace residual pressure power generation project at Sichuan Panzhihua Iron and Steel Corporation used technologies and equipment from Japan's Kawasaki Steel Co., Ltd, generating 42.63 million kwh electricity annually. This reduction is equivalent to an annual reduction of 36,000 tons of carbon dioxide emissions. The simple flue gas desulphurization project at Shandong Weifang Yaxing Chemical Corporation used technologies and equipment from Japan's

Mitsubishi Heavy Industries Ltd. and reduced 640 tons of sulfur dioxide emissions annually. Furthermore, the cement kiln waste heat recovery power generation project of the Anhui Ningguo Cement Company adapted technologies and equipment from Japan's Kawasaki Heavy Industries Ltd., achieving salient economic and environmental benefits.

Power generation: The desulfurization project at Shandong Huangdao Power Plant has a compact desulfurization absorbent preparation system layout which helps to conserve energy. Huangdao Power Plant also adopted a slim desulfurization absorber with high-diameter ration of three. As a result, it reduced the amount of space that it occupied. The plant used a high power frequency conversion motor speed control on its centrifugal spray machines which made the maintenance process much easier. After taking over the management of the introduced equipments, The Huangdao Power Plant made additional improvements with its own capacitytoenhance the plant's desulfurization efficiency.

Coal: The Yanzhou Mining Group learned from the success of the water saving coal preparation projects at the Dongtan Coal Preparation Plant. The group purchased a number of ash monitors for their coal mines to improve coal quality and efficiency. After the Yanzhou Mining Group got connected to the internet in 1999, coal preparation plants acquired greater access to external information. In addition, coal washing plants also publishes information through the internet. The Yanzhou Mining Group extended the network throughout its workshops, integrated their information, in order to better adapt to the changes in coal market and management pattern. In order to further improve on-site management, the Dongtan Coal Preparation Plant took advantage of the technology of surveillance cameras to ensure greater accountability and production.

2.7 Experience and Lessons

Green Aid Plan demonstration projects have a good chance for future distribution and development in China. However, there are obvious obstacles and problems in project organization, implementation and management. These problems mainly exist in the following four aspects:

The first problem is an issue of funding. The Green Aid Plan demonstrates that it is difficult for projects to find fluid channels of external financing. Due to economic differences in Japan and China, the cost of technology commercialization, design and equipment in Japan is much higher than it is in China. In the Green Aid Plan, the Japanese companies are responsible for design and manufacturing of key equipment , which caused the high cost of the whole set of equipment. One method to reduce cost is to maximize localization of the outcome of the GreenAid Plan in China. However, due to intellectual property rights, it is very difficult to rely solely on the Chinese side to distribute the developed technologies.

The second issue is that China does not have the capacity to manufacture some of the key technologies. In general, the technological standard of the Green Aid Plan projects is high. The Chinese either don't have the manufacturing capability for key technologies, or the technological level of the entire industry is too low to adapt to new technologies. The country faces difficulty in receiving and redistributing transferred technologies and there is little chance for a free transfer of patented technologies.

The third problem is a development gap in management levels that inhibits the development of projects. There are three management levels in Green Aid Plan projects: Organization, construction and operation. A huge gap exists in all three levels between China and Japan. The project management level in China is low, and this incurs delay in equipment, import procedures, deadline postponing, poor construction quality and operations not complying with requirements.

The fourth stumbling block is supporting policy. Although clean coal demonstration projects have salient environmental benefits, many enterprises are not enthusiastic about them due to the low economic benefits. Therefore, there is a profound need for government policies that provide sound guidance. An example of this would be environmental standard policies. If the government raises the environmental standards, enterprises have to consider energy saving and environmental protection projects to comply with the requirement. The briquette project in Linyi has difficulty in selling its bio-coal because the project is not located in areas where the state controls sulfur dioxide and acid rain. If the country raises its sulfur dioxide emissions standards, bio-coal will have increased potential to be developed into a real market commodity. Major problems also exist in the country's discharge levy policy. The current discharge levy level is low. Therefore, it makes more economic sense for enterprises to pay the discharge fee instead of installing environmental protection facilities. In fact, some plants have installed the environmental facilities but refuse to run them in order to reduce cost.

Denmark, Germany, and Spain's Wind Power Promotion Plan in China

In the 1990s, wind power technology in Europe got matured, and European wind power enterprises began to seek overseas markets with China and other large developing countries as potential targets. Denmark, Germany, and Spain launched their wind power promotion plans in China. They used grants and set up the first connected wind power pilot project in Rongcheng, Shandong province. Since then they have constructed several pilot projects in Dabancheng in Xinjiang and Jurh in Inner Mongolia in the same manner. They have also used bilateral aid preferential loans to construct wind farms including the second phase in Dabancheng, the first phase in Tongyu of Jilin province, Dongfang in Hainan and the East Mangrow Bay in Guangdong province. Thus they have completed their first phase of the development of China's wind market.

In order to develop the wind power market, the Chinese government initiated a "Wind Power Development Plan" in 1999, trying to set up the domestic wind power equipment manufacturing capacity. The much hoped "Wind Power Development Plan" produced two joint ventures. The Xi'an Aeroplane Engine Co. Ltd and Luoyang First Tractor Group set up joint ventures with Germany's Nordex and Spain's MADE respectively on producing wind turbines. They were organized by the former National Planning Commission, and called "national team." The results, however, were not satisfactory. As Mr. Shi Pengfei, the pioneer on China's wind power said,"The 'Market for Technology' concept has not been well executed. China did not have a good wind power market environment. Foreign manufacturers directly brought parts into China for assembly, and China did not gain new technologies. Xi'an Weide and Luoyang MADE, which were set up under ODA and the concept of 'market for technology' both failed in the end. "

