清洁发展机制在中国

2ND EDITION

56643

CLEAN DEVELOPMENT MECHANISM IN CHINA

TAKING A PROACTIVE AND SUSTAINABLE APPROACH

THE WORLD BANK

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seco

THE GOVERNMENT OF THE
PEOPLE'S REPUBLIC OF CHINA

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The World Bank
Ministry of Science and Technology, P.R. China
The Deutsche Gesellschaft für Technische Zusammenarbeit,
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Notes

All tons are metric tons.

All dollars are U.S. dollars.

Currency name = Renminbi (RMB)

Currency unit = Yuan

1 Yuan = 100 fen

Y 1.00 = $0.12 (as of February 2004)

$1.00 = Y 8.28 (as of February 2004)

C = Carbon

CO_2 = carbon dioxide

CO_2 values can be converted to C values by multiplying the CO_2 value by 12/44 (the ratio of the molecular weight of C to CO_2).

Table of Contents

CD-ROM (Attachment)

FIGURES

TABLES

BOXES

Abbreviations and Acronyms

3-E	Energy, Environment and Economy (Institute at Tsinghua University)
AAUs	Assigned Amount Units
ABARE	Australian Bureau of Agricultural and Resource Economics
AC	Alternating Current
ADB	Asian Development Bank
AIJ	Activities Implemented Jointly
AIM	Asian-Pacific Integrated Model
ALGAS	Asian Least-Cost Greenhouse Gas Abatement Strategy
AMI	Agro-Meteorology Institute (of CAAS)
BAU	Business As Usual
BJ3TPP	Beijing No. 3 Thermal Power Plant
BP	British Petroleum
BOF	Basic Oxygen Furnace
C5	China-Canada Cooperation on Climate Change
CAAS	Chinese Academy of Agricultural Sciences
CASS	Chinese Academy of Social Sciences
CCAP	Center for Clean Air Policy
CDM	Clean Development Mechanism
CDM M&P	CDM Modalities and Procedures
ce	coal equivalent
CERs	Certified Emission Reductions
CERT	Carbon Emission Reduction Trading Model
CERUPT	Certified Emission Reduction Unit Procurement Tender
CFBC	Circulating Fluidized Bed Combustion
CGE	Computable General Equilibrium
CHP	Combined Heat and Power
CH_4	Methane
CHN	China
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand

COP	Conference of the Parties
COP/MOP	Conference of the Parties serving as Meeting of the Parties to the Kyoto Protocol
CP	Capacity of electric power
DA	Domestic Action
DAE	Dynamic Asian Economies
DC	Direct Current
DNA	Designated National Authority
DOE	Designated Operational Entity
DTE	Department of Thermal Engineering (at Tsinghua University)
EASES	Environment and Social Development Department of the East Asia and Pacific Region (the World Bank).
EB	Executive Board of CDM
EE	Energy Efficiency
EEC	European Union
EEX	Energy Exporting countries
EF	Emission Factor
EFSU	Eastern Europe and the former Soviet Union
EIA/USDOE	Energy Information Administration/U.S. Department of Energy
EIT	Economies in Transition
EM	GHG Emissions
EN	Energy Consumption
EPPA	Emission Prediction and Policy Assessment Model
ER	GHG Emission Reduction
ERB	Edmonds-Reilly-Barns
ERI	Energy Research Institute, NDRC
ERUs	Emission Reduction Units
ET	Emission Trading
ETH Zürich	Swiss Federal Institute of Technology
EU	European Union
FDI	Foreign Direct Investment
FSU	Former Soviet Union
gC	gram carbon
GCCI	Global Climate Change Institute (at Tsinghua University)
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GSCC	Gas-Steam Combined Cycle
GTEM	Global Trade and Environment Model
GTZ	Gesellschaft fur Technische Zusammenarbeit
GW	Gigawatt
HFCs	Hydrofluorocarbons
ICER	Incremental Cost for Emission Reduction
IEE	Institute of Environmental Economics (at Renmin University)
IGCC	Integrated Gasification Combined Cycle
IMET	Italian Ministry of Environment and Territory

IND	India
INET	Institute of Nuclear and New Energy Technology (at Tsinghua University).
IPAC	Integrated Policy Analysis Model for China
IPCC	Inter-Governmental Panel on Climate Change
IPP	Independent Power Producer
IRR	Internal Rate of Return
JI	Joint Implementation
JPN	Japan
KP	Kyoto Protocol
kVA	kilo-Volt Ampere
kWh	kilo-Watt tour
LA	Latin America
LFG	Landfill Gas
LULUCF	Land Use, Land Use Change and Forestry
MAC	Marginal Abatement Cost
ME	Middle East
MFA	Ministry of Foreign Affairs
MOA	Ministry of Agriculture
MOF	Ministry of Finance
MOST	Ministry of Science and Technology
MP	Methodology Panel
MPa	Mega Pascal
MT	Million Tons
Mtce	Million Tons of Coal Equivalent
Mtoe	Million Tons of Oil Equivalent
MVP	Monitoring and Verification Plan
MW	Megawatt
N_2O	Nitrous Oxide
NC	National Communication
NCCC	National Coordination Committee for Climate Change
NDRC	National Development and Reform Commission of China (former SDPC)
NEDO	New Energy and Industrial Technology Development Organization, Japan
NGCC	Natural Gas Combined Cycle
NGO	Nongovernmental Organization
NOx	Nitrogen oxides
NPC	National Project Coordinator
NPC	The National People's Congress
NPV	Net Present Value
NSS	National Strategy Study Program (sponsored by the World Bank)
O&M	Operation and Maintenance
ODA	Official Development Assistance
OE	Operational Entity
OECD	Organisation for Economic Co-operation and Development
OECD-P	Pacific parts of OECD
OECD-W	European and Canadian parts of OECD

