EU-China CDM Facilitation Project

Assessment of the Impact of China's CDM Projects on Sustainable Development

Policy Research Center for Environment and Economy of the Ministry of Environmental Protection
Research Center of Urban Development and Environment of the Chinese Academy of Social Sciences
Energy Research Institute of National Development and Reform Commission

November 2009

This document has been produced with the financial assistance of the European Union. The contents of this document are the sole responsibility of the project Consortium and can under no circumstances be regarded as reflecting the position of the European Union.

Acknowledgement

This report is one of the important achievements of the EU-China CDM Facilitation Project. The Policy Research Center for Environment and Economy of the Ministry of Environmental Protection (PRCEE)) has chaired and supervised the production of this report. Technical guidance has been provided by Dr. Ren Yong (Ministry of Environmental Protection) and Ms. Tian Chunxiu (PRCEE). The report has been written by Li Liping, Feng Xiangzhao, Shang Hongbo, Cao Fengzhong, Song Xuna (PRCEE); Chen Hongbo, Chu Chengshan, Zhen Yan, Wang Mou, Zhang Bo, Shang Jikun (Research Center of Urban Development and Environment of the Chinese Academy of Social Sciences (CASS)) and Yang Hongwei, Feng Shengbo, Zhang Minsi (Energy Research Institute of National Development and Reform Commission). We would like to express our special appreciations to Li Liping and Feng Xiangzhao. They have contributed greatly to the report regarding the methodology research and application as well as its drafting.

Furthermore, we would like to thank Ms. Gao Si (IVL Swedish Environmental Research Institute) who has participated in the research and discussions on the related cases. We would also like to thank Jonas Fejes, Philip Thörn, Erik Särnholm and Mark Sanctuary (IVL Swedish Environmental Research Institute） for providing important feedback and comments on the report. Above all, we would like to thank Ms. Lin Na (Development Solutions) for her contribution to the translation and revision of the report’s English versions.

Executive Summary

The Clean Development Mechanism (CDM) is one of the three flexible mechanisms defined in the Kyoto Protocol under the United Nations Framework Convention on Climate Change (UNFCCC). It is a project-based mechanism to allow for GHG emission reduction cooperation between developed countries and developing countries. The CDM has two purposes. They are to stimulate developing countries to achieve sustainable development and reach the final targets listed under the Protocol, and at the same time to help developed countries to meet their quantified emission reduction commitments.

Since the Kyoto Protocol entered into force, the CDM has experienced fast development and is now a major component of the global carbon market. However, the degree to which CDM projects contribute to sustainable development in developing countries and deliver real additional reductions has come under scrutiny. This has been a major concern globally and the reform of current CDM has become one of the important issues for post-Kyoto negotiations.

Under such a context, Chinese and European partners under the EU-China CDM Facilitation Project implemented the joint research project Assessment of CDM Projects' Impact on China's Sustainable Development. The core objective of this joint research is to develop a scientific evaluation methodology to assess CDM projects' impact on China's sustainable development based on quantified data, and to analyse the assessment results through the stakeholder approach, and finally to propose policy recommendations to improve the CDM.

Based on the international experience and Chinese practice, this research adopted Multi-attribute Utility theory, and developed a China-specific evaluation methodology to assess the impact of CDM projects on sustainable development, entitled the Multi-Attributive Assessment of CDM specific for China (MATA-CDM-China)[1]. This methodology allows for the quantified assessment of the general impact of CDM projects in China on sustainable development (apart from HFC23 and N_2O projects)[2], which is indicated by the Sustainable Development Impact Level (U). The values of U range from -1 to 1. A positive U value shows that the CDM project will have a positive impact on sustainable development. A high value, which approaches 1, indicates that the project has a high positive impact on sustainable development, and vice versa. Thus, we can calculate the sustainable impact level of an individual CDM project and a category of CDM projects, and can compare the sustainable

[1] The MATA-CDM-China methodology is applicable for assessing impact of single CDM project in terms of sustainable development. For information on this methodology's limitation see section 3.2.4 of this report.

[2] MATA-CDM-China is only applicable for energy-related CDM projects as it is mostly built on energy consumption-related indicators. It is thus unsuitable for assessing the impact of non energy-related CDM projects (such as HFC-23 decomposition and N_2O decomposition projects) on sustainable development.

impact levels of different categories of CDM projects through the Sustainable Development Impact Level (U).

The basic approach of the evaluation was to generate a score/value to compare with the baseline. Since most of the CDM projects are related to energy or power generation, **in this project, the baseline was defined as a virtual power plant with all the average features of a coal-fired power plant in China**. Based on an extensive literature review, a number of expert workshops, questionnaire survey and other methods, this research established the following nine indicators and their weight and utility functions under the three pillars of sustainable development, which are social improvement, environmental protection and economic development: employment, social equity, capacity building, energy, emission reduction effect, ecosystem protection and land resources, technology, microeconomic efficiency, and regional development. Each indicator was represented and illustrated through various measurable elements. The single utility value (u) of each indicator was generated by the mathematical calculation from the utility function, which was based on each indicator's feature and the status of the evaluated item. The total utility value (U), the impact level of individual CDM projects on sustainable development, was calculated from the single utility of all the indicators based on a mathematical model.

Applying the above methodology, the research team studied all the 202 CDM projects[3] in China registered at EB by 1 May 2008, and summarised and analysed all of their PDDs. Among these projects, we further selected 14 on-going CDM projects and conducted field surveys, which covered all CDM project categories and all of the major geographical areas in China as representative cases of Chinese CDM projects. The research calculated and extensively analysed the impact levels of 12 non-HFC23 and non-N_2O CDM projects on sustainable development.

Based on the definition and the analytical methodology, **the research results show that, the average sustainable development impact level was 0.49, and all the studied projects had positive sustainable development impact levels (above 0). This indicates that, in general, CDM projects in China contribute to sustainable development. However, they have not achieved the goal of promoting sustainable development in developing countries as defined in the Kyoto Protocol**[4].

Specifically, the following conclusions were made: firstly, the sustainable development impact levels of CDM projects in China basically matched the priority areas of CDM project outlined in national regulations. Secondly, CDM projects mainly contributed to environmental protection and contributed relatively less to economic development and social improvement. Thirdly, the contributions of CDM projects in China to sustainable development differed across the project categories, sectors, and

[3] See also "Technology Transfer in CDM Projects in China"-report. Besides that, we also studied the PDDs of other CDM projects not yet registered and entering into the CDM pipeline, including the two cases of Wuhan Steel Coke Dry Quenching project registered on April 20, 2009 at EB and Jiangsu Taizhou Ultra Super Critical Plant Project registered at China's authorized DNA on July, 18, 2008.

[4] Article 2, The Kyoto Protocol, by the UN, 1998

among individual case. Fourthly, the scores of Chinese CDM projects impacts on sustainable development were closely related to the level of technology transfer in these projects. Fifthly, the sustainable development impact level of CDM projects in China was linked to the local economic development level, the nature of the project owner, the information availability, regulation, etc., and had no direct link with the geographical location of the CDM project.

The analysis of the sustainable development impact of CDM projects in China showed that, with the joint efforts from various stakeholders, the CDM projects in China have contributed positively to the sustainable development. First of all, from the international perspective, the Kyoto Protocol has established the contribution of CDM to sustainable development in developing countries as an important principle and target. Second, COP/MOP and CDM Executive Board established relevant regulations and rules to ensure that CDM helps host countries to achieve their sustainable development targets. For example, the CDM project design document (PDD) is required to contain a section on how to stimulate sustainable development. Third, whether a CDM project fulfills necessary sustainable development criteria/meet sustainable development objectives is a matter for the relevant host country to judge/decide[5]. China has adopted measures, e.g. implemented relevant policies and regulations, set priority areas for CDM project development and facilitated energy conservation and emission reduction measures, which furthermore have significant synergy effects on reducing GHG emissions, in order to guarantee that CDM projects contribute to China's sustainable development. China has also established the Clean Development Mechanism Fund (CDMF), to support and facilitate national efforts to address climate change and to facilitate the energy conservation and emission reduction programme to achieve sustainable development.

Although CDM projects have had some success in promoting sustainable development in China, the CDM has not fully fulfilled the expected objective as defined in the Protocol. The reasons mainly covered the following aspects: first, the rules of CDM have not been perfected due to lack of overall coordination of the mechanism. Many stakeholders focus only on maximizing their own profit and have no interest in cooperating in order to promote sustainable development. Second, different stakeholders have different or incomplete understandings of sustainable development. Some stakeholders understood sustainable development as exclusively economic development, or exclusively as environmental protection, and did not see the sustainable development evaluation as an integrated consideration of economic development, environmental protection and social improvement. Third, while the CDM, a market-based mechanism, has generated economic profits and revenues its potential sustainable development benefits have not been capitalized.

Therefore, this research proposes that Chinese policy-makers should increasingly

---

[5] This is stated in the CDM-rules that the assessment of CDM's contribution to sustainable development is made by the DNA of each country. There is no set of unified evaluation standards adopted by the international community.

acknowledge CDM's potential to contribute to sustainable development in China. Chinese leaders should speed up the amendment of the Measures for Operation and Management of Clean Development Mechanism Projects in China from the CDM project supervision and management point of view; develop and establish scientific, concrete and China-specific indicators for sustainable development; institutionalise the assessment of CDM projects' impact on sustainable development, introduce a clear definition of technology transfer to China's National CDM Project Board in order to enhance the management of CDM projects and strengthen the post-evaluation of CDM projects. The government should further more strengthen the capacity of industries, ensure the availability of information, increase public awareness and facilitate the role of public supervision.

The European policy-makers should identify European interests and introduce policies and measures that enable businesses to take advantage of CDM business opportunities, take action to eliminate supply-side barriers to technology transfer and facilitate the technology transfer in CDM projects[6], enact new bills to increase the share of credits from CDM in EU-ETS carbon market and establish a specific carbon fund for purchasing CERs generated from CDM.

The UN should perfect the CDM project management institutions and regulatory framework, issue favourable policies and incentive measures (such as shorten the review cycle of the CDM projects alike) to encourage "Gold Standard" CDM project development, establish reasonable international mechanisms and methodology development compensation schemes which provides rewards and compensation to CDM methodologies which evidently enable technology transfer and highly contributes to sustainable development in developing countries. The UN should further more strengthen and improve the supervision and management of DOEs, perfect the additionality tools proposed in the Protocol, and ensure that the additionality requirements in real sense serve rather than hinder the purposes of the CDM. The UN also should enhance the capacity building of CDM and sustainable development in developing countries.

[6] See Technology Transfer in CDM Projects in China report

Abbreviation

AAU	Assigned Amount Units
CBM	Coal-Bed Methane
CDM	Clean Development Mechanism
CDMF	Clean Development Mechanism Fund
CER	Certified Emission Reductions
CMM	Coal Mine Methane
DNA	Designated National Authority
DOE	Designated operational entities
EB	Executive Board
ERPA	Emission Reduction Purchase Agreement
ET	Emissions Trading
EU ETS	EU Emission Trading System
EUA	EU emission Allowance
HFC	HydroFluoroCarbon
IRR	Internal Return Rate
MATA-CDM-China	Multi-Attributive Assessment of CDM specific for China
MoFA	Ministry of Foreign Affairs
MoST	Ministry of Science and Technology
NDRC	National Development and Reform Commission
NGCC	natural gas/steam combined cycling
PCDM	Programmatic Clean Development Mechanism
PDD	project design document
PFC	Per-FluoroCarbons
tCO_2e	Tonnes of CO_2 equivalent
UNFCCC	United Nations Framework Convention on Climate Change

Contents

Introduction

Climate change and sustainable development are the two great challenges that the mankind must face today and it is internationally recognized that the climate change shall be addressed under the framework of sustainable development. The United Nations Framework Convention on Climate Change ("the Convention") taking effect in 1994 includes sustainable development as one of the three basic principles for addressing climate change and specifies that "the Parties have a right to, and should, promote sustainable development. Policies and measures to protect the climate system against human-induced change should be appropriate for the specific conditions of each Party and should be integrated with national development programmes, taking into account that economic development is essential for adopting measures to address climate change." The Delhi Ministerial Declaration on Climate Change and Sustainable Development ("the Delhi Declaration") adopted at the Eighth Session of the Conference of the Parties to the Convention held in New Delhi, India in 2002 further defines that climate change issues should be addressed under the framework of sustainable development. In this context, all the countries formulate national strategies against climate change and integrate them with those for sustainable development.

As the Kyoto Protocol ("the Protocol") entered into force in 2005, the idea that the mankind shall address climate change under the framework of sustainable development becomes clearer and takes shape. The Protocol introduces three flexible mechanisms – joint implementation (JI), emissions trading (ET) and clean development mechanism (CDM), in order to stimulate the Annex I Parties (mainly developed countries) to achieve their quantified emission reductions during the first commitment period (2008-2012) by means of cost efficiency. The Protocol clearly defines that the purpose of the clean development mechanism "shall be to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments". In other words, sustainable development is the overall purpose of addressing climate change, while the clean development mechanism and others are concrete measures, approaches and methods for addressing climate change and such measures, approaches and methods must serve sustainable development.

As one of the three mechanisms specified in the Protocol, CDM is a flexible project-based mechanism by which both developed and developing countries may cooperate to achieve emission reductions. Such trade mechanism is intended to combine climate change and sustainable development in an organic fashion, so as to realize a "win-win" situation, creating greenhouse gas emission reductions by means of cost efficiency throughout the world and facilitating the sustainable development of developing countries. Since the Protocol's entry into force, CDM projects have developed fast in lots of developing countries and become the key contributor to the global carbon market. Up to 1st June 2009, a total of 4,995 CDM projects have been submitted to designated operational entities (DOE) for approval. The emission reductions generated by all the CDM projects submitted for approval are expected to come to about 2.748 billion tons of carbon dioxide equivalent by 2012 and to about 7.756 billion by 2020, with the amount of carbon emissions trading reaching nearly USD 80 billion[7]. From this point of view, CDM has not only made a great success in stipulating developed countries to reduce greenhouse gas emissions at low cost, but been widely recognized for changing the emission methods of certain enterprises and enabling the enterprises of developing countries to participate in the world carbon market. In the meantime, the public awareness of climate change has been enhanced to a certain degree, due to extensive implementation of CDM projects in a great deal of countries.

However, with continuous development and gradual progress of CDM projects, there has been doubt that CDM projects can or to what extent help developing countries achieve their sustainable development objectives. There is an increasingly louder call for reform of the existing clean development mechanism, which has become one of the significant topics of post-Kyoto climate change talks. The European Union (EU) suggested to find balance between EU Emission Trading System (ETS) and CDM carbon market and to make more use of EU ETS during the next commitment period. African countries also raised some issues in relation to the balance of regional allocation of CDM projects.

At the same time, researches on CDM projects and sustainable development have been actively initiated home and abroad in recent years and reached a key conclusion that CDM projects have not fully achieved the goal of assisting developing countries in promoting their sustainable development. However, such conclusion is insufficient to explicitly judge whether CDM projects help developing countries realize sustainable development, especially for China. The reason is that: first, there is insufficiency in the research methods, that is, current research and assessment is mainly based on documents, such as project design document and summary of literature, and lacks of field investigation and interviews with stakeholders; second, such researches mainly relate to CDM projects in India and South Africa rather than in China; third, the evaluation methods used are in defect of credibility and much few assessment indicators can seldom reflect every aspect of sustainable development; fourth, most of the assessment of impact upon sustainable development is qualitative description instead of quantitative evaluation; fifth, the assessment is limited to individual cases and does not extend to macro assessment and rise into the policy and institutional level.

As the largest developing country and the second largest greenhouse gas emitter in the world, China has great potential in the development and implementation of CDM

[7] From 2009 statistics on UNEP Risoe Center website, see details on http://www.risoe.dk

projects. In recent years, the Government of China has thrown itself into the promotion of CDM projects, to face the severe challenges of climate change with actual efforts. China has now had the largest amount of CDM projects registered with and CERs issued by the CDM Executive Board. Up to 19th July 2009, China has registered 588 CDM projects with the CDM Executive Board, accounting for about one third of total CDM projects in the world, which are expected to generate about 190 million tons of CERs annually. CDM Executive Board has issued 121 CDM projects out of the above 588 projects and the CERs issued come to nearly 144 million tons of carbon dioxide equivalent, reaching about two thirds of total CERs issued in the world[8]. Therefore, it is of significance to make research on the impact of China CDM projects upon sustainable development.

According to Marrakesh Accords adopted in 2001, the criterion for judging whether CDM projects realize the sustainable development objectives shall be set by the Host Party. Taking into account the calls for balanced regional allocation of CDM projects and for reform of the existing clean development mechanism, and the harmonious development between CDM carbon market and EU ETS, China should focus its attention on how to exercise the rights of the Host Party and give full play to the advantages of CDM, in order to promote China's sustainable development to the utmost extent. Therefore, it is necessary to correctly understand the impact of China CDM projects upon sustainable development, in other words, to research and assessment such impact.

As a result, relevant organizations of China and EU decide to, through EU-China CDM Facilitation Project, do joint research on assessment of the impact of China CDM projects upon sustainable development. This joint research begins with an expatiation of international rules and China's policies on CDM, gives an overview of the development of CDM and the carbon market, proposes a scientific method appropriate for assessing the impact of China CDM projects upon sustainable development, assesses with such method the actual impact of China CDM projects upon sustainable development in the form of quantitative result, conducts analysis of stakeholders and ends with policy suggestions for improving the clean development mechanism and enhancing the impact of CDM upon sustainable development.

[8] From UNFCCC website, see details on http://cdm.unfccc.int

1. International rules and China's policies on CDM

Entering 1980s, the whole world has been gradually recognizing the severity of climate change issues and there have been an increasingly louder call for researches on climate change and for preparation of relevant countermeasures. In view of this, the 45th session of the United Nations General Assembly adopted the Resolution No. 45/212 on 21st December 1990, deciding to establish an Intergovernmental Negotiating Committee for framework convention on climate change, which was responsible for the preparation of an international convention on climate change through negotiations. On 9th May 1992, the Intergovernmental Negotiating Committee adopted in New York the United Nations Framework Convention on Climate Change which was executed on 21st March 1994.

The objective of the Convention is to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. As to how the countries share the responsibilities when addressing climate change, the Convention provides that developed and developing countries assume "common but differentiated responsibilities", that is, all the parties to the Convention are obliged to take action against climate change, while developed countries taking historical and current liabilities for climate change ought to bear more obligations and developing countries should give priority to economic development and poverty eradication. In this context, Parties to the Convention are divided into two classes: Annex I and Non-Annex I parties. At present, there are 41 Parties included in Annex I, most of which are developed countries, with the European Communities as a single Party. Non-Annex I parties are usually known as developing country parties, who make general commitment to climate change, do not have binding emission reduction targets and need external assistance to address climate change. The Convention requires all the Parties included in Annex I to take the lead in modifying longer-term trends in anthropogenic emissions of greenhouse gas, but it doesn't provide concrete quantified emission limitation or reduction criteria for developed countries.

In 1997, the 3rd session of the Conference of the Parties to the Convention held in Kyoto, Japan adopted the Kyoto Protocol ("the Protocol"), which provides binding quantified emission limitation or reduction criteria for developed countries, but doesn't set up emission limitation or reduction obligations for developing countries. According to the Protocol, the countries included in Annex I to the Convention shall reduce their overall emissions of greenhouse gas averagely by 5.2% below 1990 levels in the first commitment period 2008 to 2012, each country subject to a specific emission reduction criteria, e.g. EU 8%, Japan 6%, Russian "0" and Australia -8%. The USA withdrew from the Protocol in 2002 and has been not assuming any substantial emission reduction obligations since then.

The Protocol establishes three “flexible mechanisms” enabling the Annex I Parties to cooperate with other Parties and achieve some of their emission reduction goals at lower cost. The three mechanisms are: joint implementation (JI), emissions trading (ET) and clean development mechanism (CDM). The former two mechanisms mainly mean the cooperation between Annex I Parties; the CDM is the cooperation between Annex I Parties and developing country Parties, with an aim to assist non-Annex I Parties in achieving sustainable development and in contributing to the ultimate objective in favor of the Convention and to assist Annex I Parties in achieving compliance with their quantified emission limitation and reduction commitments. In other words, Annex I Parties, by offering financial and technical support, develop project-level cooperation with developing countries in emission reduction, and additional “certified emission reductions” (CER) resulted from such projects can be regarded as Annex I parties’ compliance with their emission reduction commitments under the Protocol.

Following adoption of the Protocol at the 3rd session of the Conference of the Parties to the Convention, the 7th session of the Conference of the Parties to the Convention held in Marrakesh, Morocco in 2001 further adopted a series of concrete rules in respect of the flexible CDM under the Convention. In 2005, the first session of the meeting of the Parties to the Protocol made relevant decisions to enable the abovementioned rules to come into force. Since then, the international rules system for CDM begins to work.

In China, the Interim Measures for Operation and Management of Clean Development Mechanism Projects (“Interim Measures”) was promulgated on 31st May 2004 and took effect as of 30th June 2004, to facilitate the effective management of CDM projects. After more than one year implementation of the Interim Measures, China made certain modifications to it in accordance with the circumstances and promulgated and implemented on 12th October 2005 the Measures for Operation and Management of Clean Development Mechanism Projects in China (“the Measures”) which defines the basic management framework, rules and procedures for the development of CDM projects in China.

At present, the development of CDM projects in China shall not only be consistent with international management systems and rules, but also comply with the management systems and policies in China. Organic combination and gradual improvement of international and domestic CDM systems provides an institutional support for effective development and implementation of CDM projects in China.

1.1 International CDM rules and regulations

1.1.1 International CDM management system

The international administrative organization for CDM consists of the meeting of the

Parties and CDM Executive Board. The Conference of the Parties to the Convention serving as the meeting of the Parties to the Protocol is the supreme authority and guidance body for CDM, taking the responsibility for preparation of essential CDM rules and settlement of significant issues in CDM through negotiations, as specified in the Protocol. CDM Executive Board (EB) is the supervisory body for CDM, which supervises the clean development mechanism under the authority and guidance of the Conference of the Parties to the Convention serving as the meeting of the Parties to the Protocol (CMP) and is fully accountable to the CMP.

CDM Executive Board comprises ten members from the Parties to the Protocol, as follows: one member from each of the five United Nations regional groups, two other members from the Parties included in Annex I, two other members from the Parties not included in Annex I, and one representative of the small island developing states. Members of the Executive Board are elected by the meeting of the Parties for a term of two years and be eligible to serve a maximum of two consecutive terms. The Executive Board shall elect its own Chair and Vice-Chair, with one being a member from a Party included in Annex I and the other being from a Party not included in Annex I. The positions of Chair and Vice-Chair shall alternate annually between a member from a Party included in Annex I and a member from a Party not included in Annex I. The Executive Board shall meet as necessary but no less than three times a year. For the purposes of rules of the procedure, decisions by the Executive Board shall be taken by consensus, whenever possible, as specified in relevant regulations. If all efforts at reaching a consensus have been exhausted and no agreement has been reached, decision shall be taken by a three-fourths majority of the members present and voting at the meeting. Members abstaining from voting shall be considered as not voting. Meetings of the Executive Board shall be open to attendance, as observers, by all Parties and by all UNFCCC accredited observers and stakeholders, except where otherwise decided by the Executive Board.

As the most important body in the implementation of CDM, the CDM Executive Board is responsible for boosting, guiding and supervising the implementation of CDM projects and deciding whether to approve and register CDM projects and to issue the CERs generated by such projects. Other functions of the Executive Board are shown as follows:

I. To prepare detailed procedures for implementation of CDM, according to the decisions and guidance by the Meeting of the Parties;

II. To propose simplified modalities of small-scale CDM projects;

III. To review and approve the baselines and monitoring methodologies of CDM;

IV. To be responsible for the accreditation of "designated operational entities" (DOE), in accordance with relevant accreditation standards, and make recommendations to the Meeting of Parties for the designation of operational entities, including decisions on re-accreditation, suspension and withdrawal of accreditation and operationalization of accreditation procedures and standards;

V. To develop and maintain the CDM registry, and develop and maintain a publicly available database of CDM project activities containing information on registered project design documents, comments received, verification reports, its decisions as well as information on all CERs issued;

VI. To propose and draft various policies relating to CDM and report on them to the Meeting of the Parties for approval.

1.1.2 Rights and obligations of developed and developing country parties in CDM implementation

According to relevant decisions in the Protocol and by the Meeting of the Parties, developed and developing country Parties and their enterprises have the rights and obligations as follows, when participating in CDM projects:

(1) Governments of developing country Parties: to be responsible for reviewing the compliance of the CDM project that has been submitted for approval and will be implemented within its country with its sustainable development requirements; to decide to approve the project as a CDM project and issue an approval document to the CDM Executive Board. The government of the host country of the project may, through issuance of policies and regulations and establishment of specific authorities, manage the CDM project cooperation between the business entities of the host country and the enterprises or organizations of developed countries. According to the rules, the government of a developing country Party may serve as a participant in CDM projects and carry out the CDM projects. However, in practical operations, the participant of a developing country Party in CDM projects is usually its enterprises.

(2) Governments of developed country Parties: to decide to approve the project that has been submitted for approval as a CDM project and issue an approval document to the CDM Executive Board. According to the rules, the government of a developed country Party may participate in CDM projects as a buyer, but in practical operations, the government of a developed country Party can assign its emission reduction task to the enterprises within its country. Accordingly, the participant of a developed country in CDM projects is its enterprises. Certainly, the government of a developed country Party can provide financial support and entrust financial institutions with the participation in CDM projects.

(3) Project participants of developed country Parties: the enterprise or financial institution of a developed country Party can provide financial or technical support in its cooperation with the project owner of a developing country Party, to obtain CERs generated by CDM projects.

(4) Project owners of developing country Parties: the enterprise of a developing country Party is responsible for carrying out CDM projects, getting financial and technical support from the enterprise or financial institution of a developed country

Party through cooperation and transferring the CERs generated by the projects to the enterprise or financial institution.

1.1.3 Requirements for eligibility of CDM project activity

(1) Qualification for participation

As specified in the Protocol and other relevant regulations, the countries participating in CDM project activities must be Parties to the Protocol. Parties participating in CDM project activities must designate a national authority (DNA) for CDM. Participation in a CDM project activity must be voluntary. In addition, any Annex I Party participation in CDM project activities shall also meet the following requirements:

- The Party has in place a national estimation system for greenhouse gas emissions, in accordance with relevant requirements;
- The Party has in place a national registry in accordance with relevant requirements;
- The Party has submitted annually the inventory of greenhouse gas emissions, including national inventory report and the common reporting format, in accordance with relevant requirements.

(2) Project emission reductions must be additional

In light of relevant provisions in the Protocol, prior to turning into a CDM project, a project must be certified to be able to generate emission reductions with such methods as have been recognized by the CDM Executive Board, and such emission reductions must be additional to any that would occur in the absence of the project baseline emissions. To put it simply, without a CDM project, such project or its equivalent cannot be implemented based on current conditions in China and such emission reductions cannot be generated, because of difficulties in financial benefit, financing, technologies and market or absence of relevant compulsory provisions in China's laws.

Take the wind power CDM projects for example. The power generation with wind can generate much less greenhouse gas emissions than that with coal. However, it would be difficult to construct a wind power project due to lack of funds or low expected earnings, if such project fails to obtain financial support through the implementation of CDM project. To the contrary, a coal-fired power project that can create higher earnings will be constructed to meet social needs. If a CDM project is carried out, the wind power project will be able to be constructed because of the reasonable economic benefits resulting from the selling of CERs. Accordingly, the CERs generated by the wind power CDM project should be additional to any that would occur in the absence of such CDM project.

1.1.4 CDM project activity cycle

The operation of a typical CDM project consists of seven steps, shown as follows:

(1) Preparation and submission of project design document (PDD)

The project owner need, during this step, focus its consultation and discussion with the foreign partner on the funds and technologies provided by the foreign partner and the CERs offered by the project to the foreign partner. Therefore, this step is the most important one for starting the whole project.

The project owner prepares the project design document in accordance with the official format of "project design documents (PDD)" issued by the CDM Executive Board, after consulting with its foreign partner of a developed country Party, and submits such PDD to the governments of both countries for approval. In doing so the project owner often needs to invite specific academic or consulting organization to help it with the PDD, especially with the issues relating to selection and calculation of the project baseline, project monitoring methodology and plan, design of project boundary, CERs possibly generated by the project, technologies and funds needed by the project.

(2) Approval of project design documents by authorities of both countries

In this step, the government of the developing country Party, i.e. the government of the project owner, should consider the compliance of the project with its sustainable development and CDM development policies and with its financial and technical regulations, when reviewing and approving the project. Upon approval of the project design document by the governments, an approval document will be issued and submitted to the CDM Executive Board.

(3) Validation of eligibility of CDM project activity by Designated Operational Entity (DOE)

Serving as a certification body, a designated operational entity, in accordance with CDM rules and requirements, validates the CDM project activity the project owner applies for, submits the project activity it considers eligible to the CDM Executive Board for approval and registration, and after such project activity is carried out, certifies the reductions in greenhouse gas emissions generated by such CDM project activity, and applies to the CDM Executive Board for issuance of CERs.

After the governments of both project participants review and approve the CDM project activity, the enterprise involved submits its project design documents to a DOE and entrusts the same with the validation of the CDM project activity. The enterprise need pay validation fee to the DOE. The DOE invited will, based on CDM rules and requirements, validate every aspect of the declared project activity. The DOE will firstly review the integrity and standardization of the documents; if the DOE finds the documents qualified, it will send experts to the site for verification, collect and listen to the opinions of stakeholders, and place the project activity on the Internet for public comment. The DOE will submit the project activity to CDM Executive Board for registration, after it validates that such project activity is eligible in accordance with all the terms and conditions in CDM rules.

(4) Approval and registration of project activity by CDM Executive Board

The designated operational entity submits the CDM project activity it considers eligible to the CDM Executive Board, and, under normal conditions, such project activity can be deemed to be approved and registered 8 weeks after the date of submission, unless at least three members of the CDM Executive Board or a Party involved in the project activity raise an objection.

(5) Monitoring the implementation of CDM project activity

When the project activity is registered, the project owner and its partner carry out the project activity and monitor the implementation of the project activity based on the monitoring scheme proposed in the project documents.

(6) Verification/ certification of emission reductions

When the project activity has been carried out for a certain period of time, the project owner and its partner shall decide to invite another designated operational entity (DOE) to verify the reductions in greenhouse gas emissions generated by such project activity. However, the rules currently in force do not specify a time period after which the reductions in greenhouse gas emissions shall be verified. Such period can be agreed upon by both project participants. In addition, a conventional CDM project activity prohibits the invitation of the same designated operational entity that has validated the project activity for verification of the emission reductions of such project activity. Therefore, it is necessary to invite another designated operational entity to perform the verification. The designated operational entity shall, based on its verification report, certify in writing that, during the specified time period, the project activity achieved the verified amount of emission reductions, and shall inform the project participants and the Parties involved of its certification report in writing immediately upon completion of the certification process, submit the same report to the CDM Executive Board for approval, and make such report publicly available. Such certification report includes the quantity of CERs the Executive Board is requested to issue.

(7) Issuance of CERs by CDM Executive Board

Upon receipt of any request for issuance of CERs, the CDM Executive Board shall, within 15 days, approve the issuance of such CERs, unless at least three members of the CDM Executive Board or a Party involved in the project activity raise an objection, and shall, in accordance with the allocation scheme specified in the contract entered into by and between the project participants involved, forward the remaining CERs to the special “account” designated by the project participants involved in a prompt fashion, after deducting administrative expenditure and adaption fund from such

CERs.

Below find a graphical representation of the abovementioned project activity cycle in Figure 1.1:

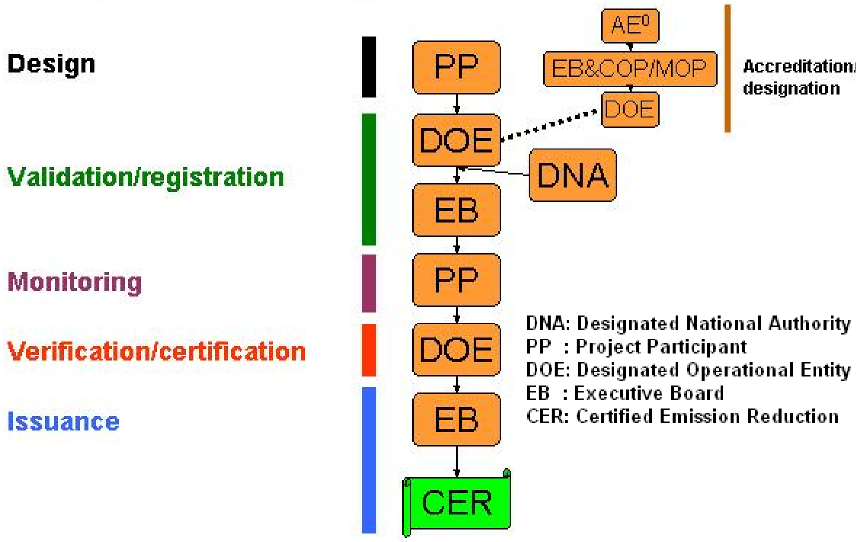

Figure 1.1: CDM project activity cycle

1.2 China's CDM management system and policies

1.2.1 China's CDM project management system

The Measures for Operation and Management of Clean Development Mechanism Projects in China ("the Measures") currently in force in China stipulates that China's CDM institutional bodies include the National Leading Group on Climate Change, National CDM Board, National Development and Reform Commission (NDRC), CDM Project Management Center and CDM Fund Management Center. NDRC is China's Designated National Authority (DNA) for CDM.

(1) National Leading Group on Climate Change

The National Leading Group on Climate Change is in charge of review and coordination of important CDM policies, with responsibilities for reviewing national CDM policies, rules and standards; approving members of the National CDM Board; and reviewing other issues that need to be decided by the Leading Group.

(2) National CDM Board

As specified in the Measures, National CDM Board ("the Board") is hereby established under the National Leading Group on Climate Change. National

Development and Reform Commission (NDRC) and Ministry of Science and Technology (MOST) serve as co-chairs of, and Ministry of Foreign Affairs (MFA) serves as the vice chair of, the Board. Other Board members are Ministry of Environmental Protection, China Meteorological Administration, Ministry of Finance, and Ministry of Agriculture. The Board is responsible for reviewing CDM project activities; reporting to the National Leading Group on Climate Change the overall progress of CDM project activities, issues emerged, and further recommendations; making recommendations on the amendments to the Measures.

(3) Designated National Authority

At present, NDRC is China's Designated National Authority (DNA) for CDM, with the responsibilities for accepting CDM project application; approving CDM project activities jointly with MOST and MFA, on the basis of the conclusion made by the Board; issuing written CDM approval letter on behalf of the Government of China; supervising the implementation of CDM project activities; establishing the CDM project management institute, in consultation with other departments; dealing with other relevant foreign affairs.

(4) CDM Fund

The Measures specifies that whereas emission reduction resource is owned by the Government of China and the emission reductions generated by specific CDM project belong to the project owner, revenue from the transfer of CERs shall be owned jointly by the Government of China and the project owner. The Government of China will collect national benefits from CDM projects by type. The Measures also provide that the revenue collected from CER transfer benefits of CDM projects will be used in supporting activities on climate change. Currently, such revenue is collected and managed by China CDM Fund.

Established with the approval of the State Council of the People's Republic of China, China CDM Fund is a policy and development served, long-term, open, non-profit state-owned fund. Its assets are owned by the State and protected by the Constitution of the People's Republic of China and the laws. No organ, organization or individual is allowed to infringe upon such assets. The Ministry of Finance of the People's Republic of China is in charge of the Fund which is designed to, under the direction of the national strategy of sustainable development, support and promote domestic activities to address climate change. The objective of fund management is to give long-term financial support to China's activities against climate change issues and achieve value preservation and appreciation of the Fund, through operation and management of the Fund. The principles of fairness, justness, openness, efficiency, risk control and cost benefit apply to the management and use of the Fund. In this context, the MOF took the initiative in creating the CDM Fund Management Center in order to manage the China CDM fund.

The CDM Fund works under the direction of National CDM Fund Board. Members of the National CDM Fund Board are: National Development and Reform Commission

(NDRC), Ministry of Finance (MOF), Ministry of Foreign Affairs (MFA) and Ministry of Science and Technology (MOST). Detailed rules on raising and use of the fund are prepared jointly by MOF, NDRC and other related authorities. Key responsibilities of the CDM Fund include: to execute the resolutions of the National CDM Fund Board, organize and carry out fund operations under the supervision of fund authorities; to propose schemes for significant issues, such as fund management and use, and implement such schemes with approval of the National CDM Fund Board; to establish fund management rules and regulations, in order to standardize the fund operations and relevant financial management and accounting activities; to supervise and manage the whole process of fund projects; to organize the development and implementation of CDM Fund projects; to initiate international, domestic and local cooperation; to formulate reports on annual financial budget and final accounting of the Fund.

(5) CDM Project Management Center

NDRC authorized its Energy Research Institute to establish a national CDM project management center, in order to promote the development of CDM and international cooperation in climate change. The Center mainly performs functions as follows: to organize experts for review of CDM projects and provide comments; to establish the CDM project management database; to provide the information on development and management of CDM projects; to register and record CERs into the information system; to monitor and supervise the implementation of CDM projects; to carry out CDM-related capacity building activities; to provide management and technical consultation services; to be responsible for management and coordination of international cooperation implemented by the Department of Climate Change, NDRC; to be responsible for collecting information of the projects financed by China CDM Fund, under the direction of the Department of Climate Change, NDRC; to undertake related researches entrusted by the Department of Climate Change; to undertake the management and implementation of other international cooperation projects, as entrusted by other organs and authorities.

Below find China's CDM project management system in Figure 1.2:

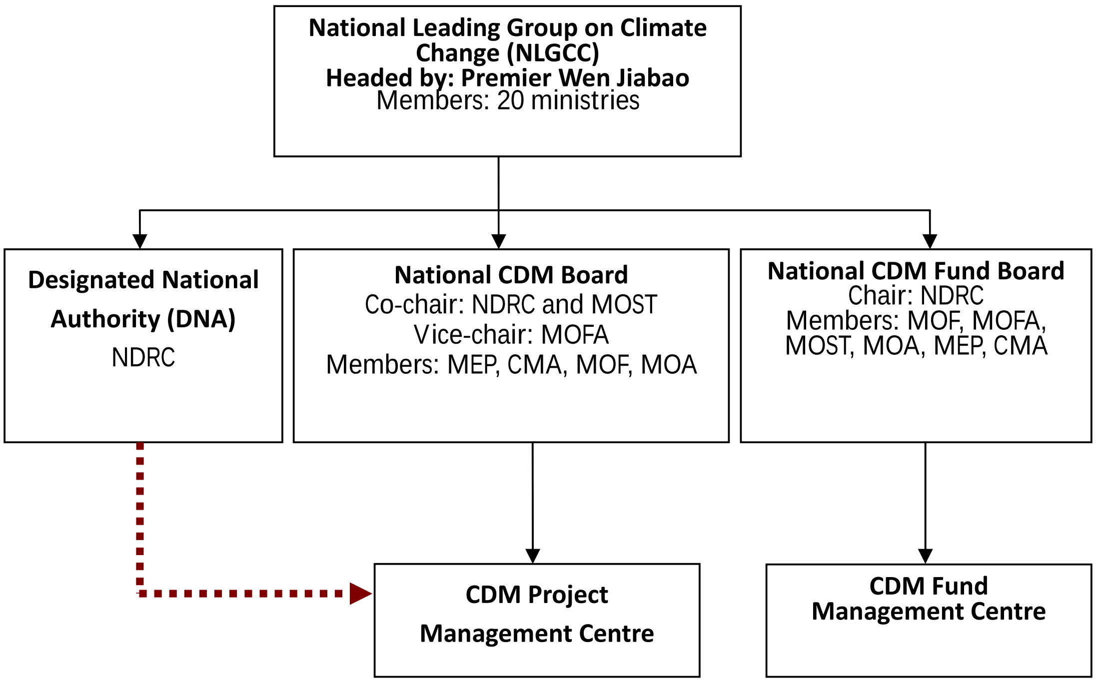

Figure1.2: China's CDM project management system

1.2.2 China's key CDM policies

China's key CDM policies are defined in the Measures for Operation and Management of Clean Development Mechanism Projects in China, including priority areas for CDM projects in China, collection of national benefits, requirements for eligibility of CDM projects in China. Related management measures with respect to the operation of CDM fund are to be issued. In addition, the Board will also formulate supplemental regulations in respect of the common issues in the operation of CDM projects, as the case may be.

(1) Priority areas for CDM projects in China

The priority areas for CDM projects in China are energy efficiency improvement, development and utilization of new and renewable energy, and methane recycle and use, as specified in the Measures.

(2) Collection ratio of national benefits

The Government of China will collect national benefits from CDM projects by type, with CDM projects within the priority areas enjoying the minimum ratios, shown as follows:

- The Government of China takes 65% CER transfer benefit from HFC and PFC projects;
- The Government of China takes 30% CER transfer benefit from N_2O project;
- The Government of China takes 2% CER transfer benefit from CDM projects in priority areas defined in the Measures and forestation projects.

(3) China's requirements for eligibility of CDM projects

The Measures define specific requirements for eligibility of CDM projects in China, which are consistent with the Protocol and relevant international rules, with details as follows:

- CDM project activities shall be consistent with China's laws and regulations, sustainable development strategy and policy, and its overall requirements for national economic and social development planning.
- The implementation of CDM project activities shall conform to the requirements of the Convention, the Protocol and relevant decisions by the Conference of the Parties.
- The implementation of CDM project activities shall not introduce any new obligation for China other than those under the Convention and the Protocol.
- Funding for CDM projects from the developed country Parties shall be additional to their current official development assistance and their financial obligations under the Convention.
- CDM project activities should promote the transfer of environmentally sound technology to China.
- Chinese funded or Chinese-holding enterprises within the territory of China are eligible to conduct CDM projects with foreign partners.

(4) Domestic procedures for implementation of CDM projects

According to the Measures, the implementation of CDM projects in China should, on the premise of compliance with international procedures and rules with regard to CDM, go through domestic procedures for approval of CDM projects, in addition to those for approval of specific construction projects in China (see Figure 1.3):

- Chinese funded or Chinese-holding enterprises applying for implementation of CDM projects within the territory of China, together with its foreign partner, shall submit to National Development and Reform Commission (NDRC) project application, as well as the CDM project design document, certificate of enterprise status, general information of the project, and a description of the project financing. Relevant departments and local governments may facilitate such project application;
- NDRC entrusts relevant organizations for expert review of the project

application is made for, which shall be concluded within 30 days;

- NDRC submits those project applications reviewed by the experts to the National CDM Board;
- NDRC approves, jointly with the Ministry of Science and Technology (MOST) and the Ministry of Foreign Affairs (MFA), the projects based on the conclusion made by the National CDM Board, and issues approval letter accordingly;
- NDRC will make a decision on project application within 20 days (excluding the expert review time) as of the date of accepting the application. The time limit for decision-making may be extended to 30 days, with the approval of the Chair or the Vice-chair of NDRC, if a decision could not be made within 20 days. The project applicant should be informed of such a decision and the reasons therefor;
- Project owner shall report to NDRC on the approval decision by the CDM Executive Board within 10 days as of the date of receiving the notice from the Executive Board.

