Comprehensive Analysis and Evaluation of CDM Projects in China

Final Report of the International Collaboration Project on Sustainable Societies

Economic and Social Research Institute, Cabinet Office, Government of Japan

March, 2006

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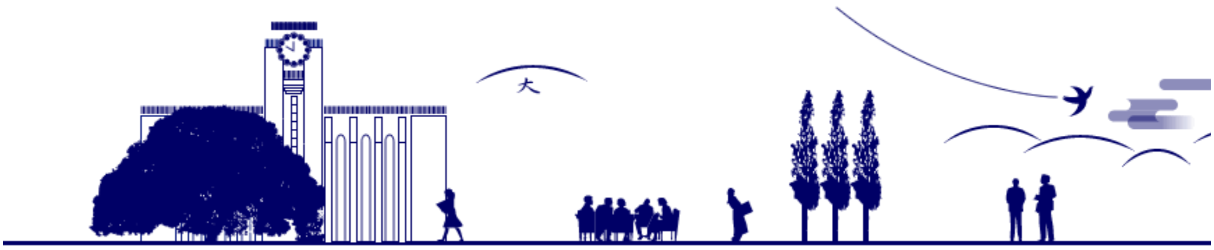

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Chapter1 Introduction

Evaluation of the projects under clean development mechanism (CDM) can differ by stakeholder. Normally, project developers evaluate it by internal rate of return (IRR) or rate of equity (ROE), while host country governments do it by its impact to sustainable development of local and/or host country.

Previous researches have clarified that climate change mitigation policies and projects may have significant ancillary benefits. An efficient power plant project will reduce both CO_2 and SO_2 emissions through energy saving. A biogas recovery for electricity project will reduce CH_4 emissions from biogas plant and CO_2 and SO_2 emissions at a coal-fired power plant at the same time. Reduction of SO_2 emission will improve local air quality, and bring health benefits. Markandya and Halsnaes (2002) implies that the ancillary benefits will be large where air pollution is serious. Aunan et al. (2004) shows that CO_2 reducing abatement options in Shanxi, PRC entail large ancillary benefits and are highly profitable in as socio-economic sense.

Benefits can be expanded to economic, social and environmental dimension of sustainable development or quality of life. This includes gas for kitchen, rural electrification, generation of employment, time saving for fuel collection and increase in opportunity for human capital investment. We will categorize all of these benefits as sustainable development impacts, the concept on which Markandya and Halsnaes (2002) and Olhoff, Markandya, Halsnaes and Taylor (2004) emphasized.

It should be noted that sustainable development impacts can critically affects the decision of host country and/or local people on whether to accept and/or to cooperate to the project. As an option of change mitigation measures, we can expect that CDM project will play the same role.

Our research team started CDM studies with special focus on ancillary benefits. Ueta et al. (2004) focused on health benefits that come from reduction in SO_2 emission, and conducted a preliminary case study of CDM project of efficient power plant to analyze how much they generate CERs and health benefits, and who gains and loses from the project. Ueta et al. (2005) turned its focus on the other aspect of ancillary benefit -economic and social dimension-, and analyzed the spillover effect of CDM projects to reduce regional imbalance of income—one of the goals of sustainable development in China. This report will focus on enhancement of the quality of life in poor region and conduct a case study of livestock waste management. The above researches have led us to the comprehensive evaluation framework that enables us to compare the CDM projects with different types of ancillary benefits. One of the key concepts is sustainable development impact. It includes not only conventional ancillary benefits, but also wider impact to the quality of life, such as generation of employment and poverty alleviation, alleviation of regional imbalance, and decrease in the pressure to natural resource deployment[1].

The aim of this report was threefold:

(1) Show how sustainable development objective of the CDM is to be advanced in theoretical arguments, in the host country's criteria and at the project level, and clarify the discrepancies among them
(2) Examine the effectiveness of the evaluation framework that includes sustainable development impacts by conducting case studies of different types of CDM projects i.e. efficiency improvement of coal-fired power plant and livestock waste management system
(3) Obtain implications for establishing evaluation guideline or manual for CDM projects with due consideration to sustainable development impacts

The structure of this report is as follows. The next chapter will clarify how different the sustainable development impacts are among theoretical analysis, host country criteria, and the description in the actual CDM projects. Then we take China as a case for further investigation. Chapter 3 will review the case study of efficient power plant project that was conducted in Ueta et al. (2004) to revise it in view of sustainable development impact. By the incidence analysis of costs and benefit s, we will show some CDM options will not be implemented without external financing even if they bring positive social net benefit. In Chapter 4, we will take another type of CDM project – livestock waste management system – to investigate the internal rate of return, sustainable development impacts in the short and long term, and social net benefit of the project. Chapter 5 is for concluding remarks.

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1 According to Dasgupta (2001), the quality of life consists of non-welfare characteristics of social states, such as human rights and liberty.

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Chapter 2 The CDM Climate Change and the Sustainable Development: Methodological Framework for Evaluation

2-1 Introduction

As the Kyoto Protocol came into effect in February 2005, an international framework for greenhouse gas (GHG) mitigation and flexibility mechanism was eventually constructed. However, the international negotiation for GHG reduction after the first commitment period of 2008-2012 has been faced to a deep antagonism over the participation of United States and developing countries. They refuse to set quantitative reduction target for the reason that it will generate adverse impacts to the economic activities. Scientific uncertainty on the cause and mechanism of the climate change, and claims for historical responsibility of industrialized countries add another difficulty in advancing the negotiation.

Taking it into consideration that GHG emission in the BRICs (Brazil, Russia, India and China) and other developing countries have been increasing in parallel with the economic growth, it is also obvious that achievement of the ultimate objective in the Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC) requires cooperation of developing countries. Clean Development Mechanism (CDM) is an innovative mechanism to make GHG reduction projects through the cooperation of developed and developing countries. The CDM aims to contribute not only to GHG reduction but also to sustainable development of developing countries. However, developing countries often put priority on policies and measures for economic development and local environmental issues rather than climate change mitigation. Therefore, developing countries attach more importance on the impacts on their national development goals and sustainable development when they select and design CDM projects.

Conventional evaluation approach has employed internal rate of return (IRR), cost effectiveness analysis (CEA), and cost benefit analysis (CBA) in evaluating development projects. The extended CBA and multi-criteria analysis (MCA) has gradually been employed to take distributional impacts and social value into consideration. However, these approaches are not enough to evaluate climate change policies or CDM projects: Climate change is super long-run issue that raises arguments on how to ensure inter-generational equity. Climate change policies and

CDM projects can generate sustainable development impacts at both local and global level that conventional approaches cannot take into account.

In this chapter, we reviewed how sustainable development objective of the CDM is to be advanced in theory, in host country criteria and at project level, and clarified the discrepancies among them. We also take China to examine the discrepancy among them.

2-2 The relationships of the CDM, climate change and the sustainable development

This section examines, referring to the confrontation of developing countries and developed countries in the international negotiation on climate change issues, the relationships of the CDM, climate change and the sustainable development. Figure2-1 shows those relations from such three different points of views as global dimensions, developed countries and developing countries.

Let us start with the relation of sustainable development and climate change. Since sustainable development is a composite of such contradictory concept as sustainability and development, there is no international consensus on the definition or understanding on sustainable development. In other words, there are plural streams on definitions of sustainable development and various kinds of sustainable development indicators have been proposed so far accordingly. All of the sustainable development indicators more or less take such three points of view as economic, environmental, and social. The synthesis report states the relationship between sustainable development and climate change as follows: “the climate change issue is part of the larger challenge of sustainable development” (IPCC, 2002). Some sustainable development indicators, such as ISEW[1], Green NNP[2], Ecological footprint[3], and Genuine Saving[4], indirectly refer to climate change. Others, such as

1 The index of sustainability development (ISEW) was proposed by Daly and Cobb(1989) that employs an extended utility function that takes environments, house keeping labor and leisure into consideration.

2 Green net national product (GNNP) is estimated as a quotient that pulls natural capital consumptions from the conventional NNP.

3 The concept of ‘ecological footprints’ was proposed by Rees and Wackernagel (1994). It is based on the area of the land that is resource supplier and contamination absorber simultaneously.

4 The concept of ‘Genuine Savings’ was proposed by Pearce and Atkinson(1998) that derived a condition of ‘weak sustainability’ based on the relation of saving and capital accumulation.

CEI[5], ISD[6] and MDG[7] include climate change as one of the employed indicators.

Because the view concerning sustainable development is extremely various like this, most of researches relate sustainable development based on climate change policies (mitigation or adaptation policies) rather than climate change based on sustainable development when they discuss the relation sustainable development and climate change, whereas they agree that climate change policies should be designed at least to contribute sustainable development. However, there is no consensus on sustainable development indicators that is a qualification of sustainable development and a lot of methods to evaluate climate change policies are proposed, so the relation of climate change and sustainable development is still fussy in the current state. Therefore, we focus on the relation between sustainable development and the climate change measures in Annex I countries that commits to the reduction of GHG emissions under the UNFCCC and Kyoto Protocol.

The climate change mitigation measures in Annex I countries are classified as domestic measures and the Kyoto mechanisms. When they choose the measures, they tend to focus exclusively on the marginal abatement cost of GHG reduction. On the other hand, there are lots of options whose marginal abatement cost becomes negative when ancillary benefits are taken into account (Climate change 2001). This implies that ancillary benefits, or in a broader sense, sustainable development impacts should be taken into account when Annex I countries choose measures. However, no evaluation manual has established so far. They have pursed to choose measures in order to attain their development goals, but without assessing its sustainable development impacts.

Next, let us see the relation between climate change and the CDM. As Table2-1 indicates, CDM started from is Clean Development Fund (CDF) that Brazil proposed in AGBM-7 in 1997 and was adopted in the Third Conference of Parties (COP-3) as one of the flexible mechanisms. The CDM is a kind of foreign direct investment from Annex I countries to Non-Annex I countries. Therefore, GHG

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5 Core of environmental indicators (CEI) was developed by OECD (2003). It contains approximately fifty indices un the framework of PSR (Pressure, State and Response).

6 Indicators of sustainability development (ISD) was developed by UNCSD in 1995. It includes such four categories as economy, environment, social affairs and institution.

7 Millennium development goals (MDG) was proposed in the United Nations Millennium Summit of September 2000. It contains 18 targets and 48 indicators, covering poverty reduction, universal primary education, gender equality, child mortality reduction environmental sustainability, etc.

emissions within Annex I group may be increased because they can reduce it through CDM projects in developing countries when they achieve their quantified emission reduction commitments. This is called ‘carbon leakage’. However, reduction of GHG emissions by CDM leads to the climate change prevention, and is the same as that by domestic measures in developed countries from the global point of view. Annex I countries implement the CDM when it has lower marginal abatement cost of GHG reduction than other measures such as domestic actions, international emission trading (IET) or joint implementation, and it generates bigger sustainable development impacts to both host and investment countries than other measures. Yet, most of the on-going CDM projects are aiming reduction of abatement cost since there is no definite criterion to evaluate CDM projects in view of sustainable development.

Finally, let us see the relation between the CDM and sustainable development. The purpose of CDM under Kyoto Protocol is to assist non-Annex I countries to achieve sustainable development and to assist Annex I countries to achieve their emission reduction commitment. It is critical to decide who and how to evaluate the CDM’s contribution to sustainable development in host countries.

Table 2-1 summarizes such controversial issues related with CDM and sustainable development. As to who evaluate the sustainable development impacts of developing countries, COP-7 confirmed it is sovereign matters of each developing country; besides the CDM EB (Executive Board) 18 approved ‘unilateral CDM’ where a developing country initiates a CDM project for itself. As to how to evaluate sustainable development impacts of developing countries, many countries have already announced their own sustainable development criteria and the list of priority fields for CDM projects. Since we will see it in the next section, we’ll focus on sustainable development that the COP or the CDM EB has approved (Table 2-1).

Firstly, COP-7 provided that an investment country should refrain from appropriate ODA (Official Development Assistance) in funding for CDM projects and that environmental impact assessment should be implemented, if necessary. EB16 also provided that projects participants can use the tool (investment analysis or barrier analysis) to demonstrate the additionality of the projects. In other words, the EB recognizes strict application of additionality contributes sustainable development of developing countries.