2.8 Conclusion

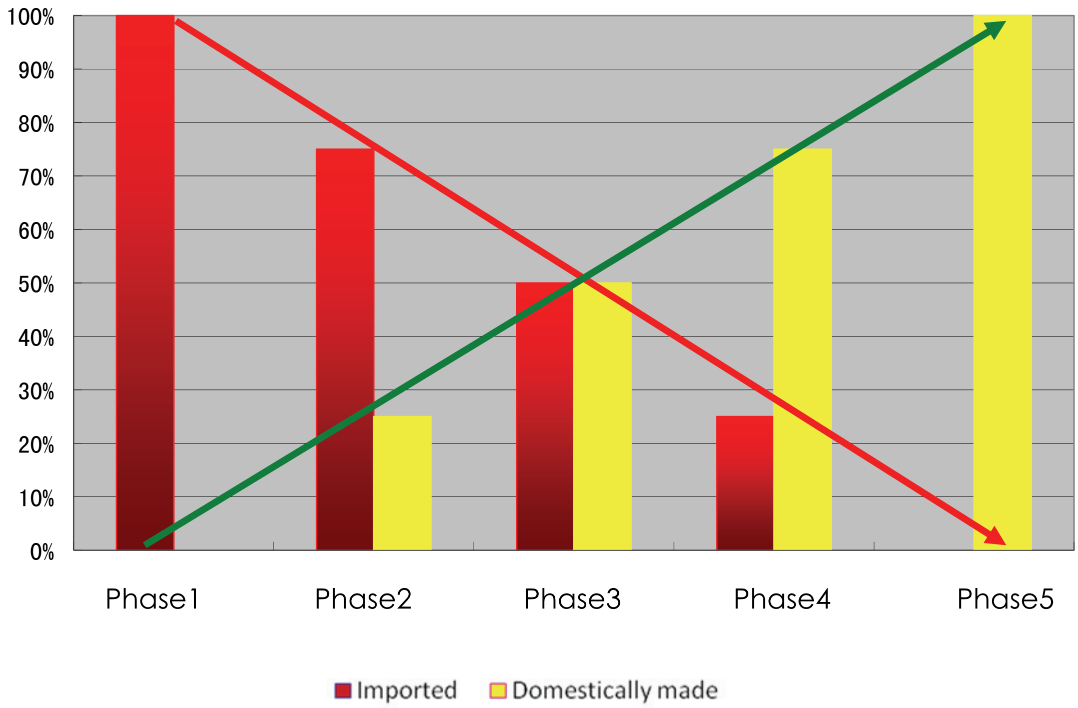
Under the ODA mechanism, developing countries offer market share to exchange for technology from developed countries. Because technologies are normally in the hands of private sector, the ODA mechanism can not complete the whole process of technology transfer. Developing countries provide pilot sites for advanced technologies from developed countries, while developed countries make advanced technologies known to companies in developing countries. The real substantive technology transfer needs commercial channels. Therefore, due to intellectual property rights constraints, governments cannot buy technologies directly from the private sector for transfer.

3. Commercial Transfer of Technology

Technology transfer through commercial channels is the most active and productive mode of climate change mitigation technology transfer. Most of China's renewable energy and energy saving technologies, particularly related to equipment technologies, are realized under the commercial mode. The most efficient means of transfer are direct purchase and the Market for Technology. Direct purchase includes production license purchase, commissioned R&D and joint R&D. Market for Technology also includes production license purchase, co-production, and joint R&D. All successful technology transfers must be a process of importing, receiving, absorbing and re-inventing.

3.1 The Market for Technology mode

It is critical that the Market for Technology receives government support. Generally, with government support, the two sides negotiate to jointly develop a certain market share in a predetermined period of time. The foreign partner, in cooperation with the Chinese, designs and manufactures the first equipment according to the needs of the Chinese market. The Chinese gradually increase their involvement in the design and manufacturing process, until the final equipment is completely engineered and built in China. This approach started with the transfer of large hydropower equipment, and has gradually been distributed to other sectors. The "linear model" (see below) has been the typical technical path for the Market for Technology.



Large Hydropower Equipment Market for Technology transfer Process Diagram

The Market for Technology has been pushed from hydropower to the whole power generation equipment manufacturing industry. T his includes major power groups, major transformer manufacturers and modern nuclear technologies. In the following a typical case study of Tianwei

Group, a well known transformer equipment manufacturing company in China and a successful sectoral case of clean coal technology, shall be examined.

3.1.1 Case Study: Tianwei Group

From the Market for Technology mode to "Digestion, Assimilation and Re-innovation" Success of technology cooperation and transfer at the Tianwei Group

Background

Transformers are key pieces of power transmission and transformation equipment and their efficiency is an important factor that affects the loss on the transmission lines. Since the economic reform began in1978, China's power industry was rapidly developed and the grid needed new and efficient transmission and transformation equipment. Founded in 1958, the Baoding Tianwei group was a state owned holding company that specialized in transformers and other transmission and transformation equipment. This company was an important enterprise in heavy and large equipment manufacturing. Over the years, Tianwei lagged behind on R&D, and its products were inefficient and failed to meet the needs of China's rapidly developing power industry. There was a need to introduce advanced technologies to improve the quality and standards of transformers made in China. At the same time, some overseas transmission and transformation equipment companies, such as Siemens and Toshiba, were eager to enter the Chinese market. This common need became a prerequisite for technology transfer.

Process of Technology Transfer

Tianwei started to introduce overseas technologies in the mid 1990's. It first introduced and adapted technologies from Japan's Toshiba Corp., and produced the group's first 500-kilowatt turbine. Then led by the former Ministry of machinery, Tianwei introduced technologies from Japan's Hitachi Corporation. In the mid 1990's, Tianwei sent a large number of personnel to Japan for long term study and research. They received training in design, processing and manufacturing capabilities for various periods of time ranging from one month to 3 years. Through intensive training and practice, they were gradually able to produce prototypes based on what they learned in Japan.

In1999, under the "Market for Technology" policy, the Tianwei Group and Germany's Siemens AG won a joint bid for providing transformers to the Three Gorges Project. The bundled tender process of the Three Gorges Project provided an opportunity for Chinese state owned enterprises to work with foreign companies on advanced technologies. During this process, the two sides jointly designed, conducted R&D and manufactured products according to the proposed agreement. Personnel from both sides participated in every step of the process, completing the 840,000 KVA/500 KV class transformer production contract. Tianwei's technology capacity was further developed during the process.

In addition to sending over 600 staff overseas for technical training, Tianwei also cooperated with Tsinghua University, Xi'an Jiaotong University and the Chinese Academy of Sciences to train the country's top technical employees. Tianwei improved its personnel's quality and technical skills through continuous seminars, trainings, and international cooperation. In addition, the group kept pursuing technology exploration and innovation, built up a strong technical team, and developed independent intellectual property rights.

The Distribution of Interests

Tianwei Group gained access to advanced manufacturing technology of transmission and transformation equipment through technology transfer and developed its own R&D team. This company has become one of China's top two leading producers in transmission and transformation equipment. Their annual output of 50 million KVA makes them one of the PRC's leaders in wind turbine production. This group also secured an important position in the international market. Overseas enterprises such as Siemens, Toshiba and ABB have successfully entered Chinese markets through their cooperation with Tianwei Group. They also developed new types of equipment that suited the local market through market oriented R&D and they established wholly owned enterprises as well as joint ventures. This partnership enabled them getting a great share of the flourishing Chinese market.