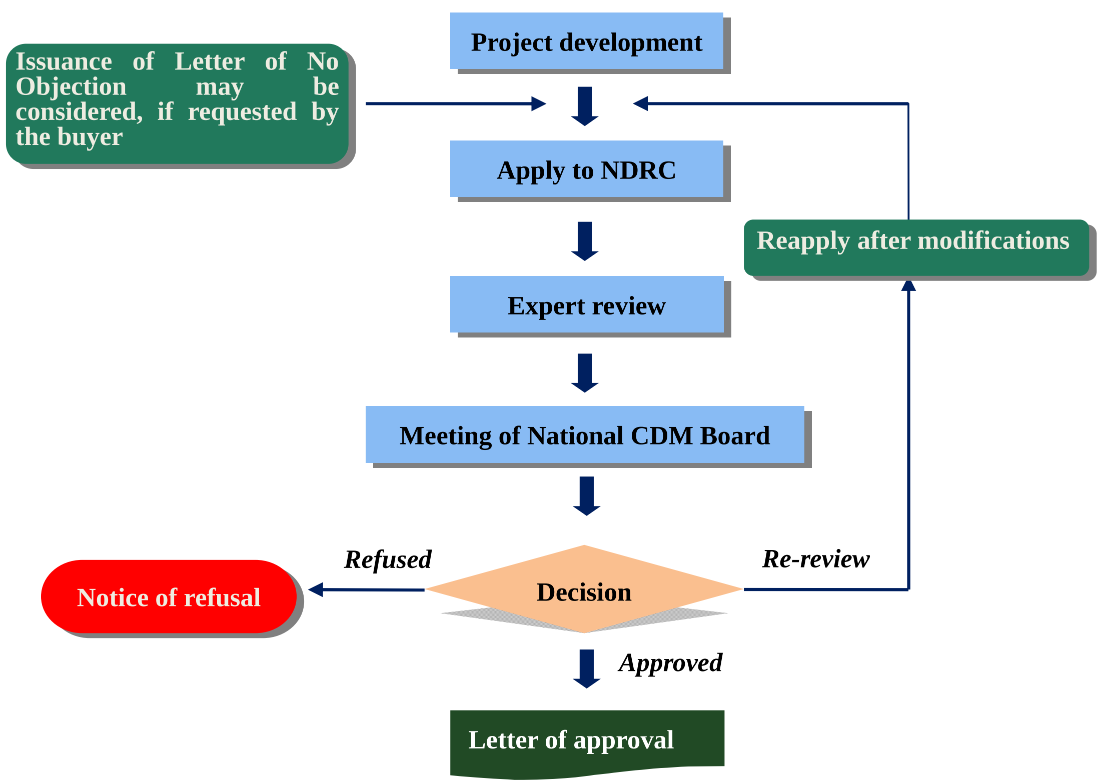

Figure1.3: Domestic procedures for approval of CDM projects in China

(5) Supplemental regulations

For any matters not mentioned in the Measures, e.g. specific requirements for and format of application documents submitted to the Board, the Board has issued supplemental regulations, to further improve China's CDM project management system. For example, CDM project owner must submit to NDRC such documents as: CDM project design document, certificate of enterprise status (business license), general information of the project, letter of approval for feasibility study of the project issued by NDRC or local Development and Reform Commission, and certificate of environmental impact assessment issued by national or local authority for environmental protection. In addition to these, the project owner must also submit to the Board the emission reduction purchase agreement (ERPA) or letter of intent to purchase, as well as consultation service contract, for review.

1.2.3 Other domestic policies relating to CDM

The Government of China also issues relevant policies and measures for the priority areas for CDM projects in China, such as new and renewable energy.

(1) Policies on new energies and renewable energies

As to the energy production realm, the Renewable Energy Law taking effect on 1st January 2006 specifies that the Government encourages and supports various types of grid-connected renewable power generation; grid enterprises shall enter into grid connection agreement with renewable power generation enterprises that have legally obtained administrative license or for which filing has been made, and buy the grid-connected power produced with renewable energy within the coverage of their power grid, and provide grid-connection service for the generation of power with renewable energy. The on-grid price of renewable energy power generation projects shall be determined by the price authorities of the State Council based on the characteristics of power generation with different types of renewable energy and on the conditions of different regions, and in the principle of being beneficial to the exploitation and utilization of renewable energy and being economic and reasonable, where timely adjustment shall be made on the basis of the development of technology for the exploitation and utilization of renewable energy.

The Provisional Measures on Administration of Pricing and Cost Sharing for Renewable Energy Power Generation taking effect on the same date as the Renewable Energy Law stipulates that the Guidance Price of the Government applies to the on-grid price for wind power projects and the pricing standard will be determined through bidding by the price authorities of the State Council. The Government Fixed Price applies to the on-grid price for solar, ocean and geothermal power projects and the pricing standard shall be determined in the principle of reasonable costs plus reasonable profits by the price authorities of the State Council. For biomass power generation projects where the government fixed price applies to the on-grid price, the price authorities of the State Council shall set yardstick tariff by region and the pricing standard shall be the addition of the yardstick on-grid price for desulphurizating coal-fired generating units in 2005 in respective provinces (autonomous regions, municipalities directly under the Central Government), and subsidy price which is RMB 0.25/kWh. Power generation projects shall enjoy 15 years of subsidy price, starting from the date of power production; the subsidy price shall be annulled after 15 years of operation of such projects. Since 2010, the subsidy price for power generation projects newly approved for construction each and every year shall be decreased by 2% over the subsidy price for those approved for construction in the preceding year. Mixed-fuel power generation projects with the conventional energy exceeding 20% in heat consumption for power production shall be regarded as conventional energy power generation projects and the yardstick tariff of local thermal power plants shall apply without enjoying the subsidy price. For biomass power generation projects with the investors determined through bidding, the guidance price of the government shall apply, i.e. the price of the bid winner which shall not be higher than the local yardstick tariff.

The Provisional Regulations on Allocation of Renewable Energy Tariff Surcharges taking effect on 11th January 2007 provide that the renewable energy tariff surcharges that will be collected by grid enterprise at provincial level shall be included into the revenues of such enterprise and be used to pay the renewable energy power subsidies of the province (region, city), the remaining of which is subject to quota trade and national balance. The renewable energy power subsidies include the excess of on-grid price for renewable energy power projects over the yardstick on-grid price for local desulphurizating coal-fired generating units, and the excess of maintenance fee of independent public renewable energy power system whose construction is supported by State investment or subsidy over the average sales power price for local provincial-level grid, as well as the grid connection fee for renewable energy power projects.

Regarding the utilization of renewable heat, the Renewable Energy Law provides that the Government encourages clean and efficient development and utilization of biological fuel and encourages the development of energy crops. If the gas and heat produced with biological resources conform to the technical standards for connection with urban fuel gas pipeline networks and heat pipeline networks, enterprises operating gas pipeline networks and heat pipeline networks shall accept them into the networks. The price of renewable heat and fuel gas that enters the urban pipeline networks shall be determined on the basis of price management authorities in the principle of being beneficial to the exploitation and utilization of renewable energy and being economic and reasonable. The Government encourages the production and utilization of biological liquid fuel. Gas-selling enterprises shall, on the basis of the regulations issued by energy authorities of the State Council or people's government at the provincial level, include biological liquid fuel conforming to the national standards into its fuel-selling system.

(2) Policies on energy conservation *The Law of the People's Republic of China on Energy Conservation*[9] going into force as of 1st January, 1998 provides that the State Council and the people's governments of provinces, autonomous regions and

---

[9] The Draft Amendment to the Law on Energy Conservation was adopted at the 30th meeting of the Standing Committee of the 10th National People's Congress and went into effect on April 1st,2008.

municipalities directly under the Central Government shall, pursuant to the energy strategy of promoting conservation and exploitation concurrently while giving top priority to conservation, decide on the optional energy conservation and exploitation projects for investment and work out plans for such investment on the basis of a comparative demonstration in terms of technology, economy and environment with regard to energy conservation and exploitation. The State Council and the people's governments of provinces, autonomous regions and municipalities directly under the Central Government shall allocate funds for energy conservation from funds for capital construction and technical upgrading, to support rational utilization of energy and exploitation of new and renewable energy resources. People's governments at the municipal and county levels shall allocate funds for energy conservation according to their actual conditions in order to support rational utilization of energy and exploitation of new and renewable energy resources. Special demonstration of rational use of energy shall be included in the feasibility study reports of fixed-assets investment projects. The design and construction of fixed-assets investment projects shall be consistent with standards for rational use of energy and for energy conservation design. Organs authorized with power of review and approval shall not approve the construction of any projects failing to conform to such standards; or accept such projects upon their completion.

The enterprise income tax may be exempted or reduced in relation to the incomes generated from the projects of environmental protection, energy and water conservation and satisfying the related requirements; as regards the amount of an enterprise's investment in purchasing special equipment for protecting environment, saving energy and water, work safety, etc., the tax amount may be deducted at a certain rate, as specified in the Enterprise Income Tax Law of the People's Republic of China taking effect on 1st January 2008.

(3) Other relevant regulations

Regarding projects of wind power construction, the Circular of the National Development and Reform Commission on Requirements for Administration of Wind Power Construction issued on 4th July 2005 defines that the approval of the construction of wind farm should be based on the planning for wind power development and include the size of wind farm, condition of the site, and localization rate of wind power facilities; the construction scale of wind farm should be consistent with relevant conditions such as power system, wind energy resources, etc.; the site of wind farm should be close to the power grid, for the purposes of convenient transmission of wind power; at least 70% of wind power facilities should be localized, and the construction of any wind farm failing to meet the localization rate requirements is prohibited; the customs should tax the imported facilities in accordance with relevant regulations.

Furthermore, relevant construction projects shall also comply with general regulations of China on review and approval of projects, e.g. on environmental impact assessment and feasibility study.

2. CDM and Global Carbon Market

This chapter mainly consists of three parts: firstly, the legal foundation, the main classifications of the carbon market and its development are introduced; and then the overall situation of global CDM carbon market, regional distribution and industrial distribution is discussed; finally, a simple analysis is done on the overview, regional distribution and industrial distribution of the CDM projects in China.

2.1 Overview of the Development of Global Carbon Market

As is mentioned before, in order to ensure the smooth completion of the reduction of greenhouse gas emissions in the first commitment period for the major developed countries (2008-2012), three flexible mechanisms were introduced in the Kyoto Protocol: JI, CDM and ET. Among the three mechanisms, JI and CDM are the project-based mechanisms for emission reduction; JI is applied among developed countries while CDM is mainly applied between developed and developing countries. Objectively speaking, these three flexible mechanisms for emission reduction are the important legal foundation for the formation of a global carbon market.

Although the Kyoto Protocol officially took effect in February 2005, given the potential for emission reduction generated by the CDM projects developed after 2000 in helping developed countries fulfil their emission reduction obligation in the first commitment period, and people's general optimism about carbon markets, the carbon transaction had started well before 2005. In addition, the so-called "global carbon market" in actuality includes various interconnected carbon transactions of various types. These carbon transactions include carbon trading schemes under the Kyoto Protocol and voluntary transactions beyond the Kyoto mechanism according to the transaction objectives. And the carbon transactions can also be divided into various carbon assets under different management schemes and contract categories, for example, the project-based emission reduction mechanisms including CERs under CDM and ERU under JI, and the cap & trade-based quota transactions, including AAU under ET mechanism and EUA under EU ETS. At the same time, carbon transactions can also be divided into spot and future transactions according to the delivery time; and the primary market transaction, secondary market transaction, exchange transaction and over-the-counter transaction according to the location of carbon transaction.

In light of the various complicated carbon transaction patterns, it is very difficult to get accurate statistics on the transactions of carbon market and at the same time, there are few institutions which can carry out systematic analysis on the global carbon market. At present, the relatively authoritative annual analytical reports on the global carbon market were issued by the World Bank and Point Carbon. Although the data provided in the two reports are different to some extent, they represent the changing tendencies of the carbon market. According to the Point Carbon's 2009 carbon market report Carbon 2009: Emission trading coming home, carbon transactions existed before 2004 but with a small market. As the Kyoto Protocol took effect in 2005, the carbon market has been developing rapidly and the scale of carbon transactions has doubled each year. By 2008, the total transaction volume for the global carbon market amounted to 4.9 billion tCO_2e, which has increased by about 7 times since 2005; and the amount of transactions was 12.5 billion US dollars, which had increased by about 11 times since 2005 (see Figure 2.1). According to the current situation and tendency reports from the World Bank on the carbon market in 2006 and 2009, the total transaction volume on the global carbon market is 4.811 billion tCO_2e and the transaction amount is 126.345 billion US dollars; the transaction volume increased by 592% from the 0.705 billion tonnes in 2005, while the transaction amount increased by 1050% from the 10.9 billion dollars in 2005. These two reports indicate that the carbon market is a fast growing one and its development speed has exceeded almost any other global transaction market in the same time. From the perspective of market composition, EU ETS has always accounted for a comparatively large market share, constituting around 60% since 2005. Therefore, EU ETS is considered the leading force for the development of the global carbon market.

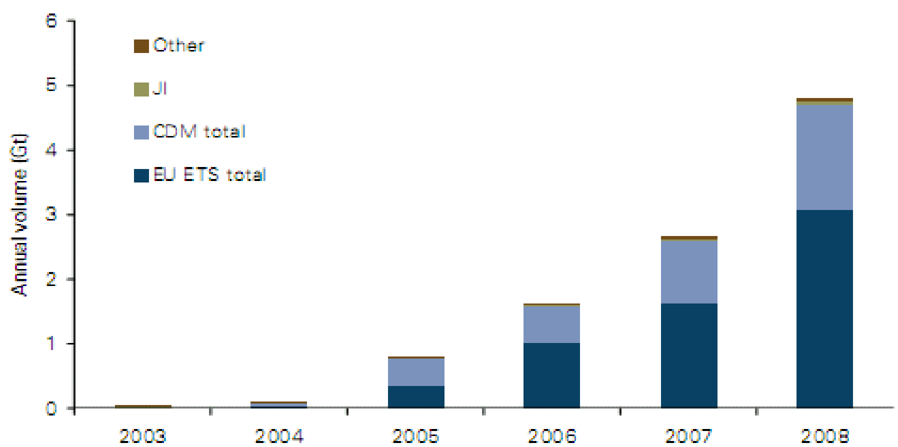

Figure 2.1: Change Tendency of Transaction Volume on Global Carbon Market

Data source: Point Carbon, Carbon 2009: Emission trading coming home.

As the transaction scale of the carbon market increases quickly, on the whole the price of various carbon commodities have also exhibited a continuous, upward trend. Based on the statistics of various carbon prices since December 2004 from Point Carbon (see Figure 2.2), the carbon prices show the following characteristics: first, the first and second transaction periods of the EU emission Allowance (EUA) are strongly linked to the transaction prices on the second market of CERs, and the prices in the second transaction period of EUA have a clear influence on other carbon prices; second, although prices fluctuate greatly, the overall tendency of various carbon prices is to rise step by step from less than 10 Euros per tCO_2e to the highest one of 29.38 Euros (among which the price of EUA reached this level in January 2008), which represents people's overall optimistic attitude toward the carbon market (the price in the first transaction period of EUA is special to some extent and it is necessary to carry out detailed analysis on the European carbon market); third, the global financial crisis has had a great influence on the carbon market and has resulted in great fluctuations in the carbon price.

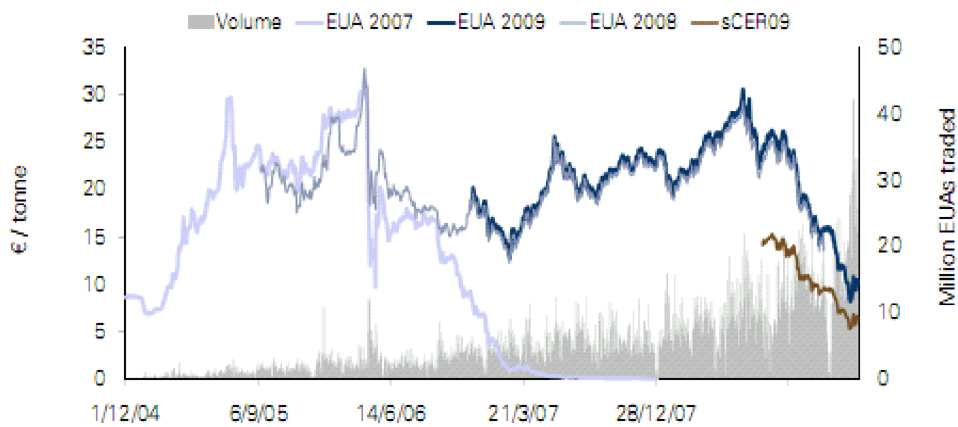

Figure 2.2: Change Tendency of ETS Carbon Market Prices in Europe

Data source: Point Carbon, Carbon 2009: Emission trading coming home.

Since 2008, the global financial crisis has become the key factor affecting the international carbon market mainly represented by the fast decrease of transaction volume on the carbon market and great slump in transaction prices. EUA prices have fallen to 7.5 Euros in March 2009 from the record 29.38 Euros in January 2008; however, carbon market begins to rise gradually (see Figure 2.3). The mechanism of the impact of the financial crisis on carbon market is: on the one hand, because of economic recession, many factories in Annex I countries stop production or reduce production, which results in the fall in energy demand and greenhouse gas emission; this automatic emission-reduction effect reduces the demand for carbon credits; In addition, because the investment of carbon resources highly relies on financial markets and several financial institutions have suffered losses during the recession, the capital supply that was used to support carbon resources has reduces accordingly. This is especially obvious in the CDM market; being affected by the financial markets, the development of many CDM projects has stopped and the transaction volume on the primary market has shrunk (see Figures 2.6 and 2.7). At the same time, the transaction prices on the CER primary market also fell by about 50% from about 14 Euros in September 2008 to 7 Euros in March 2009. However, some analysts think that at present the financial crisis could only yield a medium and short-term fluctuation in the carbon market without a long-term influence. With the rejuvenation of global economy, carbon market will return to normal. The main factors which affect the global carbon market are international climate system, energy market, long-term tendency of economic growth, etc.

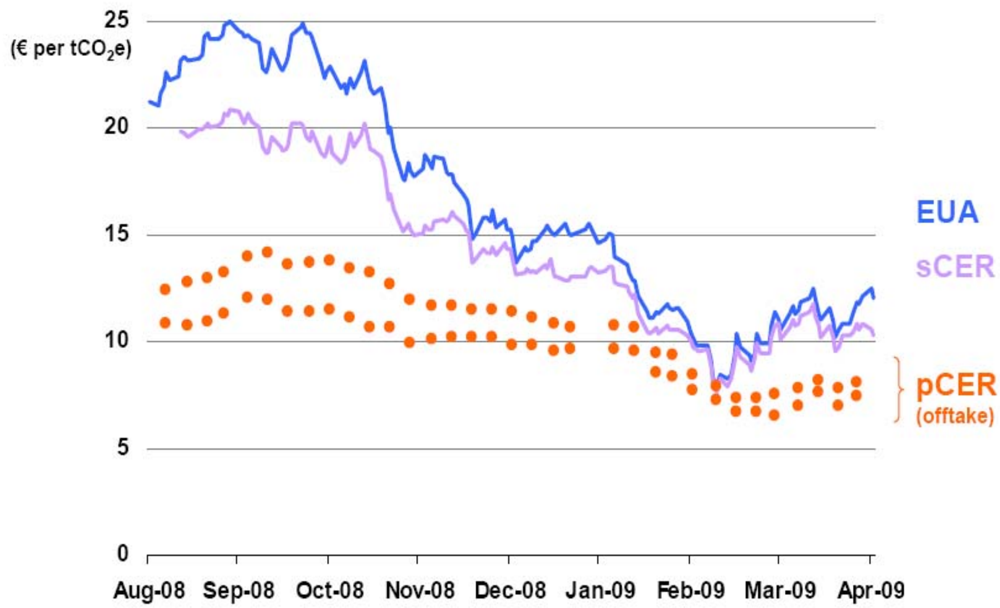

Figure 2.3: Influence of Financial Crisis on Carbon Market

Data source: World Bank State and Trends of the Carbon Market 2009

2.2 Development of Global CDM Market

2.2.1 Exploitation of Global CDM Projects

The year 2005 marked an important milestone for the utilisation of CDM projects and the development of the CDM carbon market. Before 2005, CDM projects had begun; as the Kyoto Protocol officially took effect in January 2005, CDM entered a fast-developing phase. In November 2004, only 48 projects were submitted to DOE for approval, but by 1 June 2009, 4,995 projects have been submitted for approval, a number which increased by more than 100 times. Among these projects, 1,652 projects have been registered in CDM Executive Board and 221 projects are in the review process (see Figure 2.4). It is predicted that the projects successfully registered at EB will produce reduce emission by 1.634 billion tCO_2e by 2012 (see Figure 2.5) and all the CDM projects which are submitted for approval will produce emission reductions of 2.748 billion tCO_2e by 2012. The entire generated emission reduction is predicted to be about 7.756 billion tons of CO_2e in 2020.

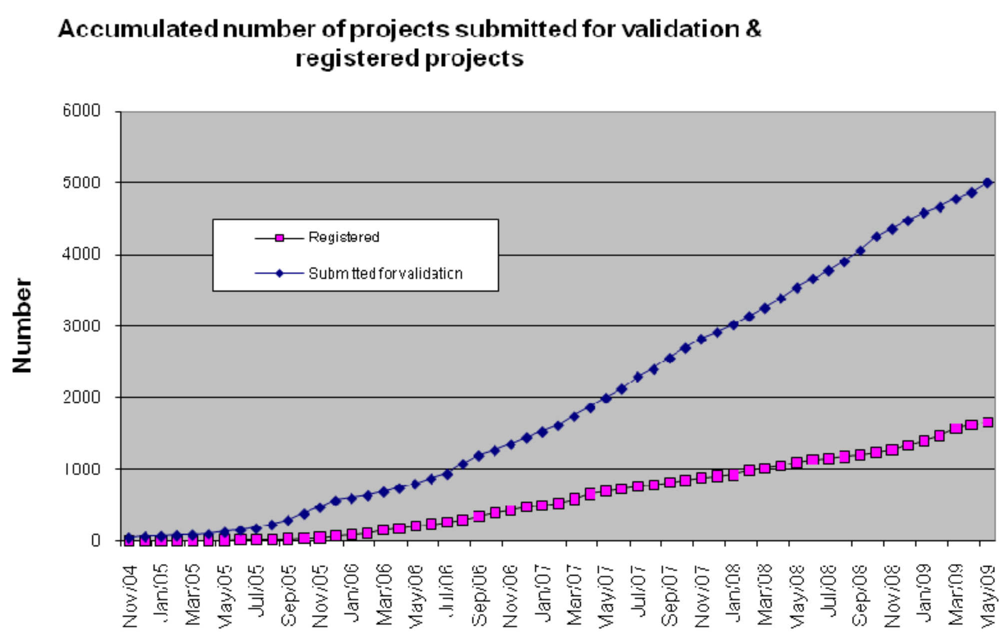

Figure 2.4: Number of CDM projects submitted for review and registration throughout the world

Data source: UNEP Risoe Center, 2009

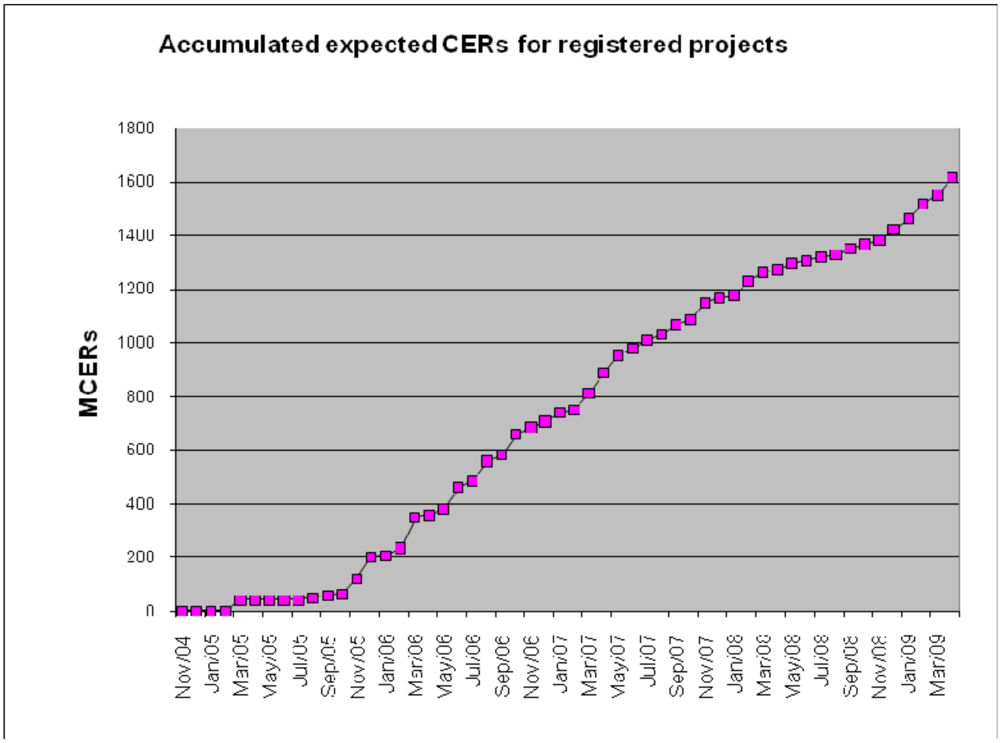

Figure 2.5: Predicted emission reduction of registered projects by 2012

Data source: UNEP Risoe Center, 2009

In recent years, the market transactions of CDM projects have been very active and develop quickly. In respect to the transaction volume, the primary markets of certified emission reduction (CERs) increased by a 252% after 2004, when it reached 0.341 billion tonnes in 2005. The CERs in 2006 also increased by about 58% from its level in 2005, and then CERs entered a phase of steady growth; however, affected by the financial crisis last year, the transaction volume in primary market for CERs has fallen nearly 30% from 2008 to 2009. We should also notice that the secondary market for CERs has maintained a high-speed increase ever since 2005: the transaction volume in 2008 increased by 107 times since 2005, with the increase in the annual growth rate ranging between 1.5 to 21 times. Even during the financial crisis, the transaction volume in 2008 also increased by 347% since 2007. In respect to the transaction amount, the primary market of CERs increased from 0.458 billion US dollars in 2004 to 7.433 billion dollars in 2007, an increase of 15 times. Affected by the financial crisis, the transaction volume in 2008 also fell by 12.3% against 2007. As for the secondary market, the transaction amount of CERs increased from 0.221 billion US dollars to 26.277 billion dollars, an increase of 117.9 times (see Figure 2.7). In addition, the transaction price for CERs has maintained a steady increase; judging from the average transaction price on the primary market for CERs, it grew from 5.15 US dollars in 2004 to 16.78 dollars in 2008 with an annual growth rate of about 40% (see Figure 2.8).

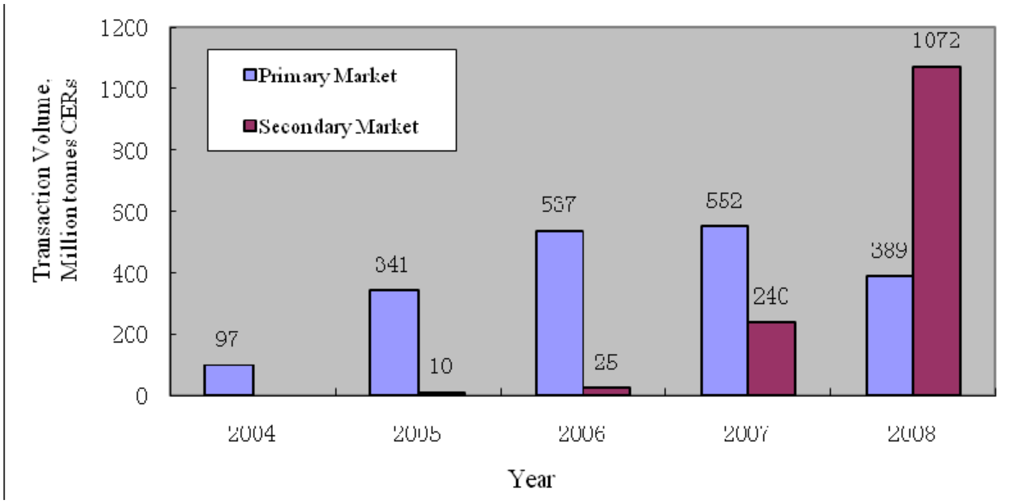

Figure 2.6: CERs transaction volume from 2004 through 2008

Data source: Based on the five annual reports of the State and Trends of the Carbon Market published by World Bank during 2005-2009

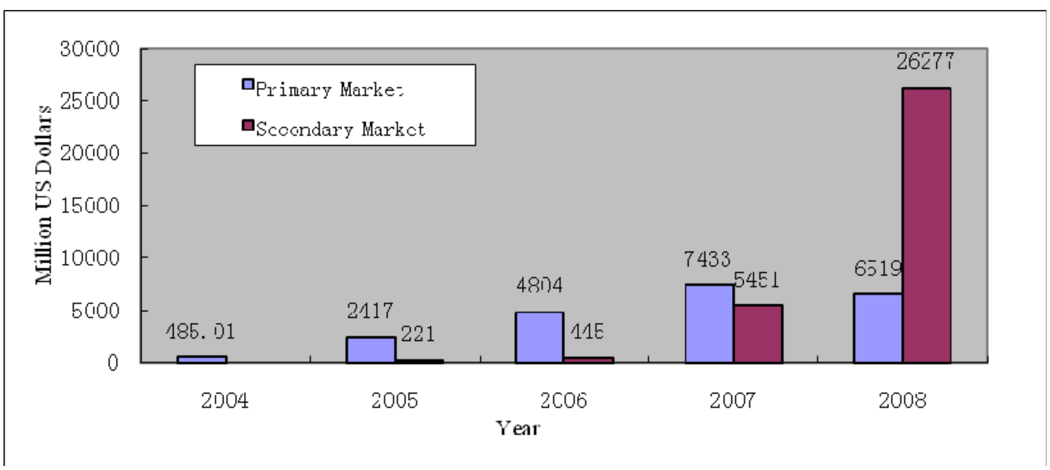

Figure 2.7: CERs transaction amount from 2004 through 2008

Data source: Based on the five annual reports of the State and Trends of the Carbon Market published by World Bank during 2005-2009

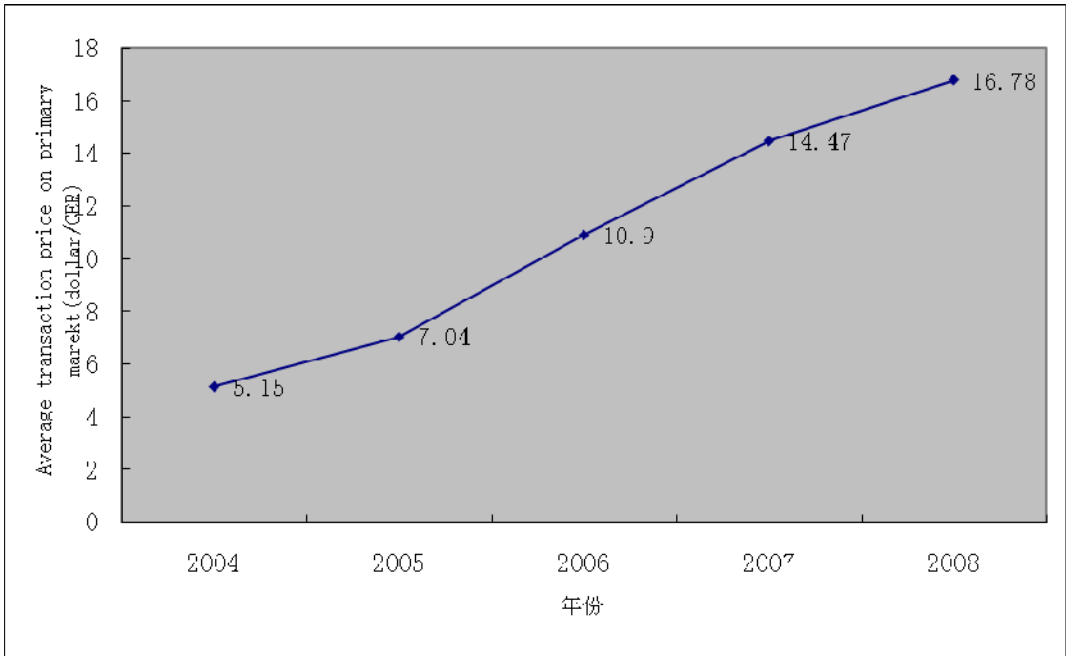

Figure 2.8: Average price on primary market of CERs from 2004 to 2008

Data source: World Bank: State and Trends of the Carbon Market 2005-2009

2.2.2Global Industrial Distribution of CDM Projects

The implementation of CDM in various fields relies on the potential of CDM implementation in various industries, the state of methodology development, and the different stakeholders' predictions regarding revenue, cost and risks inherent in the implementation of the CDM projects. First, in light of the greenhouse gas emissions related to the energy industry accounting for about 70% of the total greenhouse gas emission, the energy industry shall be the industry with the greatest potential for the development of CDM projects. Second, the project design documents must be compiled for the development of CDM projects according to the approved methodology; industries with more and easily applicable methodologies would have more CDM projects. By 5 July 2009, EB had approved 168 methodologies (including large-scale methodologies, methodologies for small project and large and small methodologies for afforestation and re-afforestation); among these methodologies, 44 belong to the industry for energy production (including the renewable and non-renewable energy), 26 belong to the manufacturing industry, 18 belong to the afforestation and re-afforestation industry, 17 belong to chemical industry, 15 belong to the waste treatment and 12 belong to the energy efficiency promotion at the demand side. The CDM methodologies are the most in energy industry; however, the number of methodologies is not directly related to the exploitation of projects in this industry, because many methodologies are ones that span multiple industries. In addition, although in some fields the methodologies in some fields are numerous; these methodologies are too complicated and applied rarely. Moreover, the utilisation of CDM projects in each industry also relies on the revenue, costs and risks of project development, the complexity of project development and additional issues. As a whole, the project development in the field of renewable energy (like wind power and hydraulic power) is relatively simple with clear additionality, and is where the risk is comparatively small and the cost is low for project implementation.

Based upon the three factors mentioned above, the implementation of CDM in various industries is different to some extent. As table 2.1 shows, in respect to project number, the renewable energy is the most important field for CDM implementation with 2,877 projects entering the approval procedures (including the registered ones), accounting for 65% of the total number of projects; the second one is the coal-bed methane field with 623 projects accounting for 14%; and the third is the field of energy efficiency at the supply side with 452 projects accounting for 10%. Viewed from the perspective of the anticipated annual emissions reduction for these projects, the renewable energy also accounts for the highest proportion, or more specifically, 41%. As for the decomposition projects involving HFCs, PFCs and N_2O, because the emissions reduction of single project is generally large, although there are not many of this kind of project currently under operation, their anticipated annual emissions reduction is great, which ranks second at 22%. The next is coal-bed methane and energy efficiency at the supply side, which are 16% and 12% respectively.

Table 2.1: Industrial distribution of CDM projects

Type	Projects in CDM approval procedures		Annual emission reduction		Emission reduction by 2012	
	No. (pcs)	Proportion (%)	Million tons (Mt CO_2)	Proportion (%)	Million tons (Mt CO_2)	Proportion (%)
HFCs/PFCs/N_2O decomposition	100	2%	133.26	22%	739.03	27%
Renewable energy	2877	65%	248.59	41%	1009.68	37%
Coal-bed methane	623	14%	97.76	16%	482.94	18%
Energy efficiency at supply side	452	10%	73.47	12%	288.1	10%
Fuel substitute	122	2.80%	40.58	6.72%	178.16	6.50%
Energy efficiency at demand side	185	4.20%	7.02	1.16%	33.08	1.20%
Afforestation and re-afforestation	48	1.10%	2.39	0.40%	12.36	0.40%
Communications	10	0.20%	0.99	0.20%	4.78	0.20%
Total*	**4417**	**100%**	**604.06**	**100%**	**2748.14**	**100%**

Data source: Risoe Centre of UN Environment Programme. Since the figures have been rounded, some of the sub-totals may be different from the sum of all items.

It is obvious that no matter one examines from the project number or the anticipated annual emissions reduction, the energy industry, especially the renewable energy industry, is the most important area for CDM. However, it was once anticipated that projects from energy conservation in the construction and communications industries for enhancing energy efficiency would also become the most important fields for CDM implementation, however the end result was quite different. This is mainly because these fields are hard to measure and monitor, and the project implementation is too complicated and the additionality is difficult to prove, which results in excessively high cost and greater risks during project implementation. Take energy conservation in the construction industry for example. The potential of energy conservation and greenhouse gas reduction in the construction industry is great; however, because the large number of related technologies, the boundaries are hard to define. At the same time, energy consumption in the construction industry is affected by various factors such as weather, terrain, management, way of life, etc., therefore, there are many complications when measuring and monitoring the emission reduction caused by energy conservation transformation in the construction industry. In addition, the investment of capital required will be massive in order to make existing buildings energy efficient, and the revenue brought by emission reduction is small. Because of the abovementioned reasons, it is not economically possible to implement CDM for energy conservation in the construction industry. Therefore, there is no CDM project of energy conservation in the construction industry submitted to EB for registration.

2.2.3 Regional Distribution of CDM Projects

The CDM implementation is also imbalanced in different regions and countries. From the number projects submitted to DOE for approval, the Asia-pacific region takes a dominant lead; at present, the CDM projects have amounted to 3,432 in this region, accounting for 77.65% of those submitted for the whole world. The anticipated emission reduction of these projects is 2.225 billion tCO_2e by 2012, accounting for 80.88 % of the entire world’s reductions. The second is Latin America: the CDM projects have amounted to 791 accounting for 17.9% and the anticipated emission reduction by 2012 will be 0.392 billion t CO_2e accounting for 14.24% of the whole world. Meanwhile, the implementation of CDM in Africa, the Middle East and Central Asia is not ideal; neither the project number nor the anticipated annual emission reduction exceeds 3% of the whole world. The CDM distribution is imbalanced between regions and the distribution in countries is also clearly different: the project number in only three countries of China, India and Brazil accounts for 72.1% of the whole world and the anticipated emission reduction of these projects will be as high as 77.11% by 2012.

Table 2.2: Regional distribution of CDM projects

Region/country	Number (pcs)	Proportion (%)	Emission reduction until 2012	Proportion (%)
Latin America	**791**	**17.90**	**391.72**	**14.24**
Incl.: Argitina	25	0.57	29.42	1.07
Brazil	340	7.69	173.82	6.32
Chile	69	1.56	40.08	1.46
Columbia	41	0.93	18.62	0.68
Mexico	155	3.51	65.53	2.38
Peru	29	0.66	14.71	0.53
Asia-pacific region	**3432**	**77.65**	**2224.72**	**80.88**
Incl.: China	1726	39.05	1520.24	55.27
India	1123	25.41	426.97	15.52
Indonesia	89	2.01	39.40	1.43
Malaysia	130	2.94	37.74	1.37
Philippines	77	1.74	12.02	0.44
Singapore	8	0.18	2.02	0.07
Korea	61	1.38	102.56	3.73
Sri Lanka	18	0.41	2.42	0.09
Thailand	96	2.17	25.82	0.94
Viet Nam	68	1.54	18.27	0.66
Europe and Central Asia	**48**	**1.09**	**19.31**	**0.70**
Incl.: Armenia	7	0.16	1.36	0.05
Cyprus	8	0.18	1.37	0.05
Moldova	6	0.14	1.43	0.05
Uzbekistan	10	0.23	7.08	0.26
Africa	**101**	**2.29**	**81.53**	**2.96**
Incl.: Egypt	12	0.27	16.27	0.59
Kenya	14	0.32	2.91	0.11
Morocco	10	0.23	2.60	0.09
South Africa	27	0.61	19.57	0.71
Uganda	10	0.23	1.23	0.04
Middle East	**48**	**1.09**	**33.45**	**1.22**
Incl.: Israel	27	0.61	11.94	0.43
Jordan	3	0.07	2.66	0.10
United Arab Emirates	13	0.29	2.93	0.11
Whole world	**4420**	**100.00**	**2750.72**	**100.00**

Data source: Risoe Center of UN Environment Programme

At present, it is one of the reasons for people to denounce CDM mechanism that the regional distribution of CDM projects is not balanced; however, people could discover with deeper analysis that it is inevitable for the imbalanced distribution. Firstly, the implementation potential of CDM in different countries or regions is determined by the potential of emission reduction of greenhouse gas in this country or region and the potential of emission reduction is closely related to factors like population and economic scale, development stage, utilization of energy, etc. Major countries for CDM projects, like China, India and Brazil, are all countries with a large population and comparatively large economic scale and countries which have entered the primary or middle industrialization stage; moreover, in these countries, the economy develops fast, the energy utilization rate is comparatively low and the energy consumption focuses on the fossil energy. Therefore, the overall potential on emission reduction of greenhouse gas is huge and potential CDM projects are many, which is applicable for large-scale implementation. On the contrary, many countries in Africa have not entered the industrialization stage with a small economic scale; in this way, the industrial projects are few and the energy utilization focuses on traditional bioenergy (firewood); therefore, the emission reduction after the energy being substituted is small and the projects which are applicable for CDM implementation are few.

Secondly, the implementation of CDM is closely related to the supporting policies and capacity building of each country. Large amounts of investment are needed for the renewable energy projects and projects for promoting energy efficiency. At the same time, the revenue from CDM projects is relatively limited and it is hard to attract private investors only with the CERs profit; therefore, the host country should formulate relevant policies for promotion. Take China for example, the Chinese government has formulated special CDM management method for CDM implementation and taken renewable energy projects, projects for promoting energy efficiency and coal-bed methane as the preferential fields. At the same time, China also formulates preferential policies aiming at renewable energy projects and project for promoting energy efficiency to encourage enterprises to invest in these fields. In addition, the Chinese government makes stakeholders recognize, understand and master the relevant CDM knowledge through development of capacity building to enhance the implementation capacity of CDM projects and promote CDM implementation.

Thirdly, large-scale projects are more popular because of the CDM system. CDM is a project-based flexible mechanism and the developers of the project are the main body of economic benefit orientation; therefore, they would like to exploit projects with huge emission reduction and profit, low cost and risks. However, because there are few industrial projects and comparatively large renewable energy projects in African countries and the commercial objective of the developers could not be fulfilled if the size of the project is not large enough, it is hard to realize large-scale CDM implementation in areas such as Africa. Only when these areas develop to the corresponding stage could the CDM be implemented effectively.

2.3 Exploitation of CDM Projects in China

2.3.1 Overall Situation

China has always actively fulfilled the relevant commitments in the Convention and Protocol, including the promotion of implementation and exploitation of CDM projects. Within one month after the Kyoto Protocol took effect in 2005, the National Development & Reform Commission of China (DNA for China) approved two CDM projects of collection and utilization of landfill gas from Beijing Anding Landfill and Inner Mongolia Huitengxile Wind Farm. And the Chinese government has been gradually improving the CDM management system since then to formulate CDM management method and enhance capacity building at various levels and in various fields to further promote the implementation of CDM projects in China. Since 2006, the implementation of CDM projects in China has entered a fast-growing stage and China has become the largest country for the development of CDM projects in the world. By 1 July 2009, China's DNA has approved 2,063 CDM projects and 579 projects have been registered in UN CDM Executive Board which accounts for about 34% of the number of registered projects in the world and ranks first; the generated annual emission reduction of these projects is predicted to be 0.18 billion tons of CO_2e, which accounts for about 58% of the annual emission reduction generated by all these CDM projects in the world and takes a commanding lead; moreover, 120 projects have been approved, totalling 0.141 billion tons of CO_2e[10].

The extensive implementation of CDM projects in China has played an important role in global response to climate change, domestic energy conservation and emission reduction and sustainable development. First, CDM will be a crippled mechanism without China's participation and active implementation, because China is the largest developing country in the world and the country with the most potential in the implementation of CDM projects. At present, the annual emission reduction generated by the registered projects in China amounts to 0.18 billion tons, which greatly reduces the cost for the fulfilment of quantitative emission reduction of the developed countries in the first commitment period. At the same time, the successful implementation of CDM projects in China has set an example for other developing countries and provided precious experience. Secondly, it is predicted to introduce about 1.8 billion Dollars' investment with the registered CDM projects of China and this investment will play a leverage role in China's energy conservation and emission reduction which is conducive to attract tens of times the capital into fields of renewable energy and energy conservation. In recent years, CDM has played an active role to a great extent for the high-speed development of the renewable energy and promotion of energy efficiency in China. Thirdly, CDM has been pressing for a new industry. Driven by the CDM capacity building and interest, large numbers of technicians and market developers have devoted into energy conservation and

[10] Data source: Statistics of Riscoe Center, UNEP

renewable energy exploitation; in this way, enormous technical consulting and market development teams have formed and this new industry will play an important role for future energy conservation and emission reduction and sustainable development in China.