Secondly, the COP and the CDM EB approved preferential measures such as priority approval of methodology for transport, energy efficiency and local heating that are considered to contribute to sustainable development, and admitted simplification of procedure for small-scale CDM projects related to renewable energy and energy efficiency. Those projects can contribute not only sustainable development at local and national level in developing countries but also at global level.

Thirdly, Marrakesh Accords states that nuclear project should be refrained as a CDM projects in view of sustainable development. Also, the CDM EB already began talks to the direction where HCFC-22 projects should be restrained as an extension of conservation of the ozone layer. A new methodology for a project that switches non renewable to renewable biomass is being discussed in the CDM EB on the ground that it has high potentiality to contribute to sustainable development in developing countries.

2-3 Sustainable development and CDM approval criteria in host countries

As mentioned in the previous session, purposes of the CDM are to assist host countries in achieving sustainable development, while allowing developed countries to achieve the goal of reducing GHG by implementing CDM projects. However, the difficulty lies in balancing the stated purposes above, and sustainable development is now recognized as a secondary purpose in some way.

In current rules of the CDM that is adopted as the Marrakesh Accords, the affirmation of sustainable development impacts of CDM projects was left to each host country as a sovereign matter. During the COP-7 negotiation, the developing and developed countries tried to keep away from conceptualizing the idea (Kenber, 2005). As a consequence of the negotiation, the COP decided not to define the sustainable development priorities to developing countries, and each developing country could decide whether proposed projects would advance sustainable development by using criteria.

However this brought up another issue to developing countries. Some small developing countries had no capacity to decide whether proposed projects advance sustainable development or not, while the other countries approved projects without developing sustainable development criteria. While small countries had difficulties to set up the criteria, large countries could recognize sustainable development in line with their development objectives and approve CDM that may harm environmental sustainability. This capacity gap may generate imbalanced project distribution to the developing countries.

2-3-1 Classification of the approach s

We can classify host country’s criteria for assessing proposed projects into four approaches: *Guidelines, Checklists, Scoring and Multi-Criteria Analysis* (Olhoff et al., 2004; Sutter, 2003). Here, it introduces the feature of each approach, and Table 2-2 indicates approaches and contents of criteria of following host countries: China, India, Brazil, Morocco, Honduras and South Africa as a host country that have registered CDM projects under UNFCCC. The criteria of Indonesia, Malaysia and Cambodia are also introduced though no projects are registered.

A: Guidelines

This approach describes how projects contribute to sustainable development in general and vague manner. It often refers to the CDM basic rules such as non-ODA, voluntary participation, technology transfer and measurable emissions reduction. However, it does not give any further guidance how to assess such issues as definitions of sustainable development and/or a type of technology.

Many host countries, such as China, India, Honduras and Morocco, adopt this approach. Malaysia and Brazil partly includes this approach in their own criteria.

B: Checklists, positive lists

Checklists approach defines what project developer can/ cannot do in CDM, or give direct questions (i.e. “Minimum paid-up capital of RM 1,000,000” to justify the ability of project implementation by project participant). This method is to answer the questions with “yes”, ”no” and ”not applicable”. In this method, projects are approved only if it has obtained “yes” as answers to all the criteria applicable to the project.

Some criteria give the list of priority project areas of renewable energy and energy efficiency projects. It means those projects have high possibility to get host countries’ approval if they follow other criteria rather than other projects types. On the other hand, few countries such as Brazil published a negative project list (i.e. negative projects that are not nationally approved by each host country).

This approach is taken by Indonesia and Brazil, and Malaysia and China included it partly.

C. Scoring

This approach gives four dimensions of sustainable development generated from CDM - environment, economic, social and technology-. Each dimension has several items. The indicators are assessed by rate or tick system. In this rating system, negative figure denotes that project gives negative impacts, 0 represents neutral impact or no damages, and positive figure means positive impacts, and host countries do not approve projects if any negative figures are marked. In the approach, project developers are often required to submit additional documents to the project design document (PDD) to justify each criterion. Cambodia adopts this approach, while Brazil included it partly.

D. Multi-Criteria Analysis

This approach can analyze a project with different set of criteria and indicators but not a single measure. Each indicator or criteria is given the allocated weight based on their importance of sustainable development, and combine total weight to examine the result. This approach is expected to assess the sustainability impacts of climate change mitigation options because it can analyze options quantitatively (Olhoff et al., 2004). However, no country has adopted this approach.

Regarding to each approach's validity of assessment of a project, guideline approach does not provide such a high credibility but gives the room for interpretation to the organizations that assess the proposed projects, while checklist approach is formulated in a filter-like manner therefore the validity of assessment is high. Scoring and Multi-Criteria Analysis also provides detailed categories and items and assess them quantitatively, therefore it has high validity (Sutter, 2003).

From the view of project developer, guidelines approach likely to attract them because criteria have no strict requirements, while checklist, scoring and multi-criteria analysis requires rigorous questions to contribute to sustainable development by implementing projects therefore project developers have difficulties to achieve their criteria. However it should be noted that Guidelines attract investors while the quality of the projects or promotion of sustainable development may have high uncertainty.

2-3-2 Classification of contents

Most of the target countries mainly divide their own criteria into four dimensions –environment, economic, social and technology transfer-. As the Table 2-2 shows, almost all the country list technology transfer, and it is clear that many developing countries expect technology transfer as one of the main benefit obtained from CDM.

Half of the target countries point that compliance of the regulation and policy, generation of employment, protection of biodiversity, and access and sustainable utilization of national resources should be considered. A few countries list that use of local business industry, alleviation of poverty and improvement of poverty.

While improvement of infrastructure, enhancement of local welfare, rent distribution, improvement of quality of life of local community, rent distribution, and foreign exchange are given low priority in their criteria.

2-4 Analysis of expected sustainable development Impact in the CDM projects under registration and application

Here it examines projects that have been registered under the UNFCCC by the end of 2005 and projects that have been applied for project registration and that have already got approval from host countries.

Figure 2-2 shows the number of projects that have been registered by the CDM EB. The first CDM project "Nova Gerar Landfill Gas to Energy Project" in Brazil, supported by the Netherlands, was registered in November 2004. The number of project registration increased slowly until July 2005, however it grew dramatically after August 2005. There are some reasons for the trend: dispelling of uncertainty of methodology and CDM rules, CDM EB's adoption of unilateral project as the CDM, the deadline for allowing project to claim retroactive CERs (Certified Emission Reductions)[8].

Figure 2-3 shows host country's share in CDM projects. We can see the serious concentration to some regions and countries, such as Latin America and some Asian countries. This imbalanced project distribution attributes partly to the economic ties between Annex I countries and host countries. A host country has an advantage in attracting the CDM that has closer ties through the past international trade and investment. It is also attributed to the capacity to design and propose the CDM. Only few developing countries have enough capacity for implementing unilateral CDM projects.

Figure 2-4 indicates host country's share in GHG reduction (CO_2 equivalent). The total amount of annual reduction is more than 30.2Mt, and the share of South Korea, Brazil and India dominate 84% of total reduction. The geographical distribution is of the amount of reduction is more imbalanced than that of the number of project. This imbalance is caused by the high GHG incineration projects, such as

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8 Due to the COP decision that extends the deadline to 2006, the number of CDM project is expected to increase by 2006. However, it will be adversely affected by the international emissions trading and the joint implementation that is to be started in 2008.

HFC-23 and N_2O. More than three quarter of GHG emission reduction comes from HFC-23 and N_2O reduction projects (Figure 2-5). The discussion on HFC-23 project regarding to the consistency with the Montreal Protocol for ozone protection has been continued in the COP, while there is no regulations on N_2O, hence none can restrict the N_2O projects. It is often explained that HFC-23 and N_2O incineration project have no impact to the sustainable development, hence it may be needed some rigorous criteria for approving those projects in developing countries.

Figure 2-6 denotes the types of project. Hydro and wind power projects have the largest share in number, while have only 4.7% in the amount of GHG reduction. The share of biomass energy projects is 16% in number while only 2.3% in the amount of reduction. It should be noted that priority areas in the assessment of methodology, such as transportation and energy efficiency, have the small share of project and its reduction.

Small-scale CDM projects have potentially high sustainable development impacts, for small hydro, wind and biomass projects may meet the needs of project site, hence they are likely to enhance the quality of life in the local community. To reduce the transaction cost of these projects, the CDM EB adopts the simplified procedures and methodologies. However, as Table 2-3 shows, its share amounts only to 44.9% in number.

Table 2-4 shows how sustainable development is explained in the PDD. Most of the PDDs explain that their projects contribute to economic sustainability, and especially about 70% of the project developers estimate that they will generate positive impact on generation of employment. It also states the contribution to improvement of local pollution and development of regional economy. Poverty alleviation and improvement of income distribution are listed as social sustainability.

It should be noted, however, that some issues remain here: that the sustainable development impacts in the PDDs is just on paper, and may not be actually realized. This anxiety mounts due to the fact that cost of projects and generation of CERs are identified in the short term, while sustainable development impacts are generated in the long run. Project developers will lose incentive to generate sustainable development impacts once they earn sufficient amount of profit from the project.

The Marrakech Accords states that affirmation of sustainable development depends on each host country. Once a host country gives project approval to a project, it is considered that the project contributes to sustainable development of the host country. We found in this session, however, that most of the projects do not meet host country's sustainable development criteria, because (a) most of the GHG emission reduction comes from N_2O and HFC-23 reduction projects that can hardly expect sustainable development impacts, (b) Only small number of small-scale CDM projects have been conducted while they are likely to advance sustainable development at local level, and (c) host countries tend to consider only economic dimension and technology transfer among the sustainable development impacts. Therefore sustainable development impact should be recognized as the one that project developers expect to realize, instead of that host countries hope to obtain.

2-5 Sustainable development criteria of the CDM in China

2-5-1 Measures for operation and management of CDM projects in China

On 12th October 2005, the Chinese Government released the "Measures for Operation and Management of Clean Development Mechanism Projects in China". The rule was set aiming at "strengthening the effective management of CDM projects by the Chinese Government, protecting China's rights and interests, and ensuring the proper operation of CDM projects (Art.1)." According to the rule, "energy efficiency improvement, development and utilization of new and renewable energy, and methane recovery and utilization is designated as priority areas (Art.4)".

Regarding to sustainable development, it stated "CDM project activities shall be consistent with China's laws and regulations, sustainable development strategies and policies, and the overall requirements for national economic and social development planning (Art.6)", and projects should "promote the transfer of environmentally sound technology to China. (Art. 10)"

The rule also mentioned about revenue from CERs transfer. 65% of the revenue that generates from CERs transfer from HFC and PFC projects, 30% of N_2O projects and 2% of priority project areas and afforestation/ reforestation are to be collected by the Government (Art.24). By giving the differentiated tax weights, China restricts the number of HFC or PFC projects that may not lead to technology transfer and local sustainability.

Many researches recommend host countries to translate their own national development plans and strategies into the CDM projects approval and sustainable development criteria (Olhoff et al., 2004; Figueres, 1999; Kenber, 2005; Dixson. 1999). Chinese government has not yet done. However it can be inferred that the Chinese criteria is reflected the two sustainable development relating documents - *Program of Action for Sustainable Development in China in the Early 21st Century*

(2003) and the 11th Five- Year Programme (2005)-.

The Program was issued in 2003 to help China to implement its sustainable development strategy. The program introduces China's achievement on its sustainable development and problems since 1992 and gives forward objectives, principles and priority areas for the further progress[9].

As remarkable achievements of sustainable development in last 10 years, the Program introduces that China maintains its rapid and healthy growth (i.e. it is now the largest recipient of direct foreign investment in the developing countries). It is also made notable steps to poverty alleviation, shrink in the regional development imbalance, as well as change in the energy consumption pattern and protection of natural environment.

To achieve China's sustainable development, it highlights six priority areas: (a) economic development, (b) social development, (c) resource allocation, utilization and protection, (d) ecological protection and buildup, (e) environmental protection and pollution control, and (f) capacity building. Each priority area has been divided into several priorities in details (Table 2-5).