OHF	Open Hearth Furnace
OOE	Other OECD countries
PCF	Prototype Carbon Fund
PDD	Project Design Document
PFBC	Pressurized Fluid Bed Combustion
PFCs	Perfluorocarbons
PNNL	Pacific-Northwest National Lab
PPA	Power Purchase Agreement
PR-I	1st Progress Report (or PRI) of the China CDM study project
PR-II	2nd Progress Report (or PRII) of the China CDM study project
R&D	Research and Development
RMB	*Ren Min Bi* (Chinese Currency)
RMUs	Removal Units
ROW	Rest of the World
SA	South Asia
SC	Steering Committee
SC	Super-Critical
SD	Sustainable Development
SDPC	State Development Planning Commission (now NDRC)
SECO	Swiss State Secretariat for Economic Affairs
SEA	South and East Asia
SEPA	State Environmental Protection Administration of China
SERC	State Electricity Regulatory Commission
SETC	State Economic and Trade Commission
SF6	Sulfur Hexafluoride
SGM	Second Generation Model
SH	Shanghai
SICP	Sino-Italian Co-operation Program for Environmental Protection
SO_2	Sulfur Dioxide
TAG	Technical Advisory Group
Tce	Ton of Coal Equivalent
Toe	Ton of Oil Equivalent
TOR	Terms of Reference
TRT	Top Gas Pressure Recovery Turbine
TWh	Terawatt-hour
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNFCCC	United Nation Framework Convention on Climate Change
US	United States
VAT	Value Added Tax
WB	The World Bank

Foreword

The Clean Development Mechanism (CDM) offers important opportunities for sustainable development in China. The energy sector, in particular, could benefit through new approaches in energy efficiency and renewable energies. Emissions reduction options, which can be transferred to industrialized countries to meet their obligations under the Kyoto Protocol, are also available in other sectors.

The CDM sets out a challenging and complex procedure to be applied in country-specific circumstances. China still has to decide on a detailed national approach for the CDM. In addition, policy issues will also influence the CDM approach. When initiating this study-project in late 2001, the four principal sponsors—the Chinese Ministry of Science and Technology; the Deutsche Gesellschaft für Technische Zusammenarbeit (German Technical Cooperation GTZ), on behalf of the Federal Ministry for Economic Cooperation and Development; the Swiss State Secretariat for Economic Affairs (SECO); and the World Bank—therefore realized this would be a challenging task.

The study's sponsors also realized that established CDM methodology could be challenged in the face of China's varied economic conditions and potentially critical role in the international climate change regime. From the outset, the Chinese Government emphasized that the study should have a strong upfront focus on CDM case study development in order to optimize its operational relevance. Since other studies also were under way in China, the sector focus was narrowed to the electric power generation sector.

Furthermore, the Chinese Government expressed keen interest in obtaining scientifically based projections of China's potential position in an international carbon trading market under different scenarios. The study also needed to include estimates of CDM's possible impact on China's national economy.

Based on this analysis, the study came to a number of conclusions.

First, the study questions the conventional wisdom that a rather large pool of cheap carbon dioxide reduction options are available in China, at least in the power sector. The potential share for China in the world carbon trading market still appears large—perhaps on the order of 50 percent in the long run. At the same time, there are large differences in emission reduction costs among sectors, indicating that only a limited part of the studied sectors—the low-cost sectors—may immediately be relevant for CDM application. These factors suggest that China may not completely dominate the market.

Second, there is a strong need for capacity building through actual CDM project development and in transferring this knowledge to the provinces and local areas in China where CDM projects are being developed. It is important to strengthen the linkages between the central government's interest in CDM and local initiatives.

Since the Kyoto Protocol—and thus CDM—may become a reality, China has many challenges ahead in capitalizing on possible CDM options. China is now soundly engaged in formulating a CDM policy that responds to many of the issues reflected in this report. We are convinced that China will—as it has in so many other cases of international cooperation—shape and implement a policy that wisely integrates the achievements of international agreements with specific Chinese development demands.

We believe this study-project was an important step that will help China's efforts to develop a proactive and sustainable approach to CDM.

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NOTE TO THE 2ND EDITION

Immediately following the publication of the first edition of this report, it was presented at the China CDM Conference in July 2004. At this event, the Government of China also presented and discussed the I*nterim Measures for Operation and Management of CDM Projects in China,* which was put into effect the day before the conference. The conference became a forum to discuss China's CDM potential among the main Chinese and international institutions—including enterprises—working on CDM application in China. This second edition adds the main outcomes from the conference, including written material and video clips of important presentations and discussions, as well as the new interim measures. It also includes some corrections and modifications to the original text. This edition also is in response to the unexpectedly large audience that has requested information about possible CDM application in China.