Achievement

Through technological innovation and the process of import, digestion, assimilation, and re-innovation, Tianwei developed independent intellectual property rights of core technologies of transformer design and manufacture. It has also become a world famous transformer manufacturing company with an extensive set of core technologies, the widest coverage of voltage levels and the largest variety of products. Tianwei used its own technologies and independent intellectual property rights to develop transformers for China's 1,000 kV power grids. This was achieved based on the previous experience from manufacturing 500 kV transmission equipment and the company's constant learning of new knowledge. The development of Tianwei encouraged the innovation of China's electricity technology and the upgrading of equipment manufacturing technical standard.

Successful Experience

Tianwei's factors for success:

- Mutual market demand as the basis of successful technology transfer
- Fierce market competition is the prerequisite for technology transfer
- Fair negotiations as the key to achieve a win-win situation

Lessons

The key lessons of Tianwei's case are:

- Fierce market competition caused duplication of technology import, this led to a waste of limited finance and human resources
- The rapid development of Chinese enterprises caused apprehension among foreign technology owners

3.1.2 Case Study: Supercritical Coal-fired Power Generation Technology

Background

China's current thermal power generation is still dominated by coal. By the end of 2008 China's coal-fired power generation accounted for more than 80% of the country's total energy output. The average power generation efficiency for domestic coal fired power plants in operation is below 35%. However, 1Kwh electricity generation requires more than 380 grams of Standard coal. The power generation efficiency for sub-critical generating units in design and manufacture is 38%, with a 350 grams. In addition, the power generation efficiency for introduced super critical generating units is 41%, with a Standard coal intensity of 310 grams per Kwh. The power generation efficiency for ultra super critical generating units owned by Japan's Mitsubishi Corporation, is 48%, with a Standard coal intensity of 265 grams per Kwh. If China uses ultra-super critical generating units, its unit electricity coal consumption can be cut by 50 grams. Based on the country's estimated installed capacity, there is the potential to save 300 million tons of coal and reduce 600 million tons of carbon dioxide emissions annually. Therefore, it is of great significance that there is an introduction of ultra-super critical generating units to save energy and reduce GHG emissions. China has put an emphasis on R&D of supercritical and ultra-supercritical technology since the 1990's. In the year 2000, the former State Power Corporation initiated a feasibility study of ultra-supercritical technologies. As a result, this project was given top priority and it was enlisted as a national high-tech research project.

Process of Technology Transfer

The Chinese government encouraged enterprises to introduce oversea technologies through joint ventures and joint R&D under the "Market for Technology" mode. The Shanghai Electric Group, the Harbin Power Plant Equipment Group, and the Dongfang Electric Group are the three major players actively introducing advanced coal-fired electricity generation technologies. These three companies are the key equipment suppliers for China's coal power plants and are recognized as top coal power equipment manufacturers in the world.

In recent years, China's power generation equipment manufacturing industry made vast improvements in product variety and quality through the introduction and assimilation of foreign advanced technologies. The Chinese companies have narrowed the gap with their foreign counterparts. The introduction of technologies from Japan's BHK allowed the Dongfang Boiler

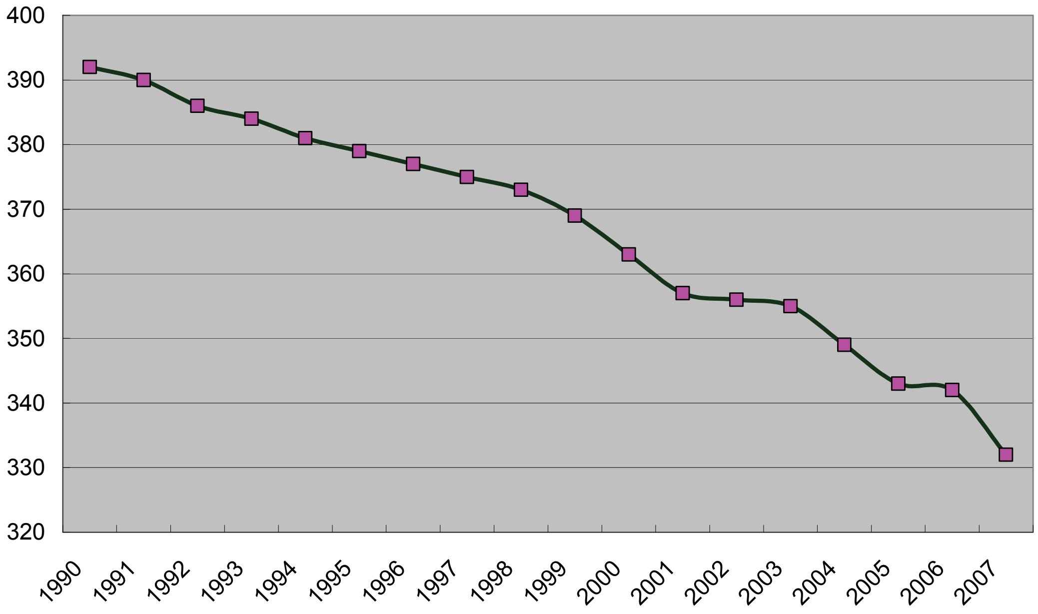
Group to produce China's first 600,000 kilowatts demonstration supercritical boiler in 2004 (matching with the turbine and generator produced by the Harbin Power Group). Since then, the Dongfang Boiler Group produced 7 additional units. In 2005, the first 600,000 kilowatts supercritical boiler produced by Harbin Power Plant Equipment Group and the steam turbine produced by Donfang Power Plant started operation in the Changshu coal facility. In 2004, Dongfang Boiler exported its own 135,000 kilowatts circulating fluidized bed boilers to Turkey. This trade made it the first large Chinese mechanical and electrical equipment manufacturer to enter a market monopolized by European enterprises. The three major boiler manufacturers Harbin, Shanghai and Dongfang havemade vast improvements and developed their own specialties in large scale circulating fluidized bed boiler technology.