The energy issue is expressed in the section (c): the resource allocation, utilization and protection. This section puts priority to the energy efficiency, renewable and new energy (including solar and wind energy), methane energy, natural gas, hydraulic power, clean-fuel buses and clean coal.

In the China's new Five-Year Program (2006-2010), not only giving the high target to economic development, the program also concerns about energy issue and it plans to make a 20% energy consumption reduction by the year 2010.

Development of independent innovation, promotion of the development of rural areas considering agriculture system, villages and farmer as well as urban areas considering increment of employment and promotion of harmonized society are also recognized as key plans of the program. Regarding to the gap between the rich and the poor, it denotes to make efforts to alleviate the gap considering the adjustment of income distribution.

Although the priority areas of CDM such as energy efficiency are covered by those sustainable development -related documents, it should be noted that there remains that are not given the priority for the CDM while contribute to the Chinese

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9 Since 1992, the Chinese government have issued sustainable development related reports such as "National Report on Sustainable Development of the People's Republic of China" in 1997 and 2002 to provide to the 19th UN Special Session in 1999 and to the World

sustainable development. Examples are transportation and local development. They will generate high health benefits and are listed up in the Chinese sustainable development priority while are not listed in priority areas of the CDM.

2-5-2 Consistency of Chinese sustainable development criteria, and proposed projects

China gave the project approval to 18 projects by the beginning of January 2006 (Table 2-6). Renewable energy such as wind and hydro has the largest share in number followed by methane recovery and utilization, energy efficiency and HFC incineration. Apart from HFC projects, these projects are within priority areas of the CDM in China. Many affirmed renewable and energy efficiency projects promote renewable industry and technology in China, and contribute to diversification of energy sources.

Technology transfer was also mentioned in the rule, and renewable energy projects expressed that the projects lead to technology transfer. Because the rule does not clearly define the types of the technology, two HFC incineration projects also expressed that the project lead to the technology transfer.

The consistency with Chinese regulations and sustainable development policies is mentioned to their PDDs: a wind power project expresses that the project contribute to China's west economic development initiatives: an energy efficiency project referrers to the promotion of circulate economy which is one of the contents of 11th Five- Year Program (11th FYP): most of the PDDs state that their project would generate employment, which is also mentioned in the 11th FYP[10]. Some projects are implemented in the poverty area, thus the PDDs mentions that employment may lead to alleviation of poverty.

China has stated in the sustainable development related documents that renewable energy, energy efficiency and methane utilization are important, and made them as priority areas in the operational rules for CDM. Based on the rules, China has given approval mainly to priority areas, and proposed project types are also consistent the priority ones. The above analysis implies, that, unlike host countries tendency shown in the section 2.4, proposed CDM projects are consistent with priority areas in the CDM rules and the plans and programs of sustainable development in China. If the expected sustainable development impact is realized, China may utilize CDM as a vehicle to achieve the goal of the sustainable

Summit on Sustainable Development in 2002.

10 However, only one project states the estimated number of employment.

development programs.

However, as China has the largest potential for HFC-23 incineration projects in the world, the number of HFC project will increase in the future. This will discourage investments on CDM projects that have significant sustainable development impact, because the profit generated from CERs drop sharply. To avoid that situation, China has to devise a countermeasure with balancing the project type and attracting investment for priority areas.

Modification of project approval criteria can be a measure to avoid this situation. Currently China has adopted the guideline approach, and as mentioned above, this approach may provide the room for interpretation to the organizations that assess the proposed projects. If China has a preference to implement priority projects that lead actual sustainable development contribution, transparent and specified indicator may be required in the criteria.

2-6 Conclusion

In this chapter, we reviewed how sustainable development objective of the CDM is to be advanced in theory, in host country criteria and at project level, and clarified the discrepancies among them. Theoretical arguments suggest that CDM projects that advance sustainable development both globally and locally should be implemented. We found, however, that most of the GHG emission reduction comes from N_2O and HFC-23 reduction projects that can hardly expect sustainable development impacts. In addition, only small number of small-scale CDM projects has been conducted while they are likely to advance sustainable development at local level. Host countries tend to consider only economic dimension and technology transfer among the sustainable development impacts. This implies that it is highly unlikely for host countries to advance its sustainable development goals through the CDM.

We also examine the discrepancy among them to take China as a case. We find that most of the GHG emission reduction comes from HFC-23 reduction projects, and only small number of small-scale CDM projects have been conducted as like in the above. However, China emphasizes not only economic dimension and technology transfer, but also social dimension in the sustainable development impacts. This may reflect China’s current challenge that regional economic imbalance and widening income gap may raise social unrest that will harm political and economic stability. It may also reflect China’s advantageous position in international negotiation backed by large potentials for the CDM.

In the next two chapters, we will conduct tow case studies to see how the CDM can advance the sustainable development that the Chinese government has published in the programs.

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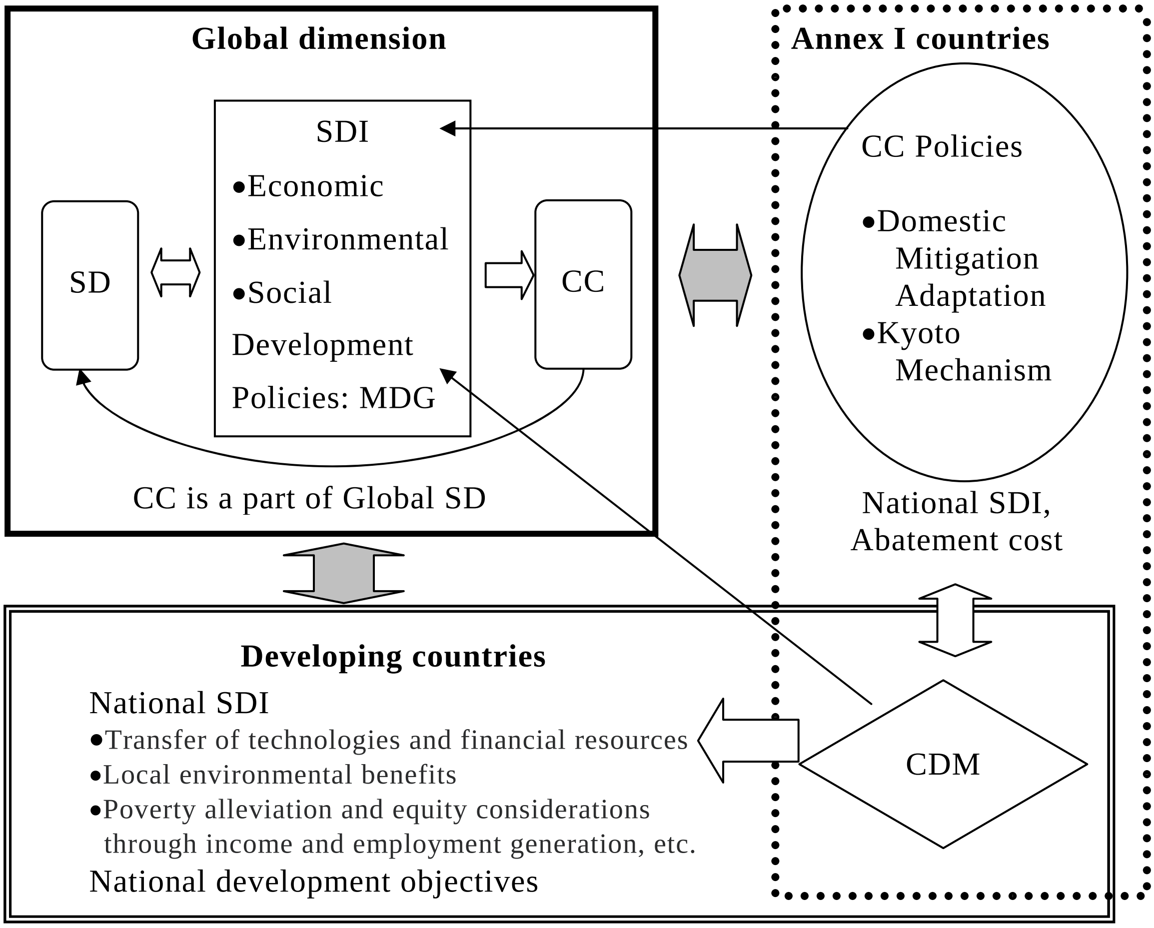
Figure 2-1 Relationships of the CDM, climate change policies and sustainable development



Note: SD, CC and SDI are abbreviation of sustainable development, climate change and sustainable development indicators, respectively.