Acknowledgments

This report is the result of a collaborative research effort by joint Chinese and international staff. In order to coordinate the work by a large number of Chinese research staff from different Chinese institutions, a Chinese research association was established under the overall coordination of the Global Climate Change Institute (GCCI) at Tsinghua University. Additional researchers came from Ernst Basler & Partners, a World Bank consultant; INTEGRATION, a GTZ consultant; the World Bank; the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ); and MOST. For an overview of project participants, refer to Annex 8 in the CD-ROM attachment.

We would like to express our deepest gratitude to the Governments of Switzerland and Germany, which provided the funds to carry out the study, publish the findings, and present the study results to a larger audience. Without their support, the CDM capacity building project and the study would not have been possible.

Within the Chinese research association, a wide range of technical research institutions contributed substantially to this effort, including the Energy Research Institute (ERI) of the National Development and Reform Commissions (NDRC); the Institute of Environmental Economics (IEE) at the Renmin University; the Institute of Energy, Environment and Economy (3-E), the Institute of Nuclear and New Energy Technology (INET), and the Department of Thermal Engineering (DTE), all at Tsinghua University; the Department of Resource Conservation and Comprehensive Utilization of NDRC (formerly part of SETC); the Agro-Meteorology Institute (AMI) of the Chinese Academy of Agricultural Sciences (CAAS); and the Electric Power Division of NDRC (formerly part of SDPC).

Researchers in the association included Wu Zhongxin (GCCI, Vendor Manager), Liu Deshun (GCCI, National Project Director), Duan Maosheng (GCCI, team leader for methodology chapter), Zou Ji (IEE), Li Yu'e (AMI), Su Mingshan (GCCI), Wang Yanjia (GCCI), Ma Yuqing (INET, team leader for case studies), Hao Weiping (NDRC), Zhao Yong (INET), Zhao Xiusheng (INET), Gu Shuhua (INET), Zhang Xiliang (INET), Lu Chuanyi (3-E), Tong Qing (3-E), LuYingyun (3-E), Wei Zhihong (3-E, team leader for CDM modeling), Jiang Kejun (ERI), and Chen Wenying (3-E). The team has also been supported by other technical experts in the association from local institutions and industries, including Beijing Zheng Dong Electronic-Electricity Co. Ltd., Beijing Municipal Commission of Development Planning, Shanghai Wind Power Co. Ltd., Beijing Jingjin Thermal Electric Power Co. Ltd., Guangzhou Light

Industry Design Institute, QinBei Super Critical Project Construction, Huaneng Group Co., Shanghai Meishan Iron and Steel Co. (Nanjing) and Beijing Third Thermal Power Plant. Researchers in the Ernst Basler & Partners INFRAS team included Othmar Schwank (team coordinator), Markus Sommerhalder, Gerard Sarlos, Juerg Fuessler and Juerg Gruetter. For the INTEGRATION team, researchers included Andreas Oberheitmann (team coordinator), Gert Oljeklaus, Fenno Brunken, and Gunther Haupt.

The work was coordinated by a project steering committee (SC), which included representatives from the MOST, GTZ, SECO, and the World Bank.[1] SC participants included Lu Xuedu (MOST, SC Chairman), Holger Liptow (GTZ, Climate Protection Programme), Paul Suding, and Xu Zhiyong (GTZ-China), Gerrard Burgermeister and Zhang Huihui (Swiss Embassy in Beijing), Peter J. Kalas and Eduardo Dopazo (World Bank), Jostein Nygard (World Bank Task Team Leader), and Andrea De Angelis (Italian Ministry of Environment and Territory).[2] Project operations have mainly been managed by Liu Deshun, Jostein Nygard, and Holger Liptow.

As part of the research process, several workshops were arranged that included external participants from other government agencies and Chinese enterprises; refer to Annex 7 in the CD-ROM attachment for participants and minutes from stakeholder meetings.

A technical advisory group (TAG) for the study—including Zhou Dadi (ERI), Ma Aimin (NDRC), Pan Jiahua (Chinese Academy of Social Sciences-CASS), Anne Arquit Niederberger (Policy Solutions), and Michael Rumberg (TÜV Süddeutschland)—presented their report to the SC in December 2003. Thereafter, the TAG actively assisted in drafting the institutional and concluding parts of the report.

Additional inputs, comments, and review of the text draft were provided by Gao Feng (MFA), Li Liyan (NDRC), Zhang Zhonxiang (East-West Center), Franck Lecocq, Neeraj Prasad, Daniel Hoornweg, Todd Johnson, Masaya Inamuro, Liu Feng, Nuyi Tao, Salvador Rivera, Chandra Shekhar Sinha, Andres Liebenthal, Robert Crooks, Robin Broadfield (World Bank staff) and Qi Zhai (World Bank intern).

The report was edited by Robert Livernash (consultant). Circle Graphics did the design and managed the typesetting. Production was supervised by Denise Marie Bergeron. Photos have been provided by Circle Graphics and Anne Arquit Niederberger.