Distribution of Interests

The three major groups made further advances in research and development of the 1 million kilowatts ultra-supercritical boilers. The 4x1million kilowatts ultra-supercritical generating units at the Zhejiang Yuhuan Power Plant were supplied by the Harbin Boiler, the Shanghai Electrical Machinery, and the Shanghai Steam. The additional three 2×1 million Kilowatts ultra-supercritical generating units at Zouxian County, the Waigaoqiao and the Taizhou Power Plant were supplied by Dongfang Electric, Shanghai Electric, and Harbin Power Group. Haibin Power Group is the leader in the manufacturing of the 600,000 ultra-supercritical units, with contracts for 4 additional units in the near future. The manufacture of ultra-supercritical units is in fact a process of technology import, assimilation, and innovation. The process of, "Technology import, joint design and co-production" has been adopted throughout all segments of the process including project design, equipment selection, supplier selection and project construction. Chinese businesses are able to carry out technology cooperation and innovation while introducing advanced technologies. The process of joint or co-innovation is in fact a process of Market for Technology. The Chinese government attracts foreign companies to cooperate or have joint ventures with Chinese enterprises by providing shares of the market for the exchange of technology. Under this policy, the three major power equipment groups of Harbin, Shanghai, and Dongfang got technologies transferred from foreign enterprises including Hitachi, Mitsubishi, Toshiba, Siemens, and Alstom.

Achievement

Currently, Chinese enterprises have acquired the design, construction, adjustment and operation technologies of 600,000 kilowatts supercritical power generating units through technology import, digestion and assimilation. In addition, they have also mastered the engineering technology of 1 million kilowatts of ultra-supercritical generating units. In the 1 million kilowatts ultra-supercritical unit designed by the Huadian Group for the commercial operation in Zouxian County, 73% of the parts are domestically made. Over the Eleventh "Five-Year" period, China planned the construction of over 100 units of 600,000 kilowatts and above ultra-supercritical generating units with higher efficiency and lower emissions. By the end of 2007, China had built and put into operation 120 supercritical units with a total of 50 million kilowatts. There were roughly 100 units of 600,000 kilowatts supercritical units being manufactured, and over 100 units of 600,000 kilowatts supercritical units scheduled for production. The eight ultra-supercritical units put into operation are mostly located in eastern coastal regions. There are two 600,000 kilowatts units in Liaoning province, one 1 million kilowatts unit and one 600,000 kilowatts unit in Jiangsu province, four 1 million kilowatts units in Zhejiang province, and two 1 million kilowatts units in Shandong province. This is one of China's great technological leaps forward in the upgrade of technologies. This allowed China to reduce coal consumption for power generation by a large margin and reduce GHG emissions.



Coal Consumption Reduction for China's Power Generation（gram Standard coal/kWh）

(Source：China Electricity Council: Power Situation after Three Decades of Reform and Transparency)

Successful Experience

China has successfully encouraged the transfer and distribution of the supercritical and ultra-supercritical power generation technologies through a market pricing scheme, profits, and government policies.

- There is a growing market demand. Between the years 2000-2008 China reached its peak in power plant construction and became the world's largest market for coal fired power generation equipment. This has created a demand for technology transfer. All major international power equipment manufacturers' focus on the Chinese market.
- There is increasing domestic pressure to reduce emissions. The power sector is of high priority in the national energy saving and emissions reduction strategy. Enterprises face intensified pressure to save energy after the introduction of China's energy conservation

benchmarking system. This created the need within the enterprises for cleaner and more efficient technologies..

- Currently, the price – performance ratio of technologies is at an acceptable level. The additional investments for supercritical and ultra-supercritical units are small. The total investment is about 10% higher in than it of the conventional units. And its efficiency is 5%-10% higher. This increase in efficiency, together with the country's energy saving incentives, cut the additional cost for enterprises to adopt supercritical and ultra-supercritical technologies.
- The transfer and diffusion of technology enjoys national policy support. In addition to the development of Market for Technology mode and energy saving and emission reduction policies, China has also adopted a policy that uses advanced power generation technologies to benchmark the electricity price to encourage enterprises to use new technologies. The country introduced a policy requiring all projects over 600 MW to adopt supercritical and ultra-supercritical technologies. This makes it necessary for companies to use new technologies for their further development.

Lessons

The key lessons are as the following：

Dependence on oversea technology

- The country uses policy tools through the Market for Technology mode to support innovative technology endeavors of domestic enterprises, but this has also increased domestic enterprises' dependence on oversea technology transfers. Japanese enterprises introduced super-critical and ultra-supercritical technologies from Germany in the early 1990's and exported the technology to China in 2000. Although the three major Chinese power generation equipment groups also have become global giants, relying on foreign technologies have harmed their own R&D capabilities. The consequence is that large scale power generation equipment in China has a low localization rate and they lack core technologies and key components. Therefore, it is easy for Chinese companies to get stuck in the cycle of "import, lag behind, and re-import".

Multi-import and repeated import

China's domestic market has been dominated by the three major power generation equipment groups and the competition created technological difficulties amongst themselves. Due to intellectual property right protection during the transfer process, these companies have to re-import similar technologies from oversea companies. For example, the ultra-supercritical technology was re-imported several times through multiple companies. The Harbin Power Plant Equipment Corporation introduced technologies from Toshiba. The Shanghai Electric Group introduced technologies from Siemens, and the Dongfang Steam Turbine introduced technologies from Hitachi.

3.1.3 The Role of the Government

The Chinese government plays the following roles in the Market for Technology mode:

- The Chinese government allows Chinese companies to trade shares of the market for the exchange of technology and it provides legal protection for this practice. For example, when some equipment cannot be produced domestically, the country levies zero tariffs on its import. The new and the high-tech companies enjoy preferential treatment in income tax "exemption for the first two years and a half to three years".
- The Chinese government encourages Chinese enterprises to follow the path of "import, assimilation, and re-innovation" through the R&D fund. Technical cooperation is included in China's national high-tech scheme, and encourages Chinese enterprises to carry out joint R&D with foreign partners to improve their own R&D capabilities.
- The Chinese government provides incentives to foreign investors, such as value-added tax rebates for foreign enterprises to procure equipment in China and preferential treatment in income tax for high and new-tech enterprises.

Foreign governments contribute little in the Market for Technology mode.

3.1.4 Conclusion

Basic Characteristics of the Market for Technology mode

Successful cases of Market for Technology mode, whether business or industry, have the following characteristics:

1) Market for Technology requires strong support of government policies. Technology providers have to be assured that they will get a satisfactory share of the market for a long period of time through technology transfer process. The technology recipients will acquire sufficient technologies and equipment manufacturing capability during satisfactory period of time so they can gain a share of the market.

2) The Chinese enterprises get technologies at the expense of giving up a piece of the market. This mode has given them time and mobility in the market and enables them to have their own manufacturing and R&D capabilities. Technology providers secure stable shares of the market for a certain period of time in return for access to their technology. Presently, they are receiving a fairly large market share at the expenses of future long term gains.

3) Deficiencies in the Market for Technology mode is the basic reason for its prevalence. Enterprises on both sides benefit from Market for Technology, and technology providers know that they will gain access to the market as long as they have advanced technologies. Therefore, they focus their resources on developing advanced technologies. Recipients of the technology believe that they will always get technology at the expense of market share, so they develop a strong dependence on technology transfer.

