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Possible Development of a Technology Clean Development Mechanism in a Post-2012 Regime

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THE HARVARD PROJECT ON INTERNATIONAL CLIMATE AGREEMENTS

The goal of the Harvard Project on International Climate Agreements is to help identify key design elements of a scientifically sound, economically rational, and politically pragmatic post-2012 international policy architecture for global climate change. It draws upon leading thinkers from academia, private industry, government, and non-governmental organizations from around the world to construct a small set of promising policy frameworks and then disseminate and discuss the design elements and frameworks with decision-makers. The Project is co-directed by Robert N. Stavins, Albert Pratt Professor of Business and Government, John F. Kennedy School of Government, Harvard University, and Joseph E. Aldy, Fellow, Resources for the Future. For more information, see the Project's website: http://belfercenter.ksg.harvard.edu/climate

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Possible Development of a Technology Clean Development Mechanism in a Post-2012 Regime

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1. INTRODUCTION

Technology is central to the transition to a low carbon society and the global effort to cope with climate change. Many technologies that could mitigate GHG emissions do exist, but not in developing countries. The economy and energy demand is growing rapidly in developing countries in an unsustainable way. Therefore, transfer of climate friendly technologies and additional investments from developed to developing countries is vital to solve the global climate challenge. The importance of technology transfer has been recognized since the Earth Summit in Rio de Janerio. Both the UNFCCC and the Kyoto Protocol emphasized the importance of technology transfer. Yet technology transfer activities remain weak compared to the gravity of the issue. After the 2007 Conference of the Parties in Bali, transfer of technology is becoming increasingly important in negotiations on a future climate regime, even as significant disagreements persist between developing and developed countries.

In the Kyoto Protocol, the Clean Development Mechanism (CDM) was set up by Article 12 to achieve two-fold objectives: to help Annex I countries to meet their emission targets in a cost-effective way and to support non-Annex I countries in achieving the goal of sustainable development. Although technology transfer is not a requirement for CDM, experience shows that CDM may contribute significantly to technology transfer. However, it is difficult to induce large-scale technology transfer through CDM in its present form. The project-specific nature of CDM leads to high transaction costs and makes it difficult to create economies of scale and pool risks across projects of the same type. Thus CDM is not effective in attracting more low-carbon investors. The CDM does not address the competitiveness concerns of the private sector in developed countries. This paper addresses these challenging issues by proposing an enhanced CDM regime with greater emphasis on technology transfer from developed countries to developing countries.

The paper is organized as follows. Section 2 surveys possible ways to enhance the Clean Development Mechanism by drawing on the recent literature and ongoing climate talks with a focus on the relationship between technology transfer and the CDM. Section 3 presents a case study on transfer of natural gas turbine technology in China and suggests a new CDM regime based on technology transfer. Section 4 analyzes the operational issues and international governance of technology transfer through CDM. Section 5 concludes this paper.

2. POSSIBLE DEVELOPMENT OF CDM

CDM is the only market mechanism in the Kyoto Protocol that is open to the participation of developing countries. Since the Marrakech Accords in 2001, CDM has proved surprisingly effective in promoting sustainable development in developing countries and achieving market volume. As of September 2008, 3,909 CDM projects were in the pipeline with 1,152 projects already registered and 200 projects in the stage of requesting registration. If all projects in the pipeline are registered and expected certified emission reduction (CERs) are issued, then total CERs would amount to 528.6 million tons of carbon equivalent per year (UNEP Riso, 2008) which is higher than the national emission of Australia in year 2005[1] and equal to 2.8% of Annex 1 aggregated emission in the year 2005. In the most optimistic scenario, these CERs will bring USD 5 billion (assuming \$ 10/tCO_2) per year to the host countries for financing CDM projects. According to IEA (IEA 2008), the investment in clean energy technologies and energy efficiency needed to meet a goal of 50% reduction in greenhouse gas emissions by 2050, is dramatically higher than the current investments. The existing scale of CDM market only can meet 0.5%-0.75% of annual investment needs in non-OECD countries.

Baseline and additionality are two important concepts in CDM. The baseline emission for a CDM project is emission that would have taken place in the absence of the proposed project. The difference between the baseline emissions and GHG emissions after implementing the project is the estimated emission reduction. A CDM project is "additional" only if GHG emissions are reduced below the baseline level.

The existing CDM is project-based, as the baseline setting and additionality test is done on a project basis. The project-specific nature of CDM imposes substantial transaction costs and time delay. The complete cycle, from preparation of a detailed project report (DPR) to registration of a project, takes almost one year and costs about $500,000 per project (Ellis and Kamel, 2007). CDM needs to move from a project-based approach to a more "wholesale" approach to achieve scale (Stern, 2008). There are several proposals to enhance the regular CDM such as programmatic CDM, policy CDM, and sectoral CDM.