[1] NDRC, Ministry of Finance (MOF) and Ministry of Foreign Affairs (MFA) have also participated in several of the critical study review meetings.

[2] IMET, through their representative in the Sino-Italian Cooperation Program for Environmental Protection, participated in the SC based upon a separate activity focusing on CDM application in energy efficiency in buildings and industrial production projects. The result from this study is being published separately.

Executive Summary

The China CDM study analyzes key methodological issues related to the Clean Development Mechanism from China's perspective. It includes six case studies of potential CDM projects—five power generation projects and one landfill gas project—and evaluates China's CDM potential through 2010.

Based on the analytical results and experience gained through the China CDM study, and considering both the evolution of the international CDM regime and China's particular national circumstances, this report outlines a Chinese CDM approach that:

- Emphasizes *sustainable* CDM by ensuring the contribution of CDM project activities to sustainable development in China.
- Takes a *proactive* approach to take early advantage of CDM opportunities during the first commitment period.

The recommended approach is based on the following main insights from the methodological, case study, and modeling work undertaken by the study team:

- Implementation of the CDM in China can deliver significant local economic and sustainable development co-benefits.
- China's CDM potential represents a substantial component of the global carbon market.
- CDM projects must be identified and developed within the next couple of years for China to capitalize on its CDM potential during the first commitment period from 2008 to 2012.
- Chinese enterprises face barriers to CDM development and implementation in practice.

Based on the assessment of the significance of CDM opportunities for China, the study considers barriers to CDM project implementation, including needs for capacity building based on China's special circumstances and interests. In addition, the study makes a number of recommendations for decision makers regarding:

- *China's CDM strategy, policy, and implementation plans*: adopt a proactive and sustainable CDM policy.
- *Urgent steps to facilitate CDM transactions:* provide basic services to allow CDM in China; ensure that critical capacity is developed; and encourage CDM project identification and implementation.
- *Longer-term considerations:* consolidate results/enhance synergies across CDM initiatives and undertake follow-up analysis on key issues.

Combining a top-down with a bottom-up approach, the study sought to analyze China's real circumstances. The study presents a comprehensive package of conclusions and recommendations to the Chinese Government, potential project proponents, and the interested national and international audience.

Introduction

INTERNATIONAL AND DOMESTIC CONTEXT FOR CDM IN CHINA

Introduction to the CDM

The Clean Development Mechanism (CDM) is one of the three flexible mechanisms established under the Kyoto Protocol (KP 1997). The CDM allows developed countries listed in Annex 1 of the United Nations Framework Convention on Climate Change (UNFCCC) to invest in greenhouse gas (GHG) emission reduction projects in non-Annex 1 developing countries and to claim the resulting Certified Emission Reductions (CERs) to assist them in compliance with their binding GHG emission reduction commitments under the Protocol. At the same time, CDM project activities contribute to sustainable development in the host developing countries. The CDM is thus conceived as a project-based win-win mechanism that can provide increased flexibility (temporal, geographical, sectoral) to developed countries, which can reduce their overall cost of compliance with Kyoto commitments, while providing the CDM project hosting partners with additional funds and advanced technology.

At the Seventh Session of the Conference of the Parties to the UNFCCC (COP-7) convened in Marrakech in November 2001, a package of high-level political decisions on Kyoto Protocol issues (in particular, the CDM) was adopted as documented in the Marrakech Accords. This agreement paved the way for Annex I Parties to ratify the Kyoto Protocol and thus bring it into force. The Marrakech Accords elaborated the modalities and procedures for the CDM, including institutional, methodological, technical, and procedural aspects, with a view to a prompt start to CDM project implementation, even before entry into force of the Kyoto Protocol. Under the Marrakech mandate, the CDM Executive Board (EB) and affiliated panels—such as the Methodology Panel, Small-Scale CDM Panel, and Operational Entity Accreditation Panel—were established to make the CDM operational.

China's Climate Change and other Related Policies

China signed the UN Framework Convention on Climate Change in 1992, but climate policies have not been high on the agenda of government decision makers, and no explicit climate mitigation or adaptation policies are in place. China's pursuit of sustainable development, however, has in many respects been consistent with climate protection. China takes active part in international and domestic activities regarding global climate change. Furthermore, China ratified the Kyoto Protocol in August 2002, making the country eligible for CDM participation in competition with other developing countries. China's initial national communication is in the final stage of preparation and is expected to be approved by the central government in 2004. This will provide official greenhouse gas emission inventory data, which are important for assessing priority areas for CDM projects.

Sustainable development is a national strategy, and related policies and measures also generate climate benefits. During the past two decades or so, China has promulgated dozens of laws and regulations that promote sustainable development, with positive impacts on climate change, including laws on environmental protection, energy conservation, development of new and renewable energy, reforestation, soil and water conservation, and the like. From 1998 through 2002, a total of 580 billion yuan, accounting for 1.29 percent of GDP, was invested in improvement of the environment and preservation of ecosystems. Efforts are now under way to prepare regulations or detailed policies to implement the China Energy Conservation Law. Forest cover has increased from 13 percent in 1988 to 16.7 percent today, which contributes to carbon sequestration. International cooperation has been strengthened to assist with building capacity to address global climate change.