Needed Improvement in the Market for Technology mode Mode

The following areas need further improvement :

1) Fairness

The government's participation in market share division has created unfairness in the entrance of new technologies into the market. At present, industries which have had success under the Market for Technology mode are monopolistic and it is the large enterprises within those industries that benefit directly from this mode. The enterprises, either state owned or privately held, have to be large in order to take full advantage of the Market for Technology mode. Small enterprises only get indirect benefits since they have fewer market resources. Small and medium sized businesses only enjoy the radiation effects from large enterprises that are benefited from technology transfer.. Since market resources belong to the state, the Market for Technology mode has acquired technologies for a small number of enterprises at the expense of most enterprises' market share or market access. It is necessary to strike a balance between fairness and efficiency.

2) Transparency

The technologies introduced through the Market for Technology mode have intellectual property rights. However, both the technology provider and the recipient do not put a price tag on the transferred technology. This is a secretive process to outsiders. There are only a few enterprises participating in this system and frequent controversies arise over the injustice incurred by this unorthodox plan.

3) Equity

Unsuccessful cases under the Market for Technology mode are conducted by companies that give up market share but cannot acquire the needed technologies in return. For example, china's automobile industry gave up a market share of 10 million vehicles a year, but has not yet acquired the needed technologies through the Market for Technology mode. It is because of providers' natureto protect their own competitive advantages and the low technological standard of the recipients. Unequal position in the negotiation makes it impossible to attain the desired effects of the Market for Technology mode.

3.2 Technology transfer through purchase

Most technology transfers through direct purchase take place among medium and small-sized enterprises. Direct purchase is based on promising market demand. Before 2005, China's annual installed capacity of wind power was less than 100 mw and there were few wind turbine manufacturers in the market. Initially, licensing fee was very affordable costing a little more than $3 million for mw-class wind turbine. However, after the China issued the Renewable Energy law, the price jumped significantly to $30 million. In addition to the initial charge for the production permit, the licensing fee also included commission from the sale of the turbines. The technology buyer paid a commission for each wind turbine sold in the market as a technology transfer fee. Prior to this, the price of producing the thin-film solar cells was less than $1 million before 2005; however, it has risen to the current price of just over $100 million.

New methods of allocating technology include the purchase of production license, commissioned R&D, joint R&D and individual investors. In addition, some establishments may buy up their technology providers after they become strong enough. Successful cases include Goldwind and the cement industry.

3.2.1 Case Study: Goldwind - a Leader in Wind Turbine Manufacturing through the direct Purchase of Technologies

Background

Goldwind originated from the Xinjiang Wind Power Co, which operated and maintained wind farms. Since 1997, Goldwind joined the wind turbine manufacturing industry. Technology transfer, national support, and independent R&D played an important role in developing and increasing Goldwind's technical capacity. In 2008, Goldwind became the 8th biggest wind turbine producer in the world.

Process of Technology Transfer

Licensing, joint R&D, and the buying of a technology provider are examples of the technology transfer process in action. Goldwind produced its first 600 kW fixed pitch turbine in 1997 through direct purchase of a production license. In conjunction with its own technical improvement, Goldwind was able to gradually localize and produce the wind turbines in China. Based on the experience of the 600kw turbine, Goldwind worked with its foreign designing partners and developed the 750kw fixed pitch turbine. Due to Goldwinds joint research and development programs, the company was granted partial intellectual property rights on the 1.5 MW direct drive wind turbine (for domestic sale only). In late 2007, Goldwind bought up the entire assets of its foreign partner, a German wind turbine technology provider, after its Initial Public Stock Offering (IPO) in China. Goldwind obtained full intellectual property rights for all its products. To illustrates how Goldwind successfully took advantage of the technology transfer process, Goldwind followed the process of technology transfer through technology import, digestion, assimilation, and finally re-innovation. Furthermore, joint R&D paved the way for initial partial Intellectual property rights and ultimately to full ownership of these rights.

Distribution of Interests

In the beginning of the technology transfer process, Goldwind paid the foreign technology provider high licensing fees for producing 600 kW fixed blade wind turbines. Initially, these turbines were obsolete and were not competitive on the international market. Its foreign partner benefited from both the licensing charge and the access to China's market information. Goldwind improved its technical research capacity with the development of its 600 kW fixed pitch turbines. This company became the first domestic supplier of wind turbines and gradually developed to be China's leading supplier. This case study illustrates the "win-win" situation for both developed and developing countries.

The Role of the Government

The Chinese government provides various types of support to encourage companies from developed countries to transfer new technologies to Chinese enterprises. The national 863 High Technology Development Plan provides stipulations on international cooperation. This plan encourages technological innovation through technology import, digestion, assimilation, and re-innovation. The Chinese government also provides support for the commercialization of technologies.

The German government or the EU commission has played a small role in this successful technology transfer. This may be attributed to the unproductive negotiations on climate change. There has been no substantial agreement made on technology transfer, and there is a lack of financial and technical assistance to businesses from developing countries interested in technology transfer projects.

Experience

Goldwind's success comes from its ability to efficiently develop new technologies. Progress was gradual and moved from simple projects to more technically complex products. Initial development of the 600 kW type turbines, led to the development of 750 kW type turbines. Gradually the projects became larger and more complex with the completion of the 1.5 MW and 2 MW wind turbines. The Goldwind case study is a good example of the gradual introduction and assimilation of technology into a company based on the enterprises production capacity and technological background.

3.2.2 Case Study: The Cement Equipment Manufacturing Industry

Background

Since 1985, China has been the world's largest producer of cement. Domestic production reached 1.069 billion tons in 2005, which is equivalent to 40 percent of the global cement production. The production capacity of China's cement industry was 1.39 billion tons, of which 76%-77% was utilized. During the tenth Five-Year Plan, the annual cement production climbed from 597 million tons in 2000 to 1069 million tons in 2005, registering an average annual growth rate of 12%. In the same period, the average annual growth rate of the production capacity was 7.87%; the real operation rate of the capacity was 71.35%. This 6.45% increase is higher than that of the ninth Five-Year Plan. In 2006, the PRC's cement production reached 1.24 billion tons, 17% increase compared to the year before. The production amounted to 1.354 billion tons in 2007, and the rapid growth generated an urgent need for new technology. This need created the ideal market conditions for technology transfer.