2.3.2 Regional Distribution of CDM Projects in China

The regions where CDM projects are distributed in China are very wide. By 1 July 2009, DNA has approved 2,063 CDM projects in provinces, municipalities and autonomous regions except for Tibet because of special reasons (see Table 2.3). Among these places, projects in Yunnan and Sichuan are the most with the numbers of 251 and 210, which separately account for 12.15% and 10.17% of the total in China. Projects in Inner Mongolia and Hunan are the second most with the numbers of 133 and 121. Moreover, there are 15 regions where there are 50 to 100 projects: Gansu, Shandong, Shanxi, Zhejiang, Hebei, Hubei, Guizhou, Guangxi, Jiangsu, Henan, Heilongjiang, Guangdong, Liaoning and Jilin. In light of achievements which China has made in CDM capacity building and judging from the number of projects which DNA has approved, the project number in most provinces and municipalities tends to increase greatly; the regional difference of project distribution is mainly determined by the regional resource difference. For example, among these projects exploited in China, most are hydraulic and wind power ones; because the hydraulic and wind resources in provinces and municipalities such as Yunnan, Sichuan, Inner Mongolia and Hunan, there are many projects correspondingly. Viewing from the anticipated emission reduction generated by the approved projects, the anticipated emission reduction of projects in Shanxi (second), Zhejiang (fifth), Jiangsu (sixth) and Shandong (seventh) is more than other regions besides Sichuan, Yunnan and Inner Mongolia rank in the front because the project numbers are absolutely predominant. This shows that the average scale of single CDM project in developed region is larger than that in central and western China.

At the same time, 579 CDM projects approved by the Chinese DNA have been registered in EB. In respect of regional distribution, there are projects registered in EB in 30 other provinces, municipalities and autonomous regions except for Tibet; the registered number basically accords with the sequence of projects approved by DNA: Yunnan (73), Sichuan (53), Inner Mongolia (43), Hunan (41) and Gansu (33) rank the top five; moreover, there are separately 20 to 30 registered projects in Shandong, Guizhou, Henan, Jiangsu, Hebei and Shanxi. As for the proportion of registered project to the projects approved by DNA, there is only one project in Tianjin and is registered with the proportion of 100%; the other provinces with high proportion include Beijing (45.45%), Ningxia (40.91%), Guizhou (37.68%), Hunan (33.88%), etc. Because the exploitation term for CDM projects is long, the CDM project has been started early in these provinces with high proportion and these provinces are generally provided with comparatively good consulting services and technical support institutions.

Table 2.3: Regional distribution of CDM projects in China

Region	Number of projects approved by DNA	Proportion (%)	Anticipated annual emission reduction of approved projects	Proportion (%)	Number of registered projects	Proportion (%)	Proportion to the approved projects (%)
Heilongjiang	54	2.62	9572876.92	2.87	14	2.42	25.93
Jilin	50	2.42	6895462.82	2.07	13	2.25	26.00
Liaoning	52	2.52	11783992.1	3.54	14	2.42	26.92
Inner Mongolia	133	6.44	23066956.8	6.93	43	7.43	32.33
Shanxi	87	4.21	32105662	9.64	20	3.45	22.99
Beijing	11	0.53	3879461	1.16	5	0.86	45.45
Hebei	76	3.68	11604667.4	3.48	20	3.45	26.32
Tianjin	1	0.05	48597	0.01	1	0.17	100.00
Shandong	92	4.46	15937958	4.79	30	5.18	32.61
Qinghai	19	0.92	1779359	0.53	4	0.69	21.05
Xinjiang	42	2.03	7967958.6	2.39	11	1.90	26.19
Ningxia	22	1.07	2879902	0.86	9	1.55	40.91
Gansu	99	4.79	11442802	3.44	33	5.70	33.33
Shaanxi	42	2.03	4311018	1.29	10	1.73	23.81
Anhui	48	2.32	8614976	2.59	12	2.07	25.00
Jiangsu	68	3.29	16607767	4.99	20	3.45	29.41
Zhejiang	83	4.02	22474978.37	6.75	15	2.59	18.07
Shanghai	12	0.58	5333928.68	1.60	1	0.17	8.33
Jiangxi	41	1.99	3173407	0.95	10	1.73	24.39
Fujian	64	3.10	9460632.9	2.84	19	3.28	29.69
Henna	61	2.95	8883214.23	2.67	20	3.45	32.79
Hubei	75	3.63	8382995.977	2.52	16	2.76	21.33
Hunan	121	5.86	12597301.5	3.78	41	7.08	33.88
Guangdong	53	2.57	10479433	3.15	17	2.94	32.08
Guangxi	69	3.34	10289528.5	3.09	17	2.94	24.64
Hainan	14	0.68	706797	0.21	4	0.69	28.57
Sichuan	210	10.17	33098184.2	9.94	53	9.15	25.24
Chongqing	44	2.13	8342329	2.51	8	1.38	18.18
Yunnan	251	12.15	25303250.51	7.60	73	12.61	29.08
Guizhou	69	3.34	6000640	1.80	26	4.49	37.68
Total	2063	99.90	333026037.5	100.00	579	100.00	28.07

Data source: statistics from the CDM Project Management Centre of China and UNFCCC

2.3.3 Industrial Distribution of CDM Projects in China

Based on the industrial classification of UNFCCC on CDM projects, we divide the CDM projects in China into 15 industries (see table 2.4). On this basis, we obtain the following meaningful conclusions through data analysis on industrial distribution of CDM projects in China in this research.

Firstly, the dominant projects in China are the wind and hydraulic power ones. These two kinds of projects are predominant absolutely no matter from the number of projects approved by the DNA or from the number of projects registered in EB. There are 1,335 projects of these two kinds which are approved by the DNA and 402 projects which are registered in EB, separately accounting for more than 60% of the number of projects approved by the DNA and the number of projects registered in EB. Although the average scales of these two kinds of projects are relatively small, the anticipated annual emission reduction of the 1,335 projects approved by the DNA also accounts for nearly 45% of the total. It is obvious that these two kinds of projects have made important achievements for implementation of CDM in China. There are two reasons behind this: first, the hydraulic and wind power resources in China are abundant and the development of hydraulic and wind power resources witnesses high-speed development in recent years with the stimulation of national policies for the development of renewable resources and CDM; second, the CDM methodologies for these two kinds of projects are comparatively simple, which is easy to implement CDM projects; in this way, various consulting institutions have made vigorous efforts in these projects.

Secondly, the registration rate of HFCs and N_2O decomposition projects is very high, nearly 100%. In total, 38 projects of these two kinds are approved by the DNA and 37 ones are registered in EB with only one N_2O decomposition project which was approved in March 2009 being not registered. In addition, the average scale of these two kinds of projects is comparatively large; especially the HFCs decomposition project, the project number only accounts for 0.53% of the total while the anticipated annual emission reduction accounts for 6.25%. These two kinds of projects are the earliest ones in China and the Chinese project developers have seized the opportunity for timely implementation; in this way, the project potential has been fully exploited.

Thirdly, as for the new projects such as recycling of sulphur hexafluoride, substation of concrete material, burning of garbage for power, etc., because of the long development cycle, the registration rate is not high at present but the potential is great; therefore, they deserve close attention.

Table 2.4: Industrial distribution of CDM projects in China

Type	Number of projects approved by DNA	Proportion (%)	Anticipated annual emission reduction of approved projects	Proportion (%)	Number of projects registered in EB	Proportion to the total registered ones (%)	Proportion to the total approved ones (%)
Hydraulic power	991	48.04	107797685.7	32.53	275	47.50	27.75
Wind power	344	16.67	39726041.24	11.99	127	21.93	36.92
Biomass energy	81	3.93	14970808.57	4.52	12	2.07	14.81
Solar energy	4	0.19	143184	0.04	2	0.35	50.00
Coal-bed gas	73	3.54	36168527.7	10.92	22	3.80	30.14
Methane utilization	31	1.50	2163885	0.65	3	0.52	9.68
Garbage landfill gas	38	1.84	4303579	1.30	18	3.11	47.37
Burning of garbage for power	17	0.82	1793116.7	0.54	0	0.00	0.00
Energy conservation and promotion of energy efficiency	381	18.47	58107740.94	17.54	64	11.05	16.80
Conversion of fossil energy	41	1.99	30033703.68	9.06	14	2.42	34.15
Substitution of concrete material	18	0.87	3221854	0.97	4	0.69	22.22
HFCs decomposition	11	0.53	20692713	6.25	11	1.90	100.00
N_2O decomposition	27	1.31	11969229	3.61	26	4.49	96.30
Recycle of sulphur hexafluoride	1	0.05	156465	0.05	0	0.00	0.00
Re-afforestation	5	0.24	98520	0.03	1	0.17	20.00
Total	2063	100.00	331347053.5	100.00	579	100.00	28.07

Data source: statistics from the CDM Management Centre of China and UNFCCC

3. Methodologies on the Assessment of the Influence of CDM Projects on Sustainable Development

In recent years, China has made important contributions to the fulfilment of the quantitative emission reduction objects of developed countries and has contributed to the mitigation of global climate change by vigorously developing CDM projects. However, few documents say whether these CDM projects have promoted China's sustainable development or how much they could promote sustainable development. Therefore, it is necessary to develop the methodology research on the assessment of the influence of the China CDM projects on sustainable development to measure whether CDM projects have promoted China's sustainable development in the true sense.

This chapter mainly consists of two parts: first, a review of the progress of the research on CDM projects at home and abroad on sustainable development; second, a detailed introduction of the methodology of the assessment of the influence of the China CDM projects on sustainable development, which is explained in detail in this research, i.e. MATA-CDM-China method.

3.1 Summary of the Progress of the Research at Home and Abroad

3.1.1 Profile

There are many literatures and information related to CDM research, however, few are related to research on the impact of CDM on sustainable development. Overall, the impact of CDM on sustainable development can be divided into two kinds generally: one is research based on the first-hand materials of the registered CDM projects, such as reviews, investigations, interviews, etc.; the other one is literature research; see table 3.1 for the present research profile:

Table 3.1: Profile of research on the impact of CDM on sustainable development

Research	Method or data source	Impact on sustainable development
De Coninck (2008)	Discussion about CCS	With CCS, the emission of greenhouse gas which might be brought about with other fuel could be reduced; therefore, it should be the recognized technology of CDM.
Borges da Cunha et al. (2007)	Reference to the research literature about power generation with Bioenergy in Amazon area, Brazil.	Provide more reliable power guarantee and the productivity of the local people is promoted; the production pattern is no longer the previous low-level one.
Ellis et al. (2007)	Qualitative assessment on 23 CDM projects	Realize selection between low-cost CO_2 emission and sustainable development
Gan L and J. Yu (2007)	Research on the conversion of rural Bioenergy utilization in the pattern of consulting experts	In respect of Bioenergy utilization, it is more beneficial to scatter to each house than build a large central power plant with biological energy; the indoor air quality could be promoted and the fuel could be obtained more conveniently.
Gundimeda (2004)	70,000 interview records and research on the impact of Indian forest resources utilization and CDM re-afforestation project on sustainable development.	Potential conflicts between utilization of traditional common-pool resources and long-term requirements of carbon storage
Kim (2004)	Interview with the pilot project party of solar battery homestead	The local object of sustainable development is fulfilled but there is still some distance to the anticipation of governments at higher levels.
Kolshus et al. (2001)	Assessment on sustainable development of Chinese coal industry based on 6 supposed CO_2 emission reduction options.	Research of the balance between emission reduction and sustainable development through the scoring system.
Sirohi (2007)	Assessment on poverty alleviation capacity of CDM projects in rural areas based on 65 Indian PDD documents.	Because these projects are not closely connected with the societies in local rural areas, CDM projects have made no achievements in rural poverty alleviation.
Sutter et al. (2007)	Quantitative analysis on the sustainability of 16 registered CDM projects with the MATA-CDM assessment method.	The two set objects of CDM are not realized in all the 16 projects.

3.1.2 Review on Research Findings

The main research findings are summarized according to industries in the following passage:

(1) Fossil Energy

Kolshus (2001) takes Shanxi coal industry for example and qualitatively appraises the sustainability of CDM projects under 6 emission reduction technical proposals of cogeneration, improvement of boiler design, boiler replacement, improvement of boiler management, coal washing and pressing; the results show that the cost for emission reduction with the technical proposals of cogeneration, improvement of boiler design and boiler replacement is too high while the cost with the proposals of improvement of boiler management, coal washing and pressing is relatively low.

In addition, Kolshus et al. carry out qualitative assessment on the impact of CDM projects aiming at non-carbon profits such as quality of water and air, protection of biological variety, economic benefit, regional economy, equity and poverty alleviation. The research results show that all these emission reduction measures are conducive to improving the urban air quality but also have some negative non-carbon impacts. Kolshus et al. have just made a few explanations on the equity. For example, it is conducive to the promotion of equity with only coal washing and pressing, because this pattern could improve the indoor air quality of poor farmers. Although coal pressing could bring profit locally, it is still an expensive plan on emission reduction. There is great potential of coal washing on emission reduction but with a high cost and negative impact on environment, because large amounts of water are needed in the process of coal washing. Kolshus et al. have drawn the curves for marginal costs of emission reduction with the six proposals and stacked the curves of marginal social costs. The results show that the total cost of the technical plan of coal washing is high but this technical plan plays a great role in improving air quality. At the same time, in light of the large amount of water needed for this proposal, the non-carbon benefits are reduced greatly. The cogeneration could improve the air quality but the non-carbon benefits with this proposal are negative. As for these two proposals of improving boiler design and boiler replacement, the cost for emission reduction is the lowest but the social benefits are not prominent; nor are the environmental benefits as it is not obvious that these two proposals could only improve air quality to some extent.

From this research, it is anticipated that most of the energy-consuming projects will play an active role in improving air quality in prophase, however, they are not related to environmental impacts. The cost for emission reduction and sustainability are related to each other in the way that a gain for one means a loss for another. CDM requires that the emission reduction should be above the datum line, and in this regard some proposals on emission reduction do not meet the CDM requirements.

(2) Bioenergy

Borges da Cundah (2007) et al. made a brief introduction of the potential emission-reduction effect of the CDM projects of the energy supply type and the state of sustainable development in the Amazon region; the Reserva Extrativista do Médio Juruá power generation project with bioenergy is taken for example in his works. This pattern of power generation could substitute traditional power generation with diesel engines and could provide about 120kVA of power for the local vegetable oils industry and the power supply for local residents at night. With this project, the local productivity has been greatly increased, which promotes economic growth and industrial upgrading.

With the method of consulting experts, Gan et al. (2007) carry out the research to use efficient domestic biological stove technology to substitute the traditional pattern of bioenergy utilization and estimate the possible environmental and social benefits. The research results show that efficient utilization of biological fuel could reduce serious indoor air pollution and associated health problems such as fluorosis, dental fluorosis, durative pains of bone, etc. In this research, they also list some examples of utilization of bioenergy in communities, such as small-scale decentralized heat supply and power equipment, direct burning or gasification technologies, methane pool (for gas production, heating and power generation, organic fertilizer) and civil boilers with biological fuel (power generation with straw). In this research, they also discuss the utilization of biological fuel and the adjustments corresponding to the utilization of biological fuel which should be made under the background of safe grain supply.

Besides research on utilization of biological energy, Gan et al. (2007) also compare the advantages and disadvantages of modern biological boilers and power plants with biological energy. Their research report points out that with the same investment, the household-based biological boiler could produce job opportunities which are more than 5 to 10 times that of power plants and revenue which is 5 to 9 times that of power plants. More importantly, the CO_2 emission reduction in the decentralized pattern is 14 to 25 times that of the centralized one. Moreover, the byproducts of the small-scale bioenergy utilization technology could be used as agricultural fertilizer. The development of bioenergy should be realized in order to bring benefit to farmers, but at the same time, it is necessary to take other daily requirements into consideration. This reports also points out that although the government often tends to favour the large scientific and technological projects arranged by the power department, the small-scale decentralized proposal mentioned above will yield more benefits in the long run.

(3) Renewable energy

Kim (2004) appraises the impact of CDM projects on sustainable development from the viewpoints of different stakeholders. The selected example is the CDM project of South Africa's Exxon-Shell domestic solar system. The corresponding sustainable development indicators in South Africa are very strong, including social equity, job opportunities, poverty alleviation and others. The CDM pilot project is a rural electrification project with the plan to provide energy for 50,000 families in remote areas to substitute candles with electric lighting and supply power for auto batteries.

The research shows that the anticipation of each stakeholder in the aspect of promoting sustainable development is different, and in this way, some projects that are conducive to sustainable development could not be effectively implemented. Shell Company hopes to make progress in employment, taxation, labor efficiency, utilization of renewable energy, rural power supply, technical promotion and population management. At the same time, the government requires that CDM projects should provide sufficient energy and should promote sustainable development more generally (for example in areas of regional development) with the main fields being exploitation of water resources and infrastructure construction for communications and health. The project owners point out that the benefits of sustainable development include promotion of the development of small and medium-sized enterprises, supply of 160 jobs locally, provision of electric lighting for the promotion of health conditions, reduction of smoke and dust indoors, reduction of the frequency of fire, etc. Moreover, the benefits also include the opportunity for residents to receive education via TV or radio.

(4) Afforestation and re-afforestation

Based upon the data collected from 69,206 farmers in India, Gundimeda (2004) researches the potential impact of CDM on CPRs (common-pool resources). CPRs are owned by collectives not individuals and include grasslands, forests, undeveloped land, wetlands and rural ponds, rivers and their surrounds. The CDM project selected for this research has increased the farmers' income by 12 to 25% (from supplied firewood, wood and fodder). Moreover, the poor benefit more than the rich, because they have obtained more opportunities to use CPRs. If CPRs are proved to be conducive to carbon storage, they could be a part of the CDM project of re-afforestation; if these kinds of projects are successfully exploited, the benefits acquired from CER selling could not only increase the farmers' income, but also be conducive to reducing rain loss and guaranteeing the safe supply of local drinking water. However, it should be noted that CPRs might not accord with the long-term requirements of carbon storage. In addition, if re-afforestation projects are successfully exploited, it might cause much speculation and result in further marginalization of the poor in a vicious circle. On the contrary, if we restrict the CPRs exploitation, it might result in unlawful felling of forest and CERs loss. Therefore, Gundimeda thinks that it is necessary to select a proper solution for replaceable energy, wood and fodder to make the development of CPRs promote the sustainable development and take the short-term and long-term requirements into consideration (daily demand and carbon storage).

(5) CCS

CCS is not recognized by CDM because it is controversial whether this technology could make active contributions to sustainable development. The research results of

De Coninck (2008) points out that the connotations of sustainable development are different to different people and to different regions, and it should be discussed whether to make the contributions of CCS to sustainable development the standard for CDM to recognize CCS. At the same time, one of the main results of other researches is that although the spread of fossil fuel is contradictory to the strategic object of sustainable development, CCS should be contained by CDM in light of the fact that CCS could effectively reduce air pollution and greenhouse gas emission from burning of fossil fuel and promote economic development.

(6) Qualitative assessment of different industries

Ellis (2007) summarizes the development of CDM and thinks CDM should also be developed after 2012. This research selects 23 CDM projects and discusses the direct or indirect benefits on environment, economy, technology transfer, health, society, employment and education. The results show that the promotion effect of CDM projects on HFC decomposition is not obvious. The recycling of landfill gas makes a low cost for the emission reduction but the public could not accept the spread of projects of this kind. Although the CERs of projects of household energy efficiency are few and the costs are high, local people could benefit directly. Therefore, the project executors are inclined to HFC, N_2O and CH_4 projects because of their comparatively low cost. The research of Ellis and others (2007) shows that the emission reduction of CO_2 and sustainable development could be balanced and expensive projects that are conducive to sustainable development still have a certain market to some extent.

Sirohi (2007) takes India for example and appraises impacts of CDM on sustainable development through reference to policies, strategies and PDD documents. The results of this research basically accord with the opinions of Ellis (2007) and others, i.e. the benefits of projects with large emission reduction on sustainable development is often small. Sirohi (2007) analyzes 65 PDD documents and appraises the sustainability of each type. The research results show that power generation projects with bioenergy and hydroelectric projects could provide more job opportunities in construction and the economic benefits of small-scale power generation with methane are huge, which is similar to the opinions of Gan. Projects of bioenergy have certain development potential in India because they can increase income through selling crop residuals, increase job opportunities through collection and transportation and improve the air quality for health promotion. The environmental benefits are high to substitute fossil fuel with natural gas or bioenergy but with little effect to reduce poverty. The research of these Indian cases shows that CDM projects could also have active impact in aspects such as education, professional training, comprehensive valley management, medical and health facilities, etc.

(7) Quantitative grading on sustainability of different projects

Due to the limit of data collected, only Sutter et al. (2007) carry out the quantitative assessment and research on the sustainability of CDM projects. He adopts the MATA-

CDM assessment method (Sutter, 2003) and researches 16 different CDM projects, including 3 recycling and burning projects of landfill gas for power generation, 6 hydro-power stations, 2 HFC23 decomposition projects, 1 natural gas project, 1 high-pressure steam turbine project and 1 project for energy efficiency promotion. Sutter selects 3 indicators in the process of appraising the impact of these projects on sustainable development: newly added job opportunities, distribution of CER benefits and local air quality. The employment Indicators are mainly used for measuring change of laborer number each 1,000 CERs above the datum line. Ninety nine per cent of CERs come from the lowest employment grade of C and the average datum is 2.3 people*month/1,000 CERs; the datum for projects with A-grade employment could reach 235 people*month/1,000 CERs. Among these 16 projects, 13 are B-grade in respect to CER benefit distribution, accounting for 76% of CERs. The research report points out that in light of the CER scale, the effect of 96% of projects, including projects with HFC-23 and CH_4 as the gas for emission reduction, on reducing local main air pollutants is not obvious and the grade of these projects is C. At the same time, 3% of projects are B-grade ones including projects of substituting fossil fuel by the high-voltage transmission and substituting coal by natural gas and these projects yield obvious effect on reducing respiratory diseases, pollutants and carcinogens (UN millennium development goals); only 1% of projects reach grade A and after the diesel generating set is substituted, the respiratory diseases, pollutants and carcinogens could be reduced.

The overall conclusion of Sutter et al. (2007) is that the grades of three indicators of CDM projects on the assessment of sustainable development are very low; the water conservation projects and projects of power generation from biomass could realize sustainable development moderately; the HFC-23 and landfill gas projects realize additionality to a great extent but make little contributions to sustainable development and wind power project could play a moderate role in these two aspects.

3.1.3 Overview on Research Methodology

In fact, many developing countries have formulated corresponding standards for measuring sustainable development to promote CDM development; these measurement standards assess whether CDM projects meet the requirements of sustainable development mainly through the process of setting checklists. For example, the checklist of the Indian Government includes social welfare, economic welfare, environmental welfare, technical welfare, etc. The checklist of Brazil and Mexico is general and is mainly used for measuring whether CDM projects accord with the requirements of sustainable development policies. The checklist of South Africa mainly includes three aspects of economic, social and environmental development (Olsen et al., 2008).

As for China, although the Chinese government has not clearly set the standards for measuring sustainable development in the management method, we could find out that some regulations in the method represent the purpose of China to use CDM to promote sustainable development through careful interpretation, e.g. the fourth article regulates that the key fields for exploitation of CDM projects in China are promotion of energy efficiency, exploitation and utilization of new energy and renewable energy, and recycling of methane and coal-bed gas. The 24th article stipulates that based on the contributions of different CDM projects to sustainable development, the government imposes some expenses to a certain proportion from the gains on sale of CERs in the following way: the imposition proportion of CDM projects of hydrogen-fluorine carbide decomposition and perfluoro carbide which have no great contributions is 65%; the CDM projects of nitrous oxide is 30% and the imposition proportion of CDM projects in key fields and CDM projects of afforestation is as low as 2%; the project owner must issue the report on assessment of environmental impact according to corresponding requirements in the process of declaring project to the DNA to explain the environmental impact which might occur in construction and operation and the prevention measures.

Objectively speaking, the standards which each country sets for measuring the contribution of CDM projects to sustainable development could only qualitatively describe whether CDM projects could promote sustainable development in developing countries on a macro level, however, their effect on appraising how and how much the CDM project could promote sustainable development is not obvious. At the same time, with this method, people could not compare the contributions of different CDM projects. In light of this issue, some international research institutions carry out some beneficial exploration on method for assessment of CDM sustainability and have made some active progress. With an overview of these documents, we find out that the main research methods for appraising the impact of CDM on sustainable development include South-South-North Matrix Tool (SSN), method of department ranking, gold standard method and MATA-CDM method. These methods will be summarized in the following:

(1) South-South-North Matrix Tool (SSN)[11]

This tool for appraising influence on sustainable development is exploited by a South African non-governmental organization. This SSN tool mainly includes key steps of primary selection for qualification, selection of sustainable development indicators, selection of feasible Indicators, Indicator grading, base line setting, assessment, etc. With this method, the grading and assessment results of each Indicator should be corresponding to the interval of [-3, +3]. -3 means that CDM makes very active contributions to sustainable development, 0 means no change against the base line and -3 means serious negative influence on sustainable development (Lenzen et al. 2007). In addition, it also requires that a qualified CDM must make active contributions to all the Indicators of sustainable development with this method. However, no weight is set for each Indicator with this method and only the structure of each indicator is simply added.

[11] Abstract from South South North Website, i.e. http://www.southsouthnorth.org

(2) Method of department ranking

This is the method adopted by the WRI and Indian Energy Institute. With this method, nine different indicators are set for assessment of CDM projects in India and the weight of sustainable development benefit is voted upon by researchers and government officials. Finally, the CDM projects of each department are ordered according to different sustainable development benefits (Austin et al. 1999). A major disadvantage of this method is that there is nearly no other quantitative indicator except for the cost indicator for emission reduction. Moreover, projects are ordered in each department and projects in different departments are only ordered in respect of cost for emission reduction.

(3) Gold standard method[12]

The WWF has set a label named "gold standard" for high-quality CDM projects. One of the important prerequisites for acquiring this label is to appraise the influence of CDM projects on sustainable development in other examinations and requirements. Projects must pass the inspection of gold standard after being approved by the host country to acquire this label. At present, the gold standard is mainly applied to projects of renewable energy, energy efficiency at demand side and energy substitution. In addition, the gold standard will enhance the contributions of CDM to sustainable development to some extent through the following patterns: first, stick to the optimum assessment on environmental impact and rely on the participation of local stakeholders rather than only rely on the participation of developers and local government; second, specify the public participation process; third, set the "sustainable development matrix" (i.e. divide the theme of sustainable development into a series of environmental, social, economic and technical Indicators first and then appraise project performance in respect of various Indicator systems); finally, projects meet the gold standard requirements only when each Indicator of projects has benefits in the true sense. In the process of appraising with the gold standard method, the data quality should be high, which is hard to realize practically; this is one of the reasons why few CDM projects could pass the authorization of gold standard. However, as for these CDM projects which are authorized by gold standard, the price of their CER is comparatively high on the international carbon market.

(4) MATA-CDM

MATA-CEM is the method for appraising the sustainability of CDM projects which is developed by Swiss Federal Institute of Technology, the World Business Council for Sustainable Development and International Emission Trading Association. Some CDM projects were assessed with this method in countries such as Uruguay, India, and South Africa. The main contents of this method are to set the indicator systems of sustainable development including three aspects of society, economy and environment. The characteristics of MATA-CDM stress the selection of base line and meet the requirements of relevant measurement; stress the participation of different

[12] Abstract from "golden standard website of CDM projects, i.e. http://www.cdmgoldenstandard.org

stakeholders and the transparent assessment process to ensure the efficient assessment results; stress the weight selection and scientific acquisition to meet the conditions of preference adjustment; stress the comprehensive results of weighted value of all Indicators to meet the overall requirements (Sutter, 2003).

3.2 Assessment Method of Impact of CDM Projects on Sustainable Development in China

Although the Chinese government has specified the object requirements that CDM should promote sustainable development in the Measures, the government only regulates the preferential fields for CDM projects. For example, the fourth article specifies the key fields for exploitation of CDM projects in China are promotion of energy efficiency, exploitation and utilization of new energy and renewable energy and recycling of methane and coal-bed gas, and does not provide specific measurement standards and Indicator systems.

The method for assessing the impact of the CDM project on sustainable development in China is also the method used for conducting quantitative impact assessment of the entire CDM project cycle for China's sustainable development. It is formed with the multi-attribute utility theory as a guide with reference to the international MATA-CDM method. It also takes into consideration comprehensive consideration of objective facts of CDM project development in China and the specific requirements of China's sustainable development. This method is called MATA-CDM-China method for short hereinafter. It needs to specially point out that in the assessment process with the MATA-CDM-China method, we should adopt several research methods concurrently, such as Delphi method, field investigation, questionnaire investigation, interviews with main stakeholders, etc. And now we will introduce the MATA-CDM-China method with the emphases of theoretical basis, main characteristics, assessment steps, etc. in detail.

3.2.1 Theoretical basis—theory of multi-attribute utility

With the multi-attribute utility theory (MAUT), people could appraise individual projects when the overall situation of industry or department is not clear. The assessment of CDM project is often faced with this. For example, the decision-makers often think about how to select from the alternative projects and what kind of projects could promote sustainable development in their countries. With this characteristic, the issue of impact assessment of CDM projects on sustainable development could be solved. Based on this theory, the research of method for appraising CDM projects influence on sustainable development is carried out in the world.

Essentially, the MAUT is a kind of multi-criteria decision making (MCDM). The research of MCDM is mainly about the decision issue when people face with more than one decision-making criterion. Generally speaking, multi-criteria mainly aim at two kinds of issues for analysis: first, it is used for selection from multi-attribute discrete options, i.e. "multi-attribute decision making" (MADM); second, it is used for solving issues of selection from multi-attribute continuous set options, i.e. “multi-object decision making” (MODM) (De Montis and others, 2000). As for specific assessment of CDM projects, it could be regarded as a kind of MADM and MADM could be divided into three kinds according to different measurement standards: 1) single synthetic standard method; 2) senior method; 3) mutual method (Guitonuni et al. 1998); see the following Figure.

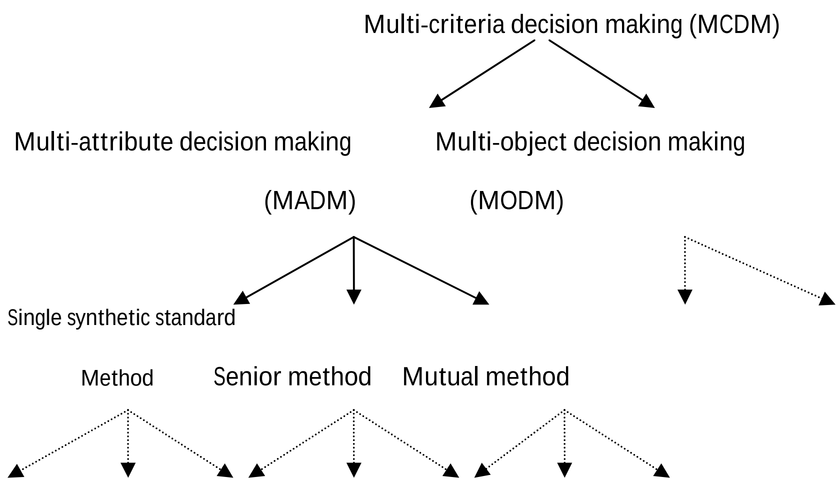

Figure 3.1: Sketch map of classification in multi-criteria decision-making field

Historically, the multi-attribute utility theory is one of the most important milestones in the development of multi-criteria decision-making theory. In treating many objects and decision-makers, this theory could not only provide criteria and rational method, but also combine the quantitative data and qualitative data (De Montis et al. 2000). The multi-attribute utility theory is based on the utility theory and its object is to comprehensively measure the advantages (utility) of a set of alternative projects. In order to realize this object, the multi-attribute utility theory decomposes the comprehensive advantages of each alternative option into several attributes (Von Winterfelt et al. 1986). Each attribute is the standard for assessment and comprehensive assessment on single attribute could be carried out with model according to importance weight or other converted coefficient quantitative attributes. The multi-attribute utility theory uses one-dimensional utility function to measure the utility value of single attribute. The application of multi-attribute utility theory usually includes five steps: establishment of attribute hierarchy tree; definition of utility function; conversion from preference to weight; description of alternative option and summation of utility values.

3.2.2 Main characteristics of MATA-CDM-China

MATA-CDM-China aims at directly representing the influence of CDM projects on China's sustainable development through organic treatment of quantitative and qualitative information of various attributes. The method mainly includes the following characteristics:

1. Use the absolute utility function to convert the assessment results of all attributes into a single utility value (u) which is between -1 to 1 and realize the organic combination of any quantitative and qualitative information.

2. Adopt mathematical model to convert the structural calculation of all indicators with different standards to a total utility value (U) which is between -1 to 1 and called the influence degree of sustainable development. If the influence degree is a positive value, i.e. U is greater than 0, the CDM project will play an active role in sustainable development; moreover, the closer the value is to 1, the greater the positive influence on sustainable development is; on the contrary, if the influence degree is a negative one, i.e. if U is less than 0, this project, compared with the basic plan, will play a negative role in sustainable development as a whole; moreover, the closer the value is to -1, the greater the negative influence on sustainable development is.

3. The application of this methodology is the assessment of CDM projects related to energy activities and this methodology is not applicable to impact assessment of CDM projects of HFC-23 and N_2O decomposition on sustainable development.

In addition, it is necessary to explain that the core formula of MATA-CDM-China assessment method could be:

$$U(P) = \sum_{i=1}^{n} \omega i \mu i \, [ci(P)]$$

In the above formula, P represents the appraised CDM projects, U represents total utility of project, ωi represents Indicator weight, μi represents the utility of Indicator I, ci represents the sustainability of I and n represents the number of Indicators for appraising the Indicator system.

3.2.3 Main steps of Mata-CDM-China

MATA-CDM-China method includes the five following steps:

Step 1: establish the Indicator system for impact assessment on sustainable development

The indicator system for impact assessment on sustainable development is the core content of MATA-CDM methodology and the indicator system should be established according to certain standards for measuring sustainable development. In light of there being difference between understandings of different countries on the connotation of sustainable development and their selected standards for measuring sustainable development, the indicator systems which different countries need to establish for impact assessment on sustainable development are different to some extent. Theoretically speaking, many indicators could be used for impact assessment of project on sustainable development; however, the number of selected assessment indicators should be limited to a controllable range to ensure the operability. Some current international experience shows that in the process of multi-attribute decision making, it is optimum to arrange 3 to 7 object branches under the general object (Scholz et al. 2002) and the terminal branches should be not more than 20 (Von Winterfelt et al. 1986).

Being specific to this research, based on the requirements and facts of China's sustainable development, we confirm the indicator systems of MATA-CDM-China method through convention of expert symposium and pertinent questionnaire investigation and individual interviews. The indicator systems for appraising MATA-CDM-China method mainly include four hierarchies of object, system, variable and element. Specifically, seeing that the general object of this research is to appraise the influence of CDM projects on sustainable development in China, therefore, this general object is defined as the object hierarchy; based on the three supports of sustainable development, this general object is always affected by the three systems of society, economy and environment and therefore, this general object is divided into three sub-objects of social progress, economic development and environmental protection which is called the system hierarchy; each sub-object usually includes some influence variables which are so-called sustainable development indicators—the variable hierarchy; the variable hierarchy is divided into 9 indicators of employment, social equity, capacity building, energy, emission-reduction effect, biological protection, land resources, technology transfer, micro-economic efficiency and regional economic influence (see the following Figure); in respect of appraising specific CDM projects, these indicators are not specific enough and hard to fulfill on the factual assessment operating hierarchy; therefore, each indicator should be provided with some appraisable elements with explanation; these specific assessment elements form the element hierarchy. In fact, it is necessary to set each specific element through the element hierarchy for ultimate embodiment to measure and appraise the degree of CDM projects according with the standards of sustainable development (SD). See the following Figure for the hierarchy tree of MATA-CDM-China assessment method:

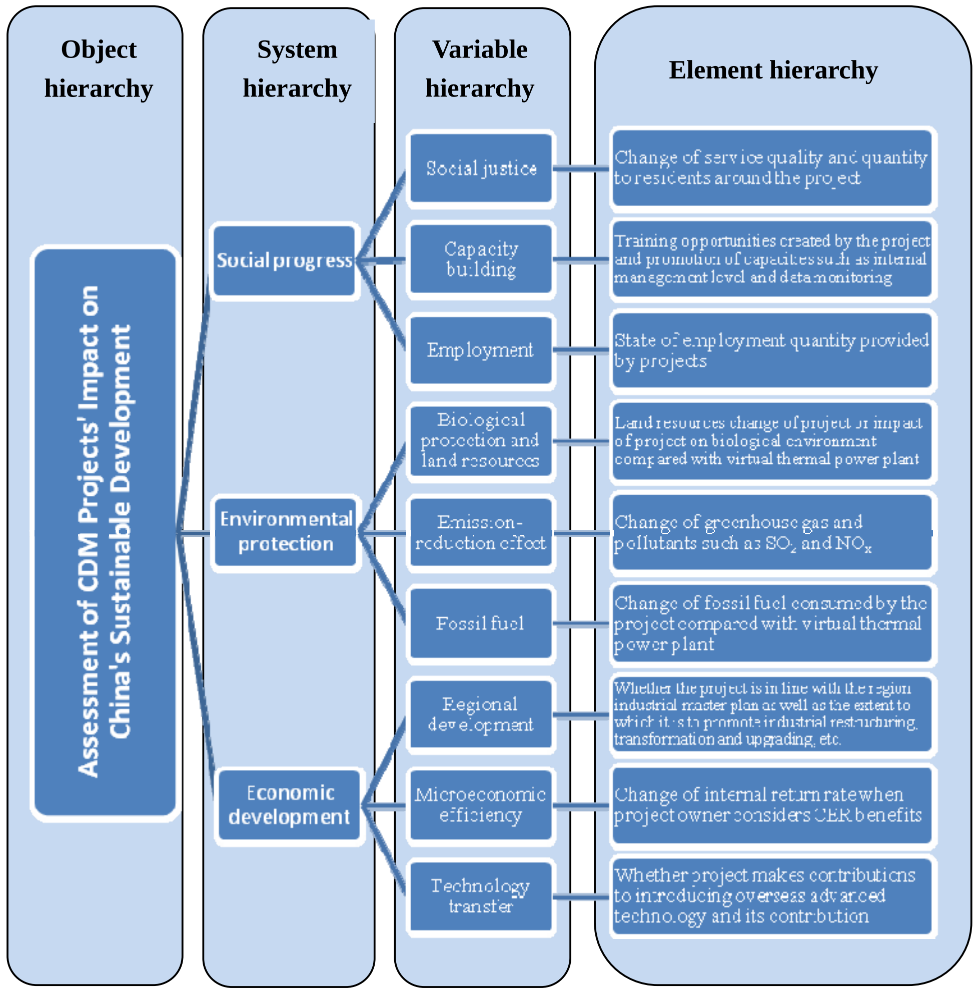

Figure 3.2: Sketch map of hierarchy tree of MATA-CDM-China assessment method

The assessment indicator system of MATA-CDM-China includes 9 indicators which could be divided into three kinds, i.e. quantitative indicator, semi-quantitative indicator and qualitative indicator. The quantitative indicator includes the clearly defined indicator measuring range and procedure for result standardization. The standardization process could ensure that the result is unrelated to the project scale, which is convenient for comparison between projects of different scales. For example, if the project scale is not clear, the employment indicator (people in CDM project ·years) is hard to explain, and the standardization indicator of employment people · months / unit generating capacity) could compare with other indicators directly without consideration of project scale. Semi-quantitative indicators include one quantitative assessment and one qualitative expert's judgment. First, various pertinent quantitative indicators are listed (like the emission levels of pollutants in different places). Based on the known quantitative data, experts need to judge qualitatively to score for indicators (for example, experts should judge whether the emission level in a specific location rise or fall compared with the base line). The qualitative indicator is the supplementation of quantitative and semi-quantitative indicators. When people could not carry out quantitative (semi-quantitative) assessment or the quantitative data are not accurate or reliable enough to be used as indicators, the qualitative indicator could be used; moreover, the qualitative indicator in this research is divided into five levels for assessment.

In the process of both quantitative assessment and qualitative judgment, a base line should be defined in advance as the basis for assessment or judgment of the indicator concerned. The situation is the same with MATA-CDM-China method. The following should be taken into consideration for confirming the base line in this research: First, the appraised CDM projects are mainly related to power generation with energy and the difference of each power plant. Therefore, a virtual thermal power plant is established as the baseline. This thermal power plant is provided with the average particularity of thermal power plants in China and the indicator assessment should be obtained through comparison with this virtual thermal power plant. Moreover, the indicators of employment, emission-reduction effect, biological protection and land resources and internal rate of return are all applicable to this base line. Second, it should be taken into consideration that with many factors such as the Kyoto Protocol taking effect in February 2005, China has begun to carry out CDM project since 2005. The year 2005 is the basal year for China's Eleventh Five-Year Plan and the availability of data. Therefore the year 2005 is taken as the basal year in the process of indicator assessment in this research and the "fossil fuel" indicator is applicable to this situation, i.e. the average coal consumption for power generation of national thermal power plants in 2005—343g standard coal/KWh is taken as the assessment base. Third, the situation of no project implementation is taken as the assessment base. The indicators of social equity, capacity building, technical transfer and regional development belong to this kind.

Table 3.2 Assessment Indicator system of MATA-CDM-China

Type	Weight	Name	Weight	Type	Base line
Social progress	0.25	Social equity	0.37	Semi-quantitative	No change of service quality and quantity obtained by residents around project
		Employment	0.30	Semi-quantitative	Reference to the virtual thermal power plant and with international experience, suppose the newly-added employment (people. month) each 1000 CER equals to 3 people. month/1000 CER
		Capacity building	0.33	Qualitative	No other additional training except for ordinary employee training
Environmental protection	0.43	Fossil energy	0.34	Quantitative	The coal consumption for power generation of each MWh in virtual thermal power plant is 343g/KWh
		Emission-reduction effect	0.37	Semi-quantitative	As for the emission of pollutants from the virtual thermal power plant, such as CO2, SO2, NOx, dust, CDO, etc., the measurement standards are that the emission concentration of SO2 is 400mg/m3 or the emission concentration of NOx is 650mg/m3.
		Biological protection and land	0.29	Semi-quantitative	Compared with the virtual thermal power plant, the needed land resource of this project retains the same or there is no influence of this project on biological

		resources			environment.
Economic development	0.32	Microeconomic efficiency	0.36	Quantitative	The internal rate of return (IRR) of the virtual thermal power plant is 8%.
		Technical transfer	0.38	Qualitative	Introduction of overseas technologies (i.e. equipments) on commercial terms (i.e. market price). No introduction of core technologies or advanced technical know-how.
		Regional economy	0.26	Semi-quantitative	These projects are located in economically backward regions or economically moderately developed regions or developed regions, which basically accords with the overall industrial arrangement in these regions; there is no technical spillover or basically no influence on the adjustment, optimization and upgrading of regional industrial structure.

Step 2: Multi-level description and utility evaluation

After the assessment baseline of each indicator is confirmed, it is necessary to carry out multi-level description on indicators. In this research, indicator description includes two parts: the quantitative indicator adopts triple-level description with the corresponding utility evaluations of -1, 0 and 1; the qualitative and semi-quantitative indicators are applicable to five-level description with the corresponding utility evaluations of -1, -0.5, 0, 0.5 and 1.

The advantage of MAUT is to adopt different measurement units which are proper to some standard to measure the corresponding indicator. The use of "utility" could standardize number of different units and combine them as a single value. In order to fulfill this object, the element value c_i (P) is converted to its corresponding indicator utility through the utility function of $u_i= u_i$ [c_i (P)]. The utility function could be represented by different figures (linear one, concave one, convex one, etc.). Moreover, the typical MAUT utility function value u (c_i) is between 0 and 1.

In respect of this research, the key issue is whether CDM project will play an active or a negative role in China's sustainable development. Therefore, it is supposed that the utility function of each indicator could be negative with MATA-CDM-China method. If some indicator has the positive utility, this project will play an active role in sustainable development compared with the base line and its utility value is between 0 and 1. If some indicator has the negative utility, this CDM project will play a negative role in local sustainable development compared with the reference case of no CDM project and its utility value is between -1 and 0. In this research, the utility function of CDM on sustainable development in China derives from international experience and factual experience of assessment experts and is defined by assessment group in advance. However, the basic principle is that the quantitative indicator acquires value in a linear way between -1 to 0 or 0 to 1 according to the utility function. The qualitative and semi-quantitative indicators acquire values among five ones of -1, -0.5, 0, 0.5 and 1 according to the utility function.