Energy Consumption and Greenhouse Gas Emissions in China

Energy consumption

Together with rapid economic growth, energy production and consumption in China have increased quickly. China's power industry has been experiencing rapid development in recent years, with 338.6 GW (Gigawatt) installed capacity and 1483.8 TWh (Terawatt-hour) annual generation as of 2001, and with capacity and generation increasing at 6.0 percent and 8.4 percent annually, respectively. Coal-fired power plants accounted for 81 percent of total electricity generation in 2001. Construction of transmission lines at the 35 kV (kilo-Volt) and higher voltage levels reached 7.8×10^5 km in 2001, 7.7 percent greater than that in 2000, while the corresponding transformer capacity rose to 1.1×10^9 kVA (kilo-Volt Ampere), a 12.2 percent increase over the level in 2000.

The central government of China's long-term target is an average economic growth rate slightly higher than 7 percent, which will lead to a four-fold GDP increase by 2020. It is estimated that the annual increased rate of electricity demand will range from 5.5 to 6.0 percent, which could be as high as 6.5 to 7.0 percent through 2010.

During the period from 1980 to 2000, energy consumption in China doubled (*Table I.1*). Because of energy resource limitations, coal dominates energy use in China, accounting for nearly 66 percent of total primary energy consumption in 2000. There was a decrease of energy consumption after 1997 and a rebound since 2000, with energy consumption increasing to 924 Mtoe in 2001, 1,015 Mtoe in 2002, and about 1,080 Mtoe in 2003.

Greenhouse gas emissions

Even though no official national GHG emissions inventory has been published so far, several studies have developed emissions data for 1990. These inventories mainly cover emissions of carbon dioxide (CO_2) and methane from different sources, including fossil fuel combustion; fugitive emissions from coal mines and natural gas and oil exploitation; emissions from industrial process; and emissions from agriculture and land use change.

Estimates of carbon dioxide emissions from fossil fuel combustion range from 2,050 to 2,445 million tons of CO_2. Emissions from industrial processes range from 81 to 104 million tons of CO_2. Fugitive emissions from fossil fuel production range from 5.7 to 18.5 million tons of CH_4, while emissions from agriculture, land use, and land use change range from 12.6 to 20.9 million tons of CH_4. The biological carbon sink associated with land use and land use change ranges from -154 to 315 million tons CO_2.

The total emissions of CO_2 for the period 1990-2002 are estimated in *Figure I.1*. Studies to compile emission inventories have estimated that emissions from fossil fuel combustion account for around 80 percent of total emissions. The breakdown of CO_2 emissions from fossil fuel combustion is calculated and presented in *Figure I.2*. Carbon dioxide emissions from the power generation sector represent the biggest share of primary energy consumption (41 percent). Taking account of other GHGs (N_2O, HFCs, PFCs and SF_6), the share of CO_2-equivalent emissions captured by the power generation sector would be lower.

Not all power sector technologies are suitable for CDM project activities. In this study, technologies to be evaluated in the case studies were selected according to their contribution to the overall attractiveness of projects in a CDM project pipeline, including their (a) potential to reduce GHG emissions significantly; (b) local environmental benefits; and (c) the availability of data regarding the status of project progress.

The case studies selected thus cover a considerable share of the total emission reduction potential in the Chinese power sector.

TABLE I.1 Structure of Primary Energy Consumption in China

		Shares(%)				
	Energy Consumption (Mtoe)	Coal	Oil	Natural Gas	Hydropower	Nuclear
1980	422	72.2	20.7	3.1	4.0	0
1990	691	76.2	16.6	2.1	5.1	0
2000	912	65.9	24.5	2.5	6.7	0.4

Source: State Statistical Bureau

ONGOING CDM-RELATED ACTIVITIES IN CHINA

Overview of the Various Initiatives

A number of major CDM activities (capacity building, analysis, case studies, pilot CDM projects) sponsored by international donors are cur-