Technology transfer process

New dry-process cement technology

In the 1980s, the Chinese government organized domestic companies to purchase set facilities to improve cement production from F.L.Smith (Denmark), Japanese Onoda Co and Mitsubishi Co. Through cooperative installment, adjustment and operation, Chinese companies learned to use the new dry-process cement technology. Between 1984-1993, around 20 new types of cement equipment were introduced into China. Examples of these would be the D-D furnace, the primary crusher, the vertical mill, the highly efficient cooling machine, the electrical dust collector, the bag dust collector, the automatic(manual) packing machine, the dynamic powder selector, the pre-homogenizing silo and the homogenized stirring silo. Integrated with new dry-process cement equipment, these technologies enabled China to produce its own machinery with a daily production capacity of 2000 tons of cement per day. Cooperation with F.L.Smith (Denmark), foreign loans and an investment firm from Yunnan province, Chinese companies installed 17 production lines, which could supply 11 million tons of cement each year. In addition, ten production lines were developed in partnership with KHD (Germany) which could produce 7.1 million tons annually. A joint partnership with a Japanese company developed four additional lines that produced 4.8 million tons of cement per year. Further development through manufacturing plants and engineering facilities allowed the Chinese cement industry to gain control of over 80 production lines for new dry-process cement which brought the production capacity to 45 million tons. Ninety percent of all equipments are made by Chinese domestic companies and some components such as high-powered deceleration machines, large-sized vertical mills, large-sized roller presses, testing instruments and parts of electronic devices are bought from foreign countries.

International technical aid may play a limited role in pushing technology introduction to developing countries. Supportive policy incentives and consistent efforts from recipient companies are required to gain technological independence and establish domestic innovation capabilities. In August 2000, the then National Economic and Trade Commission (NETC) approved a domestic pilot production line with a capacity of 5000 tons per day. Hai Luo Group also built three similar production lines in Tongling and Chizhou, which adopted all self-owned technology through cooperation from domestic research institutes and industrial groups. These lines produced domestic equipment such as deceleration machines for vertical mills, furnace integrated preheaters, and calciners. The large-sized 3rd generation grate coolers have made the "5000 tons per day" production line the dominant technology in the cement industry. Furthermore, the NETC supported the additional development of 10,000 tons/day production line. Hailuo Group built four production lines capable of producing 10,000 tons/day. This level of processing, equipment deployment and intelligent controlling positioned China to be the global leader in cement production. Additionally, with vast improvements in production technology and equipment manufacturing being byproducts of the cycle of "repeated re-import into the market", the cement industry has moved into an optimized industrial structure.

Power generation technology from medium-low temperature waste heat

This technology was developed in the late 1960's, commercialized in the middle of the 1970's and greatly distributed in the early 1980's. Japan was one of the early innovators of the technology. In the middle of 1990's, the then National Planning Commission and the National Bureau of Construction Materials had an agreement with Japanese partners that Japan's New Energy Industry Co., would provide a set of power plant equipment of 6.48 MW generating from medium-low temperature waste heat for a cement production line of 4000 tons/day at Ningguo Co, in Anhui Province. The waste heat power plant started to operate in 1998 and electricity output per ton of cement was above the designed target. In 2003, a similar power plant with a 5.7 MW capacity was installed in the 3200 tons/day production line at Yufeng Group in Guangxi Province. In recent years, the average generation capacity has been 5.91 MW and unit electricity output is 35.6 kWh.

Distribution of Interests

Because most of the players in China's cement industry are medium and small sized companies, the process of technology transfer is complicated. The common model is that cement producers collaborate with industrial design institutes and equipment manufacturers to introduce new technologies. The cement producer implements a technical pilot project. The industrial design institute works on the assimilation of newly introduced technology and the equipment manufacturer is responsible for the localization of the new equipment and facility. Three partners pay for the technical licensing together.

The Role of the Government

The government plays a role in organizing, coordinating, and supporting through the process of technology transfer. To facilitate better technology assimilation, the government can organize the participation of multiple companies and research institutions into projects such as technology import and Intellectual Property Right (IPR) purchasing. The government also coordinates the technological innovation within the leading companies to enhance their capacity of technology assimilation. This is important for the localization and distribution of introduced technology.

Achievement

Since China's economic reform, the country has implemented a policy which integrates independent R&D and introduces foreign advanced technologies. The new dry-process cement technology has matured into an operational and reliable method of production. Technology, equipment research, engineering design, installment, and management continue to improve. There has been a steep decline in the investment per unit of production capacity. The percentage of new dry-process cement in the sector keeps growing, and the efficiency of the sector is being enhanced. In 2005, the new dry-process cement production was 473 million tons, accounting for 45% of the total national production of cement. By the end of 2007, China had 797 existing production lines of new dry-process cement. These lines produced 607 million tons of cement each year, about 55% of the world's total cement production. China has also been a major exporter of cement producing technology and equipment. From 2005 to the first half of 2006, China's cement

exporting contracts reached $3 billion. China's market share in the cement technology service and equipment manufacturing has reached 30% and continues to rise at the steady pace.
Through innovations in management and technology, China's technical standard of dry-process cement is approaching the level of international leaders. Chinese companies are competitive in providing large scale production lines of 5,000 and 10,000 tons of new dry-process cement to relevant engineering projects in the world market. Through technology transfer, the energy efficiency of China's cement industry has greatly increased. These technological advances have cumulatively saved 86 million tons of Standard coal, cutting the emissions of 37.6 million tons of particulate pollution, removing 200 million tons of carbon dioxide from the atmosphere, and eliminating the use of 0.73 million tons of sulphur dioxide.[4]

Experience

Technology transfer in the cement industry is a successful case because of the following factors:

- The cement industry in developed countries has peaked and the market demand on cement equipment has largely declined. This allowed the Chinese cement industry to emerge as a major market
- The cost of technology transfer was low because the technology had already been developed and early developer's R&D cost has already been recovered.
- Cement equipment requires a small amount of high technology components, and the rapid growth of China's cement production enables increasing R&D investment, which continually helps to fill the technical gap.
- The government organizes the import of technology, supports technological assimilation, and financing IPR purchases by mobilizing the expertise in companies and research institutes..
- Companies have high demands on new manufacturing technology and are willing to make substantial investments as they continue to be optimistic about the domestic market demand.
- The government organizes the technical research to increases the capacity of companies to apply and assimilate introduced technology. This is a significant step for further distribution of technology.