[1] In year 2005, the national GHG emission without LULUCF in Australia is 525.41 million tons of carbon equivalent.

Programmatic CDM

Typically CDM projects are individual projects that belong to a single owner. If an owner has several similar CDM projects, she can "bundle" these projects to simplify the application process and reduce transaction costs. However, some emission reduction activities involve many different owners and geographic locations. At present, such mitigation activities are difficult to undertake as CDM projects; the emission reduction potential of each unit is relatively low, and the overall transaction cost is very high. The Programmatic CDM or pCDM offers a framework to realize enormous emission-reduction opportunities offered by small scale projects, distributed over space, time, and owners.

At COP-11/MOP-1 in Montreal in 2005, the Parties agreed that "a program of activities can be registered as a single clean development mechanism project activity… provided that CDM methodological requirements are met."[2] For pCDM, a two-level framework is defined. A program of activities (PoA) is considered as "a voluntary coordinated action by a private or public entity which coordinates and implements any policy/measure or stated goal, which leads to GHG emission reductions or increases net GHG removals by sinks that are additional to any that would occur in the absence of the PoA…"[3] and a project activity under a program of activities is defined as CDM program activity (CPA).

The pCDM has several important benefits. First, emission reduction opportunities in some areas, such as energy efficiency, can be fulfilled through aggregating emission reductions and reducing transaction cost. Second, the programmatic CDM can help to solve the uneven distribution of CERs over small and least developed countries, a serious concern for those countries still absent from the CDM. The small and least developed countries lacking in large scale reduction potential can design CDM programs across nations and owners to benefit from this opportunity. The pCDM regime also provides an incentive for developing countries to generate CERs by adopting climate policies and measures. Such inclusion of policy-based activities will help to scale up the CERs and create a close link between mitigation activities of developing countries and supporting actions of developed countries.

Policy-based CDM

It is not surprising that climate change is not at the top of all countries' priority list. Developing countries have a number of urgent priorities varying from country to country, such as poverty reduction, general services, education, and energy security. Nevertheless, developing countries' contribution to global greenhouse gas emissions is rapidly increasing, and they need to integrate climate policies and measures and factor in

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[2] Decision 7/CMP1, see also http://unfccc.int/resource/docs/2005/cmp1/eng/08a01.pdf#page=93

[3] EB32, Annex 38, paragraph 1, see also http://cdm.unfccc.int/EB/032/eb32_repan38.pdf

climate change considerations into national development strategies. At COP-12 in Nairobi, South Africa made a submission to the UNFCCC negotiation process on sustainable development policies and measures (SD-PAMs) approach,[4] which is not built on specified reduction in tons of CO_2, but rather on policies and measures. If these SD-PAMs are voluntary, they can be regarded as a "commitment" by developing countries. If these SD-PAMs can be proven to be additional, and the emission reduction from these SD-PAMs can be measured and financed by developed Parties, it is a policy-CDM.

The policy-CDM may include sectoral and national targets, efficiency standards, and regulation. Different from the regular CDM, the CERs generated from policy-CDM projects will flow to the government instead of the project owners. For example, the Government of China may bring a mandatory regulation for fuel efficiency of vehicles. If such regulation can be certified as additional, i.e., it would not happen without finance from the carbon market and if the baseline emission can be well established, then the Chinese government can sell these CERs into the international carbon market and receive compensation for the additional cost imposed by such regulation.

Both the SD-PAMs and policy-CDM can be regarded as "the middle road" between a voluntary-qualified commitment (Russia Proposal)[5] by developing countries and Kyoto Protocol binding-emission commitments. The former is not acceptable to developing countries because, they argue, it violates the principle of "common but differentiated responsibility". The policy-CDM can serve as an option to move forward not only because the CDM is well accepted by developing Parties, but also because it may expand the mitigation activities and scale up the carbon market.

It is still not clear what kind of policies and measures should be regarded as additional and then processed through a crediting mechanism. The difficulties mainly stem from the additionality test of SD-PAMs. First, there is wide range of energy efficiency policies with ancillary GHG-reducing benefits that have been put into place in developing countries. These policies and measures will continue in the future. Second, the additionality test of policy-CDM is almost impossible (Baumert and Winkler, 2005), as climate change is often not the primary target for these policies. Some policies and measures have macroeconomic benefits, which are difficult to accurately measure, such as the benefit from the decrease in demand for oil caused by a vehicle fuel efficiency regulation. Third, large financial transfers to a developing country government may lead to political concerns in some developed countries. Fourth, the CERs will flow to government directly and the government may transfer these CERs to private companies

[4] Submission by the Government of South Africa to the 2nd workshop of the 'Dialogue on long-term cooperative action to address climate change by enhancing implementation of the Convention', to be held in Nairobi, 15–16 November 2006, See also http://unfccc.int/files/meetings/dialogue/application/pdf/working_paper_18_south_africa.pdf.