FIGURE I.1 CO_2 Emissions in China from 1990 to 2002

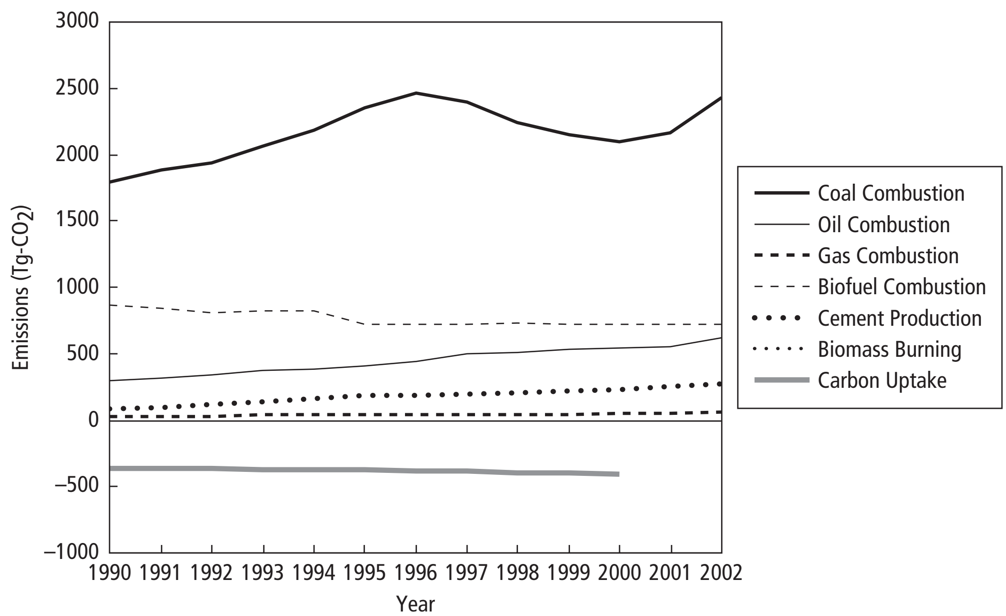
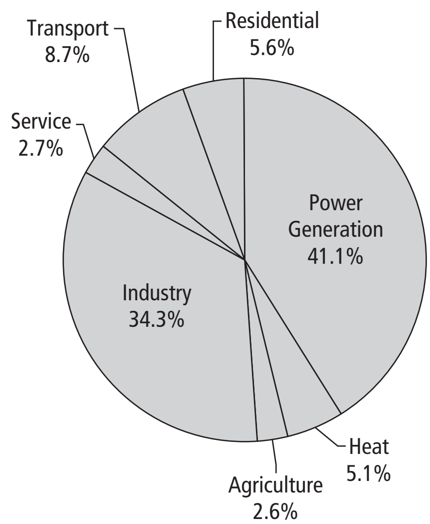


FIGURE I.2 CO_2 Emissions by Sectors



rently ongoing in China (*Table I.2*). To avoid overlap with other ongoing CDM study efforts, the case studies in this project include three fossil thermal and three renewable projects in the electricity generation sector, while other studies focus on other sectors. Of course, the full picture of potential CDM projects in China would be best reflected by integrating achievements from all the case studies carried out in these ongoing CDM project studies, including this World Bank/GTZ Germany/SECO Swiss sponsored project.

Progress on Ongoing CDM Projects

In addition to undertaking CDM project case studies, it would be desirable to utilize the capacity built through such efforts to develop some of the case studies into realistic CDM projects. Because CDM activities are in the very beginning stage in China, proponents of the CDM project case studies have great difficulties to process CDM projects without initial financial support, so assistance to find appropriate sources of financing and donors interested in CDM projects is crucial.

Several CDM financing workshops were held in past few years in China to bring together Chinese CDM proponents and potential international investors. After several years' preparation and negotiation, some progress has been achieved, and there are a number of CDM projects currently being developed for implementation in China. The following two examples are renewable energy projects, a wind farm project and a hydropower project.

Huitengxile windfarm project

The first CDM project in China is the Huitengxile windfarm project. Participants in the project are the project proponents (Inner Mongolian Wind Power Corporation, together with Chinese Renewable Energy Industries Association) and the investor (CERUPT, the Dutch Government's CDM credit procurement program). The project is located in Huitengxile, Inner Mongolia, with total wind power capacity around 34.5 MW. Nine turbines of 600 kW each were installed in 2001 and put into operation in January 2002. Another ten 600 kW turbines were installed in 2002 and put into operation in December 2002. Construction of the last of turbines was scheduled to commence in September 2003.

The annual average CO_2 reduction of the CDM project is calculated as 60,024.8 tons and the crediting period is taken as 10 years, resulting in total CO_2 reduction credits of 600,248 tons. This project has been selected as a supplier of carbon credits by the Dutch Government. After years of negotiation, the contract of this CERUPT project between the Governments of the Netherlands and China was signed in the second half of 2002. All CO_2 credits generated by the project will be purchased by the investor, and the investor will have the first right of refusal to purchase any surplus credits. According to the contract, the price being paid for the CERs is 5.4 Euros per ton of CO_2.

At the request of the investor, key project documents are currently undergoing revision (for example, the PDD must be improved to meet the

TABLE I.2 Key Information on Ongoing CDM Study Activities in China, 2004

Donor	WB/GTZ	Canada (C5)	Japan (3-E)	ADB	BP	UNDP
Study methodologies applied	Case studies Macro models Workshops	Staff training, outreach, case studies	Regional onsite survey and expert interview on	Case study	Case study	Case study
Sectors	Economy-wide modeling and case studies; Power generation sector (fossil, renewables) case studies	Renewables, urban transportation and sink	Electric power sector	Renewables	Electric power sector	Renewables, energy efficiency and coal-bed methane
Regions	Beijing, Henan, Guangdong Jiangsu, Shanghai Global Modeling	Ningxia	North China (3 provinces, Hebei, Inner Mongolia, Shanxi)	Gansu, Guangxi	Guangdong	Across China
Key issues addressed	CDM methodology applicability, CDM potential MAC, CER Price Impact analysis, policy insights, and recommendations Benefits and barriers for CDM	Awareness and outreach Adaptation and impacts National communications CDM	Estimating the potential and cost of CDM in China	Capacity building	Policy, regulatory and technical study to evaluate the CDM potential	1. CDM Policy Building Support, 2. CDM Training Package Development and Implementation 3. Prepare CDM pre-feasibility studies and pilot project facilitation 4. Develop CDM Project website and provide on-going technical support and maintenance