Step 3: Confirmation of weights of different Indicators

The MAUT theory could give each sustainable development indicator and its corresponding utility value a different weight. Before assessment, a weight should be defined for each Indicator and all these weights should form an importance weight set W= (w_1, ..., wi, ..., wn). In order to make assessment more objective, each individual weight should be added to a group total weight. The MATA-CDM-China mainly uses the direct weighted method for assessment and the direct weighted method requires the appraiser to use number to represent weight. For the summation for each hierarchy, including the object hierarchy, system hierarchy, variable hierarchy and element hierarchy. And weights between the general object on the top of the hierarchy tree and indicators at the bottom multiply to obtain the weight of indicators at the bottom.

In order to objectively appraise the influence of CDM projects on sustainable development in China, the MATA-CDM-China method is used to specifically formulate weight questionnaire aimed at both the system hierarchy and the variable hierarchy. Unlike the XXX, for which the total score value is one point, the total score value of the questionnaire is 100 points (which facilitates ease of scoring by appraisers) and different scoring weights are given to different appraisers. Being different from other research objects, CDM is a field with high professionalism and there exists a comparatively large distance between experts and the public. Therefore, three kinds of appraisers are set for the questionnaire with corresponding weights of 0.85, 0.1 and 0.05, i.e. appraisers who are very familiar with CDM, generally familiar with CDM or thoroughly unfamiliar with CDM. In total 185 questionnaires are acquired for this research and the primary weight value of each system and variable is obtained through processing of accumulation, averaging and weighting. In addition, in order to reduce the subjective bias and further reduce the inaccuracy of the result, the primary weight obtained through direct weighted method is corrected and rectified through patterns of AHP, symposium, interview with experts, etc. The finally obtained weight value of each system and variable is as shown in table 3.2.

Step 4: Assessment execution According to field investigation, interview with stakeholders and reference to the design documents of appraised projects shown on the CDM EB website, each element related to the element hierarchy is specifically appraised according to the requirements of multi-level description in this research; in this way, each indicator acquires an original project utility value first; and then each indicator converts the original project utility value into weighted utility value according to different weights and finally the weighted utility values of the 9 indicators are added to obtain the influence degree of the appraised project on sustainable development.

It needs to specially point out that the effect assessment of three quantitative indicators of employment, fossil fuel and microeconomic efficiency is a little different to the assessment of other Indicators. As for employment, the effect appraising process mainly comprises three steps: first, based on the fixed number of factually newly added workers, number of periodical employees and annual emission reduction of greenhouse gas generated by projects, the number of newly added employees corresponding to each 1000 CER of projects is confirmed, i.e. (fixed number of newly added employees*12+number of periodical employees*converted months)/annual emission reduction, among which the converted months refer to how many months could the labor days of newly added periodical employees each year be converted to, for example, 60 days could be converted to 2 months. The unit of annual emission reduction is the CO_2e of 1000CER. Second, compared with the international empirical value which is taken as the base (i.e. the base line is 3 people*month/1000CER, if the number of newly added employees equals to 3 people*month/1000CER, the project utility value is 0; if the number of newly added employees is 223 people*month/1000CER, the project utility value is 1), the Indicator utility value is calculated according to the supposed linear utility function; the calculation formula is (the number of newly added employees each 1000 CER-3)/220. Third, the weighted utility value is calculated according to weights corresponding to each Indicator.

In respect of "fossil fuel", the evaluation process is similar. Assuming its linear utility function formula is (343-coal consumption for power generation)/70, we need to establish a piecewise function for the "microeconomic efficiency", i.e. when IRR equals to or greater than 30%, the project utility value is 1; when IRR equals to or greater than 8% and less than 30%, IRR=(50*factual IRR-4)/11; when IRR is greater than 0% and less than 8%, IRR=(25*factual IRR-2)/2; when the factual IRR equals to or less than 0, the project utility value is 0.

Step 5: Conclusion analysis

First, it is necessary to appraise whether this project plays a positive role or negative role in sustainable development, based on the project utility value. Second, the contribution rate of each indicator under the three major systems of society, environment and economy should be compared and analysed. Thirdly, the relative contribution degree of each Indicator's impact on sustainable development needs to be compared and analysed. Finally, it is necessary to assess whether there are any experiences or lessons in the project as further reference. At the same time, it is possible to generalise the impact assessment of this project to the overall impact assessment on sustainable development of certain type of projects.

3.2.4 Limitations of MATA-CDM-China methodology

As introduced above, MATA-CDM-China methodology is a tool that allows impact assessment of individual CDM projects on sustainable development., However, at the same time, we have to admit there are some limitations in the process of executing assessment with this methodology with the main representations as follows:

1. These 9 indicators included in the assessment indicator system do not fully encompass all areas of sustainable development. The connotation of sustainable

development will be richer with the deepening of understanding of sustainable development, and selecting only nine main indicators does not meet the objectives for appraising impact on sustainable development.

2. The indicators included in the assessment indicator system are divided into quantitative, semi-quantitative and qualitative indicators according to the different natures of each. Therefore it is controversial to some extent to assess the degree of influence of the appraised project on sustainable development through simple weighting and summation of the utility values of the three kinds of indicators of different natures. This is because in respect of mathematics, the utility function of each indicator is not the same (for example, the utility function of quantitative indicator is a continuous one and the utility function of qualitative function is a discrete one). Under this situation, it needs further scientific argumentation to prove whether the simple summation of the utility values of different Indicator is rational or not.

3. In respect of qualitative and semi-quantitative indicators, the description of one indicator often relates to many other elements. If all these elements are included in the multi-level description of indicators, the initial setting of quintuple-level description (the utility values are -1, -0.5, 0, 0.5 and 1) could not cover everything of indicator. Therefore, the assessment of this kind of indicator is flexible, which weakens the objectivity of the assessment results to some extent.

4. The selection of some assessment bases has a great influence on the assessment results, which might cause some conflicts. For example, although the “employment” indicator selects the international empirical value of 3 people*months/1000 CER as the assessment baseline, and the applicability of it to China’s CDM projects is worth discussing, it is rational to refer to international empirical value if this kind of data falls short. As for the “microeconomic efficiency”, the assessment basic return rate is 8% which directly affects the average influence degree of all appraised project on sustainable development. If the basic return rate is reduced to 5%, the average influence degree of projects on sustainable development will increase and the overall assessment results will fall.

5. In order to simplify the assessment process, some indicators are specially defined and these definitions might be different to the one we usually understand to some extent. For example, the “technology transfer” mentioned in this research is a narrow one, only including import of equipment and transfer of corresponding manufacturing technology and know-how from foreign countries and their diffusion to developing countries. The corresponding technical training is not included and the technical training mainly represents in the Indicator of “capacity building”. As for the “employment” Indicator, we should consider the increase of fixed employment and periodical employment without the increase of temporary laborer numbers in project construction in assessment.

6. With this assessment method, the three system hierarchies are given different weighted values according to the questionnaire investigation and Delphi methods,

and the weighted value of the "environmental protection" system hierarchy is as high as 43%. This kind of setting in advance will affect the objectivity of assessment results to some extent and therefore, we acquire a main conclusion that all these appraised CDM projects have obvious environmental protection benefits.

7. This method is only applicable to CDM projects related to energy activities and could not be applied to the impact assessment of some CDM project on sustainable development, such as CDM projects of HFC23 decomposition, N_2O decomposition, etc.

4. Case Study for Impact on Sustainable Development of the CDM Projects in China

4.1 Introduction of Case Study for Impact on Sustainable Development of the CDM Projects in China

Rather than single paper review, a comprehensive set of research tools are employed for this project including case study. Specifically, expert consultation workshops and surveys were conducted with the Delphi methodology being applied to select the representative cases. Fourteen typical cases, including the projects registered by the EB and in the CDM pipeline (Table 4.1), were selected. These projects come from different sectors, including: the energy conservation and energy efficiency improvement projects such as the waste heat utilisation employed in the cement and steel production industries; ultra-supercritical power generation; the renewable energy projects such as wind power, small hydro power and biomass projects; the fuel swift projects such as natural gas-based power generation; methane recovery projects such as the coal bed methane recovery and landfill gas recovery and power generation; and the non-CO_2 projects such as HFC23 and N_2O projects.

Apart from the wide distribution of the project categories, the selection of the cases has taken a comprehensive consideration of the project size, nature, regional distribution and other factors. As a result, the selected cases better represent the general status of CDM project implementation in China and the impacts on sustainable development. Considering the large number of the wind power and hydro power CDM projects in China, two cases of each were selected. The case selection for hydro power is mainly based on regional variation, with one selected from Yunnan province in western China and the other from Hunan province in central China where most hydro power projects are located.

Further, both regional variation and the project nature are taken into consideration for the case selection of wind power projects. As a result, one onshore wind power project in Inner Mongolia was selected with the other consisting of a wind power farm in Jiangsu Province. Due to the limitation of the research methodologies, the two non-CO_2 projects are not included in the study of the impact assessment on sustainable development. They are, however, included when assessing the key indicators, especially for the study of the technology transfer issue.

The energy conservation and energy efficiency improvement CDM projects mainly include the waste heat recovery and utilisation projects from the industrial sectors such as steel and cement, and the energy-efficient power generation projects. In this study, four CDM projects from the energy conservation and energy efficiency improvement category were selected, including two projects from the steel industry, one from the cement industry and one energy-efficient power generation project. Specifically, the two energy efficiency projects from the steel industry are the waste gas recovery combined-cycle generation for Hansteel(Handan Steel Group), and the complementary coke dry quenching power generation for No.9 and No.10 coke oven in Whuhan Iron and Steel Corporation (WISCO). For the project from the cement industry, the 9100KW heat recovery power generation in Ningguo Cement Factory, Anhui Conch Cement Corporation Ltd. was selected, while Jiangsu Guodian Taizhou's ultra-supercritical power generation represents the energy-efficient power generation project

The CDM projects of renewable energy mainly include hydro, wind and biomass power generation. Five renewable energy CDM projects have been selected for case studies herein, including two hydro-power projects (the small-hydro CDM projects in Yunnan Heier and Hunan Xiaoxi), two wind power projects (the Dongshan power generation CDM project in Chifeng, Inner Mongolia and the wind power CDM project in Rudong, Jiangsu), and one biomass power generation project (the straw power generation in Jinzhou, Hebei).

A typical fuel shift CDM project is the natural gas power generation project in Beijing No.3 Thermoelectric Power Plant.

There are two types of methane recycling and utilisation projects. One is the coal bed methane recovery power generation, for which the Shanxi Yangquan Coal Group coal bed methane recycle and use project is selected. The other is the landfill gas recovery power generation, of which the Jiangsu Nanjing Tianjingwa Landfill gas power CDM project has been selected.

Table 4.1 Case Study for Impact on Sustainable Development from China CDM Project

Type	Industrial Nature	Case Name	EB Reg. ID/Ref.	EB Reg. Time
Energy Conservation and Energy Efficiency Improvement	Cement Heat Utilisation	Anhui Conch Ningguo Cement Factory	CDM1086/898	May. 4th, 2007
	Steel Heat Utilisation	Hebei Handan Steel Group CCPP Power Generation Project	CDM1547/1262	Oct. 10, 2007
		Complementary coke dry quenching power generation for No.9 & No.10 coke oven in Wuhan Iron and Steel Corporation	CDM2346/1695	Apr. 20, 2009
	Ultra-supercritical Power Generation	Jiangsu Guodian Taizhou USC Power Generation	CDM4488/NA	Not registered, under review
Renewable energy	Hydro power	Yunnan Hei'er	CDM1068/1102	Jul. 15, 2007
		Hunan Xiaoxi	CDM1765/1749	Dec. 19, 2008
	Wind power	Dongshan wind power project in Chifeng, Inner Mongolia	CDM0696/689	Dec. 31, 2006
		Jiangsu Rudong Dongling Wind Power Project	CDM0908/833	Apr. 8, 2007
	Biomass power	Hebei Jinzhou Straw Power Generation Project	CDM1001/778	May. 4th, 2007
Fuel Substitute	Natural Gas	Beijing No.3 Thermal Power Plant NGCC	CDM2257/1373	Feb. 15, 2008
Methane Recycle and Use	Coal Bed Methane Recovery	Shanxi Yangquan Coal Group	CDM1347/892	May. 22, 2007
	Landfill gas power	Nanjing Tianjingwa Landfill gas power Project	CDM0128/71	Dec. 18, 2005
Non-CO2	HFC23 Decomposition	Jiangsu Changshu San'aifu Group	CDM0472/306	Aug. 8, 2006
	N_2O Decomposition	Shanxi Tianji Chemical Group	CDM1788/1436	Mar. 10, 2008

For the specific cases, research and analysis is conducted in the following four aspects. Firstly, the industrial overview and the status of registration by the DNA and the EB for such projects are introduced. Secondly, a literature review on the relevant policies and measures are conducted. Thirdly, the profile of specific projects is introduced. This is followed by an impact assessment based on 9 key indictors covering the social progress, environmental protection and economic development with the MATA-CDM-China method. Using these assessment criteria, the evaluation results are analysed. Finally, the key findings and the major issues in the process of development and implementation for the CDM projects are illustrated.

4.2 Case of heat & pressure recovery for steel industry

4.2.1 General

While the steel industry is fundamental to the national economy, it is also a resource and energy intensive industry with high energy consumption, pollution and emissions. According to statistics by the Intergovernmental Panel on Climate Change (IPCC), greenhouse gas emissions from the steel industry contribute approximately 3-4 percent of total global emissions, making it one of the major emitters of greenhouse gas in the manufacturing industry. In China, the energy consumption by the steel industry is 15 percent of total domestic consumption, and the waste gas[13] emission (in which CO_2 emission is about 10 percent) is 21.31 percent of total domestic emission[14].

In response to national target on energy conservation and emission reduction, the Chinese steel industry is actively leveraging the Clean Development Mechanism (CDM) to build a resource-saving and environmentally friendly steel industry that is more in line with international standards. As of 30 June 2009, there were 372 energy-saving projects among the 2091 CDM projects approved by the National Development & Reform Commission (NDRC), with 139 coming from the steel and coke industry, representing 37 percent of energy-saving projects and 6.6 percent of total projects approved. China has successfully registered 579 CDM projects with EB, in which 30 are waste gas heat utilising projects for the steel and coke industry (representing 5.2 percent[15] of total monthly registered projects). Successful CDMs developed by steel enterprises are mainly classified within the energy conservation and energy efficiency improvement and emission reduction categories. These primarily involve energy-saving and emission-reducing technologies such as Coke Dry Quenching (CDQ) power generation, TOP gas pressure Recovery Turbine (TRT) power generation and gas-steam Combined Cycle Power Plant (CCPP).

4.2.2 Relevant policy overview

In order to drive energy conservation and emission reduction in the steel industry, the Chinese government has promulgated a series of policies and measures in recent years. At the macro-level, the *Medium & Long Term Specific Energy Conservation Plan* issued in 2004 targeted the steel industry as a key energy-saving sector, stating that 'coke ovens must be equipped with CDQ devices and large blast furnaces must

[13] Waste gas here refers to the by-product gas such as blast furnace gas, coke oven gas and converter gas, etc.

[14] Source: Mysteel website, see http://www.mysteel.com/gc/MRIztbg/2008/01/23/090646,1713878.html

[15] As derived from data provided by CDM management center of NDRC energy institution. There is a small amount of variation between the total number of Chinese DNA approved CDMs and the statistics of UNEP Risoe center, as the latter show that Chinese DNA has ratified 2063 CDM projects. The cited CDM statistical data in the following chapters are from such sources without special indication.

be equipped with TRT devices in large-scaled steel enterprise', and that enterprises are 'to take full advantage of blast furnace gas, coke oven gas and converter gas, as well as all sorts of steam to drive energy conservation and consumption reduction in the steel industry with self-supplied power stations as a key integration approach'.

The plan also identified heat and pressure recovery as one of the key energy conservation projects. Further, it proposed that in order to achieve the goal of saving 2.66 million tonnes of standard coal per year, combined steel enterprises must implement CDQ and TRT power generation while completing blast furnace reform on gas power generation and converter gas recovery and utilisation during the 11th 5 Year Plan period.

In the *Measures for Operation and Management of CDM Projects* promulgated in October 2005, energy improvement projects (including energy efficiency improvement projects for the steel industry) are listed among the top 3 sections, imposing a 2 percent reduction on revenue from the sale of CER.

As specified in Article 26 of the incentives section in the *Directory of Industrial Restructuring Guidance* promulgated in December 2005, the 'gas recovery and synthetic utilisation for blast furnaces, converters and coke ovens' is one of the key state-encouraged developing sectors.

In the *National Climate Change Program* promulgated in 2007, it is indicated that development and promotion of energy-saving technologies must be strengthened for key sectors such as the steel industry. This includes simultaneously equipping CDQ devices for coke ovens and TRT power generation devices for newly-built blast furnace synchronously.

In the *Circular Economy Promotion Law* developed in 2008 and implemented in 2009, companies are also encouraged to 'build grid-combined power generation projects through recovery of heat, pressure and coal bed gas as well as leveraging low heat-valued fuel such as coal gangue, coal sludge, waste'. Grid enterprises are further required 'to sign grid combination agreements, provide grid input services for companies generating power through synthetic resource utilisation in line with state rules, and buy up input from their grid-combined power generation projects'.

In addition, China issued relevant industrial development policies and specific plans for guidance on energy conservation and emission reduction practices for the steel industry. The *Steel Industry Development Policy* issued in 2005 stressed that steel enterprises must 'follow the concept of sustainable development and circular economy to improve their environment protecting and synthetic resource utilising level, reduce energy consumption, maximise utilisation of gas, water and waste, so as to achieve zero-emission and build circular steel plants. Steel enterprises must develop power generation capability of heat and energy recovery, and combined steel companies over 5 million ton capacity must try to meet the goal of self-surplus and outbound supply for electric power'. In the *Steel Industry Restructuring and Revitalizing Plan* promulgated in 2009, moreover, it is further indicated that the industry should ‘develop circular economy as well as energy-saving and emission reducing technologies such as high-temperature and pressure CDQ, sinter heat utilisation, smoke desulfurisation’ in order to speed up technical improvement in the steel industry and facilitate realisation of the planned target of ‘100% recycle and use for secondary energy source in general’.

4.2.3 Evaluation of influence on sustainable development from steel industry for multiple CDM projects

4.2.3.1 Case 1: Waste gas recovery combined-cycle generation project in Handan Steel Group

4.2.3.1.1 Project overview

The project is aimed at recycling excess gas from blast furnaces and coke ovens generated in of the production of steel. After the completion of a 2×49MW level gas-steam Combined Cycle Power Plant (CCPP), it is expected that the annual recovery of blast furnace gas will reach 2.1 billion CBM, equivalent to 250 thousand tonnes of standard coal, while the self-supply of electricity will further add approximately 677.4 million kWh per year (36 percent of annual power consumption for Handan Steel Group). In total, an annual emission reduction equivalent to 665.5 thousand tonnes of CO_2 is estimated.

The project started on 18 January 2006, with the PDD being approved by the NDRC on 17 January 2007. It was registered with EB successfully on 15 October in the same year, while its first CER was issued on 28 November 2008 with a volume of 172.53 thousand tonnes. The gas turbine for this project is supplied by Mitsubishi Heavy Industries, Ltd. of Japan, while the CER buyer is Carbon Asset Management Company of Sweden.

4.2.3.1.2 Impact assessment

Using the MATA-CAM-China method introduced in Chapter III, the following section will focus on evaluation and analysis of the influence on sustainable development.

Indicator 1: Social equity

The completion of this CCPP project will achieve the goal of zero-emission from blast furnace gas, while avoiding regional pollution and helping to improve the surrounding environment and public health of nearby residents. It will also assist in mitigating supply-demand gaps in energy consumption for the enterprise and local community, while reducing energy demand from the north China grid by about 277MW/A. It will also enhance the reliability of power supply across the Handan Steel Group as data show that an estimated annual power generation volume of 677 million kwh (36 percent of Handan Steel Group annual energy consumption) will be reached after the project is put into operation. In addition, no gender discrimination is expected to arise from this project. Taking the above into account, the utility value of this indicator is defined as 0.5.

Indicator 2: Capacity Building

Through field surveys and telephone interviews with principals of this project, a comprehensive understanding of the process of construction and operation was achieved. Mitsubishi Heavy Industries, Ltd., the equipment supplier, has arranged two batches of technical training in Japan for the project owner focusing on equipment operation and troubleshooting. In addition, Mitsubishi also dispatched their representatives to China for equipment installation, commissioning and regular on-site maintenance as well as for trainings focusing on aspects such as combustion instability.

It was also learned that Handan Steel Group has accumulated significant experience in international negotiation from the development of this CDM project, particularly during the process of negotiation with CER buyers. As a result, they have become more adept in seeking out higher CER sales prices. In addition, Handan Steel Group has been active in absorbing advanced CCPP technology, including the translation of relevant materials into Chinese; establishing technical groups to strengthen their ability to solve technical problem; adapting generator sets to meet their specific requirements; optimising ambient conditions (such as heat value conditions) for generator set operation; and inviting Japanese experts for overhaul instruction. In addition, it was learned that minor improvements have been made in the project owner's capability to gather and process data as well as in their internal management. As a result, the utility value of this indicator is defined as 0.5.

Indicator 3: Employment

Feedback suggests that this project will lead to the addition of 60 employees during normal operation as well as temporary employment during the construction period. In combination with the 665,545 tonnes of CO_2e/year from emission reduction, calculations suggest that the employment of this project is 1.0818 person.month/1000CER, which is lower than the baseline value of 3 person.month/1000CER. Therefore, the calculation from this indicator insinuates a utility value of -0.0087.

Indicator 4: Ecological protection and land resource

This project is located within the existing plant area of the Handan Steel Group, and therefore does not include the development of additional industrial land. The project construction and operation is not expected to have any noticeable influence on nearby water quality and consumes less water than a coal-fired generator set. It is further expected to have some positive influence on the local ecological system and air quality. As a result, the utility value of this indicator is defined as 0.5.

Indicator 5: Emission-reduction effect

As an 'energy conversion' processing plant with a BFG surplus, this CCPP project will assure Handan Steel Group ability to annually recycle 2.1 billion CBM blast furnace gas, equivalent to 82 thousand tonnes of standard coal, reducing emission of CO_2 by approximately 665 thousand tonnes and SO_2 by about 3200-3545 tonnes. Furthermore, the gas-steam combined cycle power generation technology is a clean energy production technology generating little smoke/dust and less CO and NOx. Therefore, the utility value of this indicator is defined as 0.5.

Indicator 6: Fossil Fuel

This CCPP project mainly uses the by-product of iron smelting – blast furnace gas – as fuel for generation, while adopting the coke oven by-product – coke oven gas – as pilot fuel, implying that additional fossil fuel will not be needed. Therefore, the utility value of this indicator is defined as 1.

Indicator 7: Regional development

Located in the moderately developed Hebei Province, it is estimated that the project will bring a high CER sales benefit and increase financial revenue for Hebei through higher income tax. As a result, it is expected that marginal contributions to the total economic volume of the district will be generated. As a fundamental industry for both Hebei Province and Handan City, the CCPP project for Handan Steel Group is consistent with the overall industry layout of the area, where Handan Steel Group l ranks 1st in the top 100 enterprises in Hebei.

In saving energy and reducing emissions, a significant step towards the optimisation of Hebei's steel industry will be achieved allowing for cleaner production and the development of a circular economy. The completion of this CCPP project is important for Handan Steel Group to drive its own energy conservation and emission reduction through CDM. Furthermore, as the CCPP project of Handan Steel Group is increasingly put into operation, spill-over effects have been observed with many domestic steel enterprises of large or medium scale starting their own development and construction of CCPP projects. Therefore, the utility value of this indicator is defined as 0.5.

Indicator 8: Micro-economic efficiency

In the financial budget of the feasibility study report for this project, the Internal Rate of Return (IRR) after income tax is calculated as 9.23 percent, which is lower than the benchmark IRR of 11 percent for the steel industry. However, if it is successfully registered as a CDM project, its economic indicators will improve will the benefit of CER sales, allowing the total IRR to reach approximately 13 percent, surpassing the benchmark level of 8 percent evaluated by the study team. By calculation, the corresponding utility value of this indicator is therefore 0.2273.

Indicator 9: Technology transfer

Calculating that the M251S gas turbine supplied by Mitsubishi will be able to meet the demand of low-heat-valued blast furnace gas combustion, Handan Steel Group imported the necessary equipment set for the CCPP project from Mitsubishi at market price. As neither the manufacturing technology of Mitsubishi's M251S gas turbine nor the technological know-how has been transferred to China, the utility value of this indicator is defined as 0.

Taking the preceding 9 indicators into account and adding together the individual weighted utility values, the degree of influence on sustainable development for this project is 0.4429.

Table 4.2 Evaluation results of Handan Steel Group CCPP project with MATA-CDM-China method

System indicator	Weight (1)	Element indicator	Weight (2)	Project utility (3)	Weighted utility (4)=(1)×(2)×(3)
Social progress	**0.25**	Social equity	0.37	0.5	0.0463
		Capacity Building	0.33	0.5	0.0413
		Employment	0.3	-0.0087	-0.0007
Sub total			1		**0.0869**
Environmental protection	**0.43**	Ecological protection and land resource	0.29	0.5	0.0624
		Emission-reduction effect	0.37	0.5	0.0796
		Fossil energy	0.34	1	0.1462
Sub total			1		**0.2882**
Economic development	**0.32**	Regional development	0.26	0.5	0.0416
		Micro-economic efficiency	0.36	0.2273	0.0262
		Technology transfer	0.38	0	0
Sub total			1		**0.0678**
Degree of influence on sustainable development	**1**				**0.4429**

4.2.3.1.3 Result analysis

From the above evaluation, it is inferred that this project has, in general, facilitated sustainable development. The justification for this assessment is supported through the following three aspects:

1) Social progress: The project has a utility score of 0.0869 at this level, which is 20 percent of the total utility value. While this implies that the project contributes little to this level, it is largely due to the nature of such projects. First, such projects will improve ambient atmosphere quality around the steel plants, which is helpful in improving the health of project staff and nearby residents. Second, while such projects mainly focus on satisfying their own energy demand, they help mitigate the contradictions between local electric power supply and demand to some degree. Furthermore, due to the features of high efficiency and technology concentration, such projects cannot be expected to create many employment opportunities. In addition, this CDM project is outstanding in capacity building. To that end, the project owner has made great efforts to absorb advanced technologies, and has created its own professional maintenance team in the process of learning and practicing, while significantly improving its ability in commercial negotiation.

2) Environment protection: This project has a utility score of 0.2882 on this level, which is 65 percent of the total utility value. This implies that this project's main contribution is derived from improvements in environmental protection; mainly deriving from the high-efficient and environment-friendly features of CCPP. In order to improve the recycling rate of blast furnace gas and converter gas, the CCPP project must locate within the plant area of Handan Steel Group in order to avoid placing additional demands on industrial land. Moreover, as this project uses the steel industry's 'waste gas' for fuel in power generation without creating additional demand for fossil fuels such as coal, the coal consumption is 0. It can therefore be surmised that such CDM projects in the steel industry are of distinct advantage in environmental protection.

3) Economic development: This project has a utility score of 0.0678 on this level, which is 15 percent of the total utility value. This implies that CDM projects have a limited impact on facilitating economic development, with the main benefits deriving from the contributions to 'regional development'. More specifically, since this project is located in an area of medium economic affluence, the marginal benefit of a CDM project is usually higher than that from similar projects occurring in developed areas.

It was also observed that the steel industry is the fundamental industry for both Handan City and Hebei Province, implying that such CCPP projects are largely utilised to increase energy efficiency of steel enterprises in the region. While the IRR of this project is 8 percent (which is above the benchmark IRR level) it exhibited minor gains in the 'micro economic efficiency' indicator. Furthermore, the project incorporates no transfers of key technologies as the project has only led to import of a generator set in order to meet its utilisation of low-heat-valued blast furnace gas.

4.2.3.2 Case 2: CDM project of CDQ heat recovery power generation in Wuhan Iron and Steel Corporation

4.2.3.2.1 Project overview

The project mainly uses Coke Dry Quenching (CDQ) technology for power generation through heat recovery. It includes the construction of a power generation station matching the CDQ capacity of 140 T/h. The rated total installation capacity is 6MW while the actual is 4.225MW, with annual utilisation of 8280 hours and generation volume of 34,980 MW. Apart from auxiliary consumption and loss, the net annual electric power supply through the 10kV power line to the internal electric power system of Wuhan Iron and Steel Corporation is estimated at 21,687 MW.

The project owner is Hubei Wuhan Steel (Group) Corp., while the Italian ENEL Trade SpA company is the contracted buyer as specified in Appendix I. It was approved by the NDRC on 16 October 2007, and was successfully registered with EB on 20 April 2009. It selected 10 years as its fixed emission reduction calculation period (since 1 June 2008) and has an estimated annual emission reduction of 16,738 tonnes (167,380 tonnes over the total 10 year period).

4.2.3.2.2 Impact assessment

Using the MATA-CAM-China method introduced in Chapter III, the following section will focus on evaluation and analysis of the influence on sustainable development.

Indicator 1: Social equity

The CDQ project has eliminated atmosphere pollution caused by heavy smoke through the wet quenching method. Further, it has reduced erosion to nearby facilities as well as pollution to surrounding environment and air, resulting in improvements to the environmental condition and residents' health. While it does not result in gender discrimination, it also fails to produce any positive improvements to women’s conditions. As above, we define the project utility value of this indicator as 0.5.

Indicator 2: Capacity building

Through field surveys and telephone interviews with principals of this project, knowledge on the process of construction and operation was obtained. Nippon Steel Corporation, the equipment supplier, has arranged two batches of training for the project owner in Japan focusing on equipment operation and troubleshooting for technical personnel. Moreover, a team of technical professionals who are familiar with CDM business have been trained, creating a solid foundation for future CDM project development. Therefore, the utility value of this indicator is defined as 0.5.

Indicator 3: Employment

Feedback suggests that the project will lead to the addition of 20 employees during normal operation as well as temporary employment during the construction period. In combination with the 16,738 tonnes of CO_2e/year from emission reduction, calculations suggest that the employment of this project is 14.3386 person·month/1000CER, which is higher than the baseline value of 3 person.month/1000CER. As a result, the project utility value of this indicator is calculated to be 0.0515.

Indicator 4: Ecological protection and land resource

This project is located within the existing plant area of the Wuhan Iron and Steel Corporation group, and therefore does not include the development of additional industrial land. The project construction and operation is not expected to have any noticeable effect on nearby water quality and consumes less water than a coal-fired generator set. It is further expected to have some positive influence on the local ecological system and air quality. As a result, the utility value of this indicator is defined as 0.5.

Indicator 5: Emission-reduction effect

The CDQ project adopts dry quenching technology which effectively eliminates direct emission of hazardous substances such as hydroxybenzene, cyanide and sulphide through wet quenching method while producing less particle dust. As a result, it can reduce emission of CO_2 by 16,738 tons per year. Therefore, the utility value of this indicator is defined as 0.5.

Indicator 6: Fossil Fuel

The CDQ project generates power through industrial heat recovery by utilising medium- or high-pressure steam generated during dry quenching. As a result, the project creates no additional consumption of fossil fuels such as coal. Therefore, the utility value of this indicator is defined as 1.

Indicator 7: Regional development

Located in the moderately developed Hubei Province, it is estimated that the project will bring a high CER sales benefit and increase financial revenue for Hubei through higher income tax. As the steel industry is a fundamental industry for Hubei, it is expected that marginal contributions to the total economic volume of this district will be generated. Wuhan Iron and Steel Corporation 's implementation of the project is consistent with the region's overall industry development plan as it will lead to energy savings and reduced emission, while facilitating clean production and the development of a circular economy. The completion of this CDQ project is important for Wuhan Iron and Steel Corporation group to drive its own energy conservation and emission reduction through CDM. As a result of the above, the utility value of this indicator is 0.5.

Indicator 8: Micro-economic efficiency

In the financial budget of the feasibility study report for this project, the Internal Rate of Return (IRR) after income tax is calculated as 9.42 percent, which is lower than the benchmark IRR of 11 percent for the steel industry. While this implies that the project is not economically attractive to the company, its economic indicators will improve if it is successfully registered as a CDM project. Under such an occurrence, it will benefit from CER sales, allowing the total IRR to reach approximately 11.53 percent, surpassing the benchmark level of 8 percent evaluated by the study team. By calculation, the corresponding utility value of this indicator is 0.1605.

Indicator 9: Technology transfer

Wuhan Iron and Steel Corporation both imported the equipment set from Nippon Steel Corporation, and obtained technical training in Japan for personnel focusing on equipment operation and troubleshooting. Wuhan Iron and Steel Corporation, moreover, exhibited great strides in absorbing the advanced CDQ technology while further evidence suggests that China has made marginal progress in introducing CDQ equipment and transferring the technology. Therefore the utility value of this indicator is defined as 0.5.

Taking the preceding 9 indicators into account and adding together the individual weighted utility values, the degree of influence on sustainable development for this project is 0.5006.

Table 4.3 Evaluation results of Wuhan Iron and Steel Corporation CDQ project with MATA-CDM-China method

System indicator	Weight (1)	Element indicator	Weight (2)	Project utility (3)	Weighted utility (4) = (1) × (2) × (3)
Social progress	**0.25**	Social equity	0.37	0.5	0.0463
		Capacity Building	0.33	0.5	0.0413
		Employment	0.3	0.0515	0.0039
Sub total			1		**0.0915**
Environmental protection	**0.43**	Ecological protection and land resource	0.29	0.5	0.0624
		Emission-reduction effect	0.37	0.5	0.0796
		Fossil energy	0.34	1	0.1462
Sub total			1		**0.2882**
Economic development	**0.32**	Regional development	0.26	0.5	0.0416
		Micro-economic efficiency	0.36	0.1605	0.0185
		Technology transfer	0.38	0.5	0.0608
Sub total			1		**0.1209**
Degree of influence on sustainable development	**1**				**0.5006**

4.2.3.2.3 Result analysis

From the above analysis, it is inferred that this project has, in general, facilitated sustainable development. The justification for this assessment is supported through the following three aspects:

1) Social progress: This project has a utility score of 0.0915 at the social level, which is 18.3 percent of the total utility value. While this implies that the project contributes little to social progress, it is largely due to the nature of such projects. First, such projects place more stress on enhancing efficiency of resources and energy utilisation. As a by-product, however they improve ambient atmosphere quality around the steel plants, which is helpful in improving the health of project staff and nearby residents. Second, while such projects mainly focus on satisfying their own energy demands, they help mitigate the contradictions between local electric power supply and demand to some degree. Furthermore, due to the features of high efficiency and technology concentration, such projects cannot be expected to

create many employment opportunities.

2) Environment protection: This project has a utility score of 0.2882 at the environmental level, which is 57.6 percent of the total utility value. This implies that the project's main contribution is derived from improvements in environmental protection; mainly due to the high-efficient and environment-friendly features of CDQ. The CDQ project has located within the plant area of Wuhan Iron and Steel Corporation thereby avoiding additional demands on industrial land. Moreover, as this project uses the steel industry's excess heat for fuel in power generation without creating additional demand for fossil fuels such as coal, the coal consumption is 0. It can therefore be surmised that such projects in the steel industry are of distinct advantage in environmental protection.

3) Economic development: This project has a utility score of 0.1209 at the economic level, which is 24.2 percent of the total utility value. This implies that it has effectively facilitated economic development to some degree. More specifically, its active contribution to economic development occurs through the attainment of three key indicators: regional development, a viable IRR and technology transfer. First, since this project is located in an area of medium economic affluence, the marginal benefit of a CDM project is usually higher than that from similar projects in developed areas. Second, while the IRR of this project is just at the steel industry's IRR benchmark, it is much higher than that defined by the study team, implying that considerable utility value exists in terms of 'micro economic efficiency'. Finally, the project has also made marginal progress in technology transfer. Wuhan Iron and Steel Corporation has not only imported the equipment successfully and received technical training courses from their Japanese counterpart, but has also made great efforts in absorbing these advanced technologies.

4.2.4 Key findings

Based on the preceding evaluation and analysis, the average degree of influence on sustainable development for CDM projects of the two types of steel heat recovery is 0.4718. It can therefore be inferred that heat recovery CDM projects have played an active role in facilitating sustainable development for steel enterprises.

More specifically, the primary benefits to economic development from steel heat recovery CDM projects are as follows:

First, at the international level, enforcement of the Kyoto Protocol and the existence of CDM have indeed provided a great opportunity to enhance energy conservation and emission reduction in the steel industry. Second, the development of relevant domestic policies has created good conditions for rapid development of heat recovery CDM projects in the steel industry, especially against the macro background of active promotion of energy conservation and emission reduction at China's current stage. Finally, at the enterprise level, fully leveraging CDM is also an objective reflection of the project owner's desire to reduce energy consumption costs for products while strengthening competitive advantage.

In addition, it should not be ignored that Chinese steel enterprises have made great efforts in introducing and absorbing advanced foreign energy-saving and energy-efficient technologies, and have gained certain progress in this regard. For example, in order to absorb advanced CCPP technology, Handan Steel Group was very active in: organising technical personnel to translate relevant materials into Chinese; establishing technical groups to strengthen their ability to solve technical problems; adapting generator sets to meet their specific needs; optimising ambient conditions (such as heat value conditions) for generator set operation; and inviting Japanese experts for assistance in overhaul instruction. Wuhan Iron and Steel Corporation, moreover, allocated a sizeable amount of its technical force to the adaption of CDQ power generation technology, ensuring that the NDRC approved the CDQ power generation projects of multiple coke furnaces as a CDM project.

Notwithstanding, some problems have been identified in the development and implementation of CDM projects for the steel industry. Further, some restrictions on steel heat recovery CDM projects must not be ignored, including:

1) Outstanding technical barriers. Although the technical level of gas turbine manufacturing is developing in China, the industry is still not capable of manufacturing the large-powered low-heat-value combustion blast furnaces necessary for CCPP. As a result, the development of these CDM projects in such a large steel-manufacturing country is greatly restricted. As for CDQ power generation technology, the introduction of technical equipment and technology transfer will also be restricted by multiple factors such as complexity of the CDQ system, the large number of equipment and facilities, the high automation degree, and the difficulty in safety assurance.

2) Remarkable capital barrier. This restriction is mainly reflected by the large transaction cost entailed in commercial negotiation as well as the equipment import cost for these CDM projects. As such, the initial investment cost remains relatively high. Handan Steel Group, for example, acquired its gas turbine technology from Mitsubishi at market price. The two gas turbines cost them over RMB 500 million, or about two-thirds of the total static investment of the project. Without the ability to be developed as a CDM project, the IRR would be 9.23 percent. However, since this project has successfully been developed as a CDM project, it has yielded benefits through CER sales, thereby raising the IRR by 40 percent (although this places it just at the benchmark IRR for the steel industry).

3) Insufficient support from finance, tax and grid-input price policies. As for finance, it usually requires a large investment from the project owner before development of heat and pressure recovery CDM projects for the steel industry. For Handan Steel Group and Wuhan Iron and Steel Corporation, the substantial preliminary investments prior to project development were obtained from financial institutions due to their position as large state-owned enterprises and key local contributors of revenue and tax. Without these pre-conditions, finance for development of such

projects would be substantially more difficult to obtain.

In view of tax policies, there are no policies allowing for deductions in tariff and VAT for the import of advanced foreign technology and equipment, or in income tax during project operation. In addition, policy support providing favourable grid power prices for inputs from such projects is lacking, greatly depressing incentives to pursue CDM projects for steel enterprises as a result.

4.3 Case of heat recovery for cement industry

4.3.1 General

Cement is one of the fundamental raw materials necessary for construction. After years of development, the Chinese cement industry has made great achievements. Since 1985, for example, China has been the world's largest producer of cement and now contributes half of the world's production. However, structural contradictions in the Chinese cement industry are significant, with the consumption of resources and energy high and its contribution to environmental pollution serious. As such, sustainable development in the industry faces substantial challenges.

As a significant consumer of energy, the cement industry takes up approximately 7 percent of total domestic energy consumption. Correspondingly, it is also a significant emitter of greenhouse gasses. Within the sector, CO_2 emission comes not only from energy consumption, but also from mineral material decomposition in the production process. Data reveals that 0.356 tonnes of CO_2 are discharged from the production of each tonne of cement, while CO_2 emission from energy consumption is about 0.3 tonnes per ton of cement[16] production. Taking 2005 as an example, cement production in China was 1.064 billion tonnes. As a result, the CO_2 emission from energy consumption was 3.19m tonnes, while CO_2 emission from the production process was 379m tonnes. With total CO_2 emission of 4.944 billion tonnes in 2005, the cement sector alone accounted for 14.1 percent of CO_2 emissions.

While there are, at present, multiple approaches to energy conservation and emission reduction within the cement industry, the industry overwhelming relies on two approaches. The first is to improve production technology, such as replacing limestone with calcium carbide dregs in producing cement clinker. The second is recycling and utilising heat recovery during cement production. These two emission-reduction approaches also constitute the two main types of CDM development for the cement industry. As of 30 June 2009 the total NDRC approved CDM projects for cement heat recovery power generation was 113, representing accumulated annual emission reductions of 12.799m tonnes. Among the 579 successful projects registered with EB, the cement industry contributed 32 projects, in which 28 (with 4.8 percent have accumulated annual emission reduction of 2.44m tonnes) were cement heat recovery power generation. In addition, 4 projects of cement clinker production have successfully been registered with EB, while 14 are still in the CDM Pipeline.

[16] Source: Cement website, for details please go to: http://www.cement.cc/NewsShow.asp?page=2&id=3650

4.3.2 Relevant policy overview

As a sector of significant national economic importance, and high energy consumption, pollution and emission, the cement industry is of particular concern to the Chinese government and their goals of energy conservation and emission reduction. At the macro-level, the *Mid- & Long-Term Specific Energy Conservation Plan* issued in 2004 listed the cement industry as a key energy-saving sector, and proposed to 'develop new dry process outer-kiln decomposition technology, increase the proportion of new dry process cement clinker, promote energy-saving grinding equipment and power generation technology through cement kiln heat recovery'. It also identified the heat recovery and pressure utilisation for the cement industry as one of the key energy conservation projects, and proposed to 'build 30 sets of low-temperature heat recovery power generation devices in cement production lines over 2,000 ton/day every year' during the 11th Five-Year Plan period so as to achieve the goal of saving 3m tonnes of standard coal per year.

In the *Measures for Operation and Management of CDM Projects* promulgated in October 2005, energy improvement projects (including heat recovery and use projects for the cement industry) were among the top 3 sections, entitling them to a 2 percent reduction on revenue from CER sales.

As specified in Article 26 of the incentives section in the *Directory of Industrial Restructuring Guidance* promulgated in December 2005, the 'heat recovery power generation for new dry process cement clinker production over 2,000 ton/day' is one of the key state-encouraged developing sectors.

In the *National Climate Change Program* promulgated in 2007, it is indicated that the cement industry is one of the significant sectors for mitigating greenhouse gas emissions. As such, 'energy-saving grinding equipment and power generation technology through cement kiln heat recovery must be actively promoted', and 'industrial dregs must be synthetically used'.

In the *Circular Economy Promotion Law* implemented on 1 January 2009, companies are also encouraged to 'build grid-combined power generation projects through recovery of heat, pressure and coal bed gas as well as leveraging low heat-valued fuel such as coal gangue, coal sludge, waste'. Moreover, grid enterprises are required 'to sign grid combination agreements, provide grid input services for companies generating power through synthetic resource utilisation in line with state rules, and buy up input from their grid-combined power generation projects'.

In addition, the government also introduced relevant restructuring guidelines, industrial development policy and specific plans to facilitate implementation of energy conservation and emission reduction. On 9 November 2005, The *No.112 State Council Executive Meeting* agreed on the *Interim Rules To Facilitate Industrial Reconstruction*. In April 2006, moreover, eight state governing ministries co-issued the *Notice About Proposals On Accelerating Cement Industry Reconstruction*, which sets to ‘strengthen resource conservation and synthetic utilisation’, and "optimise rules on favourable waste use tax for cement in current policies of synthetic resource utilisation, further establish scientific and rigorous qualification evaluation method, program and management mechanism for true implementation of synthetic resource utilisation policies’. In addition, it also proposed strengthening research in large efficient grinding systems, low-heat-valued fuel application, low-temperature heat recovery power generation, urban waste disposal, industrial dreg and combustible waste application, and new green cement-based material. It further lists areas of focus such as ‘combustible waste hazard elimination in cement production and resource processing technology and equipment’ in key national research and development. As such it calls for strengthened investment in scientific research and development, the construction of a demonstrating line, and breakthroughs in technical developments and applications.