Figure 2-2 Number of CDM projects by approved time

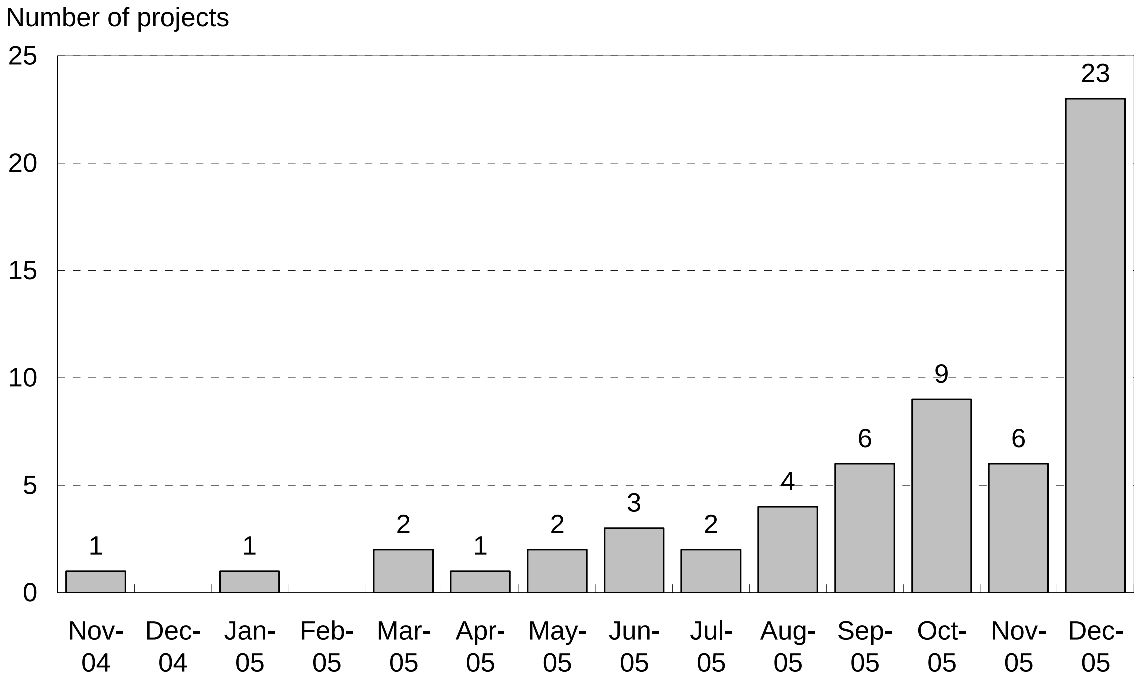


Figure2-3 Number of CDM projects by host country

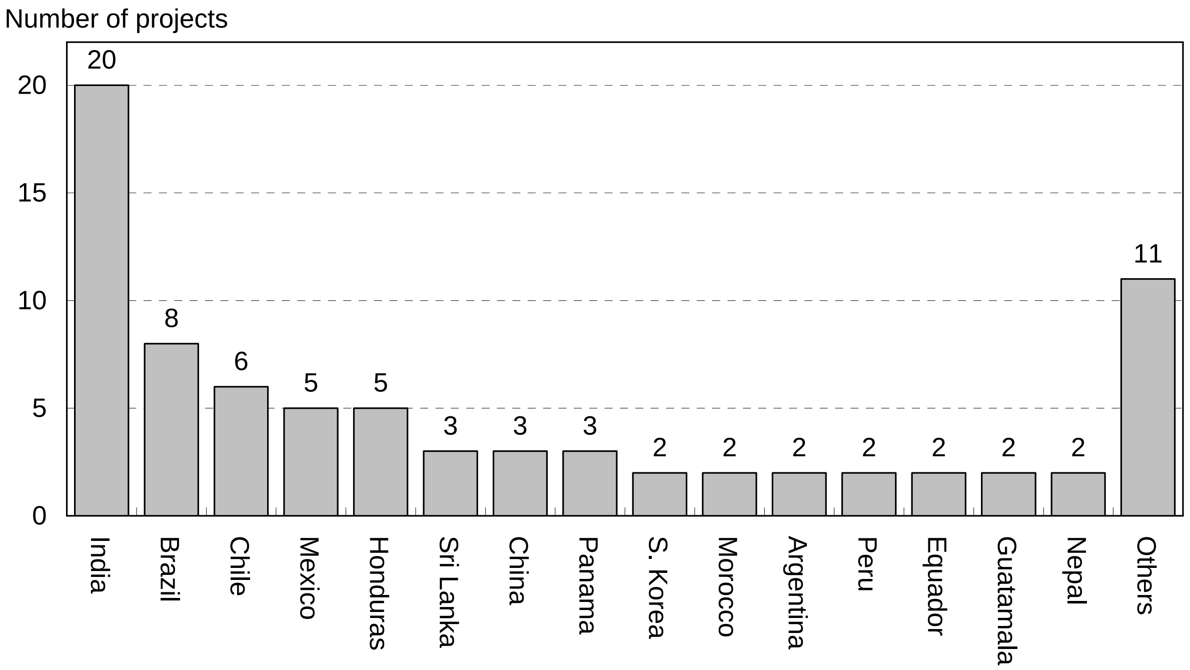


Figure 2-4 Share of CO_2 reduction amount by host country

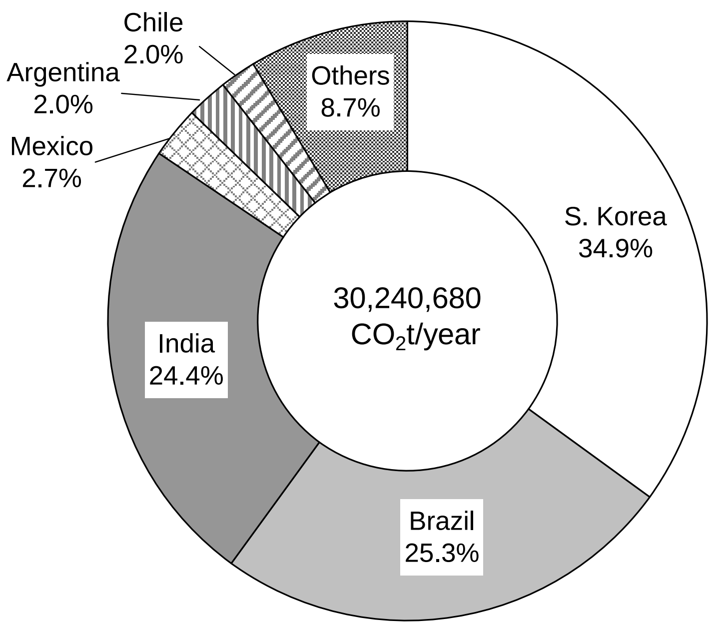


Figure 2-5 Share of the amount of CO_2 mitigation and number of projects

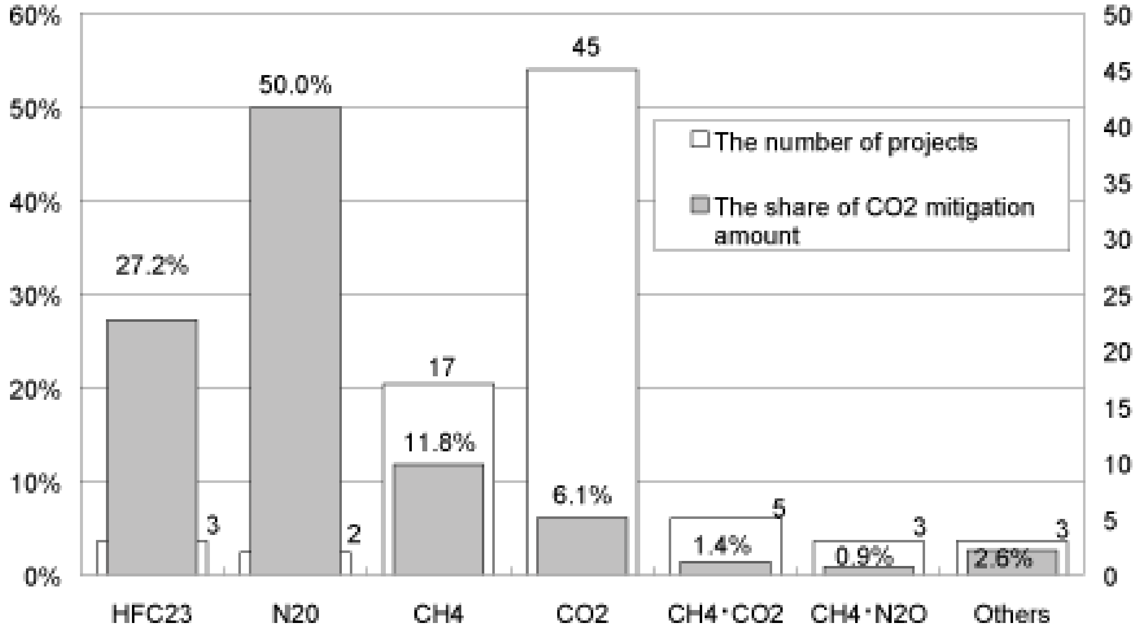


Figure 2-6 Share of CO2 mitigation amount and number of projects by type

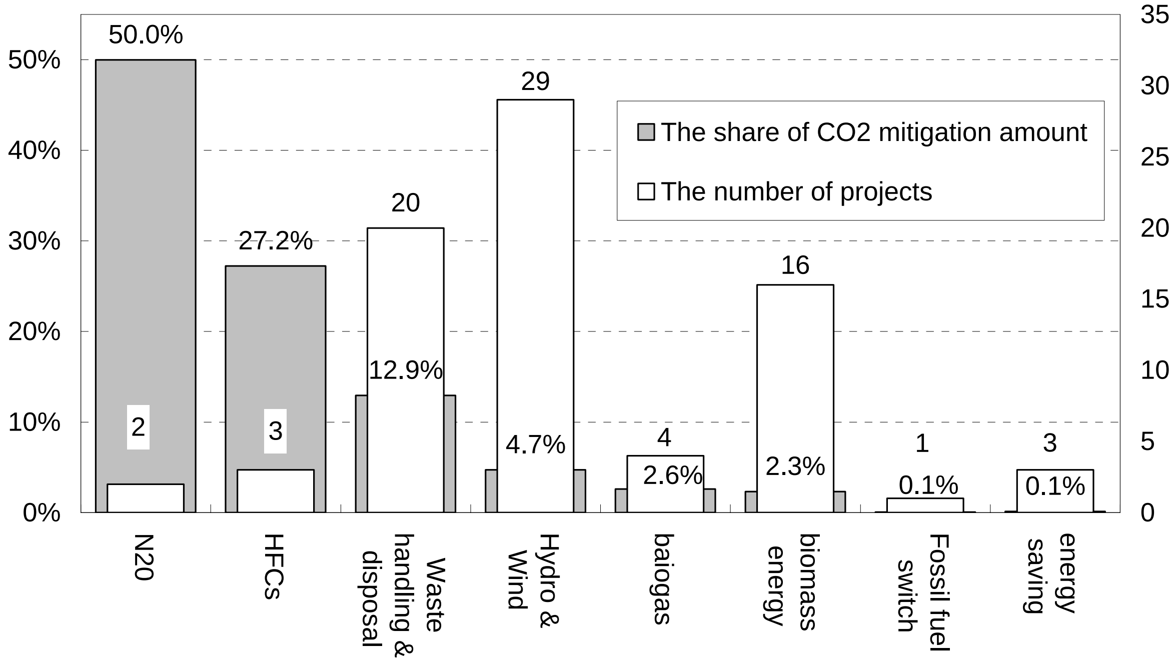


Table 2-1 CDM and SD, and its related decisions

Conference/ CDM Executive Board	Year	Decisions	Note
AGBM7	5/1997	•Brazil prorposed the idea of "Clean Development Fund"	•The Brazilian proposal was to establish the Fund, and the basic principle was to give financial penalty to the Annex 1 countries that could not comply the target and use the part of the financial penalty to adaptation measures of Non Annex 1 countries.
COP3	12/1997	•adopted the Clean Development Mechanism (CDM) as one of the flexible mechanism to achive the target of Kyoto Protocol	•The Brazilian proposal of CDF was discussed at COP3. However, this proposal was not supported: developed countries did not want new funding system, while developing countries expressed their dissatisfaction with the financial distribution based on the emission rate. Finally,with the additional proposal on CDF, the CDM was adopted.
EB1	11/2001	•opened the first CDM Executive Board (EB) meeting	
COP7	11/2001	•adopted the Marakessh Accords (including CDM Modalities and Procedures)	The Modalities and Procedures states that: •Non-Annex 1 countries can affirm whether proposed projects contribute to their own sustainable development. •Environmental Impact Assessment should be implemented, if necessary. •Nuclear project should be refrained, and funding should not result in diversion of ODA. •Non Annex 1 concerned to have determined SD priority and assereted that SD issue is sovereign matter. Annex 1 also avoided having the concept.
EB16	10/2004	•adopted the "Tool for the demonstration and assessment of additionality"	•Project participants can use the Tool to demonstrate the additionality of the project. The Tool have two alternatives such as investment analysis and barrier analysis. The use of the Tool is not mandatory.
EB17	11/2004	•requested the COP guidance to the EB regarding to HFC23 recovery project	•There was the concern regarding to the HFC 23 recovery project that it might increase the production of HCFC22 in Non Annex 1 countries. To have consistency between the Kyoto Protocol that deal with HFC and the Montreal Protocol of ozon protection that deal with HCFC, EB discussed on the issue. However it did not come to the conclusion.
COP10	12/2004	•gave priority methodology approvement to transportation, energy efficiency, and local heating etc. •decided to continue the discussion, especially regarding to "new HCFC22 facilities" project at SBSTA	•Many countries criticised EB's delay of methodology approvement. COP decided to give priority to some project types that would contribute to the shit of energy use in Non Annex 1 countries. •The existing methodology for HFC23 recovery project is only applicable to the facilities that have three years of operational history. COP decided to continue the discussion under SBSTA whether HFC recovery from "new" HCFC production facilities are eligible as CDM.
EB18	2/2005	•adopted the eligibility of unilateral CDM	•Unilateral CDM: a Non Annex1 can implement CDM project without involvement of Annex 1 countries.
EB21	10/2005	•decided to delete the reference of "non-renewable biomass" from simplified methodology for small scale CDM	•To keep the consistency to the COP decisions, EB gave the guidance that the increase of carbon pool should not be considered for the calculation of emissions reduction in the case of normal project (not sinks project). Simplified methodology was also modified by deleting the reference of "non renewable biomass" to have consistency. By the EB decision, small scale project such as transformation of energy from fuelwood to biogass was not eligible for CDM project.
EB22	11/2005	•requested COP/MOP for guidance regarding to Carbon dioxide Capture and Storage (CCS) and policy-related project if those are eligible.	• Methodologies on CCS project and on criteria setting (for energy efficiency to air conditioner) project was submitted to the UNFCCC. The EB discussed their eligibility for CDM, however it could not come to the conclusion.
COP/MOP1	12/2005	•decided to give priority to methodology development for small scale project that transfer fuel from non renewable to renewable biomass •decided to open the workshop on CCS and "new HCFC22 facilities project" to discuss whether those are eligible as CDM project •decided that policy and standard setting cannot be the CDM, and project activities including policy and standard setting as a programme could be a CDM project.	•Many developing countries opposed the EB decision to delete the reference of "non renewable biomass" from simplified methodology. Such project have high potential to promote rural development, and those projects were under preparation in some African countries and LDCs. The decision of the EB may cause the exacerbate imbalance of project distribution in Non Annex 1 countries. •China, Canada and Japan supported to implement "new HCFC22 facilities" projects under some conditions, while Latin American countries opposed.