[5] In the Russia Proposal, a developing country may commit to an absolute or relative GHGs emission reduction target. These voluntary commitments are no-regret emission reduction measures, i.e. if a party has not achieved its target, it does not enter the non-compliance regime or pay penalties. In case of fulfilling its target, a party can gain carbon units and sell them at the international exchange for profits.

who bear the cost. The efficiency of the system will depend on the way the government delivers price signals to the firms in the economy through this redistribution.

Sectoral CDM

There are at least two definitions for "sectoral CDM". The first version is in fact a sectoral baseline or benchmark for an individual project. A sectoral benchmark or baseline can be defined for a given sector, and any project in the sector emitting less than the baseline emission can earn CERs after validation and verification. For example, if the sector baseline for the power sector is 0.8 tons of CO_2 per MWh, then any generating unit with carbon intensity less than 0.8 tCO_2/MWh can receive CERs equal to the difference between project emissions and baseline emissions.

The second version of sectoral CDM is similar to the sectoral policy CDM. A national sectoral baseline is developed for the host country and the government implements policies and measures to reduce emissions in the sector and receives CERs if emissions are below the determined baseline. For example, if the sector baseline is 0.8 tCO_2/MWh in the electricity sector, the government can adopt policies and measures such as a renewable portfolio standard (RPS) or feed-in tariff to increase the share of renewable energy and reduce the electricity sector's emissions. If the actual emission rate is 0.7 tCO_2/MWh, then the host country will earn 0.1 tCO_2/MWh for each unit of electricity generated during the credit period. The CERs will flow to the government, but the government may decide to distribute them to private companies according to a cost sharing consideration (e.g., if the RPS is implemented, most of the cost may be borne by the distribution companies). Whatever form the sectoral CDM takes, the additionality standard may be abolished for the sector-specific approach.

The move from current project-based CDM to sectoral CDM is also regarded as a way to facilitate scaling-up of the carbon market by many authors (e.g., Stern 2008). Sectoral CDM shares the drawbacks associated with the policy CDM discussed before.

Technology Transfer and CDM

In the Kyoto Protocol, CDM aims to help Annex I countries comply with their commitments and contribute to sustainable development in Non-Annex I countries. It does not have to fulfill the technology transfer objective of the Protocol. In practice, CDM may help in technology transfer by funding potential projects that use technologies imported from developed countries.

A UNFCCC survey of 2,293 projects in the CDM pipeline as of September 2007 (Seres, 2007) shows that technology transfer is more common in the larger projects. There are a few projects relying heavily on imported technology, mainly in the form of equipment, coupled with import of knowledge capital in some cases.

Does CDM induce new technology transfer or does it simply extend the scope of existing technology transfer activities? Although both results are interesting, the first one is more attractive. If CDM can induce adoption of new technologies, then it will lead to technology standard dynamically improving in the host countries. If not, then the CDM activities are just picking low hanging fruit.

Technology transfer in the existing CDM regime is more or less "passive". In most cases, the transfer of technology had occurred before the implementation of proposed CDM projects and the CDM project only extended the scale of technology transfer, but did not induce transfer of a new technology. For example, in China, technology transfer in wind power began in 1986 and further expanded in 1996 through the government driven "Ride the Wind Program" (MOST et al., 2002). The leading Chinese wind turbine manufacturer, Goldwind, has a 31 percent share in the domestic market and 2.8 percent share in the global market. Goldwind started production by buying a license for a 750kW turbine from Repower, a small German wind turbine manufacturer and a 1.2 MW turbine from Vensys (Lewis, 2006). The local content of wind turbines has increased from 33% in 1998 to almost 100% now, and the unit cost has decreased dramatically from more than 10,000 yuan/kW in 1996 to 4,000 yuan/kW in 2006 for a 750kW unit (Figure 1). The cost reduction is mainly due to lower labor cost in China and lower cost of domestic made components. It is still not clear if CDM induced new technology transfer in case of wind turbines. But it does contribute to the expansion of wind power in China by making these projects financially more attractive to investors. Almost 90% of no concession wind parks have been registered or are in the process of being registered for CDM credits (GWEC, 2008b).