3.2.3 Conclusion

Most medium and small firms follow a path from the purchase of technology to cooperative research to independent innovation. However, experiences from both individual companies and the industry as a whole have demonstrated that the cutting-edge technology cannot be bought in the market. Without the capacity to perform independent research, Chinese companies have difficulty avoiding the common problem of "Import, lag behind, and re-import." Goldwind's success does not represent the entire industry. The majority of Chinese firms involved in technology transfer are still trapped in the cycle mentioned above. The major reasons for this are:

[4] China Investment and Consulting Network, August 2008

- Compared to large corporations, medium and small businesses have greater difficulty in building up a competitive R&D team.
- China does not have the national technology-based research and development organizations that are able to provide technical development and service for companies. However, many industrialized countries have such institutes, like the German Fraunhofer Institute, the American United Technical Institute and the Central Industrial Research Institute of Singapore.

These lessons should be considered when developing future international mechanisms of technology transfer. The mechanism should help developing countries to establish a far-reaching research system, which may both promote the transfer of technical patents and assist developing countries in improving research and innovation capacity.

3.3 Joint-Venture and Cooperation: the Future Direction of Technology Transfer

Globalization is a trend of economic development and joint-ventures based on technical cooperation should be a mainstream channels of technology transfer. This is particularly the case in tackling climate change. The Linuo Paradigma is a successful case study illustrating that joint ventures do lead to successful transfers of technology.

3.3.1 Case Study: Linuo-Paradigma - a Successful Technology Transfer Case Based on Joint-venture

Background

In 2002, Linuo, a Chinese company from Shandong Province that manufactured packaging material, and Paradigma, a food company from Germany, started a joint-venture to provide mid & high-end solar heating products for domestic, European, and American markets. Six years later, the joint-venture became the leader in China's solar heating industry and supplied 50% of the world's glass tubes to the solar water heater market. Linuo-Paradigma held the biggest market share of solar vacuum tubes and solar water heater exporting.

Process of Technology transfer

Paradigma used to mainly produce food; however, its decision makers believed that the solar product market had great potential and was confident in its brand name. Paradigma knew that Germany possessed the latest solar energy technology. In an effort to build a multinational company, technical experts from the Solar Energy Institute at Stuttgart and the Fraunhofer Solar Energy Research Center, were asked to support Chinese experts in a joint-venture to develop high-end solar water heaters for the European market. Chinese technicians were invited to study and receive training in relevant technology and management practices in Germany. Vast improvements in research developments and product quality allowed the joint venture to become a competitive player in the solar water heater industry.

Distribution of Interests

To avoid apprehension between the two parties, both sides made equal cash investments into the joint-venture. This 50/50 financial partnership helped alleviate the often divisive problem of invisible capital. Linuo took responsibility for the business operations in China and explored new markets and developed products according to market analysis. The German partner provided technical assistance and developed competitive products while working with Chinese research teams. Paradigma was also responsible for marketing and product distribution in Europe. Furthermore, the parties followed the same model to set up a new joint-venture to explore American and Australian markets and share profits equally.

The Role of Government

The cooperation and formation of the joint venture was a direct result from the interaction between private companies. The two groups received various types of support from both governments, including government policies on international assistance and technical introduction and application. The German scheme, known as the German Technology Cooperation (GTZ), sponsored experts working in China and financed equipment supplied in the production lines of Linuo-Paradigma. The technical assistances from the University of Stuttgart and the Solar Energy Institute of Freiburg were also financed by the German government. The Linuo Group applied for government sponsorship and professional assistance from China's State Administration of Foreign Experts Affairs to initially launch the technology transfer. The Linuo also worked with leading national research organizations such as Tsinghua University and the China Architecture Design and Research Group, to improve its capability for new independent technical innovation.

Achievement

The technical cooperation helped Linuo-paradigma set up a world-class testing center and develop the Home Solar Water Central System and PVC solar water heater. These products have been tested and, successfully entered markets in developed countries.

Experience

- "Win-Win" Strategy: The Basis For Cooperation

Without superior market placement and technical competitive advantages, Linuo could not make big difference in the domestic solar water heater market, let alone the international market. Linuo needed the advanced solar technology to realize its strategy of supplying high-end products to European and American market. Paradigma's leaders were optimistic about the future of solar development and the growing market for solar water heater in developed countries. It was eager to commercialize the result from years of German solar energy research. Paradigma realized that Linuo's market and production advantages were a perfect match with German's technical advantages, and a successful joint venture using the transfer of technology was formed.

- Providing innovative and practical products oriented by market demands

The Home Solar Water Central System was created for high-end developed foreign markets. The new solar water heater with reflector improves energy efficiency by 15%, and offers competitive prices that meet the needs of middle class consumers in the developed countries. Additional research and development has led to more products whose goal is to offer efficient options for consumers in developing countries.

- Learn from each other and make progress together

Apart from improving their technical capacity in solar water heating, Linuo also learned to implement Corporate Social Responsibility (CSR) from their German partner and made progress in the fields of energy conservation, environmental protection, and social welfare. Paradigma helped to improve glass boiler insulation technology material and reduce the electricity and natural gas consumption in the production line by 10%. China's rapidly growing market also helped their German partner improve the effectiveness of its R&D and enlarge its share and competition in European and American markets.

Lessons

The successful cooperation between Linuo and Paradigma was to some extent a coincidence. In the history, most joint-venture projects based on technology transfer have not been successful. The fatal reason is the inability to devise a "win-win" strategy and the lack of trust between partners. For example, Shanghai Electric developed many joint-ventures with Siemens Group; however, the two parties failed to work together to enter the wind turbine manufacturing industry.

3.3.2 Conclusion

There are not many successful joint-venture projects, but common needs and markets still make joint-ventures a viable option for technology transfer. The Chinese units of General Electric, Siemens, ABB, and Alstom are not generally regarded as "foreign firms" because they have employed thousands of Chinese workers and built world-class R&D centers in the PRC. The Chinese market accounts for 30%-40% of the global market for these companies.

As global leaders of technology innovation, Denmark, Sweden, Finland, and Germany have started to establish technical innovation and R&D centers in China. The European Union and the United States are also setting up clean energy research institutes in the PRC. These efforts aim to combine research and production in conjunction with emerging markets.

Domestic policy pressure on energy saving and emission reduction is getting stronger, and Chinese companies' demands for climate friendly technology is increasing. China offers the biggest market for some emerging technologies. For instance, 70% of Carbon Capture and Storage (CCS) users in the world will be China's coal power plants. Under this context, joint-venture and international cooperation may bring new change to technology transfer. Firms from developed countries may work with Chinese companies to develop new technology suitable for China to mitigate climate change. In addition, the Climate Change Technology Transfer Fund may finance an international innovation center for climate friendly technology, which will be based in China. All of these changes are very significant to the rapid development of technology transfer.