Table2-2 CDM project approval/ sustainable development criteria of target countries

Country		India	China	Morocco	Honduras	Malaysia	South Africa	Indonesia	Brazil	Cambodia
Approaches of criteria										
Guidelines approach		✔	✔	✔	✔	✔	✔		✔	
Checklists approach, positive list approach			✔	✔		✔	✔	✔	✔	
Scoring approach									✔	✔
Contents of sustainable development criteria and indicator										
Environmental	mesures for mitigation or adaptation			✔					✔	✔
	contribution to local sustainability			✔					✔	
	protection of biodiversity	✔					✔	✔		✔
	access/ sustainable use of natural resource	✔		✔			✔			✔
	improvement of health	✔						✔		✔
	abatement of pollutions (air, water, solid quality)	✔					✔			✔
Economic	employment	✔		✔			✔		✔	✔
	rent distribution								✔	
	sustainability of balance of payment			✔					✔	
	cost-effectiveness			✔					✔	
	internalisation of CER benefit in the national economy				✔				✔	
	sustainability of macroeconomic			✔					✔	
	foreign exchange, foreign direct investment						✔			
	project budget spent in country									✔
	cost of energy				✔		✔			
	use of local business industry		✔			✔				✔
	additional investment	✔								

Table2-2 CDM project approval/ sustainable development criteria of target countries (continued)

Country		India	China	Morocco	Honduras	Malaysia	South Africa	Indonesia	Brazil	Cambodia
Social	increment of quality of life of local community			✔						
	equity	✔					✔			✔
	comment from society, stakeholder							✔		✔
	poverty alleviation	✔								✔
	promote amenity	✔					✔			✔
	meeting legal framework (incl. EIA) and policy		✔	✔		✔	✔	✔		
	local welfare							✔		
	infrastructure									✔
Technology transfer (incl. Capacity building)		✔	✔	✔		✔	✔	✔	✔	✔
Reference of their own sustainable develop national plan or strategies nationally adopted in their criteria										
SD strategy			✔	✔		✔	✔			
Priority projects list and negative project list (or notification) in their own criteria										
	renewable		✔	✔		✔				
	energy efficiency		✔	✔		✔				
	forestry					✔				
	others		Methane utilisation		✔	waste management, transport				
Negative project lists									✔	

Note: Each mark in the table means the reference in their own approach and criteria. If the approaches are different among the target countries, the value of a content that is marked is different even same content is ticked. (i.e. the value of "Technology transfer" of Guideline approach and Checklists approach is not considered same.)

Table 2-3 Crediting period and size for CDM projects

Crediting period	number	
7 yearsX3	43	55.1%
9years	1	1.3%
10 years	35	43.6%
Size		
Small	35	81.4%
Large	43	100.0%
Total	78	181.4%

Table2.4 Sustainable development related CDM projects in host country

SD dimension	Number of CDM projects
Environmental	53
local pollution improvement	33
Natural resource conservation	15
Forest Conservation	5
Economic	122
Resource efficiency improvement	15
Development of regional economy	31
Employment	55
Improvement of trade balance	19
Eco-tourism	2
Social	57
Rural development	12
Poverty alleviation and improvement of income distribution	21
Capacity building	18
Amenity improvement	6

Note: Because two or more items correspond to one project, the total of the breakdown is not identical to the number of projects.
Source: author

Table2-5 Priority areas in the program of action for SD in China in the early 21st century

1. Economic development	
Industrial restructuring	Urbanization and small town development
Regional development and poverty alleviation	Economic globalization
2. Social development	
Population management	Health care
Social security	Disaster management
3. Resource allocation, utilization and protection	
Water resource	Energy efficiency
Rational land use	Marine resources
Mineral resources	Climate resources
Forest resource	Strategic mineral resource reserves
4. Ecological protection and build-up	
Ecological monitoring and security evaluation	Soil conservation
Key ecological projects	Green agriculture
Nature reserves	Scenic spot protection
Ecological conservation zones	Urban environment
Anti- desertification	
5. Environmental protection and pollution control	
Water pollution control	Urban traffic management
Marine pollution control	Soil waste control
Air pollution control	Environmental industry
6. Capacity building	
Legislation and enforcement	Information sharing
Indicator system, monitoring and evaluation	

Source: author rearranged from the Office of the Leading Group for Promoting the Sustainable Development Strategy in China (2004).

Table 2.6 Status of CDM projects in China (as of January 10, 2006)

Project status	Project Name	Project Type	Project Owner	CER Buyer	Estimated Ave. GHG Reduction ($tCO2e/y$)	SD impact refered in PDD
Projects Approved By DNA of China	Anding Landfill Gas Recovery and Utilization Project	Methane recovery & utilization	Beijing Erqing Environment Engineering Group	Energy Systems International B.V. (ESI)	90,000	* improvement of air and water quality * technology transfer * capacity building * dissemination of information
Projects Approved By DNA of China	Inner Mongolia Huitengxile Wind Farm Project*	Renewable energy	Inner Mongolia Long Yuan Wind Power Development Co., Ltd.	SenterNovem (Netherlands)	51,430	* diversification of energy sources * improvement of air quality * improvement of local livelihood * generation of employment * development of renewable energy industry
Projects Approved By DNA of China	Nanjing Tianjinwa Landfill Gas to Electricity Project*	Methane recovery & utilization	Nanjing Green Waste Recovery Engineering Co., Ltd.	EcoSecurities Ltd (UK)	265,032	* health * amenity * generation of employment * diversification of energy sources * conservation of natural resources * avoide uncontrolled waste management
Projects Approved By DNA of China	Zhangbei Manjing Wind Farm Project**	Renewable energy	Beijing Guotou Energy conservation Company (BJGT)	First Carbon Fund Ltd. (UK)	96,428	* diversification of energy sources * improvement of air quality * improvement of local livelihood * generation of employment * development of renewable energy industry
Projects Approved By DNA of China	Meizhou Landfills Gas Recovery and Utilization as Energy Project**	Methane recovery & utilization	Shenzhen PhasCon Technologies Co., Ltd.	Austrian JI/CDM Programme, Kommunalkredit Public Consulting Gmbh	278,000	* health * protection of biodiveristy * generation of employment * technology transfer
Projects Approved By DNA of China	China Xiaogushan Hydropower Project	Renewable energy	Xiaogushan Hydropower Co. Ltd.	World Bank PCF	327,300	* alleviation of poverty * promotion of renewable energy and energy efficiency * development of local industries * generation of employment * improvement of access of roads
Projects Approved By DNA of China	Yuzaikou Small Hydropower Project*	Renewable energy	Rucheng County Yuzaikou Hydropower Co Ltd.	EcoSecurities Ltd (UK)	40,480	* protection of local forest * generation of employment * development of local industries

Table 2.6 Approval status of CDM projects in China (as of January 10, 2006) (continued)

Project status	Project Name	Project Type	Project Owner	CER Buyer	Estimated Ave. GHG Reduction (tCO2e/y)	SD impact refered in PDD
Projects Approved By DNA of China	Rudong County Wind Farm Project-China	Renewable energy	Jiangsu Unipower Wind Power Co. Ltd	Cooperatieve Centrale Raiffeisen Boerenleenbank B.A.	181,274	n/a
Projects Approved By DNA of China	Shandong Dongyue HFC23 Decomposition project**	Chemical pollutants reduction	Shandong Dongyue Chemical Co., Ltd	Mitsubishi Corporation, Nippon Steel Corporation, and Natsource Europe Limited	10,110,000	* revenues from CERs transfer
Projects Approved By DNA of China	Zhejiang Juhua HFC-23 Decomposition Project**	Chemical pollutants reduction	Zhejiang Juhua Co., Ltd.	JMD Greenhouse-Gas Reduction Co.Ltd	5,790,000	* revenues from CERs transfer * mitigation of GHG * technology transfer
Projects Approved By DNA of China	The 30MW Tuoli Wind-farm Project in Urumqi, Xinjiang of China	Renewable Energy	Beijing Guotou Energy Conservation Company	Tokyo Electric Power Company	95,761	* promotion of renewable energy * abatement of pollution * capacity building * alleviation of poverty * generation of employment * promotion of local education and tourist * meet China's west economic development initiatives
Projects Approved By DNA of China	HFC23 Decomposition CDM Project at Jiangsu Meilan Chemical Co.Ltd.	Chemical pollutants reduction	Jiangsu Meilan Chemical Co. Ltd.	World Bank	8,825,831	* mitigation of GHG * revenues from CERs transfer
Projects Approved By DNA of China	HFC23 Decomposition CDM Project at Changshu 3F Zhonghao New Chemical Materials Co. Ltd.	Chemical pollutants reduction	Changshu 3F Zhonghao New Chemical Materials Co. Ltd.	World Bank	10,871,938	* mitigation of GHG * revenues from CERs transfer * technology transfer * attraction to foreign investment * generation of employment

Table 2.6 Approval status of CDM projects in China (as of January 10, 2006) (continued)

Project status	Project Name	Project Type	Project Owner	CER Buyer	Estimated Ave. GHG Reduction (tCO2e/y)	SD impact refered in PDD
Projects Approved By DNA of China	Taishan Cement Works Waste Heat Recovery and Utilization for Power Generation Project	Energy saving	Xinwen Mining Group Company Limited	Natsource Europe Limited	107,116	* generation of employment (about 45 people) * promotion of the circulate economy * diversification of energy sources * promotion of energy efficiency * mitigation of GHG * improvement of local environment
Projects Approved By DNA of China	Ningxia Helanshan Wind-farm Project	Renewable Energy	Ningxia Electric Power Group Co. Ltd.	Trading Emission Limited	216,499	* abatement of pollution * improvement of health * mitigatin of GHG * alleviation of poverty * promotion of renewable energy * technology transfer and its capacity building
Projects Approved By DNA of China	Jilin Taobei Huaneng 49.3 MW Wind Power Project	Renewable Energy	Huaneng New Energy Industrial Co. Ltd.	Endesa, S.A.	93,652	* abatement of pollution * promotion of renewable energy * mitigation of GHG * generation of employment * development of local tourism
Projects Approved By DNA of China	Jilin Tongyu Huaneng 100.5 MW Wind Power Project	Renewable Energy	Huaneng New Energy Industrial Co. Ltd.	Endesa, S.A.	255,159	* abatement of pollution * promotion of renewable energy * mitigation of GHG * generation of employment
Projects Approved By DNA of China	Guangdong Nan¨ao Huaneng 45.05 MW Wind Power Project	Renewable Energy	Huaneng New Energy Industrial Co. Ltd.	Endesa, S.A.	67,939	* abatement of pollution * promotion of renewable energy * mitigation of GHG * generation of employment * development of local tourism
					37,763,839	

Source: China CDM website (http://cdm.ccchina.gov.cn/) and PDDs

Chapter 3 Case Study of Efficiency improvement of the Chongming Power Plant in Shanghai

3.1 Introduction

Local air pollution, and resultant adverse impact on human health has been critically severe in China. World Health Organization (WHO) reported in 1998 that seven out of the ten most polluted cities in the world could be found in China. The State environmental protection agency (SEPA) of China published that more than 410,000 died of air pollution related disease in 2003.

Coal combustion has been the main cause of local air pollution such as sulfur dioxide (SO_2) and soot, particle matters, nitrogen oxides (NO_x). It has also caused regional air pollution such as acid rain, and greenhouse effects by discharging carbon dioxide (CO_2). SO_2 emissions are increasing continuously and causing serious environmental damages. Acid rain has been serious in China: it falls on about 30% of China's total land area in 2003. World Bank et al. (2001) shows it has also adverse impacts to Korea and Japan.

Industrial boilers and furnaces consume almost half of China's coal and are the largest single point sources of urban air pollution. Among them, the electricity sector is a major source of emissions of several air pollutions. In 2002, fossil fuel power generator generates roughly 48 percent of industry sector emissions of SO_2 in China. However, few abatement technologies such as scrubbers and desulfurization equipment have been installed in coal-fired power plant so far. Until 2000, the total capacity of power plants that has installed scrubbers is 5 million kW, only 0.2 percent of coal fired capacity in China.

This serious air pollution in China convinces us to suppose that China will potentially gain the improvement of local air pollution, and health benefits from the CDM. However, such CDM projects have been implemented so far, because project developers cannot often earn sufficient internal rate of return. Here we can find the conflict of interests between Chinese government and local residents on the one hand, and project developers on the other hand.