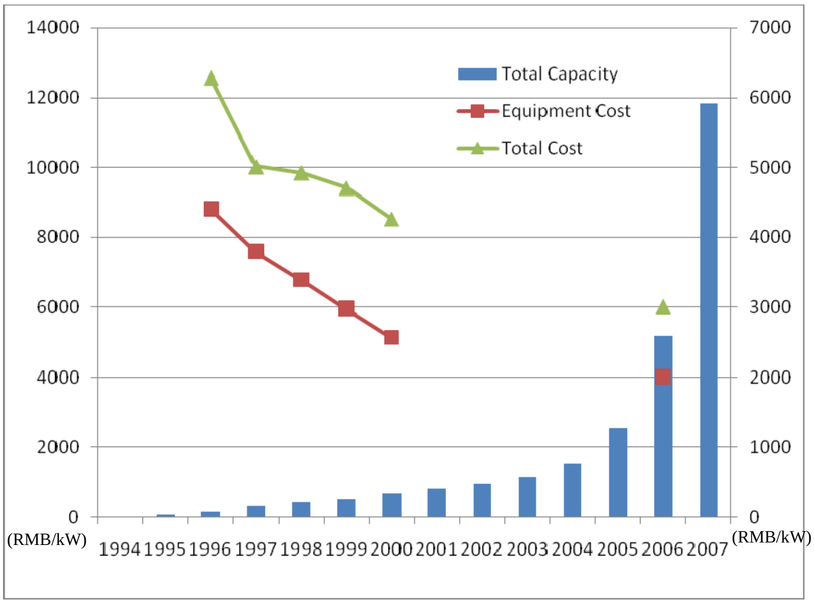

Figure 1 The cumulative installed capacity and learning curve for wind turbines (600-750kW) in China (1994-2007) (GWEC, 2008a)

It is interesting to note that there is some technology transfer involved in all N_2O and HFC mitigation projects in China. Although N_2O and HFC mitigation projects are criticized by some authors as making "no contribution to sustainable development"; technology transfer in these projects is actually induced by CDM activities. HFC23 is an inevitable by-product of HCFC 22 with a Global Warming Potential of 11,700. HFC23 can be destroyed through a thermal oxidation process. VICHEM, a French company, is the major technology provider for most of HFC23 destruction projects in China. Such technology transfer is actually induced by CDM, as there is no compulsory regulation of emission of HFC23 in China and there are no other financial incentives for companies to set up HFC23 decomposition facilities. While implementing the CDM project, one Chinese company even improved the original design of VICHEM and reduced the use of alkali from 245kg/tF23 to 80kg/tF23. The contribution to sustainable development of such projects can also be improved through "credit sharing" between project owners and the host country government. For example, the Chinese government collects a 65% and 35% levy on the revenue of HFC23 and N_2O projects. The revenue collected from the levy has been put into a CDM fund to finance renewable energy and energy efficiency projects, energy research and development and to increase public awareness for climate change.

The wind power case shows CDM could contribute to technology transfer in two ways: by inducing replicable technology transfer and by accelerating the process of learning by doing and shortening the time to reduce cost. The objective of a technology-oriented CDM should not be picking low hanging fruit but spurring new and replicable technology transfer from developed to developing countries. Neither the current CDM regime nor the proposed enhanced CDM regimes, like programmatic CDM, policy CDM, or sectoral CDM, are sufficient to induce new and replicable technology transfer. Incentives for technology transfer is still an open issue in suggested CDM regimes.

3. TECHNOLOGY-ORIENTED CDM

Reduction of GHGs is highly dependent on timing and scale of introduction of new technologies. New technologies are often more expensive than existing technologies (Figure 2). Without an innovative technology transfer mechanism, a huge amount of energy infrastructure in developing countries may be "locked-in" to a carbon-intensive mode. In order to avoid the "lock-in" effect in developing countries' infrastructure development, early investment and early application of low-carbon technology is extremely important for the future climate regime. A successful climate regime should provide sufficient and timely incentive for developing countries to invest in these most important low-carbon technologies as soon as possible. These incentives may include international efforts to transfer technology from developed countries to lower the initial investment, increased profit from the carbon market to compensate for higher costs, and domestic policies to encourage low-carbon technology (Figure 2). The case of technology transfer in gas turbines shows how the combination of these three factors can encourage low-carbon investment in developing countries and contribute to the global mitigation efforts through avoiding the "lock-in" effect.

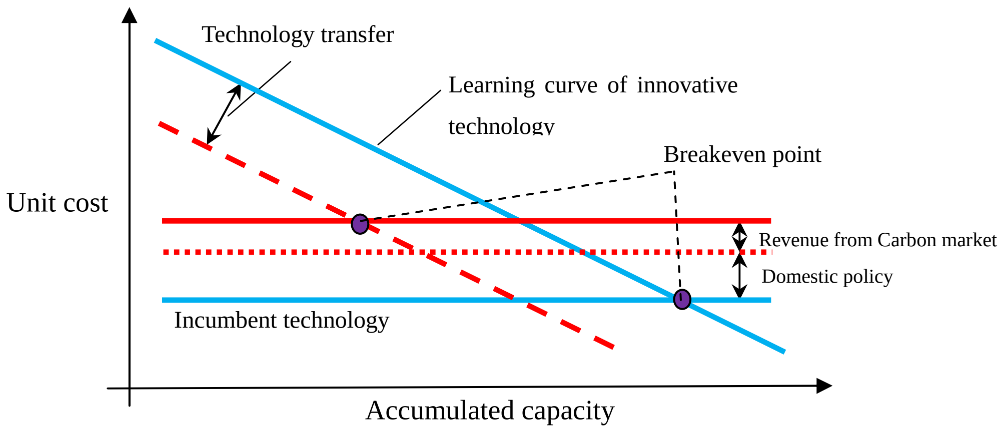

Figure 2 The importance of technology transfer for early action in developing countries