According to the *Cement Industry Development Policy* issued on 17 October 2006, ‘the government encourages and supports enterprises to develop circular economy, heat of waste gas from new dry process kiln system must be recycled and utilised, and power generation through pure low-temperature waste gas heat recovery is encouraged’. At the same time, ‘the government supports enterprises to take measures to reduce pollutant emission to atmosphere, reduce environment pollution, save energy consumption, utilise industrial dregs synthetically, use low-quality raw material as fuel actively, enhance resource utilisation, encourage cement enterprises to engage in resource conservation to meet requirements of clean production technology’.

In the *Specific Plan For Cement Industry* issued in the same year, it was also proposed to ‘promote the technologies of energy-saving grinding, heat recovery power generation, industrial waste disposal using cement kiln, and family waste assortment etc., to develop circular economy’.

4.3.3 Case study of 9.1MW heat recovery power generation project of Ningguo Cement Factory

4.3.3.1 Project overview

The 9.1MW heat recovery power generation project of Ningguo Cement Factory is located in Ningguo City, Anhui Province. A subsidiary of Anhui Conch Cement Corporation Ltd., it owns 3 new dry process cement clinker production lines. Line 1 is capable of producing 4,000 tonnes of cement clinker per day, and has successfully realised heat recovery power generation (in October 1995, the low-temperature heat recovery power generation technology and device were supplied by Japan for free). Line 2 is capable of producing 2,000 tonnes of cement clinker per day, although it has thus far not been able to realise heat recovery power generation. Line 3 has a capacity of 5,000 tonnes per day.

The CDM project is to generate power by using heat recovery from the No. 3 cement clinker production line, and is equipped with 2 sets of heat recovery boilers and 1 set of mixed-pressure concentration turbo-generators rated at 9.1MW. The total project investment amounted to RMB 150 million, with the key equipment imported from Japan. According to preliminary design standards, the volume of heat recovery power generation is 38.5kW.h for each tonne of cement clinker, making the annual volume 65100MWh and the estimated annual emission reduction 54,907 tons of CO_2. In May 2007 this CDM heat recovery power generation project was successfully registered with EB. In March 2008, the DOE went for onsite verification while the first CER was issued in August 2008.

4.3.3.2 Impact assessment

Employing the three systematic levels of the MATA-CAM-China evaluation metrics system – social progress, environment protection and economic development – this section will evaluate 9 indicators to assess the impact of the CDM project on sustainable development.

Indicator 1: Social equity

The project is expected to generate power through heat recovery from waste gas, and supply power to the No.3 cement production line, somewhat reducing demand on power supply from the local grid. Although it does not create any gender discrimination, it is not expected to improve the condition of women. Therefore, the utility value of this indicator is defined as 0.5.

Indicator 2: Capacity Building

As one of the first batches of Conch Group to implement CDM projects in heat recovery power generation, Ningguo Cement Factory has accumulated experience in successful CDM application for cement heat recovery power generation, while increasing both the quality and knowledge of personnel. In addition, with its advantage of established technology in heat recovery power generation, Ningguo Cement Factory has trained 126 persons for other subsidiaries of Conch Group on heat recovery power generation projects. From January - December 2007, Ningguo Cement Factory accepted 13 batches of trainees from other companies on heat recovery power generation technology, with each batch lasting for 2-3 months. During the period, trainees strengthened their knowledge in the technical process of cement kiln heat recovery power generation through intensive training, while also learning multiple operating skills such as pure water making, boiler inspection, regular dirt-draining, emergency operation in case of power failure, power generation and grid combination, and separation through on-the-job training. As these intensive training sessions equipped trainees with the ability to meet rigorous requirements the utility value of this evaluation indicator is defined as 1.

Indicator 3: Employment

After the heat recovery power generation project is put into operation, it requires 19 formal employees. In addition, labour employed in maintenance and repair will provide cyclic short-term employment opportunities of one month to over 50 workers per year. Combining the annual average CO_2 emission reduction of 54,907 tonnes along with the evaluation standards of the ‘evaluation indicator table’, the utility value of this indicator is calculated as 0.0094.

Indicator 4: Ecological protection and land resource

This project has been implemented in the already established cement factory, without the need to develop additional land. In addition, the temperature of exhaust gas will be reduced from 360℃ to 84.21℃ with the implementation of this project, subsequently reducing the regional air temperature, while mitigating the negative impact on the ecological environment. As a result, the utility value of this indicator can be defined as 0.5.

Indicator 5: Emission-reduction effect

This project is located in eastern China, where the emission factor of the east-China grid is 0.8847kgCO2e/kW.h. Using 2007 as an example, the project’s output of 76m KW.h through heat recovery power generation, implies that CO_2 will be reduced by 67,237 tonnes every year. As the heat recovery boiler is critical to the level of smoke and dust content, the gas discharged into the atmosphere from the boiler will be of lower dust concentration. Compared with virtual thermal power generating plants of equivalent scale, this CDM project uses heat recovery for power generation and consumes neither fossil fuel nor any other fuel. As a result, no SO_2 or NOx will be expelled in the process of heat recovery power generation. Therefore, the utility value of this indicator is 1.

Indicator 6: Fossil Fuel

This CDM project uses heat recovery from cement production for power generation, without consuming fossil fuel such as coal. According to the evaluation standards of the ‘evaluation indicator table’, the utility value of this indicator is 1.

Indicator 7: Regional development

The power generated by utilising heat recovery will be combined to the grid but not as additional input. Instead, it will be used by the No.3 production line of the cement factory, thus reducing the company's expenditure on electric power while increasing company profit and local revenue. This project is consistent with the local objective of cement industrial reconstruction and upgrading. At the same time, the pure low-temperature heat recovery power generation technology it adopted is expected to produce demonstration and spill-over effects. Therefore, the utility value of this indicator is defined as 0.5.

Indicator 8: Micro-economic efficiency

As shown by PDD data, the IRR accrued by power generation (excluding the capital used for purchasing equivalent volumes of electric power from the grid) will reach 17.6 percent when the operation time of this project reaches 7,449 hours. This greatly surpasses the 10 and 8 percent benchmarks of financial return for hydro power and thermal power, respectively. In the course of the survey, the owner claimed that the annual operation time of the project is up to 8209 - 8234 hours. Taking a conservative value of 8209 hours for annual operation time, the IRR can be calculated as 20.57 percent. As such, the utility value of this indicator is defined as 0.5714.

Indicator 9: Technology transfer

Ningguo Cement Factory is the first practitioner of pure low-temperature heat recovery power generation technology in China, and is also the first cement heat recovery power generation CDM project from China which has successfully registered with EB. The successful implementation and sound economic benefit of Ningguo Cement Factory has provided an outstanding demonstration effect for power generation with cement heat recovery as well as energy efficiency improvement for the industry.

Heat recovery power generation for No.3 production line of Ningguo Cement Factory has a total budget of RMB 150 million and adopts Japanese technology, with the key equipment being imported from Japan. To promote localisation of low-temperature heat recovery power generation technology, and reduce investment costs and construction time, Anhui Conch Cement Corporation Ltd. formally contracted with Japan Kawasaki Company to establish Conch Kawasaki Energy-Saving Equipment Manufacturing Company (Conch-Kawasaki). The joint-venture primarily focuses on development, manufacturing and installation of cement heat recovery power generation boiler and gas boiler energy-saving and environment-protecting equipment. By introducing key software technology for heat recovery boilers from Kawasaki Company, Conch-Kawasaki established the ability to completely manufacture relevant equipment locally, allowing it to also supply advanced technology and installations for energy conservation and emission reduction for Cement and other high-energy consuming industries.

Conch-Kawasaki has thus far undertaken over 50 heat recovery power generation projects for cement production lines. With localisation of production, the amount of investment needed to implement a heat recovery power generation project equivalent to that of Line 3 has been reduced from RMB 150 million to RMB 70 million.

As the first set of heat recovery power generation equipment was installed in 1995, this CDM project is not the most direct cause of heat recovery power generation technology transfer. However, the implementation of this CDM has actually pushed the distribution and usage of this technology further in China. Taking all the above into account, the utility value of this indicator is defined as 0.5.

Taking the preceding 9 indicators into account and adding together the individual weighted utility values, the degree of influence on sustainable development for this project is 0.6654 (as shown in the table below).

Table 4.4 Evaluation results of cement heat recovery power generation project of Ningguo Cement Factory with MATA-CDM-China method

System indicator	Weight (1)	Element indicator	Weight (2)	Project utility (3)	Weighted utility (4)=(1)×(2)×(3)
Social progress	**0.25**	Social equity	0.37	0.5	0.0463
		Capacity Building	0.33	1	0.0825
		Employment	0.3	0.0094	0.0007
Sub total			1		**0.1295**
Environmental protection	**0.43**	Ecological protection and land resource	0.29	0.5	0.0624
		Emission-reduction effect	0.37	1	0.1591
		Fossil energy	0.34	1	0.1462
Sub total			1		**0.3677**
Economic development	**0.32**	Regional development	0.26	0.5	0.0416
		Micro-economic efficiency	0.36	0.5714	0.0658
		Technology transfer	0.38	0.5	0.0608
Sub total			1		**0.1682**
Degree of influence on sustainable development	**1**				**0.6654**

4.3.3.3 Result analysis

From the above evaluation, it is inferred that this project has greatly facilitated sustainable development. The justification for this assessment is supported through the following three aspects:

1) Social progress: This project has a utility score of 0.1295 on the societal level, which is 19.5 percent of the total utility value. While this implies that the project contributes little to social progress, it is largely due to the nature of such projects. First, such projects will improve ambient atmosphere quality around cement plants, helping to improve health conditions of project staff and nearby residents. Second, such projects have helped mitigate the contradictions between local electric power supply and demand to some degree. Furthermore, due to the features of high

efficiency and technology concentration, such projects certainly cannot be expected to add many employment opportunities. In addition, this CDM project makes a significant contribution to capacity building, especially considering that the Ningguo Cement Factory has trained more than 100 technical personnel for other subsidiaries of Conch Group as well as many other cement enterprises on heat recovery power generation projects with their established technical advantage on heat recovery power generation system.

2) Environment protection: This project has a utility score of 0.3677 at the environmental level, which is 55.3 percent of the total utility value. This implies that the project's main contribution is derived from improvements in environmental protection; mainly due to the high-efficient and environment-friendly features of low-temperature heat recovery power generation technology. This heat recovery power generation project does not call for the development of additional land and does not place increased demand on fossil fuels such as coal. At the same time, it is able to reduce regional air temperature and mitigate negative impact on the ecological environment. Therefore, it can be surmised that such CDM projects within the cement industry are of distinct advantage in environment protection.

3) Economic development: This project has a utility score of 0.1682 at the economic level, which is 25.2 percent of the total utility value. This implies that this CDM project has certain positive effects on facilitating economic development, mainly from the high IRR of this project and technology transfer. Compared with other types of CDM project, low-temperature cement heat recovery power generation projects are of outstanding economic benefit as the IRR is usually above 20 percent. By establishing a joint venture, Conch Cement Corporation Ltd. was able to successfully localise the production of Japanese low-temperature heat recovery power generation technology thus engendering technology transfer and spill-over effects.

4.3.3.4 Key findings

From the above evaluation and analysis, the following key points have been identified:

The first is that the active development of such projects within the cement industry benefits not only from the active role CDM has played, but also from the institutional environment within China that is actively promoting energy conservation and emission reduction during the industry's restructuring. In addition, the recognised need of cement enterprises to conserve energy and reduce emissions, in combination with their objective demands to reduce production costs and strengthen competitive advantage, has also played an important role.

The second is the high IRR of such projects. If considering the income of CER sales, the IRR typically exceeds 20 percent. This helps greatly increase the incentive of multiple cement enterprises in investing in low-temperature heat recovery power generation.

The third is that low-temperature heat recovery power generation within the cement industry can be regarded as a successful case of technology transfer and dissemination. While this success should largely be attributed to CDM and the macro policy within China, it is also due to the donation of heat recovery power generation equipment for the No.1 cement production line by Japan's Kawasaki Company in 1995, as well as the efforts of the Conch-Kawasaki joint venture established in 2005 to accelerate localisation of heat recovery power generation technology and equipment.

At the same time, restrictions on the development of low-temperature heat recovery CDM projects within the cement industry have been identified. These consist of:

1) Unfair tax burden. According to domestic tax law, the VAT levied on enterprises is determined by deducting the tax amount of purchased items from that of sales items. In this regard, it is notable that no deductions can be made for enterprises of heat recovery power generation as there are no fuel purchases, implying that such enterprises will be required to pay higher VAT than a thermal power plant generating an equivalent volume of electric power. This phenomenon has depressed the incentive to invest in heat recovery power generation, especially within districts of low electricity costs and low return rates of heat recovery power generation.

2) Lack of effective grid combination and input mechanism. At present, the electric power generated through heat recovery is used by the producing factory. In order to be utilised externally, the generator set for heat recovery power generation must be combined to the grid in order to ensure supply quality. However, grid combination for cement heat recovery power generation projects is difficult to coordinate. In some districts, enterprises are required to pay a 'grid combination fee' for heat recovery power generation, and may even be required to 'input power first and then buy from grid'. Such administrative restrictions have eroded the profits from heat recovery power generation projects, and reduced incentives to invest in such projects.

3) High IRR of such projects is playing a double role, which has so far become a major restriction for its successful registration with EB. Due to additional requirements on ratification, the rate of successful registration with EB is not high in China at present.

4.4 Case of Ultra-supercritical (USC) Power Generation

4.4.1 General

Ultra-supercritical power generation technology was introduced in the 1990s. It is able to improve thermal efficiency of boilers by raising the pressure and temperature of the main boiler steam, so as to reduce coal consumption and achieve better environment-protection performance. It is of a high technical nature and is so far the most advanced coal-fired generation technology available. It is estimated that the thermal efficiency of a general-purpose super-critical boiler is about 2 percent higher than that of a sub-critical boiler, while the thermal efficiency of a USC boiler is an additional 4 percent higher than that of a general-purpose super-critical boiler. In 1998, the first set of USC power generators designed and manufactured by the Danish BWE company was put into operation at the Nordjyllands power plant in Denmark. It has thus far set a new world record of 47 percent in power generation efficiency – far higher than that of sub-critical and general-purpose super-critical generator sets.

According to statistics, there are approximately 60 USC generator sets in operation around the world, with Japan, Germany and Denmark leading in this technology. At present, the maximum capacity of a single generator set is 1050MW. In November 2006, the first million-KW level USC generator set in China – the No.1 generator set – was formally put into commercial operation in Huaneng Yuhuan Power Plant. Based on the 1000MW level engineering project, China is researching and developing boiler, gas turbine and power station systems for USC generator sets and corresponding fume purification technology with its own intellectual property rights. As of June 2007, the USC generator sets established or under construction include: 30 sets of 1000MW, 26 sets of 660MW and 8 sets of 600MW.

As of 30 June 2009, no USC power generation project has successfully registered with EB. However, China has a total of 9 USC projects under evaluation in its CDM Pipeline, estimated to reduce CO_2 equivalent of 4.9 million tonnes per year (as shown in the figure below).

Table 4.5 Status of ultra-supercritical CDM project approval by Chinese DNA

No.	Project Title	Project location	Project type	Annual emission reduction (tCO2e)	DNA approval time
1	1st phase USC power generation project of Anhui Huadian Wuhu Power Plant	Anhui	Energy efficiency improvement	452,936	Jul. 18, 2008
2	Jiangsu Guodian Taizhou USC power generation project	Jiangsu	Energy efficiency improvement	632,305	Jul. 18, 2008
3	Zhejiang Guodian Beilun USC power generation project	Zhejiang	Energy efficiency improvement	462,527	Sep. 2, 2008
4	USC coal-fired generation project of Shandong Zouxian Power Plant	Shandong	Energy efficiency improvement	586,587	Oct. 8, 2008
5	Shanghai Waigaoqiao USC coal-fired generation project	Shanghai	Energy efficiency improvement	543,066	Oct. 8, 2008
6	Zhejiang Guohua Ninghai USC power generation project	Zhejiang	Energy efficiency improvement	630,422	Oct. 8, 2008
7	Huaneng Yuhuan USC coal-fired generation project	Zhejiang	Energy efficiency improvement	393,976	Nov. 26, 2008
8	1st phase USC power generation project of Guangdong Pinghai Power Plant	Guangdong	Energy efficiency improvement	834,644	Mar. 17, 2009
9	2nd phase USC power generation project of Yuzhou Power Plant	Henan	Energy efficiency improvement	364,168	Jun. 22, 2009

4.4.2 Relevant policy overview

In order to realise continuous sustainable development of the power industry, it is critical the China accelerate the development of nuclear power, wind power and renewable energy as well as the active exploration of hydro power and clean coal technology. As China is rich in coal resources, the development of electric power will continue to play an important role in the short-term placing greater importance on thermal power. In the process of electric power development and construction, thermal energy is therefore of higher priority, making it important to balance factors such as coal and water resources, the electric power market, transportation and environment protection in order to optimise coal power industrial distribution, restructure generation capacity installation, and enhance technical level and economic viability of generator sets. It is also necessary to build large-scale projects while restricting small-scale projects and accelerating the closing and consolidation of small-capacity thermal power generator sets. Further, efforts need to be taken to eliminate laggard production capacity; encourage the construction of efficient, low-energy-consumption and large-capacity environment-protective generator sets; improve overall efficiency of the power industry; implement energy conservation and emission reductions; develop combined thermal-power production; and increase the proportion of combined thermal-power production.

In 21st century, the Chinese government has been actively stressing the development of clean coal technology, and has promulgated a series of policies and measures to encourage and support USC power generation technology and promote sustainable development of the power industry. In 2002, China listed the development of USC boilers as an item in the *National High-Tech R&D Program* (863 plan). In 2003, the National Economic and Trade Commission and National Science Ministry both listed the USC boiler in the national R&D plan of significant technical facilities.

The Medium & Long Term Specific Energy Conservation Plan issued in 2004 and the *Directory of Industrial Restructuring Guidance* developed in 2005 both placed emphasis on the development of super-critical and USC generator sets of over 600m KW capacity. The *11th 5 Year Plan Compendium* promulgated in 2006 also proposed to 'optimise thermal power focusing on efficient large-scale environment-protective generator sets, build large-scale USC power station and air-cooled power station, initiate overall coal-gasifying CCPP project'. In the *National Climate Change Program* promulgated in 2007, it is indicated that focus should be placed 'on high-performance parameter super-critical (or USC) generator set research' as it is an important opportunity for China's development of clean coal power generation and reduction of greenhouse gas emission.

Through the establishment of multiple super-critical and USC projects such as the Qingbei and Yuhuan projects, China is coming increasingly closer to being able to locally produce key equipment of thermal power generation. This has not only consolidated the success of localising general-purpose generator set production, but has also allowed China to obtain the advanced manufacturing technology of coal-fired generator sets. The improvement of electric power technology in China as well as the enhancement of equipment production will further drive sustainable development within the power industry.

4.4.3 Case study of Jiangsu Taizhou USC power generation project

4.4.3.1 Project overview

Jiangsu Guodian Taizhou USC power generation project, located at Yong'anzhou Town, Taizhou, mid of Jiangsu Province, was developed and built by Guodian Taizhou Power Generation Company Ltd. This project has built 2 set of 1000MW USC coal-fired generator. The 1000MW USC power generation technology is an efficient coal-fired generation technology of maximum capacity and highest efficiency in China, with a net thermal efficiency at about 45%. The total installed capacity of this project is 2000MW, while annual operation time of the generator set is 5,000 hours, with annual grid input of about 9380GWh. This project is estimated to reduce CO_2 emission of about 632.3 thousand tons per year. And the total emission reduction will be 6.323 mil tons the basis of 10-year fixed calculation period. .

The first generator set of this project was put into operation on December 4th, 2007, and the 2nd set was in April 2008. On July 18, 2008, this project was formally approved by national CDM project council, and became the first 1000MW level USC CDM project approved by the NDRC in China, which is regarded as a milestone for USC CDM project development in the country. The equipments of this project are jointly designed and manufactured by China and Japan. The initial CER buyer of this project was the U.S investment bank - Lehman Brothers, who went bankrupt in the later half of 2008 due to the global financial crisis. Right now, the buyer has been successfully replaced for this project.

4.4.3.2 Impact assessment

Based on the sustainability evaluation indicator system established by MATA-CDM-China methodology, we evaluate the 9 indicators at three aspects, which are social progress, environment protection and economic development.

Indicator 1: Social equity

This project plays significant role in balancing the local power supply and demand, optimizing the power source structure, and improving the adjustment capacity for Eastern China grid. In addition, the project significantly reduced the pollutant emission and improved the surrounding environment as well as the public health of local residents. There is no gender discrimination issue involved in this project, and on the other hand, it has no impact on improving women social status. According to the evaluation criteria, the utility value of this indicator is defined as 0.5.

Indicator 2: Capability Building

In order to ensure smooth operation of this project, the technical training has been provided to the relevant professionals. Through project implementation and supervision, the professional skills of relevant staff have been greatly improved. According to the evaluation criteria, the utility value of this indicator can be defined as 0.5.

Indicator 3: Employment

With the establishment of the project, it has provided approximate 200 employment opportunities for local residents. The annual emission reduction of this project is 632.3 thousand tce, which is equivalent to additional employees of 3.7957 person·month/1000CER. Comparing with the international empirical value, the utility value of this indicator is calculated as 0.0036.

Indicator 4: Ecological protection and land resource

Compared with the baseline, this project has positive impact on the local ecological system and air quality. There's no obvious impact on land resource utilization. Therefore the utility value of this indicator is defined as 0.5.

Indicator 5: Emission-reduction effect

The two generator sets of this project are estimated to reduce CO2 emission by about 632.3 thousand tons. Each unit is equipped with 1 set of low-NOx combustor and 1 set of 2-drum-4-electric-field static precipitator (with precipitation efficiency up to 99.7%).Each unit shares 1 set of limestone-gypsum wet Flue Gas Desulfurization (FGD) device (with desulfurizing efficiency up to 90%), and both units share a 240m-high double-flue bundled chimney. After static precipitation and desulfurization, the maximum dust concentration in the emission from No.1 boiler is 32.6mg/m3, the maximum SO2 concentration is 52.8 mg/m3, while the maximum NOx concentration is 224 mg/m3. For No.2 boiler, the maximum concentration of dust is 36.2 mg/m3, SO2 is 40.1 mg/m3 while NOx is 240 mg/m3. According evaluation standard, the utility value of this indicator can be defined as 0.5.

Indicator 6: Fossil Fuel

The baseline of evaluation is set as the average coal consumption of domestic thermal power plants in 2005, i.e., 343 gce/kwh. If the coal consumption for power generation equals to 343 gce/kwh, the utility value will be 0. If it reaches to 273 gce/kwh, referring to the coal consumption of the 1000MW USC generator set of Huaneng Yuhuan Power Plant established in 2005 for reference, the utility value will be 1. The coal consumption for power generation is 275g/kWh in this project, and the utility value of this indicator is calculated as 0.97 based on interpolation method.

Indicator 7: Regional development

This project is located in Jiangsu Province. In the 11^{th} 5-Year Plan of this province, one of the key objectives of the development of power industry is to promote the construction of the energy efficient power plants and to control the development of high energy consumption and high pollution industries. This include specific objectives to promote energy conservation and emission reduction to adjust the industrial structure, to coordinate the energy efficient power generation actions, and to facilitate the implementation of several "efficient power plant" construction projects. The adoption of USC thermal power technology is consistent with the overall industrial layout of this province. According to the evaluation critera, the utility score of this indicator is 0.5.

Indicator 8: Micro-economic efficiency

In the Project Design Documents (PDD) submitted to the DNA, this project adopts levelized cost of electricity generation (LCOE) as the financial indicator of investment analysis. According to the LCOE analysis, the sub-critical 4×600MW with the generation cost RMB0.314 /kwh is taken as the baseline. Without considering CDM, the cost is RMB0.329 /kwh for this project. `Combining this project with some other economic parameters, its IRR is calculated as 13.88%, equivalent to a utility value of 0.2673 for this indicator.

Indicator 9: Technology transfer

The key equipments, components and control systems for this project are imported form developed countries. The boiler is co-designed and manufactured by Haerbin Boiler Factory and Mitsubishi in Japan. The gas turbine is co-designed and manufactured by Haerbin Gas Turbine Company Ltd. and Japanese Toshiba, and the generator set is co-designed and manufactured by Haerbin Electric Motor Factory and Toshiba. Therefore the key equipments of this project are designed and manufactured with the cooperation between China and Japan, which facilitated the international technology transfer. According to the evaluation criteria, the utility value of this indicator is defined as 0.5.

After weighting the indicators and summing up the individual utility values, the impact level on sustainable development of this project is 0.5049 (as shown in the Table below), therefore it can be concluded that this project has facilitated the sustainable development of the company and the region.

Table 4.6 Evaluation results of Jiangsu Guodian Taizhou USC power generation project with MATA-CDM-China method

System indicator	Weight (1)	Element indicator	Weight (2)	Project utility (3)	Weighted utility (4)=(1)×(2)×(3)
Social progress	**0.25**	Social equity	0.37	0.5	0.0463
		Capability Building	0.33	0.5	0.0413
		Employment	0.3	0.004	0.0003
Sub total			1		**0.0879**
Environmental protection	**0.43**	Ecological protection and land resource	0.29	0.5	0.0624
		Emission-reduction effect	0.37	0.5	0.0796
		Fossil fuel reducing	0.34	0.97	0.1418
Sub total			1		**0.2838**
Economic development	**0.32**	Regional development	0.26	0.5	0.0416
		Micro-economic efficiency	0.36	0.2673	0.0308
		Technology transfer	0.38	0.5	0.0608
Sub total			1		**0.1332**
Degree of influence on sustainable development	**1**				**0.5049**

4.4.3.3 Result analysis

With the evaluation of the impact on sustainable development, we find that the scores on social progress, environment protection and economic development are 0.0879, 0.2838 and 0.1332 respectively, with contribution of 17.4%, 56.2% and 26.4%. This shows the contribution priority of this USC project is ranked as environment protection, economic development and social progress.

The lowest score on social progress is mainly because of the evaluation criteria, as the weight on this aspect is defined as the lowest. For evaluation on employment, the baseline is defined as the employees per ktCER, while the USC projects can easily reach the emission reduction capacity of thousands or even millions of tons, while the employment positions do not increase much compared with common thermal power plant, therefore its score on employment is very low.

Its highest score on environment protection is mainly because of the following reasons: 1. USC technology is so far the most advanced power generation technology which is able to reduce coal consumption, therefore it has gained high score on the "fossil fuel reducing". 2. Its emission-reduction effect is outstanding. According to the results of acceptance test by the Ministry of Environment, the maximum concentrations of dust, SO_2 and NOx emission all comply with the third-phase standard limit specified in "Emission Standard of Air Pollutants for Thermal Power Plants (GB13223-2003), and it also meet the requirements by national standards regarding sewage and noise.

Its score on economic development facilitation is ordinary compared with other projects such as coal bed methane utilization, as the IRR of USC project is generally low, therefore has little contribution to the indicator of "micro economic efficiency". As for the effect on facilitating technology transfer and regional development, the USC project does not seem be able to make a significant drive.

4.4.4 Key findings

From above evaluation and analysis on this project, this study's major findings are as follows:

1) Although CDM can bring the project owner CER sales benefit, capital barriers are still prominent as compared with the high investment costs for similar projects. Through participating in CDM projects and transferring CER, the Guodian Taizhou USC project can obtain additional income of 63.23 million RMB, and the total income between 2009 and 2012 will amount to 253 million RMB. Among Guodian Taizhou's 8.158 billion RMB worth of investments, the income from CER only amounts to 3.1%. From the view of extra carbon benefits from participating CDM, the result is not very attractive.

2) CDM projects also have driven the international transfer of equipment manufacturing technology. As China still lacks core technology, and most notably manufacturing technology for USC power generation, some key equipment, components and control systems must be imported from developed countries. The model HG-2980/26.15-YM2 boiler and model LCH generator are co-designed and manufactured by Harbin Boiler Factory and Japan Mitsubishi, and the model CLN1000-25.0/600/600 gas turbine is co-designed and manufactured by Harbin Gas Turbine Company Ltd. and Japan Toshiba. Considering that the main equipment for this project are jointly designed and manufactured by China and Japan, these projects have arguably facilitated the international transfer of manufacturing technology.

3) China has actively participated in the R&D of USC methodology. The results have been successful, and the research has made a significant contribution to the development of CDM methodology. With active support and promotion from the NDRC and National Science Ministry, the Tsinghua Nuclear Institute, the China National Water Resources and Electric Power Material & Equipment Corporation Ltd.

set to jointly develop the USC methodology beginning in April 2006 based on the two USC projects of Huaneng Yuhuan and Huandian Zouxian. In January 2007, the draft of the methodology was completed, and was submitted to EB for approval in June, a process which lasted for 19 months. The joint development team has successfully fulfilled their task and was verified by the EB.

In addition, we also observed some remarkable restrictions on the development of such projects, such as the absence of USC core technology, the need for improvement in complementary policies and measures for encouraging development of such generator sets.

4.5 Cases of small-sized hydro-power stations

4.5.1 Executive summary

Hydro-power is a type of renewable energy without greenhouse gases emissions. Therefore, it is one of the strategic options for optimizing energy structures and for promoting sustainable development in the power industry through the development of hydro-power. China has abundant hydro-power resources and great potential for the development of hydro-power-based on CDM projects. According to the latest general investigation on hydro-power resources, China's overall reserve of useable hydro-power resources is about 541 million KW, among which sources of hydro-power with estimated reserves less than 50k KW account for 128 million KW in total. Currently, 32% of these resources have been developed and the remaining 68% (equivalent to 860 million KW) are most suitable for the development of CDM projects. Even if 10% of these 860 million KW hydro-power resources are successfully developed, a reduction of 28 million tons of CO_2 emission will be achieved annually.

From the macro-level context of energy saving and emissions reduction, China has made great progress in the development of small-sized hydro-power CDM projects. As of 30 June 2009, among 579 domestic CDM projects have successfully registered at the EB, 275 are small-sized hydro-power station projects (representing an annual emission reduction volume of 2, 805 tons), accounting for 47.5% of the total. According to the statistics database of the UNEP Riso Centre, there are 2,091 CDM projects in China, which fulfils an annual emission reduction volume of 396 million tonnes. Among these, there are 998 hydro-power projects, representing an annual emissions reduction volume of 112 million tons. Thus, we can conclude that either by emissions reduction volume or by project number, hydro-power CDM projects account for a high percentage of China's energy sources.

4.5.2 Summary of related policies

The Management Rules on the Development of Clean Energy Development Mechanisms currently enacted in China has clearly identified the development of small-sized hydro-power CDM projects as one of the major fields that the state is actively supporting. China's Renewable Energy Law has clearly stipulated that hydro-power falls into the classification of renewable energy and is a field that the state encourages and develops. In particular, the state views radial flow type hydro-power stations with an installed capacity of less than 100 MW as suitable for the development of CDM projects.

For a long period of time, Chinese government has enacted favourable policies and encouraged investment in the development and utilization of hydro-power stations, particularly these of less than 50 MW by installed capacity. From the perspective of taxation, the state has adopted low value-added tax policies towards hydro-power station projects of less than 50 MW. The No.004 Document released by the Ministry of Finance in 1994 states that small-sized hydro-power stations operated below the county level are subject to a 6% value-added tax rate, compared to 17% for regular projects. Thus, small-sized hydro-power stations greatly benefit from these preferential policies. By on-grid price, the state has adopted a new price system and has set a reasonable price for newly built small-sized hydro-power stations based on the principle of allowing operators to repay loans and incurred interests as well as make reasonable profit so that the legal benefits of investors are well protected. For financing, the state provides small-sized hydro-power stations with priority government loans and gradually increases the allotments for such loans at policy-oriented banks such as the Agricultural Development Bank of China (ADBC). The Central Bank will allot dedicated funds to grass-root banks to meet capital demands of related projects. In addition, small-sized hydro-power stations have also been listed into the catalogue encouraging full access for foreign investments. By doing so, the state can attract foreign investment to accelerate the construction of small-sized hydro-power stations and get access to the operation market. For project management, the state has adopted policies prioritizing the examination and approval for these well-performed small-sized hydro-power projects contributing to watershed regional development. The investors are encouraged to make investments into the development of small-sized hydro-power stations. Some local development companies receive incentives to conduct comprehensive development over the entire watershed area.

4.5.3 Assessment on sustainable development influences of multiple CDM project cases in hydro-power industry

4.5.3.1 Case 1: Hunan Xiaoxi hydro-power station project

4.5.3.1.1 Project profile

Xiaoxi Hydro-Power Station is located in Xiaoxi Village, Pingshang Township, Xinshao County, besides the mouth of Longkouxi valley of the middle branch of the Zishui River, which is the second largest river of Hunan province. It is a major development project among the Class-4 Development Scenario of the Zishui River. The overall investment of this project amounts to 1.09 billion Renminbi (RMB), with an estimated construction period of four years. The first set was scheduled to connect to the grid for power generation in 2007. After the station is put into formal operation, the installed capacity will reach 100k KW, the annual power generation capacity 448k KW-hour, the annual sales turnover 150 million RMB. It is expected that this project will replace some fossil fuel power plants within the Middle China Grid and achieve an annual green house gas emissions reduction of up to 423.3395k tCO2e. This project adopts the renewable 7×3 year calculation period. During the first emission reduction calculation period (from October, 2007 to September, 2014), the total amount of reduced greenhouse gas emissions will be 2,963.765k tCO2e. The NDRC approved the PDD of this project on 2 July 2007 and the project was successfully registered at the EB on 19 December 2008. The CER buyer is the German RWE Company. However, the CER has not been issued yet.

4.5.3.1.2 Impact Assessment

The following are based on the evaluation and analysis of the impact of sustainable development of this project using the MATA-CAM-China methodology discussed in Chapter 3.

Indicator 1: Social equity

Regarding the settlement of migrants caused by the building of the hydro-power stations, the people designated to move were encouraged to resettle in the county area or nearby the stations. This greatly improved the living environment and condition of migrants. New roads were built for transportation and for the building of the stations. Old roads were renovated as well. Thus, the local transportation and travel conditions were greatly improved. Based on the logistical demands of the construction staff, new pipelines for drinking water were built, which has alleviated the unavailability of drinking water for people and animals in Xiaoxi Village. Previously, local villagers little access to drinking water during low-water seasons, and had to drink dirty water during high-water seasons. Mobile telecommunication base stations were built and Internet access services were made available as well for the sake of this project. This has advanced the construction of local information technology infrastructure by dozens of years. The construction of the station has also greatly improved local public health and medical conditions. Thus, the actual utility value for this item is 1

Indicator 2: Capability building

A group of core technicians familiar with CDM business have been trained and cultivated, which has laid a solid foundation for the future development of CDM project. Thus, the actual utility value for this item is 0.5.

Indicator 3: Employment

During project construction, more than 1,000 construction workers and dozens of engineering managerial staff were employed for this project. However, thanks to the application of an advanced intelligence management system, after the station is put into operation, the required persons for regular work on site reduced to 40. By considering the annual 423.395k-tCO_2e emission reduction of this project, we estimate that the number of newly added employed labourers is equivalent to 1.13327person-month/1000 CER. Based on a comparison with international experience value, the utility value of this item is -0.0085.

Indicator 4: Ecological protection and land resource

Compared with coal-powered power stations, hydro-power stations occupy little farming land. However, the cost includes submerging some sloping fields will be submerged and some bio-diversity losses be incurred. Based on comprehensive consideration, the actual utility value for this item is 0.

Indicator 5: Emission-reduction effect

The completion and operation of this project have reduced the pollution caused by wood burning and the emission of some harmful pollutants like SO_2 and NOx, which would have been produced by coal-powered power stations to supply the same amount of electrical power. Annually, the reduced greenhouse emission amounts to 423.395k tCO_2e. The elevation of water levels and stored water volume potentially can improve the local climate. It is a radial flow type hydro-power project with little stored water volume, so if there is no water supply, the stored water could only be used to produce electricity for one single day. The pressure generated by the water body only produces limited impact on the geographic environment. According to the evaluation standard of the Indicator Table, the actual utility value for this item is 1.

Indicator 6: Fossil fuel

No fossil fuel is required to keep this hydro-power station running. In addition, the operation of this station has provided local residents with a high-quality and low-cost power supply, and greatly reduced the consumption of coal resources and the destruction of forest carbon reserves by local residents. Thus, according to the evaluation standard of the Indicator Table, the utility value of this item is 1.

Indicator 7: Regional development

Based on annual power generation capacity, Xiaoxi Hydro-power Station can annually provide 35 million RMB of tax, promote the development of related industries, and stimulate the development of the local economy as a whole. Meanwhile, the building of hydro-power stations can provide effective assurance for the local electricity supply, ensure the normal operation of large-sized power consumers, including two iron and steel factories, the mineral bureau, and petrochemical factories, and alleviate the previous severe power shortage. The investment of engineering construction will not only advance the development of related industries, but also play a positive role in the retail market. By planning and constructing the populated residence areas of migrants, the situation has greatly benefited local business development and the gradual formation of shops, supermarkets and night markets, as well as stimulating the growth of the service industry. According to the evaluation standard of the Indicator Table, the actual utility value for this item is 0.5.

Indicator 8: Micro-economic efficiency

By implementing CDM, we can increase the internal return rate (IRR) from 5.41% to 8.02%. The calculated utility value of this item is 0.0009.

Indicator 9: Technology transfer

The equipments used in the station are produced by the joint venture of the Japanese Toshiba Corporation located in China and the smart management system is developed by a domestic company, and the production and management system installed and maintained by Chinese workers. Thus few new- and high-tech technologies or technologic transfer requests are involved. According to the evaluation standard of the Indicator Table, the actual utility value for this item is 0.

Based on various weighted Indicator utility values, the sustainable development rating of this project is 0.4802 (See the chart below).

Table 4.7: MATA-CDM-China Methodology Evaluation Outcomes of Hunan Xiaoxi Small-sized Hydro-Power Station Project

System Indicator	Weight (1)	Element Indicator	Weight (2)	Project utility value (3)	Weighted utility value (4)=(1)×(2)×(3)
Social progress	**0.25**	Social equity	0.37	1	0.0925
		Capability building	0.33	0.5	0.0413
		Employment	0.3	-0.0085	-0.0006
Subtotal			1		**0.1332**
Environment protection	**0.43**	Ecological protection and land resources	0.29	0	0
		Emission-reduction effect	0.37	1	0.1591
		Fossil energy	0.34	1	0.1462
Subtotal			1		**0.3053**
Economic development	**0.32**	Regional development	0.26	0.5	0.0416
		Microscopic economic efficiency	0.36	0.0009	0.0001
		Technology transfer	0.38	0	0
Subtotal			1		**0.0417**
Impact on sustainable development	**1**				**0.4802**

4.5.3.2.3 Result analysis

Based on the analysis and discussion above, we can conclude that this project in general has promoted sustainable development. Specifically, we may discuss its causes from the following three aspects:

First, it promotes social progress. According to the table above, this project has a utility value of 0.1332 by this item, accounting for 27.7% of the total. This shows that the project has a great contribution in this aspect primarily because it has promoted the building of some local infrastructure facilities and made some public services from scratch to available to the mass (such as power supply).

Second, it encourages environmental protection. According to the table above, this project has a utility value of 0.3053 in this item, accounting for 63.6% of the total amount. This indicates that the project has made a major contribution in this aspect primarily because it features utilises hydro-power technology resulting in environmental protection. The development of hydro-power as a renewable energy source not only reduces the use of fossil fuel, but also minimizes the emission of pollutants and greenhouse gases.

Third, it brings many benefits to economic development. According to the table above, this project has a utility value of 0.0417 in this item, accounting for 8.7% of the total. This shows that the project has the least contribution in this aspect primarily because it involves no technologic transfer. Meanwhile, the internal return rate basically complies with our evaluation benchmark.

4.5.3.2 Case 2: Yunan Heier Small-sized Hydro-power Station Project

4.5.3.2.1 Project profile

Heier small-sized hydro-power project is a free-adjustment reservoir storage radial flow style power station, which is located in the convergence of the Heier River and the Nanpan River within Shizong County of Yunnan Province. The planned installed capacity of the station is 25MW, and there are two units of power generation sets with a single unit capacity of up to 12.5MW each. The planned annual power generation volume is 124,075MWh, of which 90% will be transmitted into the local grid. The project owner is Heier Hydro-power Development Co. Ltd. based in Shizong County, and the CER buyer is a Dutch company, Global Energy System. This project is expected to achieve an annual greenhouse gas reduction volume of 82,663tCO_2e by replacing some fossil fuel-powered power plants of the Southern Grid within the first 7-year emission reduction calculation period (starting from March, 2007 to December, 2013). It was registered at the EB on 15 July 2007.

4.5.3.2.2 Impact Assessment

We conduct the following analysis and evaluation on impacts of sustainable development of this project based on MATA-CAM-China methodology discussed in

Indicator 1: Social equity

Roads were built to speed up the construction of this project. This has benefited the local people, allowing them to have more access to the outside world. There is no gender discrimination and the project has had no impact on female status improvement. Thus, the calculated utility value of this item is 0.5.

Indicator 2: Capability building

24 corporate employees under the project owners have received the relevant training. Through CDM project development, the project owners have had a higher capability on data monitoring and internal management. Thus, the calculated utility value of this item is 0.5.

Indicator 3: Employment

According to the information from the local on-site survey, the number of increased labourers is 24 persons, who are mostly graduates from local technologic schools, rather than local residences. During the course of construction, 73 local residents were employed on a temporary basis. PDD data shows that the annual greenhouse gas emission reduction of this project is 82,663tCO_2e. The equivalent number of increased employed labourers is 3.484 person*month/1000CER. Based on global experience values, the calculated utility value of the project is 0.0022.

Indicator 4： Ecological protection and land resource

Compared to coal-powered power plants, this project has occupied little farming land, reduced the need for wood cutting and has helped preserve the forests. But some sloping fields were submerged and some bio-diversity losses were incurred. Based on comprehensive consideration, the actual utility value for this item is 0.

Indicator 5: Emission-reduction effects

This project has greatly reduced the pollutant emission due to the reduction in wood burning, and does not discharge SO_2 or NOx. The annual greenhouse gas emissions reduction volume amounts to 82,663 tCO_2e. According to the evaluation standard of the Indicator Table, the actual utility value for this item is 1.

Indicator 6: Fossil fuel

This hydro-power project consumes no fossil fuel at all. Meanwhile, the operation of this station has provided local residents with a high-quality and low-cost power supply and has greatly reduced the consumption of coal resources and the destruction of forest carbon reserves by the local residents. Thus, according to the evaluation standard of the Indicator Table, the utility value of this item is 1.

Indicator 7: Regional development

This project is based in the economically backward areas of Yunnan Province. Based on the planned annual power generation volume, the building and operation of this project can contribute to the local public finances. Meanwhile, this project complies with Yunnan's overall layout and regional industrial adjustment planning and fundamental direction for optimization and upgrades. All the used devices and technologies come from domestic vendors with little impact of technologic propagation. Thus, according to the evaluation standard of the Indicator Table, the utility value of this item is 0.5.

Indicator 8: Micro-economic efficiency

By implementing this CDM project, we increase the internal return rate (IRR) by 5.46% to 14.45%. Based on the baseline IRR of 8% and utility value function, the utility value of this item is 0.2932.

Indicator 9: Technology transfer

All the equipments used in this project come from domestic vendors and does not involve technology transfer. According to the evaluation standard of the Indicator Table, the actual utility value for this item is 0.

Based on various weighted indicator utility values, the sustainable development rating of this project is 0.4685 (See the chart below).