4. Final Conclusion and Recommendation

4.1 Conclusion

1. From UNFCCC to the Kyoto Protocol to the Bali Roadmap, the climate change negotiation of the past 20 years has not brought crucial change to the issue of technology transfer. The breakdown in negotiations of technology transfer restricts the distribution of low carbon technologies from developed countries to developing countries. This situation is largely attributed to the difficulty of creating an effective technology transfer mechanism under the principles of global climate change negotiation. Governments cannot easily buy the latest or suitable technologies for their market needs. Even if governments were able buy the latest technologies, few companies will be interested in selling because the technology bought by governments will become publicly owned information that cannot generate profits for companies. The only way to make publicly owned technologies profitable is for the government to regulate production and consumption by planning. This approach only happens when governments are reacting to natural disasters, trying to reduce poverty, or preventing epidemics. As for combating climate change, the most complex, massive and long term action in human history, it is hard to imagine the absence of market power.

2. Technology transfer under the global climate change negotiation includes both the not-for-profit technology transfer dominated by governments and commercial technology transfer initiated by private companies. Technology transfer initiated by governments focuses on technical assistance between governments and the exchange of academic and scientific ideas. In contrast, commercial technology transfer is solely designed to maximize capital gains. In order to effectively combat climate change and reduce carbon emissions, a mutually beneficial relationship needs to be formed between commercial and not-for-profit technology transfers. It is imperative that this relationship will be formed so that the distribution of climate friendly technologies is easily implemented.

3. Official Development Assistance (ODA) is an initiative that has encourage developed countries to trade technologies to developing countries in order to secure a share of the local market. ODA, which does not comprehensively cover the whole process of technology transfer, makes only gradual contributions to carbon emission reduction. This initiative has made significant achievments in economic growth, poverty alleviation, and environmental protection. However, this is achieved through a non-market mechanism. Many projects under the ODA scheme help reduce carbon emissions over a long period of time, but these pilot programs did not blossom into large scale markets that made real long term contributions to climate change.

4. Existing commercial technology transfer models greatly reduced energy consumption and eliminated a significant amount of GHG emission. Case studies mentioned earlier in the report can give us insight into the future of the technology transfer mechanism under the international climate change regime. International cooperation and joint-ventures are the major catalysts that encourage the distribution of commercial technology transfers. The climate change negotiations

helped companies develop a better understanding of the transfer of technology principles and fundamental market rules. In addition, the Chinese government's policies on energy saving and emission reduction had a direct effect on the market. Despite the absence of additional funding, Chinese firms worked on technology transfer over long periods of time and developed a significant market for technology transfer. This has contributed to carbon emission reductions, and has encouraged many countries to revise their existing climate policies. However, the costs of climate friendly technology transfers have doubled due to the rising demand, and as a result, developing countries will face increasing financial challenges.

5. It is necessary to introduce the commercial technology transfer mechanism into international climate change negotiations and this will mobilize more effective policy initiatives and encourage private participation. Representatives from the business world have been involved in recent climate change negotiations and provided practical technical solutions. They are familiar with relevant technologies and market dynamics. They believe that public policy and public funding should offer more support to commercial technology transfer partnerships. This should be taken into account in order to create a new mechanism for cooperative international climate friendly technology transfers.

4.2 Policy Recommendations

Conclusions and recommendations are based on the case studies and research analysis that was collected for this report.

1. It should be recognized that commercial technology transfer can be used to effectively reduce carbon emissions and such technology transfer modes should be incorporated into international climate change negotiations. There are some doubts as to whether or not the commercial business technology transfer offers a viable solution. The Clean Development Mechanism (CDM) EB raised questions about the effectiveness of "Additionality" of new energy projects which are motivated by national regulations and policies on new energy development strategies. Naturally, this irrational fear creates barriers between the CDM registration and new energy projects in developing countries. According to strict legal articles in the UNFCCC and the Kyoto Protocol, commercial technology transfer must demonstrate its "additionality" of the significant contributions to carbon emission reductions. Therefore, more research is needed in order to address this issue and to consider endorsing the additionality properly. With additional research, commercial technology transfer can be expanded in scale and will be able to contribute to a significant reduction in green house gases.

The researches should include:

- Quantify the contribution of commercial technology transfer to carbon emission reduction as a base for establishing a methodology that can effectively funds and develops technical compensation to assist in the commercial mode of technology transfer.
- Further research on enterprises' participation in climate change tech transfer negotiations

and tech transfer fund distribution in terms of method, condition and occasion.

- Issue policy incentives and concrete measures to encourage the commercial transfer of climate friendly technologies.
- Discuss the role of enterprises and governments in the field of commercial technology transfer under the framework of a climate change scheme.Consider how to effectively form partnerships between not-for-profit and commercial technology transfer.
- Study assessment mechanisms for the achievement of commercial technology transfer under the climate change framework.
- Examine how commercial technology transfer influences existing trade and economic agreements.

2. Incorporate the credit of carbon emission reductions into an evaluation system of technical innovation mechanism. Furthermore, encourage support for commercial technology transfers that contribute to GHG reductions.

- Arrange special funding from the technology transfer fund to reward businesses with technology transfer projects. This incentive based program will encourage the creation of more technology transfer programs that will reduce greenhouse emissions.
- Introduce tax incentives and fiscal subsidies to motivate companies to develop commercial technology transfer projects that benefit public environmental interests.
- Sponsor licensing, cooperative R&D, commissioned R&D, and technology research centers built by corporations in developed countries. An emphasis should be put on R&D centers that are jointly developed by domestic and foreign companies.
- Establish international or regional technology research centers to improve technological capacity and enhance technical capacity of domestic companies in developing countries.
- Develop technical exchange conferences, exhibitions and training activities to enhance distribution of information and accelerate commercial technology transfers.

3. Design a market mechanism driven by a joint multilateral and international monetary fund. The mechanism should be closely connected with private investment and capital markets, and can also mobilize additional financial resources for technical research and technology transfer projects. The funding could come from the following sources:

- According to the principle of “common but differentiated responsibilities,” developed countries may contribute to the joint fund based on a specific percentage of their GDP. This is different from the funding that is generated under the ODA mechanism and developing countries may voluntarily add to the common fund.
- Create a special technology transfer fund tax based on the consumption of oil and GHG reduction trading. For example, one would pay $0.1/barrel of oil, and $1 for every one ton of Certificated Emission Reduction (CER). In addition, individuals and corporate donations would also be welcomed.
- According to traditional assistance mechanisms, 30% of the common fund will be managed by the United Nations and will be utilized to increase technology and production capacity. The other 70% of the fund will be utilized through market

mechanisms, which will attract private investment through competition. It will also provide additional guidance to businesses who participate in low carbon economy development and the transfer and development of clean technologies.