The Case of NGCC (Natural Gas Combined Cycle)

The technology transfer of gas turbines is based on a model of "binding bids". Under the principle of binding bids, the Chinese government organizes interested gas-fired plant investors and bundles their equipment for bidding. The tendering enterprise should include a Chinese partner and a foreign partner. The foreign partner also promises to transfer the technology of gas turbines to their Chinese partner and achieve a given goal of local content. All major domestic and international power plant equipment producers participated in the binding bids for gas turbines. Three joint bidding unions were: Dongfang Electric with Mitsubishi, Shanghai Electric with Siemens, and Haerbin Power Equipment with GE.

In the beginning of binding bids, Dongfang Electric contacted Alstom, GE, and Mitsubishi and finally signed a licensing agreement with Mitsubishi in April 2002 to produce and provide installation services of gas turbines in China. The agreement is based on a royalty per machine produced and has a goal to reach local content of 67%. The remaining 33% includes the core components of gas turbines, like the combustion chamber and turbine blades. The technology to produce high temperature components is not transferred to the Chinese partner but to a joint venture company controlled by Mitsubishi (51%). The major content of technology transfer includes manufacturing drawings, purchase and test specification, specific technology standards, manufacturing reference process, and corresponding training and capacity building.

The first gas turbine produced by the Dongfang Electric was installed in Beijing with a local content of 0.2%. The local content increased to 46.5% and 58.5% in subsequent turbines produced for three LNG projects in Guangdong and will achieve the targeted 67% local content by the end of the project.

Three binding bids have been conducted by the Chinese government with a total capacity of 2.05 GW, which includes 51 F-type turbines[6] and 4 E-type[7] turbines. The unit cost of gas turbines in the third bundle has decreased by about 20% compared to the first bundle, mainly due to increase in domestic components.

Although technology transfer greatly reduced the cost of gas turbines, the gas turbines still cannot compete with coal-fired power. The higher initial investment of a gas turbine and higher relative price of gas in China makes gas-fired power plants unprofitable. Since the market reform of the Chinese electricity sector, the National Development and Reform Commission (NDRC) also forces most of them to compete with coal-fired power plants in the spot electricity market. The specific situation in the gas market also makes gas-fired power projects more risky; they hold a take-or-pay contract in the gas market but do not have any guarantees in the electricity market.

Additional income from CDM has become a major solution for these investors to increase profits to an acceptable level. It is estimated that more than 20 million tons of carbon dioxide[8] emissions per year (~ 1 tCO_2/kW/year) can be avoided if all the planned gas fired power plants are built. Almost all projects under the “binding bid” have applied for CDM credits. Four of them have registered successfully while others are still in the pipeline. Unlike the coordinated “binding bid” for gas turbines, CDM application is more fragmented, as it is conducted by each owner.

The Idea of a Technology CDM

The gas turbines case provides some important lessons about technology transfer. First, the whole process is technology-oriented, with a clear goal of transfer of technology to local firms to increase the local content in gas turbines. Second, the process involves a public-private partnership, with the government as auctioneer and private firms as

[6] F-type turbine has a capacity of around 250MW.
[7] E-type turbine has a capacity of around 100MW.
[8] Assuming 3,500 hours of operation annually and 0.388 tCO_2/MWh for electricity from gas fired plant and 0.675 tCO_2/MWh for the baseline emission factor (the lowest grid build margin in China). Given the carbon price is 10$/$tCO_2$, the extra income from CERs will be equivalent to about 2 cents/kWh subsidies.

bidders. Third, competitiveness concerns of developed country firms are addressed: the core technology of gas turbines is still controlled by the technology provider through a joint venture company. Fourth, scale economies have been achieved by bundling similar projects. Finally, this effort accelerates the learning curve of domestic producers. If mitigation benefits, such as CDM credits, are considered at the very beginning of a project involving technology transfer, then the transfer of new technology could be advanced, resulting in higher emission reductions while avoiding the lock-in effect.

A successful technology transfer program should include the following steps:

1. definition of technology transfer priorities;
2. establishment of partnership between public and private stakeholders;
3. address concerns of both technology providers and recipients;
4. bundling similar projects to achieve economies of scale;
5. bundling similar projects to credit carbon emission reduction to reduce transaction costs and further offset project costs.