Table 4.8: MATA-CDM-China Methodology Evaluation Outcomes of Yunnan Heier Small-sized Hydro-power Station Project

System Indicator	Weight (1)	Element Indicator	Weight (2)	Project utility value (3)	Weighted utility value (4)=(1)×(2)×(3)
Social progress	**0.25**	Social equity	0.37	0.5	0.0463
		Capability building	0.33	0.5	0.0413
		Employment	0.3	0.0022	0.0002
Subtotal			1		**0.0878**
Environment protection	**0.43**	Ecological protection and land resources	0.29	0	0
		Emission-reduction effect	0.37	1	0.1591
		Fossil energy	0.34	1	0.1462
Subtotal			1		**0.3053**
Economic development	**0.32**	Regional development	0.26	0.5	0.0416
		Microscopic economic efficiency	0.36	0.2932	0.0338
		Technology transfer	0.38	0	0
Subtotal			1		**0.0754**
Impact on sustainable development	**1**				**0.4685**

4.5.3.2.3 Result analysis

Based on analysis and discussion above, we can conclude that this project in general has promoted sustainable development. Specifically, we may discuss its causes from the following three aspects:

First, it promotes social progress. According to the table above, this project has a utility value of 0.0878 by this item, accounting for 18.7% of the total amount. This shows that the project has a common contribution in this aspect. Undoubtedly, the building of this station has greatly enhanced the living conditions for local residents as well as improved the infrastructure construction progress, and the status of public health and medical care. However, due to the application of advanced intelligence management system, the positive influence on local employment could be neglected after it is put into operation. Relatively advanced hydro-power technologies and equipments are used in this project. This project has little impact on personnel capability building.

Secondly, it encourages environmental protection. According to the table above, this project has a utility value of 0.3053 in this item, accounting for 65.2% of the total. This shows that the project has made a major contribution in this area primarily because it features clean hydro-power technology and environmental protection. The development of hydro-power as a renewable energy source not only reduces the use of fossil fuel, but also minimizes the emission of pollutants and greenhouse gases. Although this project might incur some environment problems, such as landslides, reservoir-caused earthquakes, and species extinction, when proper solutions are implemented, these can be avoided or alleviated. Meanwhile, the building of the hydro-power station will use less land than the coal-powered facility of the same scale.

Third, it brings great benefits to economic development. According to the table above, this project has a utility value of 0.0754 in this item, accounting for 16.1% of the total. This shows that the project has the least contribution in this aspect. The project greatly pushes forward the development of related local industries, meets the demand of power consumption giants, increases the local fiscal income, and plays a positive role for the development of local economy. However, some unexpected geographic problems were encountered during the course of construction and necessitated an additional 80 million RMB in engineering costs. This exerts some influence over the investment return rate. Meanwhile, domestic advanced hydro-power technologies and equipments are applied in the project so there are no authentic software and hardware technology transfer and propagation.

4.5.4 Key findings

Based on the evaluation and analysis over the two small-sized hydro-power CDM projects, we conclude that the average sustainable development indicator is 0.4744 and that such projects basically have promoted sustainable development. Meanwhile, we have the following three positive findings:

First, small-sized hydro-power CDM projects could fulfil the objective of pollution reduction and create sound emission-reduction effects. Hydro-power CDM projects, as renewable energy projects, use no fossil fuel, and achieve emission-reductions in SO2, NOx, CO2, CH4 and other pollutants. This is greatly helpful for the fulfilment of local energy-saving and pollution reduction objectives and for the improvement of global environment.

Second, the rapid development of small-sized hydro-power projects greatly benefits from CDM mechanisms and the positive macro-level context that the state is actively developing renewable and optimising energy. The great support from the local governments remains another important factor.

Third, small-sized hydro-power projects are significant in improving the social public services of poverty-stricken rural areas. In terms of promoting local social progress and economic sustainable development, interviewed government officials and residents all acknowledged that the building of such projects improved the living condition and environment of local residents. The fact that Xiaoxi hydro-power project has a high rating on sustainable development fully indicates that this project has played a positive role for the local social and economic development.

Meanwhile, the following objective elements have restricted the further development of small-sized hydro-power CDM projects:

First, there exist some problems on the hydro-power on-grid mechanism and electricity pricing. Most hydro-power projects, particularly small ones, commonly face the difficulties getting on-grid access and a low-price for on-grid electricity. Currently, the on-grid prices for hydro-powered and coal-powered electricity vary dramatically. The reality that among the same grid there are two different prices obviously violates the rules of the market. This is not only counterproductive to coal-powered plants reducing operating costs and improving efficiency, but also exerts negative influence on the development of hydro-power industry. Most small-sized hydro-power projects of less than 50k KW by installed capacity are unable to adapt and are not reliable in power supply, because project planning and construction can not comply with the requirements of grid operational and managerial authority. Thus, it is hard for these projects to put their electrical power onto the grid. Particularly at the times of high water levels, the grid operation enterprises normally will limit the amount of power put into the grid. Thus, on average there are only 3,500 hours of usable power for these small-sized projects, representing less than two thirds of designed capacity. Some small-sized projects annually discharge 40% of restored water, which seriously jeopardized their economic well-being. Thus, during future hydro-power exploration and development, the authorities should solve the issue of hydro-power pricing discrimination. Only by internalizing external costs and utilizing reasonable electricity price policies, can hydro-power operators ensure long-term, stable, and favourable returns.

Second, hydro-power operators are facing taxation issues. Compared to coal-powered plants, hydro-power operators have a much greater tax burden. It is estimated that coal-powered plants normally are subject to a taxation rate of about 8% (coal purchase costs have deducted some taxation payments), representing half of hydro-power operators' 17%. The favourable policies concerning the 6% value-added taxation rate for small-sized hydro-power projects of less than 50k KW by installed capacity is not well implemented across the country. Some hydro-power operators are facing the issue of poor implementation of such policy. The state should clearly state the actual value-added taxation rate for small-sized hydro-power operators. In addition, the taxation authority shall strictly implement the related favourable policies towards small-sized hydro-power operators and enhance the monitoring of the on-grid power settlement for these operators.

Third, hydro-power projects face immigrant problems. Project developers believe that the local governments could play a greater harmonising role in solving these problems and that the immigration costs can be identified during the budgeting phase and will not increase the investment during the course of project implementation.

Fourth, unique risk issues are plaguing CDM projects and other related projects.

CDM projects by nature incur a number of risks, particularly those related to global systems and markets, and risks involving the design and implementation of all of the project links. What is worth mentioning is that CDM projects must pay close attention to the revision of EB adaptability methodologies. For instance, ACM002 Methodology has been changed from Version 05 to Version 06, clearly stating that this methodology is adaptable to dam building projects and that power density concept is mentioned for the first time and that related power operators shall apply the latest version of the methodology according to the rules of EB.

4.6 Wind power cases

4.6.1 Executive summary

As a type of clean and renewable energy, wind power has great potential to reduce emissions of greenhouse gases. Currently, wind power technologies are technologically advanced, using mature and large-scale commercialization conditions and low cost. Thus, all countries have emphasised the development of wind power. The installed capacity of wind power facilities has constantly grown worldwide in recent years. At present, there are more than 70 countries worldwide with wind power machine sets. According to the statistics of the Global Wind Power Association, during the period ranging from 1995 to 2007, the median annual growth rate of the global wind power market has been as high as 27%, representing more than 20 billion USD of annual investment.

China is rich in wind power resources. It is estimated that the overall usable reserves of wind power resources could amount to 1 billion KW. Furthermore, China's wind power resources primarily are concentrated in two strip-shaped areas. The first is the Great North China area (the Northeast, the North, and the Northwest), where the wind power density ranges from 200 W/square meter to 300 W/square meter. The second is the coastal and island areas with rich wind power reserves, primarily Jiangsu, Zhejiang, and the coastal area of Fujian. According to China's wind power development planning, China will take full advantage of the economic advantages in economically developed coastal areas. By utilizing the resources in the Great North China area, the state will build up large-sized and ultra-large-sized wind power farms. As for other areas, the state shall develop medium- and small-sized wind power farms to fully take advantage of local wind power resources.

In recent years, China has witnessed the rapid development of the wind power industry. In particular, the total number of CDM projects has multiplied quickly. As of 30 June 2009, among 2,091 CDM projects approved by the NDRC, there were 348 wind power projects (representing 43.058 million tonnes of annual emissions reduction), accounting for 16.6% of the total. At the same time, among 579 Chinese CDM projects registered at the EB, wind power projects accounted for 127 (representing 14.579 million tons of annual emission reduction), or 21.9% of the total.

4.6.2 Executive summary of relevant policies

To create a better environment for the long-term and healthy development of the wind power industry, since 2005, Chinese government has consistently enacted a series of favourable policies supporting wind power industry, including the

Renewable Energy Law, the Managerial Rules on Renewable Energy Generation, the Pilot Managerial Rules on Price and Cost Allocation of Renewable Energy, the Temporary Methods on Adjusting Additional Costs Incurred from Renewable Energy Power Prices, the Medium- and Long-term Planning to Renewable Energy, the Adjustment (Pilot) Method of Energy Saving and Power Generation, and the 11^{th} Five-year Plan on Renewable Energy and others. These supporting policies primarily cover the following important contents:

First, domestic production of wind power equipments will be supported. To encourage domestic enterprises to develop and manufacture high-power wind power generators, the Ministry of Finance issued a notification in April 2007, ordering that beginning in 1 January 2008, Chinese domestic enterprises that import major components and raw materials to develop and manufacture the generator set with rated power of no less than 1.2M KW could be refunded with levied import custom duties and import-related value-added tax. On 20 August 2009, the Ministry of Finance enacted the Temporary Management Method on Dedicated Capital Used for Industrialization of Wind Power Generation Equipments, clearly stating that wind power generation equipment manufacturers could be directly compensated with cash, among which whole machine and major parts manufacturers respectively account for 50%.

Second is the formulation of compulsory wind power generation objectives and the system of putting all wind power onto the grid. In 2006, the Renewable Energy Law demanded that the grid operators purchase all of the wind power generated by new energy generation approaches. According to the related renewable energy generation quota rule, in 2010 and 2020, investors of power plants of more than 5 million KW by attributable capacity shall have more than 3% and 8% of attributable capacity of non-hydro-power renewable energy generation out of the total installed capacity.

Third, the state shall grant wind power operators price compensation as well as fiscal and taxation support policies. In 2006, the NDRC enacted the Pilot Managerial Rules on Price and Cost Allocation of Renewable Energy, identifying the price and allocation mechanisms of wind power projects. It is estimated that 95% of wind power projects benefitted from governmental compensation in 2006. To improve the situation of unified price system, the state enacted the Notification on Improving On-grid Price Policies of Wind Power Energy in July 2009, clearly stipulating the benchmark wind power on-grid price policies, according to which the entire country is divided into four regions and the benchmark rates for these four regions are 0.51 Yuan, 0.54 Yuan, 0.58 Yuan, and 0.61 Yuan per KW-hour respectively. The Chinese government also adopted priority value-added tax and income tax reduction and exemption policies concerning renewable energy power technologies, among which the value-added tax rate for wind power was reduced from previously 17% to today’s 8.5% and the income tax rate of wind power projects is lowered from 33% to 15%.

According to the Medium- and Long-term Planning to Renewable Energy, China will speed up the process of industrial development on wind power and other sources of renewable energy, and aim to make renewable energy consumption account for 10% of total energy consumption in 2010, and 15% in 2020. According to the 11th Five-year Plan Framework of Domestic Economy and Social Development, the state will encourage the development of wind power industry and build 30 large-sized wind power projects of above 100k KW and form Mega-KW-level wind power bases in Inner Mongolia, Hebei, Jiangsu, and Gansu and other areas. According to the statistics on installed capacity of wind power projects across the country in 2007, presently China has had 12 provinces[17] with wind power generators having a combined installed capacity of above 110MW.

4.6.3 Evaluation on impacts over sustainable development of multiple cases of wind power generation CDM projects

4.6.3.1 Case 1: Dongshan wind power project in Chifeng, Inner Mongolia

4.6.3.1.1 Project profile

Dongshan wind power project in Chifeng, Inner Mongolia ("Dongshan Wind Power Project") is based Danianzi Township, Songshan District, Chifeng, Inner Mongolia Autonomous Region, being an on-land wind power project. This project was initiated by Datang Chifeng Wind Power Co. Ltd. on 29 May 2006 and equipped with 50 units of 850KW wind turbines. The overall installed capacity is 49.3MW. It is projected that this project could generate electricity for 2,487 hours a year. The annual power generation capacity is about 122.614GWh. After completion, this project is expected to reduce the greenhouse gas emission of the Northeast Grid by 125.557k tCO2e each year. The turbine used by this project is produced by the Danish company, VESTAS. As the CDM development of this project was initiated at the very beginning of 2006, no CER buyer was identified. However, at the end of 2006 as the project got registered, the operator reached the purchase agreement (ERPA) with Sumitomo, a Japanese company.

4.6.3.1.2 Impact Assessment

Here, we will use MATA-CDM-China methodology to evaluate the nine indicators of

[17] The 12 provinces are: Inner Mongolia, Jilin, Liaoning, Hebei, Heilongjiang, Ningxia, Shandong, Gansu, Xinjiang, Jiangsu, Guangdong, Fujia. http://www.cwea.org.cn/upload/20080324.pdf

three system levels, namely social progress, environmental protection, and economic development, and to eventually calculate the sustainable development Indicator of this project.

Indicator 1: Social equity

Upon completion, this project will reduce the electricity demands over the Northeast Grid. During the initial phase, for the sake of large-sized turbine shipments, roads were built and the local infrastructure was greatly improved. Although some pasturelands or ploughing fields were levied from local herdsmen, they received economic compensation according to the law. Meanwhile, this project has little significance to the elevation of women's status. Thus, the utility value of this Indicator is 0.5.

Indicator 2: Capability building

The turbines are all imported from Denmark. The vendor has provided trainings to field staff on turbine use and maintenance so as to improve the working staff's qualifications. By implementing this project, the capability building of advanced clean power is enhanced. Thus, the utility value of this Indicator is 0.5.

Indicator 3: Employment

This project has created 41 new employment opportunities, equivalent to an employment volume of 3.9185 person-month /1000CER. Based on methodological calculation, the utility value of this item is 0.0042.

Indicator 4: Ecological protection and land resource

This project has permanently occupied grass land of 0.13 square kilometre, or 0.37 square metres per 1KW. Compared with China's traditional coal-powered plant's 0.21-0.66m3/KW, there is no evident change on land occupation and ecologic damage. Thus, the utility value of this Indicator is 0.

Indicator 5: Emission-reduction effect

Compared with coal-fired generation sets, wind power generation will not produce SO_2 and NOx and other pollutants. Meanwhile, each year greenhouse gas emission is reduced annually by 125.557K tCO_2e. Thus, the utility value of this Indicator is 1.

Indicator 6: Fossil fuel

Wind power generation only utilizes wind resources, having no consumption of fossil energy. Thus, the utility value of this Indicator is 1.

Indicator 7: Regional development

Wind power is a type of clean energy that is abundant in Inner Mongolia. The project site is extremely rich in wind resources. The state and the autonomous region and Chifeng local government all are very supportive to the promotion and development of wind power industry. Thus, this project complies with the state and local industrial policies, and is helpful in the utilisation of local renewable resources. To some extent, this has promoted the optimization of the local economic mix and national energy sources. Inner Mongolia is one of moderately developed regions in China. This project could help to promote the balanced development. Thus, the utility value of this Indicator is 0.5.

Indicator 8: Micro-economic efficiency

According to the prevailing renewable energy on-grid electricity price formation mechanism, the wind power on-grid rates are eligible for fiscal compensation based on local coal-power energy benchmark prices. Considering this project is located in coal-rich Inner Mongolia, the coal-power energy benchmark prices are at a very low level in the Eastern coastal areas. This makes the on-grid prices of this project remain at a low level as well and internal rate of return very low. By participating in clean development mechanism, this project has gained CER sales benefits, which increases its IRR from 7.14% to 9.6%. Thus, this project is economically available by economic benefit Indicator. The utility value of this Indicator is 0.0727.

Indicator 9: Technology transfer

The major technologies and equipments used by this project were imported from Denmark VESTAS. In addition, the turbines are all imported from Denmark. The vendor has provided training to field staff on turbine use and maintenance so as to improve the working staff's qualification. Thus, the utility value of this Indicator is 0.

Based on all the weighted utility values, the consolidated sustainable development Indicator of this project is 0.4432 (as shown below).

Table 4.9: MATA-CDM-China Methodology Evaluation Outcomes of Dongshan Wind Power Project in Chifeng, Inner Mongolia

System Indicator	Weight (1)	Element Indicator	Weight (2)	Project utility value (3)	Weighted utility value (4)=(1)×(2)×(3)
Social progress	**0.25**	Social equity	0.37	0.5	0.0463
		Capability building	0.33	0.5	0.0413
		Employment	0.3	0.0041	0.0003
Subtotal			1		**0.0879**
Environment protection	**0.43**	Ecological protection and land resource	0.29	0	0
		Emission-reduction effect	0.37	1	0.1591
		Fossil energy	0.34	1	0.1462
Subtotal			1		**0.3053**
Economic development	**0.32**	Regional development	0.26	0.5	0.0416
		Micro-economic efficiency	0.36	0.0727	0.0084
		Technology transfer	0.38	0	0
Subtotal			1		**0.05**
Impact on sustainable development	**1**				**0.4432**

4.6.3.1.3 Result analysis

Based on the evaluation above, we conclude that the sustainable development indicator of this project is 0.4432, indicating that it has basically promoted sustainable development. Moreover, we also find that environmental protection benefits rated at 0.3053 contribute the most to such development, accounting for 68.9% to the entire project by contribution share. Social development benefits closely follows, rated at 0.0879, or 19.8% of the total. Economic development benefits have the least the contribution, rated at 0.05, or 11.3%.

In terms of social development, this project has a common rating. There are three major causes. First, no residents live in areas within 10km from the project or have suffered from any influences incurred. However, some land belonging to herdsmen has been occupied by this project. Second, although some training on wind turbine use and maintenances is provided to the related personnel, no further capacity building has been made available for turbine repair. Third, this project has poor performance in employment improvement.

This project has a high rating in environmental protection, primarily because wind power is a renewable clean energy that consumes no fossil fuel and produces no emission of pollutants. Meanwhile, although this project has mediocre performance in terms of land occupation, it is similar to coal-power projects.

In terms of economic development, this project has a low rating. This is because the project only uses the technologies and devices purchased abroad without involving technology transfer. Meanwhile, the CER transaction price of this project is only 7 Euros. Based on this price benchmark, the IRR is only 7.27% higher than the benchmark. In terms of regional development, this project complies with the electricity power development policies of the state and the Inner Mongolia Autonomous Region, playing a positive role for the development of Chifeng. The rating in this aspect is at intermediate level.

4.6.3.2 Case 2: Dongling wind power project in Rudong Ring Harbor, Jiangsu

4.6.3.2.1 Project profile

The Dongling wind power project in Rudong Ring Harbor, Jiangsu, is located in Dongling, Rudong County, Jiangsu of the Eastern China, facing the Yellow Sea and adjacent to the inshore areas of Yangbeiken region and the ring harbour. It is an offing wind power project. There are 67 units of 1.5MW wind turbines with a combined installed capacity of 100.5MW. According to the project design document, the annual power generation volume is expected to be 228.44GWh, the annual emission reduction volume 199k tCO_2. This project has introduced the domestically advanced wind turbines produced by U.S. GE and assembled in China. On 23 October 2006, the first wind turbine of the Rudong 100.5MW wind power project was connected to the grid and officially put into use, becoming China's first mega-watt level modelling project since the state had launched the franchised pilot projects. The CER buyer of this project is Kommunalkredit Public Consulting GmbH, which is the biggest Austrian consulting company and represents Austrian ministries of agriculture, forestry, and environment protection, and water conservation to conduct carbon reduction transactions. This project consecutively gained two CER issuances on 27 September 2007 and 3 April 2008. The accumulated issued volume is 131.769 t CO_2e.

4.6.3.2.2 Impact assessment

According to the sustainable development evaluation indicator system created under MATA-CDM-China methodologies, we alternatively evaluate the nine Indicators included in the three system levels, namely social progress, environmental protection, and economic development.

Indicator 1: Social equity

The wind power farm is built beside the coastal shallow sea area, occupied a small amount of agricultural and fishing farms. Thus few social conflicts were incurred by land compensation issues. Because the road connected to the downtown areas has been built, the transportation conditions of neighbouring residents were greatly improved. This project has little influence in terms of improvement of women's status. Thus, the utility value of this item is 0.5.

Indicator 2: Capability building

The equipment suppliers have arranged technologic operations training for this project. The daily site equipment operation and maintenance have high requirements for the qualification of technicians. The capability of working staff has been greatly improved due to on-the-job training. The managerial staff includes dedicated personnel responsible for CDM management and CER beneficence, and enhances the management's capability to apply and implement other CDM wind power projects due to their matching knowledge. Thus the utility value of this item is 0.5.

Indicator 3: Employment

There are few fixed employees at the Rudong wind power facilities. Compared to coal-powered plants, this project has less contribution to employment improvement. However, this project features high labour productivity and high requirements for the qualification of working staff and technicians. Professional technicians normally have high educational backgrounds in related subjects or are hired from other coal-power plants. During the course of construction and site cleaning and maintenance, the project employs local farmers and increases local incomes. Considering the increase of fixed and temporary employment, the calculated whole-year emissions reduction volume based on the CER emissions reduction volume issued during the period from April to July 2007 is 195.852k tCO_2. The number of newly added employment opportunities of this wind power farm is 70 fixed staff members, or equivalent to 4.2890 person-month /1000CER. Thus the utility value of this item is 0.0059.

Indicator 4: Ecological protection and land resource

Compared to coal-powered projects, wind power projects occupy little land and exert little evident influence over the ecologic environment. There are some minor noises caused by the operation of wind turbines, but because the turbines are far away from villages and residential areas, such negative influences are minimal. The project is located in the coastal shallow sea areas of Rudong County, thus having little influence to land use and quality. Thus, the utility value of this item is 1.

Indicator 6: Fossil fuel

Wind power is a type of clean energy, having sound emission-reduction effects as an alternative option to coal-power. Thus, the utility value of this item is 1.

Indicator 7: Regional development

Due to the nature being a renewable energy source, the project is subject to 5 years of income tax exemption. The taxation income to the local government is only 2 to 3 million RMB. Compared to the local economic development level, the marginal contribution of this project to the local fiscal income is insignificant. However, the owner expressed that this project will increase the local government's interests in specific wind power projects. Presently, the Rudong local government is actively supporting the related industries benefited from wind power projects. Some wind power industrial zones have been built. This project also complies with the local industrial layout. Thus, the utility value of this item is 0.5.

Indicator 8: Micro-economic efficiency

The IRR of this project is about 9%, and the calculated utility value of this item is 0.0455.

Indicator 9: Technology transfer

Because core technologies and major parts are still at the hands of U.S. manufacturers, even after the confidentiality term ends, China will still depend on foreign manufacturers to conduct repairs and maintain major parts. Thus authentic technologic transfer is hardly to implement. Thus it is difficult for domestic enterprises to acquire the required technologies by means of learning. Thus, the utility value of this item is 0.

Based on all the weighted utility values, the consolidated sustainable development Indicator of this project is 0.5648 (as shown below).

Table 4.10: MATA-CDM-China evaluation outcome of Dongling wind power project in Rudong Ring Harbor, Jiangsu

System Indicator	Weight (1)	Element Indicator	Weight (2)	Project utility value (3)	Weighted utility value (4)=(1)×(2)×(3)
Social progress	**0.25**	Social equity	0.37	0.5	0.0463
		Capability building	0.33	0.5	0.0413
		Employment	0.3	0.0059	0.0004
Subtotal			1		**0.0880**
Environment protection	**0.43**	Ecological protection and land resource	0.29	1	0.1247
		Emission-reduction effect	0.37	1	0.1591
		Fossil energy	0.34	1	0.1462
Subtotal			1		**0.4300**
Economic development	**0.32**	Regional development	0.26	0.5	0.0416
		Micro-economic efficiency	0.36	0.0455	0.0052
		Technology transfer	0.38	0	0
Subtotal			1		**0.0468**
Impact on sustainable development	**1**				**0.5648**

4.6.3.2.3 Result analysis

The overall evaluation rating of Dongling wind power project is 0.5648. To some extent, we could say that this project has actively promoted sustainable development. The three benchmark ratings concerning environmental protection, social equity, and economic development, are 0.4300，0.0880, and 0.0468 respectively. This shows that the project has the most evident influence in term of environmental protection closely followed by social progress and economic development.

First, there are clear benefits in social development. The employed workforce in Rudong wind power farm numbers more than 70 people. This, to some extent, has promoted the employment and strengthened demand for technicians on engineering and electricity. During the construction phase, some local residents have earned temporary income. In terms of capability building, there are 3 batches totalling about 15 persons who have received training by GE. Meanwhile, GE also assigns some wind power experts to give on-site operation and maintenance guidance to Chinese technicians. Meanwhile, some managerial staff members have even participated in CDM-related training.

Second, in terms of environmental protection, basically, this project has not produced many negative influences on the ambient environment. The noise from the power stations has little influence on neighbouring residents. Because there are few staff members working at the wind power farm monitoring site, little waste water or other types waste is produced. Meanwhile, the impact of the turbines on birds is minimal. Birds normally fly around the site. Some birds have been found to make nests at the top of power transmission line facilities. This is because that besides the coastal shallow sea areas there is a lack of high trees for birds to build nests. However, nests built on transmission lines might potentially a safety hazard.

Third, in terms of economic development, this project has an influence over the development of the local economy, but it is not very pronounced. However, according to some surveys, we find that the investment return is better than we expected. Because the operator has made profits from CDM CER benefits in the first year, and the debt repayment pressure will be reduced, the operator will earn more and more profit. In the long-run, this is helpful to local taxation.

4.6.4 Major findings

Based on the above-mentioned analysis and evaluation, we have reached the following major findings:

1. Wind power as a type of clean renewable energy will make positive contribution to China's sustainable development. Compared with fossil fuel-power generation, wind power generation not only produces no pollution, but it also consumes no water resources. If reasonable policies are enacted to balance the relationship between wind power investment and benefits, wind power will on one hand meet China's ever increasing power demands, and on the other hand create the win-win situation of promoting both environmental protection and economic development. This complies with the sustainable development model to which China is adhering by promoting scientific development, low-carbon development, and a green economy.

2. Compared to the investments of wind power companies, power sales income and governmental compensation, CDM benefits only occupy a small share. However, such benefits will greatly stimulate and promote China's wind power development. Although China has implemented a favourable policy toward wind power before the establishment of CDM, the wind power industry witnessed slow growth due to higher investment costs compared to coal-powered projects and low investment returns. In recent years, due to the economic stimulation from CER sales benefits under the CDM mechanism, Chinese enterprises' interest in wind power investment has increased as has the speed of the growth of the wind power industry.

3. Because the project owners and local governments play different roles in the development of the wind power industry and have different considerations, their benefits and objectives are different as well. The local governments are building wind power industrial parks, and are aiming to promote the development of related R&D and equipment manufacturing industries. However, wind power enterprises primarily

follow market rules and cost-efficiency principles, and thus are not interested in local governments' planning and policy oriented decisions. In terms of taxation, the emphasis and support of local governments upon wind power enterprises should be considered as well. Renewable energy companies are subject to five years of income tax exemption and the local government's taxation income is only 2 to 3 million RMB. Compared with local economic development, this wind power enterprise has little contribution to the local fiscal income. This to some extent might influence the enthusiasm of the local governments to support wind power projects

4. Because wind power enterprises use foreign equipment and the core technologies are still controlled by foreign manufacturers, true technology transfer can hardly be achieved. The technology transfer effect of this project is not evident. According to the survey, we find that because core equipment comes from foreign vendors and major parts can only be provided and repaired by foreign parties, and in addition foreign experts must be invited at high cost to conduct repairs, these could increase the future operational risks and management and maintenance costs of the wind power enterprises.

5. The policy environment of domestic wind power development is still lacking. For wind power enterprises, the requirement of 70% domestic production rate will compel them to purchase domestically produced equipment. However, if this equipment is purchased from joint ventures, the core technologies and major parts will still be provided by foreign parties. If domestic vendors are the option, some high-end domestic equipment are sold at a low price but greatly lag behind foreign technologies and devices in terms of quality, and will bring great operational risks to the enterprises. In addition, due to differentiated power prices, developing wind power projects in regions at different development levels might result in differences in economic benefits. For instance, even though Shanghai and Fujian are short of electricity power and economically developed, with less wind resources available compared to Jiangsu projects, these two places have high on-grid prices, favourable returns and profit margins. Although some in-land remote areas are rich in wind power resources, they are characterised by poor grid-related infrastructure and high cost of on-grid and transmission costs, which will exert a negative impacts over the project development.

6. The renewable energy policies of the state encourage various provincial governments to actively develop new energy sources and related industries. This has caused a tide of hasty investments into wind power. There are two results. First, the speed of China's wind power development outruns that of the domestic wind turbine manufacturing industry. Second, different regions are positively attracting promising projects, talents, and advanced equipments. This greatly benefits the foreign wind turbine vendors and transforms the global wind power equipment market into the seller's market. Take Jiangsu for example. Some neighbouring counties in the coastal areas, such as Rudong and Qidong counties, are promoting the development of new wind power projects. Thus, the state or the region require a unified development strategy and harmonization and planning while developing wind power industry.

4.7 A case study in the use of biomass energy

4.7.1 Summary

Straw is renewable biomass energy. Biomass energy has the advantages of wide distribution, little environmental impact and sustainable use. Now it is the most widely used renewable energy in China, and in terms of total energy consumption, the biomass energy is ranked the fourth, just less than that of coal, oil and natural gas. In the short term, using clean and renewable energy alternatives to coal and oil to adjust the structure of energy consumption and production is an important task for China. Using biomass to generate electricity has the characteristics of being highly reliable and high in power quality, etc. In addition, it is more economic than the use of wind and solar power in terms of electricity generation. China is a large agricultural country that is very rich in biomass resources. There are more than 600 million tonnes of straw produced by a variety of crops each year and about 400 million tonnes can be used as resource of energy. We can get 300 million tonnes of energy resources from the 900 million tonnes of biomass from the total of 19 billion forest biomass in China. If we can use biomass correctly, the potential for power generation as well as for rural economic development is massive. However, in China, biomass power generation has just started. Currently, China's biomass power generation is just 5% of all the renewable power generation, far below the world average level of 25%. China's industrial base for technology for biomass power generation is weak. The boilers for biomass power generation which are made in China are just in the pilot demonstration phase, and China also has little experience in the operation of direct-fire biomass power plant. To implement the energy-saving and emission reduction targets, China has made great progress in the use of biomass power generation. As of 30 June 2009, there were 12 biomass power generation projects (annual reduction is 1.695 million tonnes) in 579 projects which were successfully registered at the EB, accounting for 2.1% of the total registered projects. Over the same period, in the Centre for Statistical Database of UNEP Rios, China has 2,063 CDM projects. The annual reduction is 36,900 million tCO_2e. Among which, there are 82 biomass power generation projects; annual reduction is 15.27 million tonnes. From the above data, we find that either from the number of items or the emission reduction amount, China biomass power generation projects take only a small fraction of the total for CDM projects.

4.7.2 Summary of relevant policies

To do the emissions work well and make good use of biomass energy, the Chinese government has introduced a series of policy measures, such as (2008) No. 3052-order: The Notification on Subsidies for Biomass power generation Price and Quota Trading Scheme from October 2007 to June 2008 by the National Development and Reform Commission and National Electricity Regulatory Commission. This order provides the projects which are included within the scope of subsidies for straw direct combustion power generation projects with temporary price subsidies for electricity consumption according to the grid-connection volume. The subsidy standard is 0.1 Yuan per KWh. The Plan for Renewable Energy Long-term Development which was launched in September of 2007 designated biomass energy as a key area of development. In June and August of 2006 The Project Application Guide on Central Government Environmental Protection Special Fund and National Partnership for Advanced Pollution Control Technology Demonstration Directory (first batch) placed the direct combustion of biomass power generation technology into the scope of subsidies in the way of comprehensive utilization resource. In September of 2006, The Identified Regulations on Comprehensive Utilization of the Encouraged Resources made it clear that companies using the biomass energy as fuel for power generation belong to the scope of Resource Comprehensive Utilization companies. Chapter II article VII of Pilot Scheme of Sharing Management on Renewable Energy Prices and The Cost in May 2006 indicate that the price of biomass power generation projects was ordered by the government, and the National Council Department is in charge of the benchmark price by different regions, the standard price is made up from the price of desulfurized coal-electricity in 2005 and subsidies in each province, price subsidy standard is 0.25 RMB per KWh. Projects of energy improvement (including the energy efficiency improvement projects in iron and steel industry) are the three priority areas in Regulations on CDM Projects, such items will get the discount of 2% levy percentage from sale of CER. Generation by agricultural and forest waste as a way of comprehensive utilization of resources was clearly determined by Catalogues on Comprehensive Utilization of Resources (2003 Amendment).

4.7.3 Case study of Jinzhou straw power CDM project

4.7.3.1 Introduction to the project

The main fuel materials of the project are corn, cotton stalks and fruit branches. The steam condenser heating unit in the size of 2 × 12MW with 2 × 75 t/h straw direct-fired boiler is self-developed, designed and manufactured to generate electricity in China. The total investment of the project is 260 million RMB which started on 18 March 2006 and two units were put into normal operation. Each year it uses about 20 million tonnes of straw which replace about 100 thousand tonnes of coal and reduce about 183,009 tonnes of greenhouse gases. The annual generation is 13,200 KWh, and the heat supply is 530 thousands GJ which can meet the heating demand of 1 million square metres of building. This project was approved by DNA in 7 November 2006, successfully registered at EB in 4 March 2007, the first CER of 1.8 tonnes was issued on 16January 2009 and buyers are NATIXIS and The European Carbon Fund.

4.7.3.2 Impact Assessment

We will start a specific analysis on the 9 indicators in MATA-CAM-China evaluation indicator system of social progress, environmental protection and economic development in three system Layers one by one.

Indicator 1: Social equity

After the power plant is in operation, the heat available can be used to heat 1 million square metres of factory buildings and for civil heating purposes 1.5-2.0 km around the plant, greatly improving people's quality of life and local infrastructure. The steam generated by power plants can be used by the industrial park nearby and we can shut down small coal-fired boilers and improve the incentives for investment and the environmental quality in the industrial park. In real-life situations, as the city failed to complete the construction of heating pipe network, now the plant cannot provide heat for enterprises and residents in the zone; there are still some technical obstacles to the use of power plant steam. However, the construction and use of the plant make the use of heat and steam possible. To sum up, the utility value of this indicator is 0.5.

Indicator 2: Capacity building

In order to improve the staff's knowledge and standards of CDM, the straw power generation project CDM Working Group was built, and in the same time the professionals of CDM were invited to train the teams. In biomass power generation technology training and application, because power generation is a new field, it is still in the demonstration phase. Thus, the company has trained workers' skills through various channels. Organising workers to study from and interact with domestic relevant industries and those abroad has greatly improved the workers' ability and knowledge. Therefore, the utility value of this indicator is 0.5.

Indicator 3: Employment

After the power plant is in operation, there will be about 100 official workers in the plant. In addition, 100 stations of straw acquisition and straw transportation located outside of the plant can provide employment opportunities for more than 300 farmers on a periodic basis. Considering the characteristics and status of farming, previous studies have concluded that the acquisition of the straw can be done once every half year, and the duration of the work is 1.5 months. The number of job opportunities created by the project is $(100\times12+300\times(1.5\times2))/180000=11.6667$ Person Months/1000 tCERs. According to the evaluation criteria of "Indicator Table", the utility value of this indicator is 0.0394.

Indicator 4: Ecological conservation and land resource

Straw boiler ash emissions is a type of organic fertilizer which is used by farmers to cultivate land not only to promote crop growth but also to improve soil quality and the quality of agricultural products more suitable for human consumption. In actual situations, too much mud and sand in the straw limits the benefits and utility of the ash emissions. The impact of straw power plants on the ecological environment is significantly lower than for a thermal power plant of similar scale. However, in regards to land occupation, straw purchase and storage will demand more storage space in rural lands and factories. Based on comprehensive considerations, the utility value of this indicator is 0.

Indicator 5: Emission reduction effect

Each year the project uses 200 thousand tonnes of straw to replace the 100 thousand tonnes of standard coal for power generation, which reduces about 400 tonnes of fume and dust. According to the project design, for every year after normal operation of power plant, 180 thousand tCO_2e emissions may be reduced. Accord to the evaluation criteria of "Indicator Table", the utility value of this indicator is 0.5.

Indicator 6: Fossil fuel

Straw is a clean and renewable resource. A straw power plant can use 200 thousand tonnes annually, which saves 100 thousand tonnes of standard coal. Operating power plants only requires 28 tonnes of diesel for the combustion-supporting agent each year, and any other fossil fuels will not be required. If the calorific value is used as the benchmark, the calorific value in 28 tonnes of diesel is approximately equivalent to that of 40 tonnes standard coal. Therefore, the coal consumption for CDM power generation projects is calculated as 0.333 gce/kWh, much lower than the benchmark evaluation of 343 gce/kWh, the average coal consumption of a national thermal power plant in 2005. According to the evaluation criteria of "Indicator Table", the utility value of this indicator is 1.

Indicator 7: Regional Development

Power plants that consume 200 thousand tonnes of straw have made straw much easier than before to be used. Because of this, farmer's income and particularly the benefits of intermediary businessmen have been greatly improved. At the same time, the total investment for straw power plants is 260 million RMB. Power plant construction and operation have stimulated local economic development, and have also increased local revenue and promote the development of related industries. Hebei Province is one of the major agricultural provinces, in Jinzhou, a city in Hebei Province, straw power generation projects have set a very good example for the effective use of biomass, slowing down biomass decay, and the negative impact on the environment due to open burning in Hebei Province, and even all over the country. According to the evaluation criteria, the utility value of this indicator is 0.5.

Indicator 8: Micro-economic efficiency

According to the relevant data from the project design documents and calculation results, in the absence of CDM benefits, the internal rate of return IRR is 5.47% which is lower than 8%, the financial standard rate in the power plant industry. When the CDM revenue is considered, it will be up to 11.82%. However, the actual research findings are: straw price from the original 190 RMB / tonne up to the current 300 RMB / tonne with direct increases in the annual operating cost of about 22 million RMB. By this calculation, the actual IRR of the project is -1.115%. Based on the evaluation "Indicator Table" of the evaluation criteria, the IRR ≤ 0, so that the Indicator value is -1.

Indicator 9: Technology Transfer

In this project, all equipment independently researched and developed, designed and manufactured, and main ancillary equipment are made in China. From this perspective, the CDM project does not involve the transfer of technology to developing countries from developed countries. Based on the evaluation "Indicator Table" of the evaluation criteria, for sake of conservatism, the Indicator value is 0.

In conclusion, the influence factor of sustainable development of the project is 0.2428.

Table 4.11: Jinzhou straw powder generation MATA-CDM-China evaluation results

System Indicators	Weight (1)	Factor Indicator	Weight (2)	Project effectiveness (3)	Weighted utility (4)=(1)×(2)×(3)
Social progress	0.25	Social equity	0.37	0.5	0.0463
		Capacity Building	0.33	0.5	0.0413
		Employment	0.3	0.0394	0.0030
Subtotal			1		**0.0906**
Environmental	0.43	Ecological protection and land resource	0.29	0	0.0000
		Emission-reduction effect	0.37	0.5	0.0796
		Fossil energy	0.34	1	0.1462
Subtotal			1		0.2258
Economic Development	0.32	Regional development	0.26	0.5	0.0416
		Micro-economic efficiency	0.36	-1	-0.1152
		Technology Transfer	0.38	0	0.0000
Subtotal			1		-0.0736
Influence factor of sustainable development	1				0.2428

4.7.3.3 Result analysis

From the above evaluation, we can say that overall the project has promoted sustainable development. Specifically, it can be analyzed from the following three reasons:

1) Social progress. On a systematic level, the project's effectiveness has a score of 0.0906, accounting for 37% of the total utility scores, indicating that the contribution was significant. Construction and operation of the straw power plant has turned the original worthless straw waste into something of great value, and sale of straw was a source of additional income for local farmers. The project made heating for surrounding residents and improvement of infrastructure possible, but now these basic facilities and services have not been made available. For capacity-building, with the implementation of CDM project, the company has trained employees to develop skills relevant for biomass power generation and organized staff to study and interact with related domestic industries and those abroad, which has greatly improved staff capability and knowledge. The operation of straw power project will have offered employment opportunities for some people, while the straw purchase and transportation has also resolved local unemployment issues and increased farmers' income.

2) Environmental protection. On a systematic level, this project's effectiveness of has a score of 0.2258, accounting for 93% of the total utility scores, indicating that the level of sustainability of the greatest contribution to the project. The main reason is that biomass is a renewable clean energy. Straw power generation uses biomass, almost consuming no fossil fuels, so it can greatly reduce air pollutant emissions. At the same time, emissions of carbon dioxide can be reduced. Compared to thermal power plants of a similar scale, straw power generation plants occupied more land, which has offset the environmental efficiency of this project.

3) Economic development. On a systematic level, this project's effectiveness has a score of －0.1152, which is lower than baseline score. This is mainly due to significant fluctuation in the straw price which makes straw power plants run losses, and business investments will not have high rates of return because of the project's poor micro-economic benefits. At the same time, in the consideration of the exclusion of the straw power generation project in same area, the project has not promoted industrial restructuring and optimization of local industrial upgrading. In addition, the project has used all Chinese independently researched, developed, designed and manufactured equipment, without any technology transfer. Therefore, the contribution of this kind of straw power generation CDM project to economic development is very limited.

4.7.3.4 Main findings

From the previous evaluation and analysis, we can see that Jinzhou straw power generation CDM project has promoted sustainable development. The contributions to sustainable development created by straw as a fuel source can be generalized as decreasing the dependence on fossil fuels, turning something that was previously worthless waste into a valuable resource, and effectively easing the environmental impact due to the open burning and straw decay, and improvement of local environmental sanitation. At the same time, the income of local farmers has increased because of sales of straw and power supply has increased. At the same time, we have also found that there are still some problems in the development process. They are mainly shown in the following aspects:

1) The uncertainty of the purchasing price of straw led to remarkable decrease in the internal rate of return. The price fluctuation of straw is considerable. In this project, the price of straw can range from the original 190 RMB / tonne to 300 RMB / tonne, which has greatly increased the operating costs for investors, and business investment will witness low rates of return (in practice, straw power plant internal rate of return has dropped to -1.115%), which makes the enterprises run losses. The objective existence of this phenomenon is highly detrimental to the expansion and sustainable development of such CDM projects in China.

2) Imperfect facilities. Whether the project of straw power generation can be operated normally is also related to whether its downstream products can smoothly enter the market. Outside the Jinzhou straw power plant, there is no heat pipe network system. Actually, the surrounding buildings are not heated, so the heat cannot be effectively utilized; there is no pipe network connecting the water system, and cooling water for power plant still uses tap water rather than the water mentioned in PDD. The existence of these problems makes the normal operation of the straw power plant even worse.

4.8 Case Study of Natural Gas Power Generation

4.8.1 Summary

Currently, the development and use of natural gas as an important measure of the optimization of energy structure, environmental protection, the protection of national security of energy supplies and reduction of greenhouse gas emissions have attracted more and more attention from governments of all countries. As a clean fossil fuel, natural gas plays an important role in the primary energy structure of OECD countries. In 2007, for instance, it accounted for 25.2% of primary energy consumption in the United States, and 15.7%, 14.8%, 23.9% and 57.1% in Japan, France, Germany and Russia respectively. On the power structure, the natural gas power generation in the proportion of Annex I countries has increased from 12% in 1992 to 21% in 2006[18], in which the United States accounts for 41%, the United Kingdom for 31%, and Japan for up to 64%.

Although the development of natural gas has many advantages, in the primary energy structure and power structure of China, its advantage is not obvious. The relevant statistics show that natural gas only accounts for 3.25% of primary energy consumption, which is far below 23.7%, the world annual average. In the current natural gas consumption structure of China, urban gas accounts for a larger ratio of 49.6%, chemical industry for 28.4%, industrial fuel for 16.3%, while the ratio of power generation was only 5.7%. At of the end of 2005, for electric power capacity, coal power accounted for 71%, hydropower accounted for about 23%, and natural gas accounted for only 2.1%.

Since the Kyoto Protocol came into effect in 2005, the Chinese government began to actively promote natural gas power generation projects through the clean development mechanism to improve power generation projects. As of 30 June 2009, China has successfully registered 579 CDM projects at the EB, among which 14 projects directly use natural gas to generate electricity, only accounting for 2.4% of the total number of registered projects; these 11 CDM projects are expected to reduce annual emissions of 15.89 million tCO_2 (as shown below).