The purpose of this chapter is to evaluate sustainable development impact of the efficiency improvement CDM project in the power plant. We take the Chongming coal-fired power plant in Shanghai, for Shanghai has suffered from severe local air pollution caused by industrial boilers. Then we analyze the incidence of costs and benefits of the project to wider range of stakeholders. It will quantitatively clarify the distributional impact of the project, and give some implications how to mitigate the conflict of interests among stakeholders.

3-2 Project Design

Chongming Island is located in the north east of Shanghai covering an area of 1,200km^2. Total population of the Island is about 650,000. Chongming power plant, operated from 1958, is small scale coal fired power plant (nameplate capacity: 165MW) and the only power plant in the island. In the 1980's, most part of plant was repowered, but generate efficiency is 5% lower than the average of China. Scrubbers and NOx Burner have not been installed.

In this chapter, we discuss five CDM options with two baseline scenarios: operating existing plant with FGD (baseline scenario A) and constructing new sub-critical power plant with FGD (baseline scenario B). We assume FGD installation because Chinese government has tightened air pollution control policies. Chinese government revised the Air Pollution Control Law in 2002 and commanded new coal-fired power plant to install fuel-gas desulfurization (FGD). It also stipulated that small size power plant would be closed until 2005.

The designs of the five projects are as follows:

Option 1: repair existing plant, with baseline scenario A

Option 2: construct integrated coal-fired gasification combined cycle (IPCC) plant, with baseline scenario A

Option 3: construct natural gas combined cycle plant, with baseline scenario A

Option 4: construct IPCC plant, with baseline scenario B

Option 5: construct natural gas combined cycle plant, with baseline scenario A

Figure3-1, 3-2, and 3-3 are illustrations of baseline scenario and CDM project that we treat in this chapter. The period of project evaluation is 30 year except option 1 that assumes existing plant would be closed within ten year. Option 2 and 3 are assumed to increase generation capacity that will exceeds the current electricity demand in the island. Thus we assume that generated power will transmit to Shanghai that has suffered from shortage of electricity. Besides option 1, all the options enhance production efficiency, and save coal consumption. Thus we can expect fuel saving and both GHG reduction and physical and health benefits that come from improvement of local air pollution.

3-3 Evaluation Method

Here, we limit the sustainable development impacts to fuel savings and health benefit that comes from the reduction in SO_2 and NOx, though we can expect other significant impacts. On the other hand, we take stakeholder wider to include local residents, Japan, Korea and other developing countries, taking the impact of acid rain into account. Table 3-1 shows the boundary of our evaluation.

3-3-1 Project Cost

Construction, operation and management costs are included. In addition to these direct costs, transaction costs are included. Though baseline development, project registration, verification and certification entail considerable costs, there is not much experience with CDM project in China, we assumed transaction costs using the data of Danish Energy Authority (2003) and hearing of HFC-23 CDM project in Korea. The cost for validation is assumed JPY 1.2 million /one time ・ year, and JPY 14 million for research, registration and verification cost.

3-3-2 Fuel saving

The quantity of fuel saving can be calculated from the equation (3-1).

$$\text{Fuel Consumption (kg)} = \text{generation(kWh)} / \text{heat value(MJ/kg)} / \text{generation efficiency(\%)} \times 3.6034\text{(MJ/kWh)} \qquad (3\text{-}1)$$

Table 3-2 illustrates coefficient of each fuel.

3-3-3 Revenue by selling CER

Investor will gain all of the earnings by selling CERs. Assumed price of CER is 5USD/CO_2 ton. Actual CER of CDM projects was traded around 3-10EUR in December, 2005(Point Carbon, January 10, 2006). The amount of CER and GHG reduction are same, and calculate from the equation (3-2).

$$\text{GHG emissions} = CO_2 \text{ emissions} + N_2O \text{ emissions} \times 310 \qquad (3\text{-}2)$$

incurred sail of CER.

3-3-4 Emission charge

Table 3-3 shows emission charge of air pollution emission to coal fired power plant. Local power plant can save expense of emission chare through reduction of emissions. This also means decrease of emission charge revenue from Chinese government point of view.

3-3-5 Health benefit

Economic valuation of externalities caused by fossil fuel-fired power plant has been conducted in the Extern-E project since 1980s. In this project, methodology for valuing health damage has been established, though there remains number of issues to be solved. Markandya (1998) provides a survey of health damage cost in developing countries as well as industrialized countries. He proposed the benefit transfer, indirect valuation method, in valuing it in developing countries, because there were few studies that conducted estimation in developing countries. However, it is a hot issue how to transfer benefit from industrialized countries that have higher income to developing countries. Markandya (1998) employed two elasticity of: 1 and 0.35, and conducted sensibility analysis. Alberini and Krupnick (2002) employed elasticity of 0.3. Here we take the elasticity that Alberini and Krupnick (2002) employed.

The ranges of values for the damages per ton are wide, from \$9,390 to \$12,350 per SO_2 ton emitted, from\$4,860 to \$18,070 per NO_x ton emitted and \$15,530 to \$59,420 per particulates ton emitted. We calculated damage cost based on lowest estimate, for conservative estimate. Table 3-4 shows damage costs per ton emitted.

3-3-6 Reduction of acid rain

A part of emissions from Chongming can entail acid rain in East Asia region. Amann (1998) study indicates 0.6% of SO_2 emissions, and 0.5% of NO_x emissions from Shanghai move to Japan, and 0.2% of SO_2 emissions, and 0.3% of NO_x emissions to Korea. (Table 3-4)

3-3-7 Adaptation Fund for developing countries

Two percent of CER is deducted for developing country and calculate from the following equation.

$$\text{Adaptation Fund} = \text{Amount of CER} \times 0.02 \times 5$$

Where CER price: 5USD

Next introduces the evaluation results regarding the item of 3-3-1 to 3-3-7.

3-4 Results

3-4-1 Net benefit of stakeholders

Table 3-5 shows the evaluation results of each CDM Project in case the crediting period is for ten years and for twenty-one years. For option 1, the crediting period is for ten years. For example, the project cost of the option 4 includes the construction cost of the new IGCC power plant, incremental management and maintenance cost, and the transaction cost. The construction cost of Chongming power plant (sub-critical) that is already assumed in the base line is subtracted from the project cost. It is assumed the increment of management and maintenance cost outside the credit period is paid by the local power plant. Moreover, it is assumed that the fuel saving during the crediting period go to the project developer and that those outside the crediting period belong to the local power plant.

Let us take option 4 as an example. Figure 3-4 shows the net benefit that each stakeholder related to this project will obtain when the option 4 is implemented. Though this project is not profitable from the investor’s point of views, this project is socially meaningful because its health benefit to the residents is estimated large enough. As to the period of the project, it is natural that the longer project (21 year project) is preferable for the investors. On the other hand, longer project is less preferable for the local power plants since the revenue from fuel saving gets smaller. Similar calculation was made for the other options. These results show the option 4 and 5 generate net positive social benefit when taking health benefit into account.

3-4-2 Gains from GHG reduction and profit of project developer

Here, we evaluate the project in view of project developer. Project developer earn a revenue from CERs and fuel saving. Table 3-6 shows how much amount of the fuel consumption is changed by the project. It also shows that coal consumption reduces while the natural gas consumption increases in the option 3 and 5. Because the option 1 is to repair the small power plant, the reduction in coal consumption is smaller than other options. Among the IGCC construction project, the amount of fuel reduction in the option 2 is smaller than the option 4, since its fuel consumption in the baseline scenario is smaller. Similar consideration can be applicable to the option 3 and 5.

The annual and total reduction of GHG of each project is shown in Table 3-7, where the credit period for Option 1 is assumed to be 10 years and 21 years for the option 2, 3, 4, and 5.

It would be natural that GHG reduction in the option 1 is smaller than that of another, since the scale of the project itself is relatively small. As to the option 2, 3, 4, and 5, GHG reduction by natural gas combined cycle power generation (option 3 and 5) is three times as large as that by IGCC power plant (option 2 and 4). Though IGCC is considered leading edge of coal power generation technology, environmental load is considerably large from the viewpoint of GHG emissions compared with the natural gas power generation. Therefore, introducing the natural gas combined cycle power generation gains more considerable credit than IGCC can get.

Next, let us see the components of the cost and benefit for investor. Table 3-8 and Figure 3-5 show the structure of “project operation cost” that the investor pays, “fuel saving benefit” and “gain by selling CER” the investor will obtain. The figures are represented as present value with 11 % discount rate. The CER price is assumed to be 5USD/ton CO_2 and the credit period for the option 2, 3, 4 and 5 is assumed to be 21 years. We can see that the credit price of 5USD/ton CO_2 is below break-even point for all of the projects. However, the option 3 and 5, which use the natural gas combined cycle power generation, have a possibility to be profitable depending on the credit price because the amount of the GHG reduction in the option 3 and 5 is large. The profit of the project is largely due to the CER price.

Finally, let us think how much the break-even CER price is. We guess that must be very important for the investor. Table 3-9 shows the result of each project. Since it is said that the market price of CER would be roughly $5 to $20, it would be considerable difficult that the investor undertake the option 2 and 4 by financial reason. On the other hand, we can say that the option 1, 3 and 5 could be realized depending on the level of the CER price.

3-4-3 Health benefit as an ancillary benefits

Here we estimate amount of reduced air pollutant of fuel origin by each CDM project. The amount of the reduction of the air pollutant of each project is shown in Table 3-10. Since the air pollutant is of fuel origin, the amount of the reduction is basically proportional to the amount of the fuel consumption reduction shown in Table 3-6. However, the amount of the reduction depends on the assumed equipment characteristics like SO_2 control measures and NO_x control measures. The reason that the amount of the reduction of the air pollutant in the option 1 is relatively small is that the original fuel consumption and the reduction of fuel consumption are both small.

Let us compare the reduction of the air pollutant between the option 2 and 4. The difference of the amount of the SO_2 reduction between the option 2 and 4 originates in the difference of the amount of the fuel consumption reduction as already mentioned since sulfur content of the coal and the desulfurization rate are assumed to be common concerning the option 2 and 4. As to NO_x, the reduction in Option 2 is larger. The reason is that NO_x control equipment is not considered in Chongming power plant in the baseline scenario of the option 2, and as a result the amount of the “reduction” by the project becomes larger. As to dust, the reduction in the option 2 is also larger.

The reason is the same as the case of NO_x reduction, that is, electrical dust catchers are not equipped in Chongming power plant in the base line of the option 2, and as a result the amount of the “reduction” by the project becomes larger.

Next, let us compare the option 2, 3 or the option 4 and 5, which corresponds to a comparison between IGCC and the natural gas combined cycle power generation. As is shown in Table 3-10, the effect of IGCC concerning the air pollutant reduction is considerably similar that of the natural gas combined cycle power generation. However, dust reduction effect of IGCC is a little larger than that of the natural gas combined cycle power generation. In general, a natural gas power generation is regarded dust free. We obtained, however, such result since we summed very high dust catching rate of 99.9% on IGCC in this research.

Next, in Table 3-11 and Figure 3-6, let us show the benefit from the air pollution improvement by each project in case the discount rate is 11% per year. The benefit from NOx reduction in Option 3 is much larger than that in the option 5. That originates the fact that the NOx reduction in Option 3 starts earlier than Option 5. The benefit is calculated as a product of “the amount of the reduction” and “damage cost per ton of each pollutant”. Adjustment by the discount rate factor makes some deference in the results. If discount rate is 0%, the benefit of the option 1 increases by 1.5 times and those of the option 2, 3 4, and 5 increase by three times. The option 1 is not much influenced by the value of discount rate because the evaluation period is assumed for ten years.

Moreover, when the discount rate is assumed to be 20% oppositely, benefit of Option 1 decreases by 30% and those of the option 2, 3, 4, and 5 decrease by 40%.

We can see it is an important matter to determine the value of the discount rate because the benefit from the project changes greatly depending on the value of discount rate.