A technology CDM should include all the five steps listed above. It should not only focus on the final stage of CERs acquisition but the whole process.

The basic idea of pCDM is that a program is a "project" and the idea of policy-CDM and sectoral CDM in fact is that a policy or a sector is a "project". The idea of technology CDM can also be explained as a technology and its transfer as a "project". Bundling together of projects using similar technologies has two implications: firstly, it can benefit from economies of scale as we have discussed; secondly, experience shows that the likelihood of technology transfers is greater in larger CDM projects and bundling projects together increases the project size.

The technology CDM also shares some of the key characteristics of pCDM. First, it can lead to a reduction in anthropogenic GHG emission compared to the baseline emissions that would occur in the absence of the program. Second, all the projects in a "program" adopting one type of technology (e.g., NGCC) could use the same baseline and the same monitoring methodology (AM0029)[9]. The whole "binding bid" could be regarded as a PoA and each natural gas power plant under this "binding bid" as a CPA. Once the PoA is registered successfully, a new natural gas power plant can be automatically included in the approved PoA as soon as it starts. Such inclusion will greatly simplify the whole process and reduce the transaction costs and registration risks.

Although similar to the pCDM, the technology CDM also has some unique aspects to it. The most important difference is that pCDM only focuses on CERs acquisition, while tCDM will focus on the whole process: definition of technology transfer priority to collaboration of stakeholders in partnership, addressing concerns of both providers and recipients and bundling of similar projects. These steps are considered not only in

[9] AM0029 is an approved methodology by CDM-EB (executive board) for low-carbon generation technologies including NGCC.

designing and implementing the "technology transfer program" but also in the final stage of crediting.

First, the goal for technology transfer should be clearly identified in the "technology transfer program" based on the need assessment of host countries. The goal may include installation of a transferred technology (e.g., 2GW NGCC power plant or 20,000 hybrid vehicles) or a cost reduction goal (e.g., 20% cheaper than before) or a local content goal (e.g., 50% components made domestically). These goals will be used to assess whether a new project activity can be included. Second, the technology providers will be listed as participants of the technology CDM, and only projects using the technology transferred under the program can ask for CERs. This provision will help in resolving the intellectual property (IP) issues. For example, if the NGCC technology transfer program is successfully transferred with the participation of Siemens and Mitsubishi but without GE, then the project using GE technology can't be included in this technology CDM, but it can apply for a regular CDM. Also a project using domestic technology can't be included in this technology CDM. The CERs from technology CDM can be regarded as a guarantee for IP protection in developing countries, as the investor will prefer to be included in the technology CDM to reduce transaction costs and registration risk. Third, the CERs from tCDM may also be shared by government of host country and technology provider if they provide enabling support for technology transfer (e.g., feed-in tariff) and discounted or free licensing. The "credit sharing" arrangement can be decided through negotiation. Table 1 summarizes the distinction between pCDM and tCDM.

Table 1 Comparison between pCDM and tCDM

	pCDM	***tCDM***
Technology transfer	Without obligation for technology transfer	With a well-defined goal for technology transfer
Project Participants	Coordinating entities are participants. No role of technology provider, if any	Technology provider should be included as participants
Project boundary	May cross countries	Within a country

Termination condition	No clear termination condition	Once the predefined goal for technology transfer is achieved or the technology is no longer eligible
Baseline	Project specific baseline	Multi-project baseline
Additionality	Based on Additionality Tools approved by EB	A *de facto* list approach or incentive compatible approach based on domestic policies
Credit sharing	NA	Can be shared by host countries and technology providers

Advantages of tCDM

Best available technology: tCDM can facilitate technology transfer and push it ahead of schedule. The assumed baseline for a tCDM program is not that technology transfer will never happen but that it would happen with a delay. tCDM would call for developed countries to transfer "the best available" technologies to developing countries. The technology transfer activity can ensure its additionality for only the best available technologies.

Measurable, reportable and verifiable: The Bali Action Plan calls for the consideration of "nationally appropriate mitigation actions by developing country Parties in the context of sustainable development, supported and enabled by technology, financing and capacity-building, in a measurable, reportable and verifiable manner" (UNFCCC, 2007), through the enhanced action on technology development and transfer. tCDM can fulfill the requirements of the Bali Action Plan in the following respects. First, the tCDM builds a direct linkage between the technology transfer and financing by developed countries with mitigation action taken by developing countries. The CERs from tCDM can be shared by a technology provider or traded in carbon market. These CERs can be regarded as a metric for technological and financial support provided by developed countries, and the developed country can translate its technology transfer commitment into concrete CERs from tCDM projects. Second, the whole process will follow the regular process, including PDD (Project Design Document) documentation, validation, verification and CERs issuance.