Table 4.12: The development situation of natural gas power generation projects which were registered in EB

No.	Name of project	Address of project	Annual reduction of emission (tCO2e)	DNA Approval time	EB registration time
1	LNG power generation project in Qianwan Shenzhen,	Guangdong	1,231,549	9 November 2006	2009-5-12

[18] IEA 2008, C EA, 2008. CO*2* Emissions from Fuel Combustion 1971-2006. International Energy Agency, Paris, France.

	Guangdong				
2	Guangdong Huizhou LNG Power Generation Project	Guangdong	1,246,424	9 November 2006	2009-4-22
3	Yuyao natural gas power generation project	Zhejiang	982,096	15 December 2006	2007-12-10
4	Xiaoshan Power Plant Gas Power Generation Project of Zhejiang Southeast Electric Power Co., Ltd.	Zhejiang	984,779	15 December 2006	2008-3-26
5	Zhejiang Zhenhai power plant fuel gas reconstruction project	Zhejiang	984,779	15 December 2006	2008-3-26
6	Guangzhou Zhujiang Power Plant Gas (LNG) Combined Cycle Project	Guangdong	476,899	31 December 2006	2008-12-11
7	Golmud, Qinghai Gas Turbine Power Plant Project	Qinghai	412,099	31 December 2006	2008-7-20
8	Beijing Taiyangong gas heat power cooling united supply	Beijing	1,620,225	31 January 2007	2008-2-24
9	Zhengzhou, Henan Province natural gas combined-cycling power generation project	Henan	666,882	9 February 2007	2008-2-22
10	Shanghai Baoshan Grid natural gas combined-cycling power generation project	Shanghai	1,296,392	9 February 2007	2008-9-9
11	Sulige Gas Power Generation Project	Inner Mongolia	593,981	6 March 2007	2008-7-21
12	Fujian Putian New gas-fired power plant project	Fujian	2,305,219	10 May 2007	2009-1-14
13	Beijing third thermoelelectricity plant natural gas-steam combined cycling project	Beijing	633,341	13 July 2007	2008-2-15
14	Fujian Jinjiang LNG Power Generation Project	Fujian	2,459,890	17 August 2007	2009-2-6

4.8.2 Summary of relevant policies

At the current stage, the development of natural gas is becoming an important measure for China to optimize the energy structure, and especially the power structure, so the Chinese government has issued a series of related policies. In 2004, for example, the part of "priority projects" in "medium or long-term special plans for energy saving" proposed "using the fuel gas generator sets to replace fuel small generator sets; optimizing the layout of power supply, properly developing small distributed power with natural gas, coal-bed gas, and other industrial waste gas as fuel, enhancing electrical safety". Moreover, it pointed out that in order to promote the prevention of air pollution in urban areas, "for small and medium coal-fired boilers, in some regions with natural gas resources, the use of natural gas should be encouraged". In the "Eleventh Five-Year Plan" in the power industry issued in 2006, natural gas power generation was clearly defined as "moderate development". In order to reduce greenhouse gas emissions, in June of 2007 the Chinese Government issued the "Program on National Climate Change" which also proposed to "optimize the thermal power structure, and accelerate the elimination of laggard small thermal power units, moderately develop small-scale distributed power which uses natural gas or coal-bed gas as fuel". In the white paper of "Energy situation and policy in China" which was published in December 2007 in the part of "Enhancing energy supply capacity" has also emphasized the need to "moderately develop natural gas power generation".

In order to guide and regulate the downstream areas to utilize natural gas, on 30 August 2007, the Chinese government issued the "natural gas utilization policy". This policy paper classified natural gas utilization into four main categories (i.e., gas for urban use, industrial fuel, natural gas power generation and natural gas chemical industry); in addition, it further classified natural gas as priority categories, permitted, restricted and prohibited categories. According to this policy, natural gas power generation does not belong to a priority category, so it is only allowed in the "major electricity load centres and areas where has an adequate supply of natural gas to use the natural gas power generation project for regulating the peak time of electricity consumption", the "non-essential use of electricity load centres to build natural gas power generation projects" is restricted. In addition, the creation of base load gas-fired power generation projects is forbidden in "the 13 large coal base regions such as Shaanxi, Inner Mongolia, Shanxi, Anhui, etc". Further, compared to renewable energy power generation, so far there has been no specific policy supporting the state natural gas-fired electricity price that is similar to the renewable energy power generation policies to ensure full access, and price subsidies.

In summary, at this stage and foreseeable future, the positioning of natural gas power generation in China is power generation through the regulation of peak time and optimization of thermal power structures, and the basic policy orientation is "moderate development".

4.8.3 Case study of Beijing No. 3 Thermal Power Plant Natural gas/steam combined cycling power generation

4.8.3.1 Summary of the project

Beijing No. 3 Thermal Power Plant for natural gas/steam combined cycling power generation project (hereinafter referred to as NGCC project), is a natural gas/steam combined cycling power generation plant with rated capacity of 400 MW. Currently, this plant has only one generator set whose designed annual operating time is 3,500 hours; its rated capacity is 1.4 billion KWH, which is merged with the North China Power Grid. This project was put into trial operation in November 2005 and delivered for the formal production on 1 January 2006. On 1 May 2006, it was put into commercial operation. On 10 September 2007, it was officially approved as a CDM project by the National Development and Reform Commission and successfully registered at the EB on 15 February 2008. This project chose a renewable crediting period of emission reduction. The first crediting period is seven years and the average annual emission reduction is 623,788 tCO_2. The start time of the first crediting period is on 17 December 2007. CER buyer of the project is a Germany company, RWE Power AG, using the key technical equipment imported from Mitsubishi Heavy Industries through an international tender in the form of bundles, mainly including M701F gas turbine, steam turbine and generator sets.

4.8.3.2 Impact assessment

We will start assessment on the nine indicators in three system layers of social progress, environmental protection and economic development through MATA-CAM-China evaluation indicator system.

Indicator 1: Social equity

The NGCC unit is characteristic of fast start and stop for peak time regulation performance, which can be used to make up for the shortage of peak time regulation units of Beijing-Tianjin-Tangshan power network. Gas turbine unit capacity of this project is relatively larger (peak load can be up to 420MW in winter), which has provided strong support for the Beijing area and improved the reliability of power supply for the capital. At the same time, compared to the previous coal-fired units, the project unit using natural gas as fuel is cleaner and can improve the working environment for workers as well as for the public health of local residents. Moreover, there is no gender discrimination and no significant increase in employment opportunities for women. Therefore, the utility value of this indicator is 0.5.

Indicator 2: Capacity Building

According to field research and telephone interviews with the person in charge, we know that the relevant staff of the project received training for certain skills in several groups (organized by both parties). Currently, the staff has gradually developed its own technical team and this team has mastered the basic repair and maintenance operations, but they have not mastered the key technology of gas turbines such as combustion adjustment (combustion conditions, air-fuel ratio, etc.). It is also understood that through the development of CDM project, capabilities of the data monitoring for project owners as well as internal management capacity has been raised. Therefore the utility value of this indicator is 0.5.

Indicator 3: Employment

Field study results have shown that the number of new jobs of the project is 120. In conjunction with the 62.3788 million tCO_2e / year emission reductions of this project, the number of employment of the project is calculated as 2.3085 Person Months / 1000CER, lower than 3 Persons Months / 1000CER, the baseline value. According to the utility function, the Indicator utility value is calculated to be -0.0032.

Indicator 4: Ecological conservation and land resources

NGCC unit has the significant advantages such as less land occupation and less water consumption. As the NGCC unit equipment is small in size, there are no coal-yards, coal handling, ash handling systems, and therefore, the factory covers an area much smaller than that of thermal power plants. In addition, gas turbine does not need a large number of cooling water, the combined cycling needs only about 1/3 cooling water of the thermal power plant with the same capacity. This is important for the construction of power plants in Beijing where there is a relative shortage of water resources. In addition, according to PDD and field research, we have found that the project has not done any harm to local ecological environment. For this reason, the utility value of this indicator is 0.5.

Indicator 5: Emission-reduction effect

The annual greenhouse gas emission reduction of this project is 623.788 thousand tCO_2, and because this project unit uses natural gas as fuel, power generation boiler NOx emission concentration is about 33 mg/m^3 nearly without SO_2 emissions. Therefore, the utility value of this indicator is 0.5.

Indicator 6: Fossil fuel

Natural gas is a clean fossil fuel, the annual average gas consumption for power generation of this project is 0.22 m^3/kwh, or 250.44 gce/kwh (the coefficient of standard coal consumption of natural gas field is 1.33kgce/m^3） if converted into standard coal consumption for power generation, which is still lower than the coal consumption value corresponding to utility value of 1 in the evaluation criteria (i.e. the coal consumption of super-critical unit is 273 gce / kwh in 2005). Therefore, the utility value of this indicator is 0.5.

Indicator 7: Regional Development

The project can be expected to result in higher CER sales income, and financial revenue can be increased for the Beijing area through income tax. This project also has some marginal contributions to the overall economy of this region. The project is located at economically developed area of Beijing, and this region is also the important electricity load centre. In addition, the first and second Shaanxi-Beijing gas pipelines have been successively put into operation, and there is a sufficient natural gas supply, meeting the relevant requirements of Natural Gas Use Policy. At the same time, it is also in compliance with the optimization of energy structure in the Beijing area and the Eleventh Five-Year Power Plan regarding the structural improvement and planning of power. The project has no significant effect of technology spillovers. Therefore, the utility value of this indicator is 0.5.

Indicator 8: Micro-economic efficiency

Currently, the project has not yet issued CER. According to the project description of PDD, in consideration of the CER sales income, the IRR of the entire investment of this project is 8.36%, which is higher than 8%, the standard rate of return in the electric power industry. Based on calculations, the utility value of this indicator is 0.0164.

Indicator 9: Technology Transfer

This project should be considered as a relatively successful case in technology transfer, and it also mentioned in its PDD document that "this project directly promotes the transfer of international advanced gas-fired power generation technology to China". A more specific explanation is as follows: First, an assembly of M701F gas turbines, steam turbines and generator sets of this project are directly imported from Japanese Mitsubishi Heavy Industries Ltd., and the technology is mature, technical and the economic indicators are advanced, and it will maintain an advanced level for a relatively long period time in the future in the domestic market. Second, the relevant technical staff of the project have received technical training in Japan in two groups, and Japan provided the "Repair and Maintenance Manual" for the equipment. In addition, it is a project that was appointed by the National Development and Reform Commission for the localization of gas turbine equipment. According to the relevant approval documents by the NDRC, in order to improve manufacturing capability of China's large-scale gas turbine equipment, China National Technical Import and Export Corporation has organised this project with the other 10 projects, which contains 23 gas turbine units in total, in Eastern and Southern China. This project constituted the first batch of bundled international bidding projects in the principle of “combining technology with trade, market for technology”, and at the same time, included the import of the technology on manufacturing of gas turbine equipment and power station design. Finally, our research shows that Japanese Mitsubishi Heavy Industries Ltd. and Dongfang Electric Group have formally established a joint venture company in China in 2005 and technologies on Mitsubishi Heavy Industries M701F-class gas turbine hot parts manufacturing, testing, quality control, maintenance and after-sales service have been introduced according to "joint-venture agreement". In 2007, Dongfang Mitsubishi Heavy Industry's first f-class gas turbine plant was ignited successfully in Dongfang Steam Turbine Plant of Dongfang Electric Group in China. Every indicator was normal, and the successful trial run of the heavy gas turbine has allowed authorities to declare the birth of China's first heavy gas turbine with a localization rate up to 46.5%. Therefore, the utility value of this indicator is 0.5.

Through the weighted sum of utility value of each indicator, the influence factor of sustainable development of this project, which is 0.4799 (see the table 4.13).

Table 4.13： Beijing No.3 Thermal Power Plant NGCC power generation project MATA-CDM-China evaluation

System Indicators	Weight **(1)**	**Factor Indicator**	Weight **(2)**	Project effectiveness **(3)**	Weighted utility **(4)=(1)×(2)×(3)**
Social progress	**0.25**	Social equity	0.37	0.5	0.0463
		Capacity Building	0.33	0.5	0.0413
		Employment	0.3	-0.0032	-0.0002
Subtotal			1		**0.0874**
Environmental Protection	**0.43**	Ecological protection and land resource	0.29	0.5	0.0624
		Emission-reduction effect	0.37	0.5	0.0796
		Fossil energy	0.34	1	0.1462
Subtotal			1		**0.2882**
Economic Development	**0.32**	Regional Development	0.26	0.5	0.0416
		Micro-economic efficiency	0.36	0.0164	0.0019
		Technology Transfer	0.38	0.5	0.0608
Subtotal			1		**0.1043**
Influence factor of sustainable development	**1**				**0.4799**

4.8.3.3 Result analysis

According to the above analysis and discussion, we can say that this project has promoted sustainable development. We can discover the reasons from the following three aspects:

1) Social progress. The score of this project on this system level is 0.0874, accounting for 18% of the total utility score. This indicates that the project has only a minimal contribution at this level. Of course, this is also relevant to the functional positioning of natural gas power generation projects in China and individual characteristics of projects. First, overall positioning of natural gas power generation projects in China is power generation via regulation of peak time to ensure reliability of power supply and improve the security of the regional power grid. Second, for stations using natural gas, there is no need to build coal yards, coal handling or ash handling systems, so these types of projects will not provide too many new jobs. Finally, natural gas power generation projects have clean and green features and it is good for improving the working environment of workers and public health of residents nearby.

2) Environmental protection. The score of this project is 0.2882, accounting for 60% of the total utility score. This indicates that the project has the largest contribution in this field, which can be mainly attributed to the clean and environmental characteristics of natural gas units. Because natural gas power generation projects cover less area with less water consumption, there are almost no SO_2 emissions from power generation boilers, and just a small amount of NOx emissions. Furthermore, because fossil fuels such as coal cannot be used, the coal consumption for power generation is 0. This type of project can greatly improve environmental protection.

3) Economic development. The score of this project on this system level is 0.1043, accounting for 22% of the total utility score, indicating that the project makes positive contributions to regional development. However, through careful analysis, it is clear that this contribution mainly comes from the utility value of the indicator "technology transfer". The construction and operation of this project are the result of the NDRC's efforts to localise strategy of technology for the market, open China's gas turbine power generation market, introduce foreign advanced technology, and the generation of heavy-duty gas turbine power. In order to implement this strategic decision, the NDRC and other relevant institutions and organizations have organized the first batch of bundled international bidding projects with 23 gas turbine units, in which Japanese Mitsubishi Heavy Industries and the American firm General Electric won the bidding respectively. Mitsubishi won the bidding for 10 units, in addition to 400MW gas turbine unit of this case study; the other nine units were settled in Guangdong.

4.8.3.4 Main findings

Through the research and analysis on the natural gas power generation CDM projects, we can get the major findings as follows:

First of all, as a relatively clean fossil fuel compared to coal, oil and other fuels, natural gas not only has low GHG emissions, but also, natural gas power generation projects have significant environmental advantages because they do not release SO_2 emissions, and only release only a small amount of NOx emissions. From a regional standpoint, such projects can not only improve a region's air quality, but will also enhance the performance of peak time regulation and is beneficial to the security and stable supply of regional power. From the national level, the development natural gas power generation projects can not only promote the improvement of the energy consumption structure and diversify the power structure, but also has important practical implications for the energy-saving and emission reductions. From the international level, the development of such CDM projects is not only beneficial to the successful completion of emission reduction targets in the first commitment period of the Kyoto Protocol for those countries in Accessory I, but also it has promoted the global efforts to mitigate climate change.

Second, there are obvious technical barriers, financial barriers and policy barriers that affect the normal development of natural gas power generation projects. Technically speaking, currently domestic enterprises have mastered the manufacturing technology for the core components of high-powered gas turbines. Although there are a few domestic enterprises that have established joint ventures with Mitsubishi, General Electric or other advanced technology and equipment suppliers, the localization rate of these gas turbines manufactured by joint ventures is still quite low. As for the funds, because the gas turbine units used in the current domestic natural gas power generation projects are mostly imported from abroad, the investment costs are relatively high with lower IRR for full investment, and barriers to financing are significant. Through the first batch of heavy gas turbine bundled international bidding projects organized by relevant state departments, all the project owners must apply for CDM projects in order to overcome the financial gap. Except for the beneficial owners of the first batch, there are almost no other new owners of natural gas power generation projects. Furthermore, because of a lack of specific preferential tax policies for natural gas power generation and reasonable internet pricing policies, it has greatly limited the normal development of this type of clean fossil energy power generation project.

Finally, it is worthwhile to learn from the technology transfer of this project. That is to say, in the process of international transfers of environmental technology, the government should play a leading role. Successful practice of this case in technology transfer is greatly attributed to the strategic guidelines for the technology market, the opening of the gas turbine power market in China, and the introduction of foreign advanced technology, which were proposed by the NDRC in the "Tenth Five-Year" period, as well as the first batch bundled international bidding projects with 23 gas turbine units for implementation of this decision-making strategy.

4.9 CBM Utilization Case

4.9.1 Overview

China has abundant Coal-Bed Methane (CBM) resources. According to the national CBM resource evaluation in 2005, the CBM reserve with a burial depth less than 2,000 m in China is about 36.81 trillion m^3, ranked the third in the world after Russia and Canada, and is about three times the reserves in the U.S. The CBM reserves are about the same as the natural gas reserves in China, equivalent to 45 billion tonnes of standard coal or energy that can be used for more than 20 years in China. As a major coal producer, China discharges over 13 billion m^3 of CBM because of mining every year, which is not only pollutes the environment but is also a waste of resources. In addition, the gas explosion accidents in coal mines will also cause enormous loss to state property and of human life. The CBM power generation project can both reduce the emissions of methane by generating electric power with the gas drained out of the mine, and facilitate carbon emission reductions by generating electric power with methane instead of coal, which reduces coal consumption. Therefore, power generation with CBM has great potential in China. However, the development of the CBM power generation industry faces two major obstacles: shortages of capital and technology. By implementing CDM projects, we can introduce the foreign capital and technology to promote the development and utilization of CBM.

As of 30 June 2009, China has successfully registered 578 CDM projects in total at the CDM Executive Board, 22 of which are CBM recovery and utilization projects (annual carbon emission reduction equivalent to 15.25 million tCO_2), accounting only 3.8% of the total number of successfully registered CDM projects. Some experts predict that the CBM CDM projects in China will reach a total carbon emission reduction of 97 million tonnes, accounting for 22% of the three priority areas by 2010, and further 2.1 billion tonnes accounting for 54% by 2020. Currently, the CBM drainage and utilization in China's coal fields are relatively small scale and of low efficiency, and there are a small number of CBM CDM projects in implementation with enormous development potential.

4.9.2 Summary of Relevant Policies

In order to promote the utilization of CBM, the Chinese government has released a series of policies and measures in recent years. In June 2006, the Several Opinions on Promoting CBM (coal mine gas) Drainage and Utilization promulgated by the State Council have put forward 16 measures to define the guidelines for gas drainage before mining and simultaneous government and utilization. In 5 June, 2006, the NDRC released the Eleventh Five-Year Plan for Development and Utilization of CBM (coal mine gas). The national output of CBM is expected to reach 10 billion m^3 by 2010. Relevant authorities and local governments actively implement the instructions of the State Council, and have issued a series of policies and measures to promote gas drainage and utilization.

As for the preferential tax policies, the equipment and specialized tools for CBM exploration and development are exempt from import duties and value-added tax. Other policies include the value-added tax refund after collection policy for CBM drainage enterprises, as well as other preferential taxation policies as accelerated depreciation of equipment, investment tax credit, and additional deductions of technical development expenses etc. In addition, CBM surface drainage is currently exempted from resource tax.

As for financial subsidies, the central government will provide the gas drainage enterprises with subsidies for every 0.2 Yuan/ m^3 of CBM (pure), which is used for town gas and chemical materials. Based on this amount, local governments may further offer subsidies according to the actual situation of local development and utilization of CBM.

As for power selling, coal mining enterprises are encouraged to generate electricity with CBM for self-sufficiency; any excess electricity will be purchased by the power grid with priority and with involvement with market competition. The purchasing price will be implemented in accordance with the biomass power pricing policy, i.e. the benchmark electricity price of desulfurised coal-fired unit in 2005 plus the subsidy price (0.25 Yuan/ KWH).

Regarding resource price control, the factory price of domestic CBM will be determined through consultation of both supply and demand. The selling price of the domestic CBM not entering the urban public gas transmission pipeline network will also be determined through examining supply and demand. While the selling price of the domestic CBM that has entered the urban public gas transmission pipeline network and fallen under the administration of the government will be determined according to the principle of maintaining reasonable price relations with alternative fuels with equivalent heating value such as natural gas.

As for the mining rights management, in case of overlapped coal mining and CBM mining rights, both parties are required to consult one another or enter into a relevant safety agreement. If the parties fail to enter any agreement, relevant land and resources administration authorities mediate in accordance with the applicable provisions. If the attempt to mediate fails, the land and resources administration authority will give support to the coal production enterprises in carrying out comprehensive CBM exploration and development in accordance with the principle of integrated and coordinated coal mining and gas drainage.

In addition, it is defined in the CDM Administrative Measures that, as CBM recovery and utilization belong to one of the three priority areas under the clean development mechanism (CDM) executed in China, the government will charge 2%

of the amount of the transfer of greenhouse gas emission reductions, which is far less than that of the non-priority areas. For example, for hydro-fluorocarbons (HFC) and per-fluorocarbons (PFC) projects, the government will charge 65%, and 30% will be charged as for nitrous oxide (N_2O) projects.

4.9.3 Yangquan CBM Power Generation CDM Project Case Study

4.9.3.1 Project overview

Yangquan CBM power generation CDM project aims to generate electric power mainly by the drainage and utilization of coal mine methane (CMM). A 90 MW CMM electric generating set will be installed, and the total installed capacity to be implemented step by step. The phase-1 construction of the CBM power generation project has been officially put into production in June 2007 with an installed capacity of 28,982 KW, and was the largest finished domestic CBM power station at that time. The first phase of this project operated with a daily gas consumption of 400,000 m^3 and an annual gas consumption of 130 million m^3, and is expected to make an annual greenhouse emission reduction equivalent to 800,000 tonnes of carbon dioxide. The second phase, with an expected installed capacity of 90 MW and an annual gas consumption of 400 million m^3, obtained the approval of the NDRC in 8 October 2006 and was successfully registered at CDM EB on 22 May 2007. The first and second CERs were issued on 25 July 2008 and 14 July 2009 in the amount of 441,000 tonnes and 445,000 tonnes respectively, and have been purchased by IXIS Environment & Infrastructures Group and CAMCO International Limited.

4.9.3.2 Impact assessment

According to the sustainability assessment indicator system built based on MATA-CDM-China methodology, we carry out assessment against the nine indicators included in the three system layers as social progress, environmental protection and economic development.

Indicator 1: Social equity

Due to early CBM development and utilization in Yangquan coal mine, over 90% of the local residents had used CBM as an energy source prior to CDM projects. Therefore, the CBM development and utilization belong to a baseline scenario with the services of providing local residents energy and heating to be further improved upon. In light of this, this CDM project contributes little to social equity, and the utility value against this indicator is 0.

Indicator 2: Capacity building

The 33 employees working on this project have received limited training in the operation of equipment. Through CDM project development, the data monitoring and internal management capabilities of project owners have been improved. Thus, the utility value against this indicator is 0.5.

Indicator 3: Employment

According to the survey information, the three power plants of phase-1 projects have provided 33 job opportunities, and have accomplished an annual average greenhouse emission reduction equivalent to 2.49 million tons of carbon dioxide. Upon calculation and conversion, the employment of this project is 0.159 person/month/1000CERs with a difference of -2.841 person/ month/1000CER compared with the international standard. Thus the utility value against this indicator is -0.001.

Indicator 4: Ecological protection and land resource

CBM power plants cover only one-tenth of the land required by coal-fired power plants with water recycling and almost no waste discharge. As a result, the utility value against this indicator should be 1.

Indicator 5: Emission-reduction effect

As the global warming potential of CH_4 is 21 times greater than that of CO_2, it is efficient to reduce the greenhouse gas emissions by recovering the coal bed methane that was previously discharged into the air directly for electricity generation. The first phase of this project can make an annual carbon emission reduction of over 800,000 tonnes, which would be increased up to 2.49 million tonnes upon the completion of phase-2 construction. The coal bed methane generates pollutants while burning generally 1/40 of petroleum or 1/800 of coal. The carbon dioxide released by burning coal bed methane is 50% less than petroleum or 75% less than coal with the same combustion value. Power generation with CBM instead of coal has greatly reduced the emissions of the pollutants as SO_2 and NOx generated in the process of coal-fired power generation. Thus the utility value against this indicator is 1.

Indicator 6: Fossil fuel

This project recovers the coal bed methane for power generation instead of coal-fired power generation, which can save an annual 610,000 tonnes of coals. It has not only accomplished the comprehensive utilization of energy, but also improved the energy structure, so the utility value against this indicator is 1.

Indicator 7: Regional development

With a total investment of 870 million RMB, the construction and operation of the power plants can significantly stimulate local economy, increase local revenue and drive related local industries. Shanxi Province, where the project is located, is a moderately developed coal-rich province, and the Yangquan CBM power generation project has demonstrated CBM utilization in Shanxi Province. The project conforms to the overall local industrial layout with certain technological spillovers, and has contributed to the local industrial structure upgrades, adjustment, and optimisation. Thus, the utility value against this indicator is 0.5.

Indicator 8: Micro-economic efficiency

The first phase of this project can make an annual emission reduction of over 800,000 tCO_2e, as well as an annual income from CER sales of more than 80 million RMB. Upon completion of phase-2 construction, this project will result in an annual emission reduction of over 2.4 million tCO2e, as well as annual CER sales revenue of more than 240 million RMB, increasing the IRR of CBM power generation project from 5.89% to 27.5%. Upon calculation, the utility value against this indicator is 0.8864.

Indicator 9: Technology transfer

As for this project, the main technical equipment required by the project is imported from abroad, and the equipment supplier has provided training to the operators without any technology transfer. According to the assessment criteria specified in the “table of indicators”, the utility value against this indicator is 0.

Table 4.14: Results of MATA-CDM-China Assessment on Yangquan CBM Power Generation Project

Systematic indicator	Weight (1)	Sub-indicator	Weight (2)	Utility value (3)	Weighted utility (4)=(1)×(2)×(3)
Social progress	**0.25**	Social equity	0.37	0	0
		Capacity building	0.33	0.5	0.0413
		Employment	0.3	-0.0129	- 0.0010
Subtotal			1		**0.0403**
Environmental protection	**0.43**	Ecological protection and land resource	0.29	1	0.1247
		Emission-reduction effect	0.37	1	0.1591
		Fossil energy	0.34	1	0.1462
Subtotal			1		**0.4300**
Economic development	**0.32**	Regional development	0.26	0.5	0.0416
		Micro-economic efficiency	0.36	0.8864	0.1021
		Technology transfer	0.38	0	0
Subtotal			1		**0.1437**
Impact on sustainable development	**1**				**0.6140**

Based on the above analysis and calculation, the impact on sustainable development of this project is 0.6140, so it has high sustainability.

4.9.3.3 Result analysis

Based on the results of the above assessment, this project has generally promoted sustainable development with specific reasons to be analyzed from the following three aspects:

1) Social progress. The weighted utility value against the indicator of social progress of this project is 0.0405, accounting for only 7% of the total due to early CBM development and utilization in Yangquan coal mine, as over 90% of the local residents had used CBM as an energy source prior to CDM projects. Therefore, the CBM development and utilization belong to baseline scenario with the services of providing local residents energy and heat to be improved upon. Due to a relatively high degree of automation, this project requires fewer employees than thermal power plants.

2) Environmental protection. The weighted utility value against the indicator of environmental protection is 0.43 accounting for 70% of the total, which indicates that environmental protection of this project has made the greatest contribution to the sustainability of this project. It is because this project recovers the coal bed methane that was formerly discharged into air directly for power generation with better CBM utilization, which has not only reduced the greenhouse gas emissions, but also improved the energy structure. The CBM power generation project reduces greenhouse gas emissions in two ways: first is draining gas from the mine for power generation to reduce the methane emissions; second is generating electric power instead of purchasing electricity from the grid to reduce carbon emissions. The CBM power generation project has multiple advantages as high capability of carbon emission reduction and strong technical feasibility. CBM power plants cover only one-tenth of the land required by coal-fired power plants with water recycling and almost no waste discharge. The coal bed methane generates pollutants while burning generally 1/40 of petroleum or 1/800 of coal. The carbon dioxide released by burning the coal bed methane is 50% less than petroleum or 75% less than coal with the same combustion value. Power generation with CBM instead of coal has greatly reduced the emissions of pollutants such as SO_2 and NO_X generated in the process of coal-fired power generation.

3) Economic development. The weighted utility value against the indicator of economic development is 0.1437 accounting for 23% of the total, which indicates a relatively great contribution to the project’s sustainability. It is because the CER sales revenue has greatly improved the financial condition of the CBM power generation project, while the high CER income attracts project owners to develop CBM power generation projects. The first phase of this project can reduce emissions by over 800,000 tCO_2e, and generate an annual income of CER sales of more than 80 million

RMB which accounts for 60% of the total revenue of the power plant. It has greatly increased the IRR and attractiveness of the CBM power generation projects.

4.9.3.4 Major findings

The CBM power generation projects can make waste profitable with significant economic, social and environmental benefits. The development of CBM power generation projects will promote the CBM utilization and sustainable development of China. Although China has great potential for CBM CDM project development, the CBM drainage and utilization of China's coal fields are of relatively small scale and low efficiency, and there are only a small number of CBM CDM projects in implementation which have faced the following problems:

(1) Low capability of CBM CDM project development

In spite of great potential for comprehensive utilization of coal-mine gas, there are only a small number of CBM CDM projects that have successfully registered at EB. This is because the CBM CDM projects adopt a relatively complicated methodology integrating five methodologies with complex and rigorous CDM procedures. As a result, the development of CDM projects will face various risks regarding the success of the application. This requires us to further intensify the study on the CBM CDM methodology, system, impacts and countermeasures, and strengthen capacity building in project proposal preparation, baseline calculations, additional evaluations, project implementation planning, baseline verification, and implementation procedures to ensure the successful implementation of CDM projects in China. From the angle of safeguarding the industrial and national interests, relevant authorities should provide industry-wide guidance instructions to coal mining enterprises in developing CDM projects. The authorities may set up a CDM project research fund to give rewards to those enterprises and individuals that have successfully developed new methodologies. Authorities may also strengthen the training for basic CDM knowledge, CDM methodologies, and application procedures to improve the enterprises' capacity of developing CDM projects.

(2) Coal enterprises lacking in enthusiasm for CBM utilization

As the coal bed methane is a by-product of coal, the development and utilization of CBM is just a sideline business of the coal enterprises. As a result, the coal mines are focus on coal mining while often paying little attention to CBM development. From the perspective of legislation, the relationship between CBM development and coal production and environmental protection should be clarified. The government should further implement environmental regulation controls as well as strict administration and supervision; collect the appropriate fees from enterprises with excess emissions; and change the previous management concept of recycling only when convenient. It is recommended to set up a methane emission reduction fund and develop a series of subsidies, penalties and regulations to encourage coal enterprises to develop and utilize the coal bed methanes. It is noteworthy that currently there is no mandatory regulations on CBM utilization in China which can promote the CBM utilization, but will eliminate the additionality of CBM CDM projects.

(3) Incomplete regulations on low-concentration CBM utilization

According to the relevant national regulations, only the CBM with methane concentrations higher than 25% can be utilized, while gases with lower methane concentrations are usually discharged into air. As the gases with methane concentrations lower than 25% drained out during the mining process account for over two-thirds of the total, the CBM is usually utilized with a relatively low rate of efficiency; over 90% of gases are discharged into air, which is not only pollutes the environment but also a waste a valuable resources. More attention should be paid to adjust the standards and norms for low-concentration gas transmission and utilization with the development of technology to promote the utilization of low-concentration gas.

(4) No effective implementation of preferential policies on CBM development and utilization

In spite of certain encouraging policies issued by the state, there are no systematic economic policies, regulations or relevant standards on security management and quality. In addition, there are no security management norms and industrial quality standards on comprehensive gas utilization, or CBM resource protection regulations and CBM regulatory laws, providing no basis for CBM development and utilization as well as industrial management, and, as a result, much work cannot be conducted normally. The financial subsidies for CBM development and utilization do not cover the CBM power generation, while the on-grid prices are difficult to determine compared with the prices of biomass power generation due to the lack of supporting policies and measures.

(5) Promotion of CBM CDM projects requiring integration of coal mining and gas drainage

As provided by the CDM methodology ACM0008, the CBM drainage and utilization associated with coal mining rather than simple CBM drainage on the surface can apply for CDM projects. Therefore, in order to promote the development of China's CBM utilization CDM projects, the government should straighten out the relationship between coal mining rights and CBM drainage rights, and grant the both rights to coal enterprises to integrate coal mining and gas drainage.

4.10 Landfill gas Power Generation CDM Projects

4.10.1 Overview

With the acceleration of urbanisation, urban populations grow gradually. At present, there were about 661 cities and over 20,000 towns in China with an urban population of 593.79 million persons (living in urban areas for no less than half a year) by 2007, accounting for 44.9% of the total population. According to the statistical data, the daily waste output per capita reaches 1.4kg in big cities and 1kg in medium and small cities. Therefore, it can be expected that the annual domestic waste output in China is about 130 million tonnes and will continue to increase at a rate of 8% – 10%. In such event, people will start to seek ways of effective waste dispose , one of which is to recover the landfill gas for power generation.

There are currently three major forms of power generation using waste: first is dry fermentation, i.e. generating electricity with the gas generated in the process of landfill treatment. In this process, the gas generated will have complex composition and is both toxic and hazardous due to the chemical reactions between different materials, so landfill gas power is mainly utilized for industrial power generation; second is to generate electricity with the biogas generated from the anaerobic fermentation of the landfill leachate which is difficult to be degraded and treated due to its high concentration of organic substances; third is to generate electricity with the biogas generated from the anaerobic fermentation of the ground waste.

Generally, gas will be generated at a maximum production rate with the highest concentration of methane during the period of six months to one year after the landfill treatment. If no mechanical landfill gas drainage is carried out in a timely manner, large volumes of gas will move and spread all around and enter the atmospheric environment, bringing various impacts on the environment, such as: the greenhouse effect, public health risks, explosion, and the deterioration of vegetation. On the contrary, landfill gas also has potential benefits as the flammability of the methane contained in the landfill gas power has great potential value. The landfill gas power can be utilized to replace other fuels with equivalent weight, and is the cleanest fuel. It is important to research municipal waste recycling and environmental pollution reduction by recovering landfill gas for power generation.

Since 2005, the Chinese government has started to actively promote natural gas power generation projects through the clean development mechanism. As of 30 June 2009, China has successfully registered 579 CDM projects at EB, 17 of which are landfill gas power projects accounting for 2.9% of the total registered projects. While among the 2,091 projects registered at DNA during the same period of time, 38 are landfill gas power projects with an average annual emission reduction equivalent to 5.83 million tonnes of carbon dioxide.

4.10.2 Summary of Relevant Policies

With the increasing realization of both the dangers of hazardous waste as well as making the waste profitable as a resource, relevant policies have also been unveiled. In 1984, the Ministry of Construction proposed to focus on sanitary landfills and thermophilic composting regarding urban waste disposal in China. In 1986, the National Environmental Protection Committee pointed out that the urban waste disposal in China should set reductions, resource recycling and decontaminating as its ultimate goal. In 1995, the Chinese government promulgated the Law of the People's Republic of China on Prevention of Environmental Pollution Caused by Solid Waste, which provides that "the urban domestic waste shall be cleared and carried away without delay. Reasonable utilization and neutralization shall be actively conducted. The separate collection, storage, transport, and disposal of urban domestic waste of different classifications shall be gradually implemented." In 2006, the NDRC released the Measures for Identification and Administration of National Encouraged Comprehensive Resource Utilization which also makes relevant provisions for garbage furnaces and landfill gas power.

As a priority field of renewable energy and resource utilization, landfill gas power generation is encouraged by the relevant preferential policies issued by the state. The preferential policies mainly cover two fields: first is tax preference, i.e. exemption from VAT and a reduction in the corporate income tax. In 2008, the Ministry of Finance and the State Administration of Taxation issued the Notice on Policies of Value-added Taxes of Comprehensive Resources Utilization and Other Products (FT (2008) No.156), which provides that as of 1 July 2008, the value-added tax revenue collected from the sale of electricity or heating with waste as fuels shall be refunded. In the same year, the Ministry of Finance and the State Administration of Taxation also issued the Notice on Issues Related to the Implementation of the Income Tax Preference Directory for Enterprises with Comprehensive Resource Utilization (FT [2008] No.47), which provides that income obtained by enterprises that produce products listed in the Directory adhering with relevant national or industrial standards with raw materials taken from the resources listed in the Directory since 1 January 2008 shall be taxed at a reduced rate of 90%. The Enterprise Income Tax Law implemented on 1 January 2008 provides that the income obtained by enterprises that produce products in compliance with national and industrial policies and regulations through comprehensive utilization of resources shall be taxed at a preferential rate, equivalent to the calculation based on a decline of 10% of the income; second is the electricity price preference by selling electricity to power network. In addition, the government purchases the electricity generated in full amount, which has been specifically provided in the Interim Measures for Additional Revenue Allotment of Renewable Energy Power Price. The electricity generated with landfill gas power will be prioritised and purchased at a price of no less than 0.5 Yuan/ 2KWH (including tax); third is corporate subsidies in the form of waste disposal fees. The urban domestic waste disposal shall be currently charged of no less than 9 RMB per household per month in principle.

The landfill gas power generation also corresponds with the national climate change policies. China's National Climate Change Program has included the urban waste disposal among the six major fields of reducing greenhouse gas emissions, and requires to "develop incentive policies to encourage enterprises to build and implement the landfill gas collection and utilization system". The existing Measures for Operation and Management of Clean Development Mechanism Projects have also regarded landfill gas power generation as one of the major fields for CDM projects development.

4.10.3 Nanjing Tianjingwa Landfill Gas Power Generation CDM Project Case Study

4.10.3.1 Project overview

Nanjing Tianjingwa landfill gas power generation CDM project is located in Pukou District, Nanjing, with an installed capacity of 6MW. Registered in 12 December, this project is China's first landfill gas CDM project registered at EB. In June 2006, the project passed the carbon emission reduction auditing of EB as the first project that has successfully completed the first-phase CER delivery in the world, and successfully obtained the first CERs of 26,900 tonnes issued by EB on 3 July 2006. This project has currently obtained CERs of 42,444 tonnes in total with an estimated annual emission reduction of 265,032 tCO2e. The projects owner is Nanjing Green Waste Recovery Engineering Co. Ltd., while the purchaser is EcoSecurities Group Ltd.

4.10.3.2 Sustainable development impact assessment

According to the sustainability assessment indicator system built based on MATA-CDM-China methodology, we carry out assessment against the nine indicators included in the three system layers as social progress, environmental protection and economic development.

Indicator 1: Social equity

Before the construction of this project, Nanjing Tianjingwa landfill site received jointly-signed complaints due to its disturbing malodour[19]. Now it disposes landfill gas of over 6 million m^3 every year, which has significantly reduced the malodours and benefited the surrounding residents 500 metres away. The projects has not only relieved the tense relationship between the landfill station and the local residents,

[19] Source: China Environment News, August 13, 2007.

but has also improved the operating environment at the landfill site. The implementation of the project eliminates and reduces the potential risks of landfill gas combustion and explosion due to a high methane drainage rate of 40%-70%. The project also accomplishes recycling of renewable energy to provide convenient electricity to 2,000 households and heating power to 3,000 households. The power plant pays regular fees to the landfill station to improve the benefits of the employees at the landfill station. This project has neither caused any sexual discrimination issues nor had any influence on women's social status. Based on the above, the utility value against this indicator is 0.5.

Indicator 2: Capacity building

In the construction and operation process of this CDM project, the employees have received relevant skill training. In addition, through the CDM project development, the data monitoring capability and internal management of the projects' owners have been improved. However, there are limited training opportunities to improve capacity. Thus the utility value against this indicator is 0.5.

Indicator 3: Employment

Based on the on-site survey information, this CDM project has actually provided 20 job opportunities. According to the PDD documents, this project can result in an annual greenhouse emission reduction of 246107 tCO2e. Thus the employment of this project is 0.9752 person*month/1000CER based on evaluation methodology, and the utility value against this indicator is -0.0092 compared with the international practice value.

Indicator 4: Ecological protection and land resource

The CDM project covers an area of 0.4 hectares with the soil environment improved due to the collection of landfill gas. Green plants grow on the landfill, such as rape plants, which have improved the local environment. Thus, the utility value against this indicator is 1.

Indicator 5: Emission-reduction effect

This project will produce some noises up to 60 decibels due to power generation outside the noise control area, which may have a negative impact. However, it can dispose biogas of 5,040,000m^3 every year to reduce odorous gases like H_2S etc. The project can also reduce emissions of VOCs by 15000 m^3 per day, which may effectively reduce the damage done to the ozone layer. Meanwhile, it has indirectly reduced the pollutants discharged by coal-fired power generation, and reduced by 1.05*108 m^3 annually. As a result, the utility value against this indicator is 1.

Indicator 6: Fossil energy

The project utilizes the methane generated by waste as fuel without the consumption of fossil fuel such as coal, and as a result the coal consumption of unit power generation is 0. Thus the utility value against this indicator is 1.

Indicator 7: Regional development

Based on field research, the CER revenue of this project can make a contribution of 25% income tax to the local government. However, as the project is located in the economically developed city of Nanjing, Jiangsu, the marginal impact of the project on the local economy will be negligible. This project basically conforms to the overall local industrial layout with no obvious technological spillovers, and has little impact on the local industrial upgrades, structure adjustments and optimization. Thus the utility value against this indicator is 0.

Indicator 8: Micro-economic efficiency

If taking the CER sales income into consideration, the IRR of this CDM project has been increased from the original 6.61% to 11.72%. Upon calculation based on the baseline internal rate of return as 8% and the utility function, the utility value against this indicator is 0.1691.

Indicator 9: Technology transfer

The project adopts domestic equipment and technology without any technology transfer. The utility value against this indicator is 0.

Table 4.15 Results of MATA-CDM-China Assessment on Nanjing Tianjingwa Landfill Gas Power Generation Project

Systematic indicator	Weight (1)	Sub-indicator	Weight (2)	Utility value (3)	Weighted utility (4)=(1)×(2)×(3)
Social progress	**0.25**	Social equity	0.37	0.5	0.0463
		Capacity building	0.33	0.5	0.0413
		Employment	0.3	-0.0092	-0.0007
Subtotal			1		**0.0869**
Environmental protection	**0.43**	Ecological protection and land resource	0.29	1	0.1247
		Emission-reduction effect	0.37	1	0.1591
		Fossil energy	0.34	1	0.1462
Subtotal			1		**0.4300**
Economic development	**0.32**	Regional development	0.26	0	0
		Micro-economic efficiency	0.36	0.1691	0.0195
		Technology transfer	0.38	0	0
Subtotal			1		**0.0195**
Impact on sustainable development	**1**				**0.5364**

4.10.3.3 Result analysis

Based on the above analysis, the impact on sustainable development of Nanjing Tianjingwa landfill gas power generation CDM project is 0.5364, indicating that this project has played a positive role in promoting sustainable development.

In particular, the greatest contribution made by this CDM project to sustainable development mainly lies in its protection of the protection environmental. As seen in the above results, the utility value of this project against the environmental protection indicators is 0.43, accounting for about 80.2% of the total. Such significant environmental benefits mainly stem from the clean and environment-friendly characteristics of such projects. It covers less area and results in improvements of soil quality and landscaping, reduces malodours and VOC emissions to protect the ozone layer and reduces the use of fossil fuels.

This project has relatively small positive impact on economic development and social progress with respective utility value of 0.0195 and 0.0869, accounting for 3.6% and 16.2% of the total.

4.10.4 Key findings

Based on the field survey and research of Nanjing Tianjingwa landfill gas power generation CDM project, it is evident that the landfill gas power generation CDM project has the following positive impacts on sustainable development:

First, landfill gas power generation CDM projects may better achieve the objective of pollution and emission reductions. By generating electricity with methane collected from the landfills instead of fossil energy sources, the landfill gas power generation CDM projects can reduce emissions of SO_2, NOx and CO_2, and CH_4, promoting local energy saving and emission reductions as well as reductions in global greenhouse emissions. In addition, since the landfill gas power generation CDM project has collected landfill gas to improve the soil quality, it can also promote the improvement of the local ecological environment.