(continued)

TABLE I.2 Key Information on Ongoing CDM Study Activities in China, 2004 (*Continued*)

Donor	WB/GTZ	Canada (C5)	Japan (3-E)	ADB	BP	UNDP
Time period	2002-2004	2002-2004	2001-2005	2002-2003	2002-2003	2004-2006
Objectives	Capacity building, development of methodological guidelines for CDM in China, assessment by case studies, assessment of the China CDM market in the global context	Capacity building, poverty reduction, and contribute to Canada' s international climate change objectives	Promoting CDM, methodology, GHG ER potentials and costs of CDM in China	Capacity building for small-scale CDM projects	CDM case study	CDM policy recommendations, capacity building, CDM case study, CDM outreach
Output	Final report on the study findings Six case study reports and PDDs Final study workshop Training in PDD preparation	1. Information on CDM rules & procedures 2. Case studies 3. Methodological analysis and policy advice	Sectoral CDM Potentials, PDD	PDD Case study report	PDD Study report	1. Assessment of CDM in China 2. CDM training materials 3. Three CDM PDDs 4. A CDM website

requirements and standards issued by CDM Executive Board with respect to baseline methodology, monitoring methodology, and plan). As this CERUPT project is a pioneer CDM project in China, the cumulative experience gained from preparation of the necessary documents, submission to the host country's designated agency for approval, the price negotiation process, and project implementation and monitoring will be very helpful for promoting CDM projects in future years.

Xiaogushan hydropower plant

The second CDM project in China is the Xiaogushan hydropower plant (XHP) project. The project proponent is the Xiaogushan Hydropower Company and the investor is the Prototype Carbon Fund (PCF) of the World Bank (WB). The XHP project is located in Zhangye in Gansu Province. It is a run-of-river power plant with a total hydropower capacity of 98 MW and includes a diversion weir, intake tunnel, power plant, a road connecting the weir and power plant, and 110 kV transmission line for power evacuation. The project construction started in early 2003 and will be completed in early 2005. All components of the project lie within the same sparsely populated county. The project will contribute to easing power supply shortages, protecting the environment, and removing poverty in local regions.

The annual average CO_2 reduction of the CDM project is calculated as 372,300 tons, the credit period is taken as 10 years and the total CO_2 reduction credit produced by the project amounts to 3,723,000 tons. Recommended by the National Climate Change Coordination Office of China, the WB selected XHP as one of the potential PCF projects in China. In October 2003, the Chinese side completed the Project Concept Note and submitted it to WB, which sent a team of WB officials and international experts in November 2003 to Gansu Province for a site visit to collect relevant data and information. While preparing the necessary reports and sending them to the World Bank, the proponent (XHP) and the Bank were also processing a Statement of Intent for creating the PCF project. For this XHP project, the CO_2 price was set through negotiation at around $4 per ton of CO_2. Considering the closing date of PCF, the ERPA (Emission Reduction Purchase Agreement) of PCF XHP is expected to be signed in the fourth quarter of 2004.

CHINA CDM STUDY BACKGROUND

In 1997, the World Bank launched the National Strategy Study Program (NSS) together with the government of Switzerland. Since then, the Program has expanded to include other donor countries, including Germany, Italy, Finland, and Australia, to assist its partner developing countries in exploring the opportunities and benefits of participating in CDM projects. One form of assistance is to support country studies that develop CDM methodologies and analyze GHG emission reduction potentials in different regions by identifying promising CDM technology categories and project-type options with cheap GHG emission reduction costs. The program also would like to assist the partner countries to explore possible policies and measures and to create a sound enabling environment and platform to enhance capacity building for the CDM and overcome existing barriers to CDM project implementation, based on the partner country's real circumstances and interests.

The study program also focuses on CDM project case studies leading to development of CDM Project Design Documents (PDD) and preparation of proposals for feasible CDM project options in the selected sectors.

Based on common understanding and interests, the World Bank/GTZ Germany/SECO Swiss reached an agreement with MOST on behalf of the Chinese Government to carry out the proposed China CDM Study project funded by the Governments of Switzerland and Germany.[1]

Motivation and Objectives of the Study

The China CDM Study was developed to meet the following needs for China:

1. There is a need for China's academic and consultant institutions to develop a better understanding of CDM methodologies and how to prepare better applications for CDM projects based on China's real circumstances.
2. At the micro level, there is a need for China's project participants (public and private sectors) to learn how to identify, develop, and implement an eligible CDM project in the whole project cycle. A practical way to meet the need is "learning by doing" through CDM project case studies.
3. At the macro level, there is a need for China's policymakers to know the potential demand for CERs in the world carbon trade market, as well as price trends. In order to formulate appropriate CDM strategy and policy for China, they also need to know the least-cost CERs/CDM supply potential and priority areas by technology and sector in China, as well as their policy implications and the impact of CDM on China's economy.