Table 3-12 shows the benefit from the damage reduction by acid rain for Japan and South Korea when the discount rate is set 11%. We can see that the benefit for Japan is larger than Korean's partly because the deposition of SO_2 and NOx in Korea is larger than in Japan and partly because Japanese damage cost by SO_2 and NO_x is larger that Korean's. Moreover, compared with benefit by the air pollution reduction around the power plant in China, benefits in Jana and Korea are very small. This result is plausible because deposition in Japan or Korea is less than 1%. However, regardless uncertainty concerning the transportation model of acid materials, this amount cannot be neglected taking it into consideration.

3-5 Conclusion

We find that the option 4 and 5 generate net positive social benefit when taking health benefits into account s. This gives Chinese government incentive to attract project developers to implement the option 4 or 5. Project developer, on the other hand, will not earn a positive internal rate of return, when the CER price is no more than US$5. This discourages them to invest on the option 4 and 5. Instead they pursue the CDM that brings them higher internal rate of return to them.

The above findings imply that changing incidence and/or distributional impacts is a key in mitigating the conflict of interests among stakeholders. On behalf of the beneficiary of health benefits, Chinese government can increase financial burden to the CDM. Japan and Korea can increase financial assistance in accordance with the benefit of the reduction in acid rain, though we find the health benefit to both countries is small.

How to increase the financial burden from Chinese government on the one hand, and Japan and Korea remains a future challenge, though Ueta et al. (2005) provided some insights on it.

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Figure 3-1 Outline of Option 1

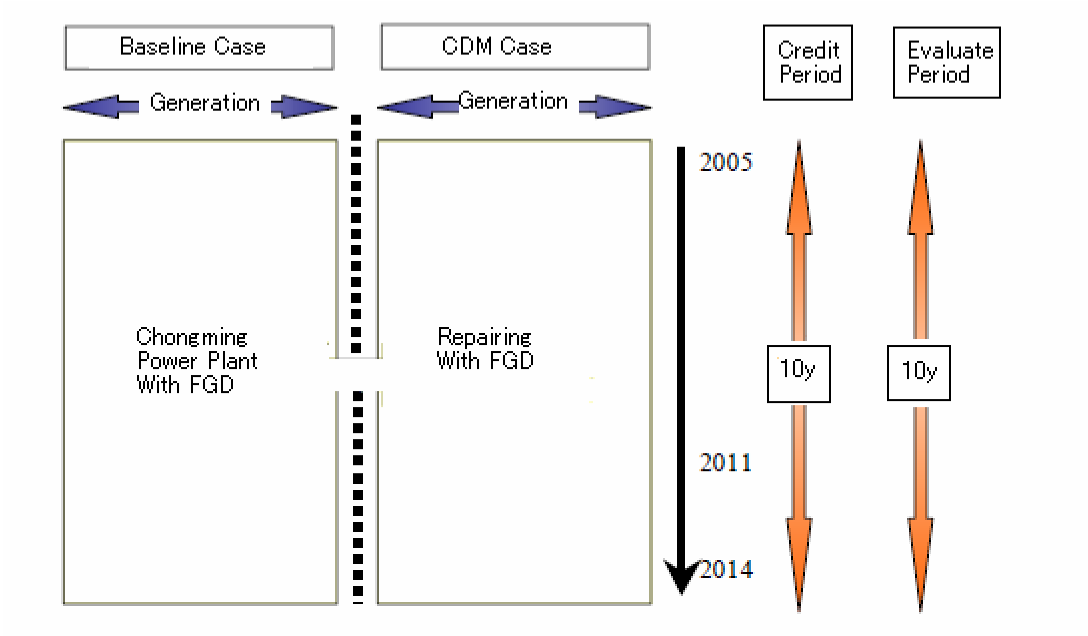

Figure 3-2 Outline of Option 2 and 3

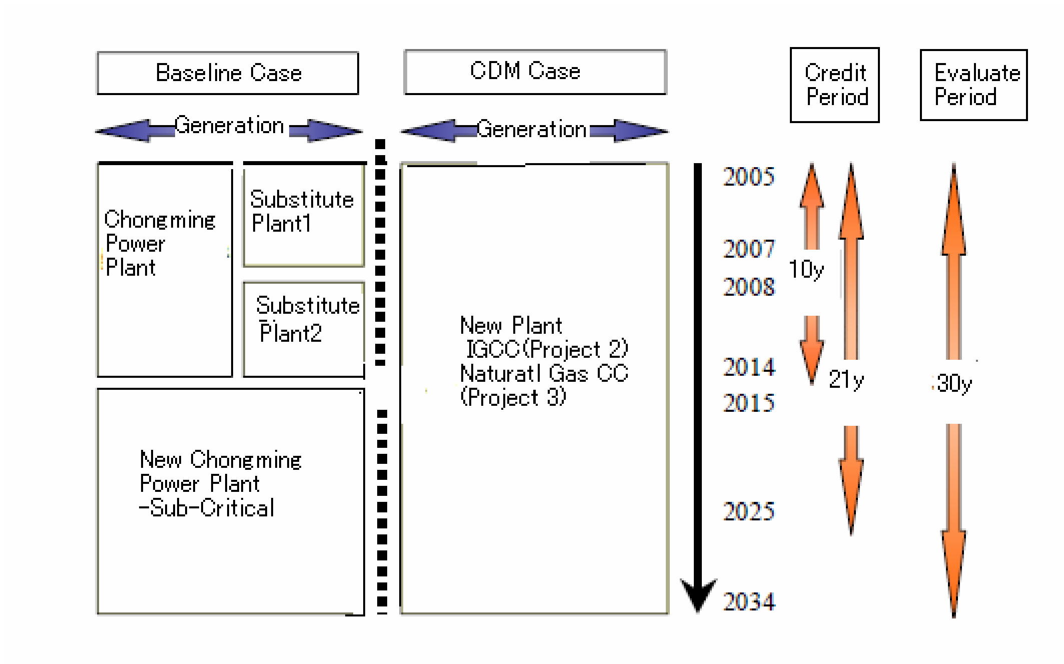

Figure 3-3 Outline of Option 4 and 5

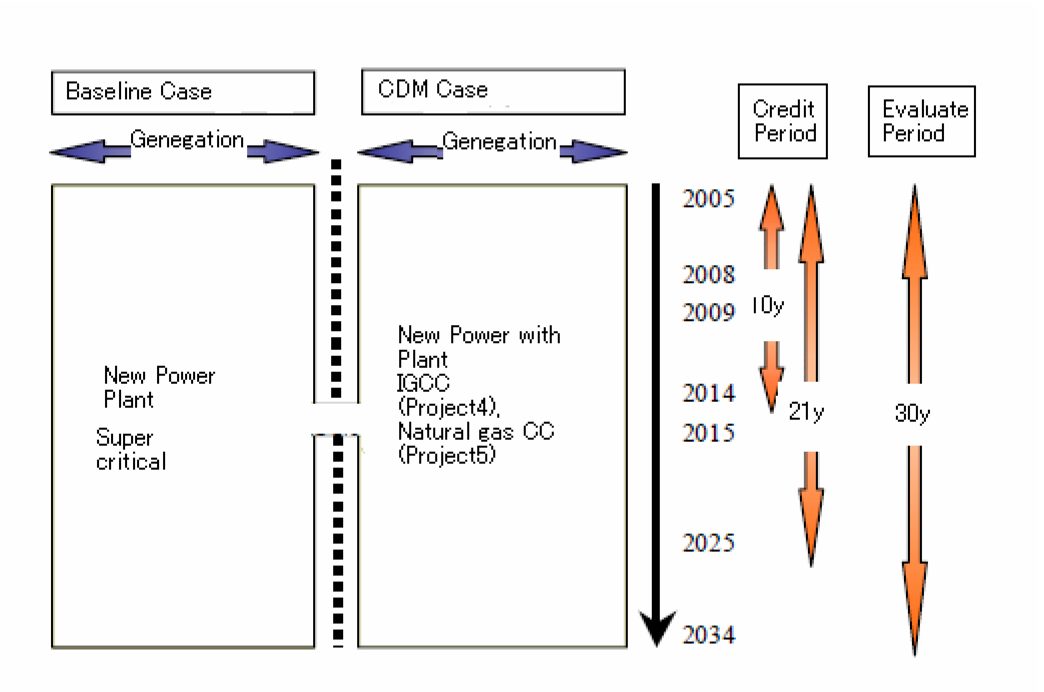

Figure 3-4 Net benefit of stakeholders (Option 4)

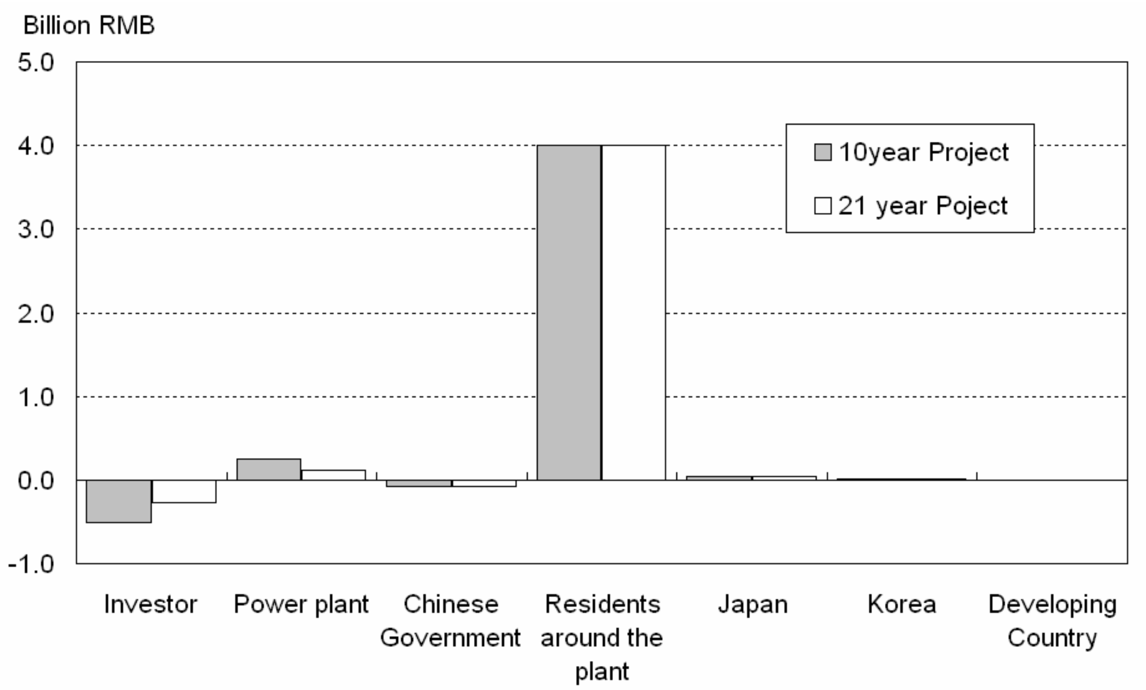

Table 3-1 Range of evaluation

	Investor	Local Power Plant	Chinese Government	Residents around the Plant	Japan	Korea	Developing Country	Total
Cost of CDM Project	(1)Construction, operation and management cost of CDM							
Fuel Saving	(2)Benefit from fuel saving							
Reduction of GHG Emissions	(3)Revenue by selling CER						(7)2% of CER reserved for adaptation fund	
Reduction of SO_2, Nox		(4)Reduction of emission charge expenditure	(4)Reduction of emission charge revenue	5)Improvement of air quality	6)Reduction of acid rain	(6)Reduction of acid rain		
Total								

Table3-2 Coefficient of fuel

GHGs	Equation	Fuel type	Coefficient	
CO_2	Fuel consumption × Heat Value × Emission Coefficient	Coal	Heat value(MJ/kg)	21.1
			$kgCO_2/MJ$	0.0906
		Natural gas	Heat value(MJ/kg)	40.9
			$kgCO_2/MJ$	0.0494
N_2O	Generation × Emission Coefficient	Coal	Turbine (g/kwh)	0.0017
			IGCC (g/kwh)	0.0044

Table 3-3 Emission Charge of Chinese Government

Pollutant	Emission Charge(RMB/t)
SO_2	630
NOx	630
Dust	275

Table 3-4 Adjusted Value of Air pollution Damages for SO_2 and NOx

Pollutant	China (USD/t)
SO_2	5208
NOx	2695

Remark: Elasticity is assumed to be 0.3

Table 3-5 Evaluation of CDM projects

Option 1 (Evaluation period: 10 year)