Second, CDM projects are important carriers to transfer technology pertaining to climate change, but the landfill gas power generation CDM project has not achieved the goal of technology transfer. Due to the high prices of foreign technology and equipment, Nanjing Tianjingwa landfill gas power generation CDM project instead uses domestic equipment. Only half of other registered landfill gas power generation CDM projects have used foreign equipment mainly including the key equipment and devices as torches and measuring and monitoring instruments.

5. Comprehensive evaluation on the effect of China's CDM projects to sustainable development

5.1 Result evaluation

Table 5.1: summary sheet for the evaluation of sustainable development effect

Classification	Nature of industry	Name of cases	Social progress				Environment protection				Economic development				effectiveness value on sustainable development
			Social equity	Capacity building	Employ-ment	Sub-total	Environment protection and land resources	Emission reduction effect	Fossil energy	Subtotal	Regional develop-ment	Micro-economic benefits	Technology transfer	Subtotal	
Energy saving and efficiency improvement	Cement waste heat utilization	Anhui Conch Ningguo Cement Factory	0.0463	0.0825	0.0007	**0.1295**	0.0624	0.1591	0.1462	**0.3677**	0.0416	0.0658	0.0608	**0.1682**	**0.6654**
	Steel waste heat utilization	Hebei Handan Steel Group CCPP power project	0.0463	0.0413	-0.0007	**0.0869**	0.0624	0.0796	0.1462	**0.2882**	0.0416	0.0262	0	**0.0678**	**0.4429**
	Steel waste heat utilization	Wuhan Iron and Steel Corp` CDQ project	0.0463	0.0413	0.0039	**0.0915**	0.0624	0.0796	0.1462	**0.2882**	0.0416	0.0185	0.0608	**0.1209**	**0.5006**
	Ultra supercritical power	SP Corporation Jiangsu Taizhou USC power	0.0463	0.0413	0.0003	**0.0879**	0.0624	0.0796	0.1418	**0.2838**	0.0416	0.0308	0.0608	**0.1332**	**0.5049**
Renewable energies	Small hydro power	Yunnan Heier	0.0463	0.0413	0.0002	**0.0878**	0	0.1591	0.1462	**0.3053**	0.0416	0.0338	0	**0.0754**	**0.4685**

	Small hydro power	Hunan Xiaoxi	0.0925	0.0413	-0.0006	**0.1332**	0	0.1591	0.1462	**0.3053**	0.0416	0.0001	0	**0.0417**	**0.4802**
	Wind power	Dongshan wind power project in Chifeng, Inner Mongolia	0.0463	0.0413	0.0003	**0.0879**	0	0.1591	0.1462	**0.3053**	0.0416	0.0084	0	**0.05**	**0.4432**
	Wind power	Jiangsu Rudong Dongling wind power project	0.0463	0.0413	0.0004	**0.088**	0.1247	0.1591	0.1462	**0.43**	0.0416	0.0052	0	**0.0468**	**0.5648**
	Biomass power generation	Hebei Jinzhou straw-fired power project	0.0463	0.0413	0.003	**0.0906**	0	0.0796	0.1462	**0.2258**	0.0416	-0.1152	0	**-0.0736**	**0.2428**
Alternative fuels	Natural gas power	Beijing No.3 Thermal Power Plant NGCC	0.0463	0.0413	-0.0002	**0.0874**	0.0624	0.0796	0.1462	**0.2882**	0.0416	0.0019	0.0608	**0.1043**	**0.4799**
Methane Recycle and Use	Coal-bed methane recovery	Shanxi Yangquan Coal Group	0	0.0413	-0.001	**0.0403**	0.1247	0.1591	0.1462	**0.43**	0.0416	0.1021	0	**0.1437**	**0.614**
	Landfill gas power	Nanjing Tianjingwa	0.0463	0.0413	-0.0007	**0.0869**	0.1247	0.1591	0.1462	**0.43**	0	0.0195	0	**0.0195**	**0.5364**
		Average	**0.0463**	**0.0447**	**0.0005**	**0.0915**	**0.0572**	**0.126**	**0.1458**	**0.329**	**0.0381**	**0.0164**	**0.0203**	**0.0748**	**0.4953**

From the evaluation and analysis in the prior chapter, we can see that the average effectiveness value of all the 12 CDM projects for sustainable development is 0.4953, and that the values of these projects are all positive. This shows that although the CDM projects being carried out in China have generally been effective in promoting sustainable development, CDM is yet to reach the goal stated in the Protocol, namely "help the developing countries to realize their sustainable development".

At the systematic level, environment protection is the main aspect in which these projects display their positive effects on sustainable development. In this column, the average score on effectiveness of all the projects that have gone through the evaluation is 0.3290, which almost accounts for 2/3 of the average effectiveness value for sustainable development. Comparatively speaking, the contribution that these projects have on economic development and social progress is relatively small. We can see that these CDM projects have abandoned or relatively reduced the use of fossil fuels, and thereby have implemented synergistic emission reductions for pollutants such as SO_2 and NOx and the substances such as CO_2 and CH_4. Although contributing to achieving the goals of energy conservation and emission reduction as well as the improvement of the global environment, these CDM projects still have not done an effective job in promoting employment due to their capital-and-technology-intensive nature.

At the Indicator column, the indicators such as emission reduction, fossil fuels and capacity building are the aspects in which these projects performed well. The main reason is that these CDM projects mostly can perform well at replacing or reducing the use of fossil fuels as well as reducing the pollutant emissions in certain areas. By carrying out the CDM projects, project implementers can obtain the necessary technology training, and at the same time the data-monitoring ability as well as the internal management of the project owners is improved. Where "social equity" is concerned, small hydro power projects have performed well. As these projects are mostly located in poor and remote mountain areas, the construction and operation of these projects can speed up the construction of infrastructure such as roads, as well as power and communication facilities, thereby helping to ensure access to these public services. In regards to "capacity building", the waste heat power project carried out by Ningguo Cement Factory of Anhui Conch Cement Co. Ltd. is the one that have given the best performance. As the first enterprise to carry out a CDM cogeneration project within the Anhui Conch Cement Co. Ltd., this factory has the experience in cement waste heat power to successfully apply for CDM, and thereby have improved the qualifications and knowledge of relevant staff. Apart from that, depending on its technical superiority at the subject of waste heat power, the factory has successively trained 126 technicians for the waste heat power projects of other branches of the Anhui Conch Cement Co. Ltd. As to the Indicator of "employment", the highlighted cases are the CDQ project of Wuhan Iron and Steel Corp. and the Hebei Jinzhou straw-fired power project. Although the CDQ project cannot reduce emissions on a large scale, it still needs more technology and operation staff due to the complicated character of its technological system, so the number of new employment opportunities per 1000 CERs is rather large. On the other hand, due to the demand on the purchase and transportation of straw, a straw-fired power project will provide the periodic employment opportunity for a certain number of peasants.

Being far away from the villages and residential areas as well as having no negative effect on ecological environment, the Jiangsu Rudong Huangang and Dongling wind power project, which is located in the coastal area, has had a good performance on the “ecological protection and land resource” indicator. As to the Indicator for “regional development”, the effectiveness scores for all the projects are almost the same and the only one that stands out from the group as the lowest is the Tianjingwa landfill gas project in Nanjing. This is caused by the limitation of evaluation methodology as well as the fact that the contribution margin of Tianjingwa project is relatively small. In regards to “technology transfer”, the highly scored projects are “cement lower-temperature waste heat utilization”, “steel CDQ power”, “ultra supercritical power” and “natural gas power” due to the fact that to some degree they are all involved in the transfer of certain manufacturing techniques. But one thing that should not be overlooked is that the core parts of these techniques and equipments still have not been transferred from the developed countries to China.

In terms of the type of these projects, we find that different types of CDM projects in different industries show different levels of effectiveness in promoting sustainable development, and the areas on which China’s CDM projects focus can basically match the priority areas spotted by the country for CDM projects. In Article 4 of Measures for the Operation and Management of Clean Development Mechanism Projects, China regulates “the priority areas for CDM projects in China are energy efficiency improvement, development and utilization of new and renewable energy, and methane recycle and use”, in which methane recycle and use is the part that produces the largest positive effect on sustainable development, and the average effectiveness score of it is 0.5752. The other projects that come succeed it are energy saving and efficiency improvement, alternative energy and renewable energy. Looking into the specific projects and industries, we find that the cement waste heat utilization project is the one that has the largest effect on sustainable development, and the average effectiveness score of it is 0.6654. After it, there is the coal-bed gas recovery project, and the average score of which is 0.6140. The one that comes ranks lower is the biomass power generation project, and its average score is only 0.2428 (see table 5.2). Apart from that, there are also some differences existing among different CDM projects of the same type when the effectiveness value is considered. For example, the Jiangsu Rudong Huangang and Dongling wind power project which is located in the coastal area and the Dongshan wind power project in Chifeng, Inner Mongolia which is located in the inland area are scored respectively as 0.5648 and 0.4432, and the reason is that a wind power plant will perform better in coastal mudflat areas than in inland prairies on protecting the environment and saving the land resources. The waste heat CDM utilization projects selected for evaluation here include cement waste heat utilization and steel waste heat utilization. Among the CDM steel waste heat utilization projects, the two major types are CCPP and CDQ. The CDM projects being selected here include the Anhui Conch Ningguo Cement Factory’s project, Hebei Handan Steel Group’s CCPP power project and Wuhan Iron and Steel Corp’s CDQ project. The scores for these three projects are 0.6654, 0.4429 and 0.5006 respectively, and apparently are not very close to each other. The main reason for this major difference is that the significant technology transfer happened for the two CDM projects in Anhui Conch Ningguo Cement Factory and Wuhan Iron and Steel Corp, while it did not happen for the Hebei Handan Steel Group's CCPP power project. Apart from this aspect, there are also some discrepancies existing among them when the issues such as microeconomic efficiency and employment matters are considered.

Table 5.2: ranking for sustainable development effectiveness value of the CDM projects in different industries

Comprehensive ranking	Nature of industry	Effectiveness value on sustainable development
1	Cement waste heat utilization	**0.6654**
2	Coal-bed methane recovery	**0.6140**
3	Landfill gas power	**0.5364**
4	Ultra supercritical power	**0.5049**
5	Wind power	**0.5040**
6	Natural gas power	**0.4799**
7	Small hydro power	**0.4744**
8	Steel waste heat utilization	**0.4718**
9	Biomass power generation	**0.2428**

In addition, we find that the effectiveness value of a CDM project for sustainable development can be related to certain issues including local economic development, the nature of an enterprise, information accessibility and the relevant regulations. When a CDM project is carried out in a large-scale enterprise that is located in an area which has a well-developed economy and has convenient and sufficient information acquisition as well as a complete policy system, its effectiveness score on sustainable development will be rather high. By analysing the data, we can see that it is usually the large-scale enterprises that have carried out the CDM projects of relatively high effectiveness scores in sustainable development, such as cement waste heat utilization, steel waste heat utilization and coal-bed methane recovery. Apart from the specific nature of these projects, the increasing emergence of this phenomenon can also be attributed to the fact that these enterprises generally prefer to pay more attention to the matters such as transfer of technology and capacity building. In the cases of small scale hydro power projects, we can see that the effectiveness scores of small hydroelectric power projects in Yunnan and Hunan are almost the same if certain circumstances are proved to be alike, including the nature of enterprises, local economic development, information acquisitiveness and relevant regulations.

5.2 Major findings

No matter whether one measures number of projects or CERs, China's CDM projects has been ranked number one in the world. It has well promoted sustainable development work in China as well as throughout the world, and can be said as having achieved a rather positive result. First, CDM has been important throughout China's implementation of its environment protection policy and the work stated in National Plans to Cope with Climate Change at a micro-level (local and enterprise level). Second, CDM can also help to increase awareness and understanding of policy makers and enterprise staff in the subjects such as climate change, clean technologies and emission trading, and at the same time the outcome is that the enterprises will have some of their work improved such as environmental management and greenhouse gas monitoring. Third, CDM helps to create a favourable environment for the development and transfer of new technologies on matters such as renewable energy and energy efficiency. For example, since China started the CDM project in 2005, the wind power industry has experienced rapid growth and a great dissemination of technology on wind power has taken place; for the same reason, CDQ technology has kept spreading in the steel industry. Fourth, the implementation of CDM projects can help enterprises to improve their microeconomic benefits, and then produces positive effects on the sustainable development of these enterprises. For example, the income from the selling of CER in steel waste heat utilization CDM project each year can help an enterprise to increase its internal rate of return by about 40%, and for the wind power CDM project, the number is 30%. Fifth, CDM has given rise to some new businesses, such as carbon market consultants and CDM trading lawyers, and has preliminarily helped to create a team devoted to the development, implementation and administration of CDM projects. Also, with the contribution of CDM, the advanced environmental consultant service industry in China has been greatly promoted.

Although China has had achievements in the implementation of CDM projects, we should note that the CDM projects in China still have not reached the goal of "helping the developing countries to realize their sustainable development" as stated in the Protocol, especially in the area of technology transfer. In other words, China has not fully accomplished technology transfer for its CDM projects registered at EB. As for the CDM projects that have been carried out, mostly the "technology transfer" mentioned only refers to the transfer of technology carriers---the equipments, and in some sense this can only be called as the trading of technology and related products and is still far from meeting the goal of "developing countries will obtain advanced technology by carrying out the CDM project". Among the three criteria that we use to evaluate a technology transfer, only "foreign" (equipments and design are from the foreign countries) and "new" (being advanced and new for China) can be met at the time, and the criterion for "capacity" (obtain the ability and knowledge to operate and maintain relevant equipments) is still out of our reach. First, from the description of PDD we can see that the CDM projects that include technology transfer account for less than 40% of the total projects. Second, even among these projects referred by the PDD as having technology transfer, field research shows that 2/3 of their transfer only act as equipment input, and the equipment is actually purchased at the market price and basically no discount is offered. Third, there is 1/3 of the transfer left as including knowledge and ability training, but it is only the operation and maintenance training for ordinary equipments and cannot be claimed to have realized the input of operation and maintenance skills for the core equipment not to say the transfer of equipment manufacturing technology. These actualities have directly limited what the CDM project can contribute to sustainable development.

The active implementation of the CDM projects in China did not obtain a significant achievement regarding technology transfer, but we can still arrive at the following two conclusions through empirical research in these cases: the first one is that there are certain limitations existing in the CDM mechanism --- the market mechanism design using a single project as the foundation cannot ensure the real transfer of climate-friendly technology from developed countries to developing countries, and what it can actively do is to promote the dissemination and commercialization of climate-sound technology in the developing countries; the second point is that the government of a host country can take advantage of the CDM to promote the dissemination and transfer of climate-favoured technology if it adopts positive measures and take full advantage of its leading role. For example, the many supporting measures issued by Chinese government is the main reason for the increasingly rapid dissemination of certain technologies in China, including the cement low-temperature waste heat power technology, wind power technology and steel CDQ technology.

5.3 The stakeholder analysis

There are a number of elements to ensure that the CDM project can produce a positive effect on sustainable development in China. First, at the international level the Protocol aims at promoting sustainable development in developing countries and regards it as an important principle and goal. Second, the COP/MOP and the CDM Executive Board have established relevant rules and regulations to ensure that the CDM can help the host country to realize its sustainable development goals, for example, it is stipulated that a CDM project design document shall demonstrate how to promote sustainable development. Third, whether a CDM project fulfils necessary sustainable development criteria/meet sustainable development objectives is a matter for the relevant host country to judge/decide[20]. China has adopted measures, e.g. implemented relevant policies and regulations, set priority areas for CDM project development and facilitated energy conservation and emission reduction measures, which furthermore have significant synergy effects on reducing GHG emissions, in order to guarantee that CDM projects contribute to China's sustainable development. China has also established the Clean Development Mechanism Fund (CDMF) to support and facilitate national efforts to address climate change and to facilitate the energy conservation and emission reduction programme to achieve sustainable development.

Although the CDM project has been largely successful in helping China to realize its sustainable development goals, it still has not completely reached the goal prescribed in the Protocol, and in another word, there is some sort of "market failure" in CDM when the issue of "helping developing countries to realize their sustainable development" is concerned. There are a number of reasons acting as the root cause of the above phenomenon. First, the game rules of CDM are not perfect and lack overall coordination. Stakeholders tend to prioritize self-interest rather than cooperation with other stakeholders in order to reach the common goal sustainable development. Second, the stakeholders do not have a comprehensive and uniformed understanding on sustainable development, and some of them even regard it simply as economic development and environment protection but fail to recognize that the sustainable development is a comprehensive subject about economic development, environment protection and social progress. Third, the CDM project is not a pure activity of markets and trading, and will become disconnected from the international background of climate change if we make it become completely market-oriented. If so, most of the stakeholders will become devoted to maximising personal benefit while failing to give sufficient attention to sustainable development --- either accept reluctantly or completely refuse to accept. In addition, as the price of carbon trade products fails to reflect the benefits derived from sustainable development, the

[20] This is stated in the CDM-rules that the assessment of CDM's contribution to sustainable development is made by the DNA of each country. There is no set of unified evaluation standards adopted by the international community.

effects on sustainable development are greatly reduced. In a sense, we can say that no stakeholder can absolve himself of the blame for the fact the CDM project fails to meet what the Protocol has stated, namely "helping the developing countries to realize their sustainable development".

Following is the discussion carried out in different angles of the different stakeholders related to CDM project.

I. UNFCCC COP/MOP (EB)

Although the COP/MOP and CDM Executive Board have established relevant regulations and rules to ensure that the CDM project can help the host countries to realize their sustainable development goals, these regulations and rules are not perfect and may fail to be executed completely. First, although there are relevant instructions manuals being drawn up they usually lack operational measurement procedures and clauses. Second, there is a shortage of relevant incentives and preferential policies for the major fields of sustainable development. For example, the registration rate is not high enough for energy efficiency improvement projects that can greatly promote sustainable development. Though there are some gold standard projects which are devoted to the promotion of sustainable development, due to the complicated feature of their operational procedure, there is not much special attraction to them, and actually a real gold standard carbon market cannot be formed. Third, additionality instruments are not very suitable additionality requirements and clauses are not flexible enough and some even violate the tenet of sustainable development. For example, a large number of steel and cement waste heat utilization projects which have rather high effectiveness values on sustainable development were turned down just because they cannot fulfil the investment additionality requirement. Fourth, there is insufficient and ineffective supervision of the DOE.

II. DOE

Delegated by the CDM Executive Board, the DOE acts as an executive agency that is responsible for the validation and verification of CDM project and is actually a separate third-party certification body. Whether a CDM project has realized its sustainable development goals is an important criterion for the DOE to carry out its validation and verification. From this, we can see that the DOE should act as a very important in realising sustainable development goals. However in reality, the DOE's practical operations are characteristic of market behaviour, and the main point with which it is concerned is to make commercial profit. There are some reasons for the emergence of this situation. First, all the validation and verification costs for DOE are paid by the project owners or developers, and this arrangement makes it very difficult for the DOE to put its attention on areas such as sustainable development which not related to projects or the owners. Second, when a project owner or developer choose a DOE for relevant operation, what he mostly is mostly concerned with is verification cost, time length of the project and project registration rate, and is usually not concerned with whether or not the project will promote sustainable development. Therefore, emphasising economic benefit and work achievement, the DOE often simplifies the verification procedure, and "voluntarily" eliminates certain content that is "irrelevant" to sustainable development. In addition, for a long time China did not have its own DOE, and at the same time the DOEs in foreign countries lacked enough understanding and knowledge of Chinese policies on sustainable development. It is at the beginning of 2009 that China started to have two of its own DOEs approved, and so we can see that it is actually in a starting stage of this. Generally speaking, it is because of the above reasons and situations that the effect of DOE is greatly cut down on helping to realize sustainable development.

III. Chinese government

As to the idea of "helping the developing countries to realize their sustainable development through CDM project", China is one of the most willing stakeholders. However, as CDM is a newly-born programme and understanding it requires a gradual process, the Chinese government still has a long way to go to maintain its rights and benefits regarding sustainable development and to fulfil its relevant responsibilities. There are some aspects on which the existing problems are evident. First, the country lacks practical operational evaluation standards that can be used to evaluate the effects of CDM projects on sustainable development. The sustainable development still remains as the principle stage and no evaluation standard has been established to evaluate the effectiveness of CDM projects and there is still an absence of a basis to direct the decision-making, examination and approval of the project. Second, the operation and management system of CDM projects urgently needs to be made complete. Take the transfer of technology as an example, although the Measures for the Operation and Management of Clean Development Mechanism Projects has specified one of the conditions for approval as "a CDM project should have the promotion effect on the transfer of environment-favoured technologies", it still lacks practical rewarding and punishment measures for technology transfer. On the other hand, the country actually did not enact any practical or restrictive regulations on technology transfer during the examination and approval of the CDM project. Other than that, in the examination and approval process of CDM projects, no preferential treatment is given to major priority fields such as renewable energy resources and improvement of energy efficiency as set in the Measures for Operation and Management of Clean Development Mechanism Projects in China.

IV. Project owner /developer

As the project owners and developers are the "practitioners" of CDM projects, they should be the first ones to take sustainable development matters of CDM project into consideration, in accordance with the both national and international regulations. However, due to some profit and capacity matters, sustainable development does not receive the attention it deserves. First, the understanding of many project owners/developers on sustainable development almost is confined to funding and equipment (or the skills to operate them), and they generally lack the initiative in paying attention to other aspects of sustainable development. Simply put, the CDM project is not driven by the goal of sustainable development but by the cost and CERs profit. Most of the enterprises applying to the CDM project only focus on funding matters. For the technology matters, as the CDM project owners are merely the users of the technology, usually they just put their attention on how to use these equipment. If no attention was paid to the manufacturing of equipment, it will become very difficult to successfully promote the transfer of systematised knowledge such as product manufacturing, manufacturing process and the supply of services. Second, the project owners/developers' ability is limited, and are unfamiliar with the relevant national and international CDM policies, as well as the energy and environment policies of the nation as well as of their own industry.

V. Some developed countries

In the framework of sustainable development and the Protocol, developed countries are responsible for helping developing countries realize their sustainable development goals. Developed countries should also observe the sustainable development principle themselves, and should also be responsible and obliged to direct their attention to the realization of sustainable development and then give priority to the purchase of CERs of the CDM projects that have high sustainable development effectiveness value. Yet, the ultimate interest of some developed countries is often not in parallel with these interests, and what they are really interested in is obtaining the ownership of carbon emission reduction credits at a relatively lower price. Therefore, the larger emission reductions a project can produce, the more attractive it is to these countries. For this concern, these countries might be more inclined to fulfil or partially fulfil their obligations at a relatively lower price, but it is inevitable that the cost will only account for a very small part of the whole transaction. In fact, not only there is no incentive in place to encourage the purchase of "green" (sustainable-development-friendly) CDM projects, there are also no restrictions in place to dissuade and punish the purchase of "brown" (not sustainable-development-friendly) CDM project. In addition, some companies in developed countries/developed countries form barriers voluntarily on the grounds of intellectual property protection and technology market monopoly[21].

[21] See Technology Transfer in CDM Projects in China report, www.euchina-cdm.org

6. Policy proposal for the promotion of the effect that CDM project has on sustainable development

6.1 Policy proposal to the decision makers in China

I. It is important to further understand the significance and the effects that CDM has on sustainable development in China. CDM is an important achievement of the international cooperation on climate change. China's understanding of CDM progresses continuously and gradually, and has undergone three stages in this process: first, progressing from a state of scrupulosity to a stage of gaining preliminary knowledge and beginning to work; second, to develop rapidly, and establish and develop the market and at last become the country with the largest amount of projects and CER sales in the world. Third is to enter a stage of contemplation and transformation. Like most other things, the CDM should not be isolated from its surroundings, and it should be viewed from the perspective of China's macro economic development and sustainable development. At the current stage, the focus of China for carrying out the CDM projects should not be obtaining limited funding, as the funding we get from the sale of CERs only produces a negligible effect on China's sustainable development. What we should really be concerned about is obtaining the advanced technologies that China urgently needs by working on CDM projects and building up the capacity to cope with climate change, as these issues are of great significance and are absolutely essential.

II. For the supervision on CDM project:

1) It is essential to speed up the amendment work on the Measures for the Operation and Management of Clean Development Mechanism Projects, set up a sustainable development indicator system that is scientific and concrete and is also in accordance with the reality of China, and thereby use this system as one of the restrictive conditions for the approval of CDM projects.

In the world, countries such as India have already established their relevant indicator systems, in addition to establishing a number of relevant policies and procedures for meeting the specific demands of their domestic sustainable development goals. Now, China needs to carry out of the following work: first, amend the Measures for the Operation and Management of Clean Development Mechanism Projects, or set up and release "Instructive Proposals for the Verification and Approval of Clean Development Mechanism Projects" or "Policy Manuals for Clean Development Mechanism Projects", establish the indicator system for sustainable development that is scientific and concrete and is also in accordance with the reality of China, and use it as one of the restrictive conditions for the approval of CDM projects. Second, the setting up of the aforementioned indicator system shall take environment protection, economic development and social progress as the basis, and the indicator should be operational and should be of an appropriate amount. At the time, the nine indicators drawn up by our institution can be used as a reference --- energy, emission-reduction effectiveness, ecological protection and land resource, micro-economy efficiency, regional development, transfer of technology, employment, social equity and capacity building, Different weights should be specifically given to the nine Indicators in consideration with the reality, and the sustainable development effectiveness values are figured out at last in a integrative way; third, criterion could be drew up while doing the evaluation, and establish the approval encouragement conditions.

2) Institutionalising the impact assessment of CDM projects on sustainable development as soon as possible.

The impact assessment of CDM projects regarding sustainable development needs urgently to be institutionalized. Environment protection is one of the three important pillars of sustainable development, or in other words, at least 1/3 of the impact assessment of CDM project on sustainable development concern environment matters. Also, as the environmental impact assessment is already a rather matured evaluation system, it has been suggested to further develop the relevant study and enclose the relevant climate change indicators into an environmental impact assessment system. At the initial stage, the professional and certified impact assessment institutions should conduct the sustainable development impact assessment of CDM project. After a while, professional certificates should be set up and the aforementioned institutions should apply for this certificate, for which, relevant departments can take the responsibility for the verification and issue the certificates for sustainable development impact assessment of CDM as well as to supervise the work of these evaluation institutions.

3) Reinforcing the administration on CDM project, introducing the absolute definition of technology transfer from the level of CDM project validation and verification council, and promoting the transfer of technology.

Both the Protocol and Measures for the Operation and Management of Clean Development Mechanism Projects of China all stress that the CDM project should promote the international transfer of climate-friendly technology. As the international transfer of climate-friendly technology shows a strategic importance in promoting sustainable development in developing countries, it is suggested that at least the CDM project validation and verification council of China should make clear the definition for the technology transfer while giving approval to the project. Second, it is important to become familiar with the requirement list for climate-friendly technology as well as taking into consideration CDM policy and emission reduction policy collaboration, balancing between the global and domestic environmental issues, and working out a collaborative achievement on domestic atmospheric pollutant reduction and global atmospheric pollutant reduction. At the same time, countries must keep up with the technological change of the world and renew the technology requirement list. Third, the CDM project validation and verification council should manage different CDM projects according to their classification and standardise market access. For example, quota management should be given as an encouragement to the projects that have a rather large synergistic effect on emission reduction, such as the waste heat utilization project in industrial enterprises. Fourth, countries should reinforce the direction and administration of relevant local departments for CDM project. Fifth, countries should facilitate innovation of relevant technologies in the country and establish innovation systems that unify the technology development, technology production and technology operation.

4) Strengthening the chain management and post-evaluation system for CDM project

At this stage, the management of CDM projects in China should move its focus from market fostering and project development to a new position that unifies market fostering, project developing and post evaluation, and fulfils its international commitments and obligations in dealing with registered CDM projects. Post-evaluation management of registered projects should be strengthened in order to ensure that all the information in PDD will run in parallel with the practice in reality, and at the same time ensure that the effects of sustainable are observable and measurable. First of all, countries should improve the supervision and examination methods and enhance the supervision and examination abilities. Second, countries should further complete the CDM management database, and continue to renew it, so as to accomplish open information sharing and transparent management. The goal for conducting post-evaluation is to ensure a systematic and transparent evaluation of each CDM project’s contribution to sustainable development.

III. Promote the capacity building of enterprises and ensure a good information access.

The limited capacity of the owners and the asymmetry in information access act as one of the major reasons why current CDM projects have not completely arrived at the prescribed sustainable development goal. Take technology transfer as an example. The negotiation of current CDM projects is mainly the buyer's market, and due to the information asymmetry it is difficult for an enterprise to obtain advanced technology. Therefore, we can see that it is very important to promote capacity building for enterprises and ensure sufficient access to information. In the future, the relevant departments in China should continue to reinforce and provide capacity building and training related to CDM projects, improve the project management capacity for owners or potential owners of CDM projects and increase their risk prevention consciousness so as to strengthen their international competitiveness. Due to the rapid development of the CDM market in China, the exchange of information can be improved by enforcing capacity building for CDM project owners through the following channels: set up information exchange platforms, which should organise regularly technology exchange meetings, for project owners and technology suppliers; make use of provincial universities and research and study institutions; integrate

CDM projects with local and regional energy efficiency improvements and the goal of pollution control; reinforce the construction of relevant websites, publish relevant information regularly etc.

IV. Reinforce the efforts for publication and education, fully play the role of the public

As the public plays a very important role in the promotion of sustainable development, we should increase their capacity and consciousness to transform them into a supervising body. We should further increase the participation of the public in the application process of CDM project, listen to them, accept their comments and give feedback on time. We also need to increase the information transparency throughout the whole process of project verification and approval, and apart from publishing the major contents such as the project information, we should also reveal to the public the process and results of the sustainable development impact assessment.

6.2 Policy proposal to the EU

I. European policy-makers should identify European interests and introduce policies and measures that enable businesses to take advantage of CDM business opportunities. The EU is currently the largest CERs buyer in China's CDM market, and the development work on China's CDM project not only has a positive impact on China's sustainable development, but also is in accordance with the interest of EU and can actually slow down global climate change.

II. Advanced technology is an important tool to realize sustainable development. We hope that European policy-makers further promote technology transfer in order to further stimulate sustainable development in developing countries. The EU should take action to eliminate supply-side barriers to technology transfer and facilitate the technology transfer in CDM projects[22].

First, the governments of the EU member states could fund CDM technology transfer i.e. the governments could raise funds and establish a CDM technology transfer fund in order to subsidize technology transfer. Second, the governments could establish policies that provide economic incentives and encourage enterprises to transfer technology via CDM, e.g. provide credit guarantees for technology export, facilitate and expedite the examination and approval procedure for technology export etc.

III. The EU should allow a larger proportion of CERs in the EU-ETS carbon market.

[22] See Technology Transfer in CDM Projects in China report, www.euchina-cdm.org

6.3 Proposal to "Convention" COP/MOP/EB

I. Complete the UN-level administrative and legislative system for CDM project. One approach is to establish the preferential policies that will encourage the development of gold standard CDM projects, and simplify relevant procedures for them. Another approach is to establish rational international mechanisms to facilitate technology transfer in CDM projects, e.g. set up compensation mechanisms which promote the transfer of advanced technology to developing countries through CDM projects.

II. Reinforce or improve the supervision and administration of DOE. One approach is to change the channels for payment to DOE. Instead of being paid by the owner/developer, the payment should be done by EB with CDM funding from the UN. Another approach is to establish and complete the DOE validation and verification guide, and sustainable development should be an important part of it, so as to ensure a validation and verification process that is coherent, transparent and highly qualified. The third approach is to draft the supervision mechanism. The projects that have been verified by the DOE will go through irregular random inspections, and if certain projects were found as failing to meet the standard of sustainable development, considering the condition, the DOE will receive penalties of different levels, from fines to revoking of certification. The fourth approach is to reinforce the sustainable development training to DOE and improve their understanding of sustainable development.

III. It is also important to complete the additionality instruments proposed by the "Protocol", reinforce the research on "additionality" and establish a dynamic mechanism, so as to ensure the additionality requirement can be well serviced and be in accordance with the two purposes of CDM project --- sustainable development and green house gas reduction. Especially for energy efficiency improvement projects that greatly affects sustainable development, financing additionality and policy additionality should not be taken as the conditions for rejection, as investment-adding and the establishment of relevant policies are all for the purpose of realizing sustainable development. Host countries should be encouraged set up "technology additionality" standards, and the DNA of all the countries should use these standards as the criteria for the approval of CDM project.

IV. Countries should adopt positive measures to promote methodological research and the development of the CDM projects that have a significant effect on sustainable development. For example, such measures can include speeding up the methodological research and development in the CDM energy efficiency improvement projects as well as in the projects that have significant effects on pollutant reduction, such as steel, cement and power projects. It is practical to use the relevant CDM funds from the UN to award or compensate this kind of methodology research and development.

V. Countries should also reinforce capacity building on CDM and sustainable development of the developing countries, and intensify the staff training and information exchange.

Appendix: Measures for Operation and Management of Clean Development Mechanism Projects in China

I. General Provisions

Article 1: This measure is formulated in accordance with the provisions of the United Nations Framework Convention on Climate Change (hereinafter referred to as ‘the Convention’) and the Kyoto Protocol (hereinafter referred to as ‘the Protocol’) ratified and approved by China, and the relevant decisions adopted by the Conference of the Parties, with a view to strengthening the effective management of Clean Development Mechanism (hereinafter referred to as ‘CDM’) projects by the Chinese Government, protecting China’s rights and interests, and ensuring the proper operation of CDM project activities.

Article 2: According to the Protocol, CDM is a project-based mechanism under which developed country Parties cooperate with developing country Parties in order to meet part of the GHG emission reduction obligations of the developed country Parties. The purpose of this mechanism is to assist developing country Parties in achieving sustainable development and in contributing to the realization of the ultimate objective of the Convention as well as to assist developed country Parties in achieving compliance with their quantified GHG emission limitation and reduction commitments. The core of the CDM is to allow developed country Parties, in cooperation with developing country Parties, to acquire certified emission reductions (hereinafter referred to as ‘CERs’) generated by the projects implemented in developing countries.

Article 3: CDM projects to be implemented in China shall be approved by relevant departments under the State Council.

Article 4: The priority areas for CDM projects in China are energy efficiency improvement, development and utilization of new and renewable energy, and methane recovery and utilization.

Article 5: In accordance with the relevant decisions of the Conference of the Parties, the implementation of CDM projects shall ensure transparency, high efficiency and accountability.

II. Permission Requirements

Article 6: 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.

Article 7: The implementation of CDM project activities shall conform to the requirements of the Convention, the Protocol and relevant decisions by the Conference of the Parties.

Article 8: The implementation of CDM project activities shall not introduce any new obligation for China other than those under the Convention and the Protocol.

Article 9: Funding for CDM projects from the developed country Parties shall be additional to their current official development assistance and their financial obligations under the Convention.

Article 10: CDM project activities should promote the transfer of environmentally sound technology to China.

Article 11: Chinese funded or Chinese-holding enterprises within the territory of China are eligible to conduct CDM projects with foreign partners.

Article 12: CDM project owners shall submit to the Designated National CDM Authority the following documents: CDM project design document, certificate of enterprise status, general information of the project, and a description of the project financing.

III. Institutional Arrangement for Project Management and Implementation

Article 13: National CDM Board (hereinafter referred to as 'the Board') is hereby established under the National Climate Change Coordination Committee (hereinafter referred to as 'the Committee'), and a CDM project management institute will be established under the Board.

Article 14: The Committee is responsible for the review and coordination of important CDM policies. More specifically, it has the following responsibilities:

1. To review national CDM policies, rules and standards;
2. To approve members of the Board; and
3. To review other issues deemed necessary.

Article 15: The National Development and Reform Commission (NDRC) and Ministry of Science and Technology (MOST) serve as co-chairs of, and Ministry of Foreign Affairs (MFA) serves as the vice chair of the Board. Other Board members are State Environmental Protection Administration, China Meteorological Administration, Ministry of Finance, and Ministry of Agriculture. The Board has the following responsibilities:

1. To review CDM project activities mainly from the following aspects:
(1) Participation qualification;
(2) Project design document;
(3) Baseline methodology and emission reductions;
(4) Price of CERs;
(5) Terms relating to funding and technology transfer;
(6) Crediting period;
(7) Monitoring plan; and
(8) Expected sustainable development effectiveness.

2. If no foreign buyer is determined by the time a project is submitted for approval, and as a result the price information requested in the above term 1 (4) is not available, it must be indicated in the project design document that the emission reductions generated by the project will be transferred into China's national account in the CDM registry and can only be transferred out with the authorization of China's Designated National Authority for CDM.

3. To report to the Committee on the overall progress of CDM project activities, issues emerged, and further recommendations; and

4. To make recommendations on the amendments to this measures.

Article 16: NDRC is China's Designated National Authority for CDM, with the following responsibilities:

1. To accept CDM project application;
2. To approve CDM project activities jointly with MOST and MFA, on the basis of the conclusion made by the Board;
3. To issue written approval letters on behalf of the Government of China;
4. To supervise the implementation of CDM project activities;
5. To establish the CDM project management institute referred to in Article 13 above, in consultation with other departments; and
6. To deal with other relevant issues.

Article 17: Project owners, which refer to the Chinese funded or Chinese-holding enterprises, shall:

1. Undertake CDM project negotiations with foreign partners;
2. Be responsible for construction of the project and report periodically to NDRC on the progress;
3. Implement the CDM project activity, develop and implement project monitoring plan to ensure that the emission reductions are real, measurable, long-term and additional, and subject itself to the supervision of NDRC;
4. Contract designated operational entities to validate the proposed project activity and to verify emission reductions of the project activity; provide necessary information and

monitoring record, and submit the information to NDRC for record purpose; and protect state and business confidential information in accordance with relevant laws and regulations;

5. Report to NDRC on CERs issued;

6. Assist the NDRC and the Board in investigating relevant issues and respond to the inquiries; and

7. Undertake other necessary obligations.

IV. Project Procedures

Article 18: Procedures for the application and approval of CDM projects:

1. A project owner, or together with its foreign partner, submits to NDRC project application, and documents as required by Article 12 above. Relevant departments and local governments may facilitate such project application;
2. NDRC entrusts relevant organizations for expert review of the applied project, which shall be concluded within 30 days;
3. NDRC submits those project applications reviewed by the experts to the Board;
4. NDRC approves, jointly with MOST and MFA, projects based on the conclusion made by the Board, and issues approval letters accordingly;
5. NDRC will make a decision on project application within 20 days (excluding the expert review time) following the date of accepting the application. The time limit for decision-making may be extended to 30 days, with the approval of the Chair or the Vice-chair of NDRC, if a decision could not be made within 20 days. The project applicant should be informed of such a decision and its reasons.
6. Project owner invites designated operational entity to validate the project for registration; and
7. Project owner shall report to NDRC on the approval decision by the CDM Executive Board within 10 days as of the date of receiving the notice from the Executive Board.

Article 19: Other existing relevant rules and procedures for the approval of construction projects shall apply to CDM projects.

Article 20: Procedures for the project implementation, monitoring and verification:

1. A project owner is responsible for presenting NDRC and designated operational entity project implementation and monitoring reports;
2. NDRC is authorized to supervise the implementation of the project to ensure the quality of the activity;
3. The contracted designated operational entity verifies the emission reductions of the project activity and submits certification report to the CDM Executive Board, which will then issue CERs for the projects and inform its decision to the project participants; and
4. NDRC or other organizations entrusted by NDRC will put the CERs issued by the CDM Executive Board in file and record.

V. Other Provisions

Article 21: Developed country Parties mentioned above refer to Parties included in Annex I of the Convention.

Article 22: CDM Executive Board mentioned above refers to the board as defined in Article 12 of the Protocol for the purpose of supervising CDM.

Article 23: The operational entity mentioned above refers to the entity as defined in Article 12 of the Protocol for the purpose of validation as well as verification and certification of CDM project activities.

Article 24: Whereas the emissions reduction resource is owned by the Government of China and the emission reductions generated by specific CDM project belong to the project owner, revenue from the transfer of CERs shall be owned jointly by the Government of China and the project owner, with the allocation ratio defined as below:

(1) The Government of China takes 65% CER transfer benefit from HFC and PFC projects;
(2) The Government of China takes 30% CER transfer benefit from N_2O project;
(3) The Government of China takes 2% CER transfer benefit from CDM projects in priority areas defined in Article 4 and forestation projects.
The revenue collected from CER transfer benefits of CDM projects will be used in supporting activities on climate change. The detailed regulations on collecting and using of the revenue will be formulated by Ministry of Finance jointly with NDRC and other relevant departments.
(4) The Article does not apply to the projects already approved by the Government of China before 12 October 2005.

Article 25: NDRC, in consultation with MOST and MFA, is responsible for the interpretation of this measures.

Article 26: This Measures takes effect as of 12 October 2005. The Interim Measures for Operation and Management of Clean Development Mechanism Projects In China taking effects on 30 June 2004 will be abolished thereafter.

Source: NCCCC
2005-11-21

References

[1]. OLSEN, K.HOLM and J. FENHANN. Sustainable development benefits of clean development mechanism projects: A new methodology for sustainability assessment based on text analysis of the project design documents submitted for validation. Energy Policy, 2008, 36 (8): 2819-2830.

[2]. LENZEN M., SCHAEFFER R. and MATSUHASHI R. Selecting and assessing sustainable CDM projects using multi-criteria methods. Climate Policy, 2007, (7):121-138.

[3]. AUSTIN D., et al. Climate Notes. How much sustainable development can we expect from the Clean Development Mechanism? Washington, World Resources Institute, 1999.

[4]. SUTTER C. Sustainability Check-Up for CDM Projects: Multi-Criteria Assessment of Energy Related Projects Under the Clean Development Mechanism of the Kyoto Protocol. Berlin, Wissenschaftlicher Verlag Berlin, 2003.

[5]. SUTTER C. et al. Does the current Clean Development Mechanism (CDM) deliver its sustainable development claim? An analysis of officially registered CDM projects. Climate Change,2007, 84:75-90

[6]. DE CONINCK H. Trojan horse or horn of plenty? Reflections on allowing CCS in the CDM. Energy Policy, 2008, 36:929–936

[7]. DE MONTIS A., et al. MCDA and Sustainable Development - A Comparison of Methods. Working paper. Cagliari, Universita di Cagliari, 2000.

[8]. GUITOUNI A. and MARTEL, J.-M. Tentative guidelines to help choosing an appropriate MCDA method. European Journal of Operational Research, 1998, 109: 501-521.

[9]. VON WINTERFELT, D. and EDWARDS, W. Decision Analysis and Behavioral Research. Cambridge, UK, Cambridge University Press, 1986.

[10]. SCHOLZ, R. W. and TIETJE, O. Embedded Case Study Methods. Thousand Oaks, London, New Delhi, Sage Publications, 2002.

[11]. Borges da Cunha K, Walter A, Rei F CDM implementation in Brazil's rural and isolated regions: the Amazonian Case. Climatic Change, 2007, 84:111-129

[12]. Ellis J, Winkler H, Corfee-Morlot J, Gagnon-Bebrun F (2007) CDM: Taking stock and looking forward Energy Policy 35:15-28

[13]. Gan L. and Yu J. Bioenergy transition in rural China: Policy options and co-benefits. Energy Policy, 2007, 36:531-540

[14]. Gundimeda H. How "sustainable" is the "sustainable development objective" of CDM in developing contries like India? Forest Policy and Economics, 2004, 6:329-343

[15]. Kim JASustainable Development and the Clean Development Mechanism: A South African Case Study. The Journal of Environment Development, 2004, 13:201-219

[16]. Kolshus H. Et al. Can the Clean Development Mechanism attain both cost-effectiveness and sustainable development objectives? Center for International Climate and Environmental Research, 2001.

[17]. Sirohi S. CDM: Is it a 'win-win' strategy for rural poverty alleviation in India. Climate Change,

2007, 84:91-110.
[18]. United Nations Framework Convention on Climate Change. Report of the Conference of he Parties on its seventh session, held at Marrakech from 29 October to 10 November 2001, Addendum part two: Action taken by the Conference of the Parties, 2002, volume 2. Bonn, Germany: Author.
[19]. Point Carbon, Carbon 2009: Emission trading coming home
[20]. UNEP Resoe Center, 2009. http://uneprisoe.org/
[21]. World Bank. 2005-2009. State and Trends of the Carbon Market Report 2005-2009.