Less risk for low-carbon investment: Under regular CDM, few would like to pay the real money for unregistered emission units, as the probability of successful registration is uncertain. For tCDM, once a technology is proven to be eligible, projects using the technology will be automatically accepted. Given the low risk in future flows of CERs, the project owner can sell their credit options to raise capital before the operation of the project. Technology providers can also discount their technology price or licensing fees in exchange for the CERs from tCDM project activity. The reduced equipment costs will make the transferred technology more attractive.

4. OTHER ISSUES RELATED TO tCDM

Some Methodological Issues related to tCDM

Given the particular characteristics of tCDM activities, some methodological issues should be considered in practice:

Baseline. Currently the procedure to establish CDM credits is cumbersome: precise calculation of baseline emissions and emissions with the project are needed irrespective of data availability, monitoring capacity, and incremental costs. For example, owners of a renewable electricity generation project using biomass as fuel need to include emission from transportation of the biomass from collection sites to the plant in calculating project emissions. Theoretically such inclusion of such data is warranted, but collecting it has very high costs. For a 25MW biomass generation plant, the project owner needs to document more than 20,000 pieces of data, including the type of each truck used, distance covered, fuel used, and fuel efficiency of trucks to calculate emission related to transportation, and these emissions account for less than 1% of total emission reduction. tCDM should switch from a project-specific baseline to a "multi-project" baseline (Ellis and Bosi, 1999) which is aggregated at the technology level and is equivalent to an "activity standard". For example, for the NGCC project, the tCDM baseline could be simply a base rate, such as tCO_2/MWh, reflecting the baseline technology mix in the host country. Although there are some outstanding issues for multi-project baseline; it will undoubtedly simplify the baseline calculation.

Additionality. Additionality is the most controversial concept in the CDM. Most project participants complain that the additionality test is the most resource-intensive part of the project approval cycle, and that criteria for additionality are not transparent, and even inconsistent. But without an additionality test, the environmental basis of CERs will be in question. The additionality test for tCDM could be simpler and more constructive. As in pCDM, a two-tier approach must be used to prove the additionality of the technology transfer programs and individual projects. In tCDM, the technology is the project. The managing entity must demonstrate that in the absence of the CDM, the proposed technology transfer activity would not be implemented or would be implemented at a smaller scale. Additionality should be tested for technology transfer using a "list approach," instead of the "principle approach". The list approach will include a list of technologies that are not available in the host country and therefore would be *de facto* additional. Such a list might be based on technology needs assessment (TNA). In the case of NGCC, additionality can be established by the fact that the technology transfer will not happen immediately in the market. Alternatively, NGCC could be identified as additional, simply by being on the "list". At the project level, it will be easier to establish additionality by using the technology barrier analysis of "additionality tools" approved by the CDM Executive Board (EB)[10], as the technology to be used is not available before the implementation of the project.

The additionality can also be established based on "signaling". The problem of an additionality test stems from asymmetric information. The host country and the project owner have better information about their project than the Designated Operational Entities (DOEs) or EB. The EB questions the additionality of proposed projects, as they feel concerned about the information they don't have. The current system of dealing with this problem, to require all the information in PDDs, is costly, time consuming and controversial.

Many developing countries have special policies for preferred low carbon technologies. These policies may include feed-in tariff, lower taxes or subsidies, and low interest debt. Such preferential policies should be regarded as evidence to prove additionality; these policies signal the lack of financial attractiveness of mitigation technologies in host countries. Also, host countries have no incentives to abuse these preferential policies.

Participants. Both the project owner and the technology provider should be listed as participants. The inclusion of the technology provider may be helpful in safeguarding the provider's intellectual property in the host country by offering him a competitive edge. The technology provider can also play the role of the sole participant and the CER buyer. In the later case, it may transfer the technology to developing country for free but ask for all or part of the CERs from the projects in return.

Crediting period. In tCDM, a project may join the program even after the starting time

[10] CDM-EB issued a standardized tool which can be used to illustrate additionality of proposed project.

of the program, and the crediting period of projects may differ.

Governance Issues Related to tCDM

Defining technology transfer: There are many definitions of technology transfer, and a host country should have the discretion to choose a definition based on its own national interests, as long as it is stated clearly. Since tCDM does not cover multi-national projects and programs, different definitions of technology transfer in different countries won't cause confusion.

Defining the technology list: The additionality test of tCDM will be based on a *de facto* "technology list"; all technologies on the list will be regarded as additional. Such technology lists can be submitted by the host country for approval by the EB, or the technology list can be negotiated at Conferences of the Parties. Some parties may not accept the first choices on the technology lists submitted by other parties. For example, the Brazilian delegation strongly opposes the inclusion of carbon capture and storage technology in the CDM. If China submits a technology list with CCS, then Brazil may oppose the list. The second approach is more time-consuming, as it may take years to negotiate a technology list. The technology list should be renewed periodically as new technologies appear and old technologies may not be "additional" any more.