	Investor	Power plant	Chinese Government	Residents around the plant	Japan	Korea	Developing Country	Total
Project cost	-76,358							-76,358
Fuel saving	39,928							39,928
Revenue from CER	8,839						198	9,037
Benefit of Air pollutant reduction		795	-795	35,022	377	127		35,526
Total	-27,591	795	-795	35,022	377	127		7,935

Option 2 Evaluation period: 30 year, credit period is 10 year and 21year (lower line)

	Investor	Power plant	Chinese Government	Residents around the plant	Japan	Korea	Developing Country	Total
Project cost	-5,931,805	1,154,557						-4,777,248
	-5,994,942	1,217,504						-4,777,438
Fuel saving	789,676	203,003						992,679
	947,894	44,785						992,679
Revenue from CER	172,942						3,879	176,821
	207,416						4,652	212,068
Benefit of Air pollutant reduction		82,249	-82,249	2,448,656	39,400	9,382		2,497,438
		82,249	-82,249	2,448,656	39,400	9,382		2,497,438
Total	-4,969,187	1,439,809	-82,249	2,448,656	39,400	9,382	3,879	-1,110,310
	-4,839,632	1,344,538	-82,249	2,448,656	39,400	9,382	4,652	-1,075,253

Option 3 Evaluation period: 30 year, credit period is 10 year and 21 year (lower line)

	Investor	Power plant	Chinese Government	Residents around the plant	Japan	Korea	Developing Country	Total
Project cost	-2,339,101	1,399,430						-939,671
	-2,211,386	1,271,527						-939,859
Fuel saving	-5,523,852							-5,523,852
	-5,523,852							-5,523,852
Revenue from CER	493,816						11,075	504,891
	647,384						14,519	661,903
Benefit of Air pollutant reduction		64,940	-64,940	1,981,627	35,070	7,133		2,023,830
		64,940	-64,940	1,981,627	35,070	7,133		2,023,830
Total	-7,369,137	1,464,370	-64,940	1,981,627	35,070	7,133	11,075	-3,934,802
	-7,087,854	1,336,467	-64,940	1,981,627	35,070	7,133	14,519	-3,777,978

Option 4 Evaluation period: 30year, credit period is 10 year and 21 year (lower line)

	Investor	Power plant	Chinese Government	Residents around the plant	Japan	Korea	Developing Country	Total
Project cost	-1,201,527	-72,761						-1,274,288
	-1,201,780	-16,052						-1,217,832
Fuel saving	572,667	245,689						818,356
	764,153	54,202						818,355
Revenue from CER	125,126						2,806	127,932
	171,567						3,848	175,415
Benefit of Air pollutant reduction		81,911	-81,911	3,997,115	43,543	9,106		4,049,764
		81,911	-81,911	3,997,115	43,543	9,106		4,049,764
Total	-503,734	254,839	-81,911	3,997,115	43,543	9,106	2,806	3,721,764
	-266,060	120,061	-81,911	3,997,115	43,543	9,106	3,848	3,825,702

Option 5 Evaluation period:30 year, credit period is 10 year and 21 year (lower line)

	Investor	Power plant	Chinese Government	Residents around the plant	Japan	Korea	Developing Country	Total
Project cost	2,221,749	164,109						2,385,858
	2,349,464	36,204						2,385,668
Fuel saving	-5,671,149							-5,671,149
	-5,671,149							-5,671,149
Revenue from CER	446,707						10,018	456,725
	612,505						10,018	622,523
Benefit of Air pollutant reduction		68,421	-68,421	3,530,086	39,212	11,803		3,581,101
		68,421	-68,421	3,530,086	39,212	11,803		3,581,101
Total	-3,002,693	232,530	-68,421	3,530,086	39,212	11,803	10,018	752,535
	-2,709,180	104,625	-68,421	3,530,086	39,212	11,803	10,018	918,143

Table 3-6 Amount of fuel saving

	Option 1	Option 2	Option 3	Option 4	Option 5
Reduction of Coal Consumption(ton)	216,764	8,836,056	56,706,127	9,326,772	57,196,843
Increase of Natural Gas Consumption(1000m^3)	-	-	22,649,155	-	22,649,155

Table 3-7 GHG reduction of CDM project

GHG Reduction	Option 1	Option 2	Option 3	Option 4	Option 5
Annual GHG Reduction (CO2t/year)	41,350	602,385	2,106,806	585,364	2,089,786
Total GHG Reduction (CO2/Credit period)	413,499	12,650,076	44,242,922	12,292,652	43,885,498

Table 3-8 Cost and benefit in CDM projects for the project developer (1000 RMB)

	Project Cost	Fuel Saving	Revenue from CER
Option 1	-76,358	39,928	8,839
Option 2	-5,994,942	947,894	207,416
Option 3	-2,211,386	-5,523,852	647,384
Option 4	-1,201,780	764,153	171,567
Option 5	2,349,464	-5,671,149	612,505

Table 3-9 Break-even CER price for implementation (USD)

Discount rate	Option 1	Option 2	Option 3	Option 4	Option 5
0%	5.75	54.2	129.58	-7.92	35.72
5%	12.3	83.9	93.62	0.88	31.28
10%	19.2	115.34	79.77	10.72	26.22
15%	26.3	146.74	75.06	20.97	21.1
20%	33.45	177.1	74.47	31.13	16.22

Figure 3-5 Cost and benefit for Project Developer

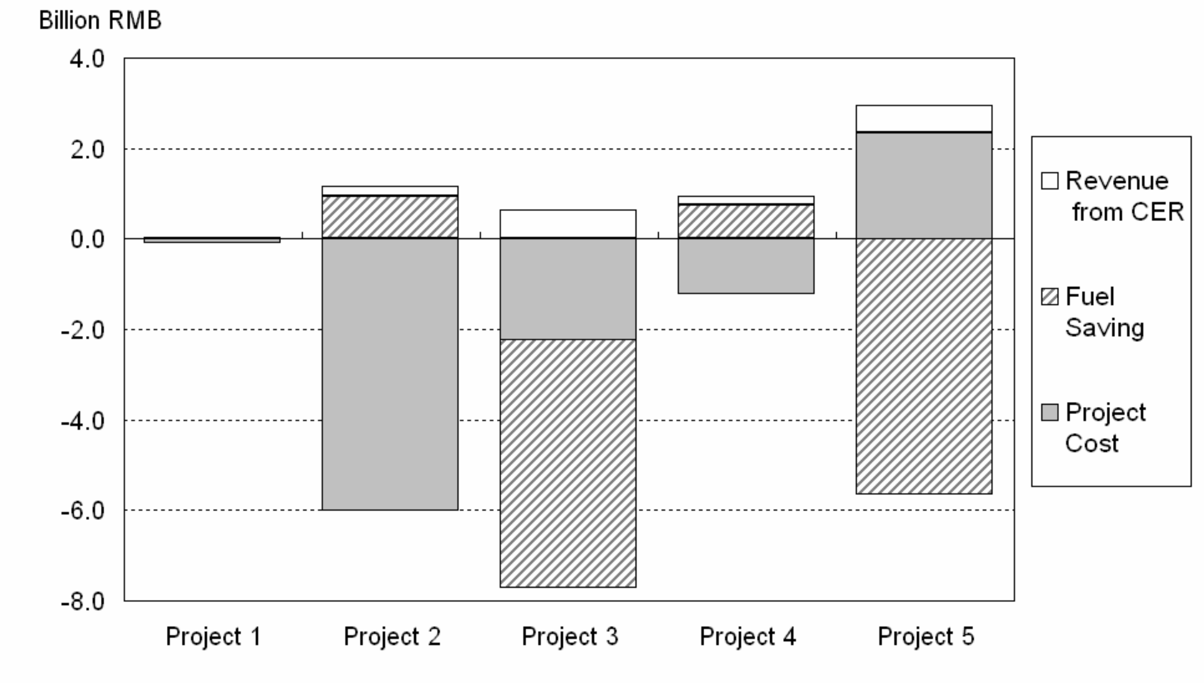

Figure 3-6 Benefit from reduction of air pollution

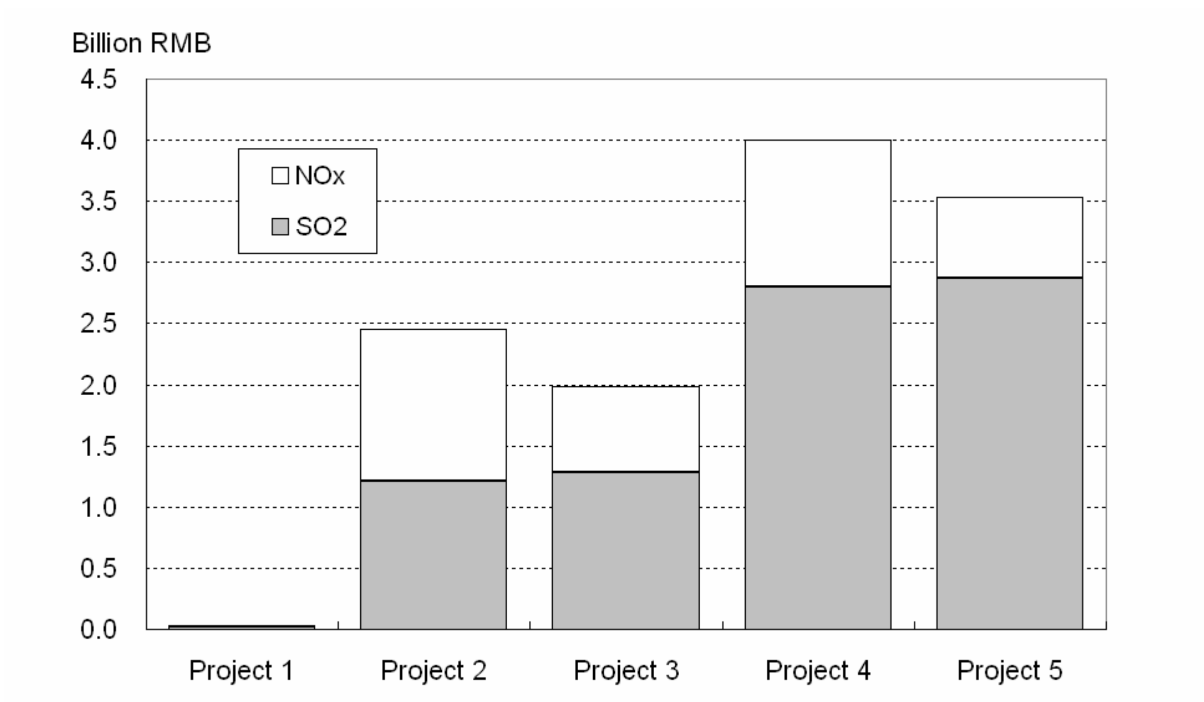

Table 3-10 Reduction of the air pollutants

	Option 1	Option 2	Option 3	Option 4	Option 5
SO_2(ton)	889	164,160	169,885	227,816	233,541
NOx(ton)	993	191,684	107,136	188,522	103,974
Dust(ton)	110	6,112	3,601	2,765	254

Table 3-11 Benefit from reduction of air pollutants in China

	Option 1	Option 2	Option 3	Option 4	Option 5
SO_2	22,194	1,209,413	2,798,695	1,279,804	2,869,086
NOx	12,828	1,239,243	1,198,420	701,823	661,000
Total benefit	35,022	2,448,656	3,997,115	1,981,627	3,530,086

(Unit: 1000 RMB)

Table3-12 Benefit from reduction of air pollutant in Japan and Korea

		Option 1	Option 2	Option 3	Option 4	Option 5
Japan	SO_2	254	23,123	23,929	32,089	32,896
	NOx	123	11,647	6,509	11,453	6,317
	Total benefit	377	34,770	30,438	43,542	39,213
Korea	SO_2	68	3,697	8,556	3,913	8,771
	NOx	59	5,685	5,498	3,220	3,032
	Total benefit	127	9,382	14,054	7,133	11,803

(Unit: 1000 RMB)