Approval of "multi-project" baseline: Once a technology list has been defined, a baseline would need to be established for technologies in the list. A multi-project baseline will greatly simplify the process of baseline setting. The multi-project baseline can be based on the existing baseline methodologies. The Chinese government has developed and maintained a multi-project baseline for renewable generation projects using the ACM0002 method. Publication of these baseline emission factors greatly facilitates CDM activities (see Figure 3). This example also illustrates how a simplified process can contribute to further realize emission reduction potential.

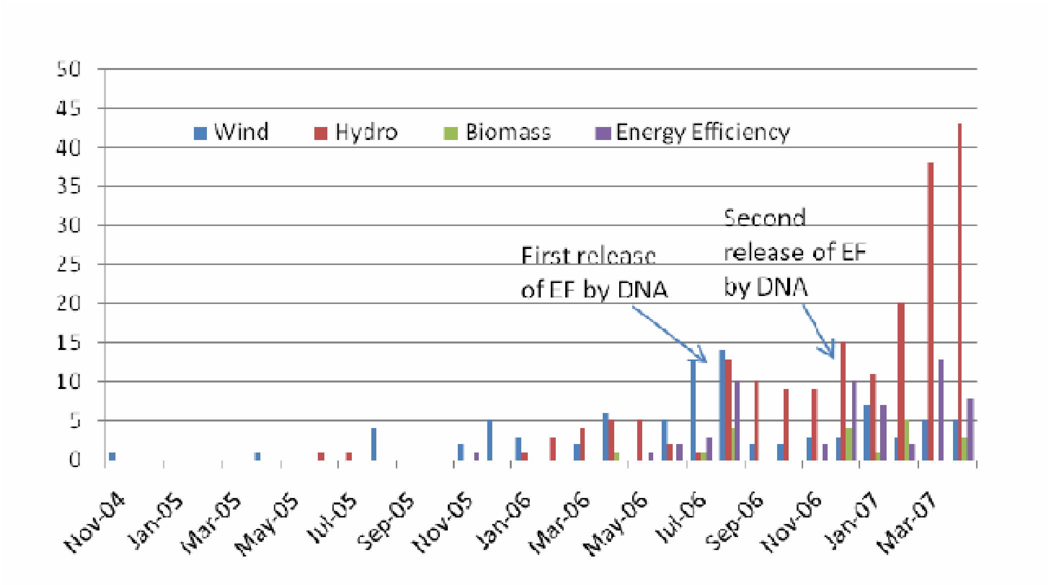

Figure 3 Influence of published emission factors (EFs) on the numbers of CDM projects in pipeline.

Monitoring and Verification: Once the baseline is determined, the only thing that needs to be monitored is the project activity level. In most cases, monitoring and verification of the project activity level is relatively simple (e.g., metering the generation of natural gas power plants). If the technology is distributed and involves small appliances, like high efficiency electric motors, then the sampling should be conducted accordingly.

5. CONCLUSION

This paper explores several possible enhancements to the CDM in the post-2012 climate regime. There are several alternatives that have been suggested in the literature and climate change policy negotiations, including pCDM, policy CDM, and sectoral CDM. These alternatives focus on scaling up the CDM market, thereby increasing the financial flow in the carbon markets. Technology transfer is not an explicit objective of the CDM but has been recognized as a possible benefit. Although developing and developed countries differ on how to deal with technology transfer, both groups agree that technology transfer should be enhanced in the post-2012 regime.

Transfer of technologies from developed to developing countries should be a continuous process that is replicable. tCDM offers the opportunity to strengthen the technology transfer through CDM in the near term without redesigning the whole system. tCDM can spur transfer of climate friendly technology through the following means. First, tCDM provides incentives for developed countries to transfer the best available technologies to developing countries to avoid possible "lock-in" effect. Second, the inclusion of the technology providers as participants provides an advantage to them over their competitors and thus addresses the concern about IP protection. Third, the aggregation over projects on the basis of common technology can reduce project risk and transaction costs and thus can attract more low-carbon investments. Another significant advantage of tCDM over other alternatives is the relative ease of proving additionality, as the transfer of best available technology is always impossible in the absence of additional finance support.

The focus of this paper is not to design a new and comprehensive solution for post-2012 climate regime but try to improve the existing regime. The experience involved in several rounds of climate negotiation makes the authors believe that the climate negotiation is an evolutionary and path dependent process. A breakthrough idea is needed, but it should be arrived at through a series of gradual changes. As the old Chinese saying tells us: "without accumulation of small steps, one cannot get miles away."

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