Hence, the overall concept of the China CDM Study project is to enhance capacity building in implementation of CDM at the level of individual projects (micro level), while simultaneously developing CDM strategy and policy at the macro level for the Chinese side. The overall objectives of the study are to:

- Better understand CDM methodological and technical issues in order to provide technical advice on how best to apply the CDM methodology guidelines to real CDM projects in China.
- Build up capacity and experiences in CDM project development through typical case studies in the electric power generation sector (fossil, renewable) in China, with a view toward preparing eligible CDM PDDs and establishing a project pipeline with industries in China and abroad.
- Better understand the market opportunities and economic benefits for China when participating in CDM by identifying China's CERs supply potential; analyzing marginal abatement cost curves (MAC) and priority technology and sector areas; simulating the market price trends of CERs and China's market share in the world CDM carbon market under selected scenarios; assessing the impacts of CDM on China's economic development; and evaluating barriers, so as to identify the policy implications of CDM for China.

In general, these objectives also mean an overall far-reaching objective: to enhance overall capacity building for China to participate in CDM. The structure of the study follows these objectives.

Structure of the Study Report

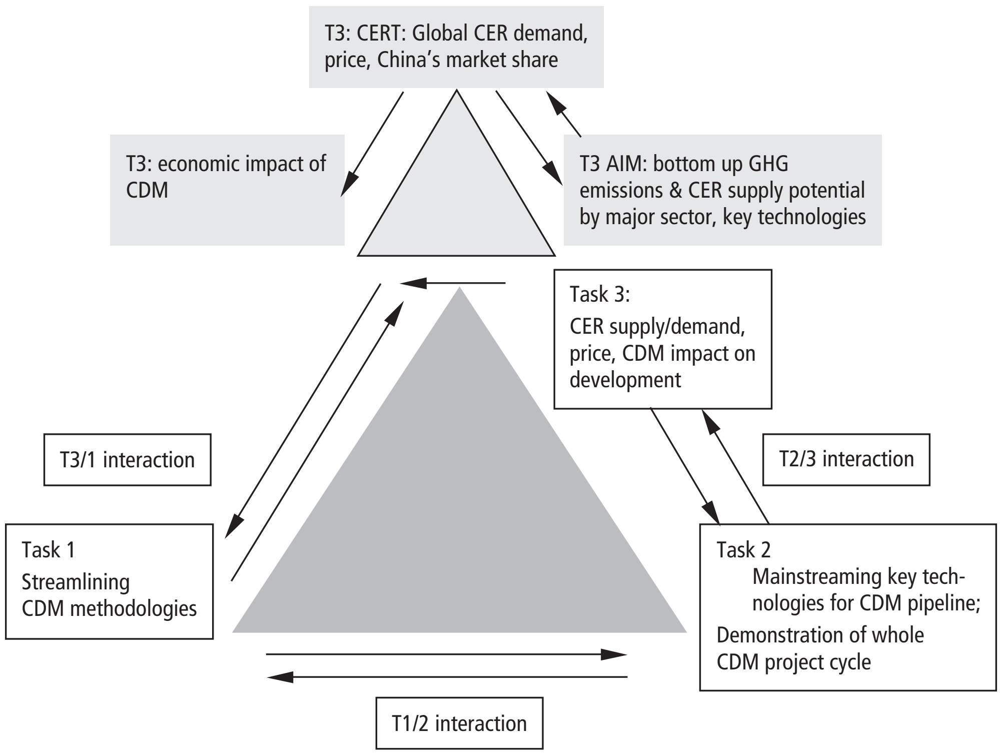
The Chinese Government and World Bank/GTZ Germany/SECO Swiss agreed that the content of the study is based on the real needs and interests of the Chinese side. The project activities were structured as three tasks:

- **Task 1**: Methodological and technical issues for CDM.
- **Task 2**: CDM project case studies.
- **Task 3**: Analysis of China's CDM potential and impacts on economic development.

Meanwhile, inter-linkages between the three tasks were established to support each other. The linkages are illustrated in *Figure I.3.*

The inter-linkage between Task 1 and Task 2 was established in such a way that Task 1 provided technical training and assistance to Task 2 regarding methodological and technical issues in the case studies, and discussed with Task 2 the appropriate application of related CDM methodologies in case studies. Task 2 then ensured that

FIGURE I.3 Overview of Main Outputs and Inter-linkages Among Tasks 1, 2, and 3



each of the CDM methodological issues addressed by Task 1 was studied in-depth in one selected case study, in cooperation with Task 1.

Moreover, as far as the inter-linkage between Task 3 and Task 2 is concerned, the linkage is established in such a way that Task 3 provided results of the IPAC-AIM technology model regarding CO_2 emission mitigation potential in China and their share by sectors for 2010, as well as the priority list of technology options for CO_2 emission reductions, including the advanced electric power technologies. Task 3 also supplied the marginal abatement cost analysis for most key sectors, including the power generation sector. This information proved to be a useful reference for Task 2 to identify and select appropriate sectors, and then energy technologies suitable for the CDM project case study in the electric power sector.

The final report is divided into two Parts. Part I covers the CDM Methodology and Case Studies, which contains the results of Task 1 and Task 2. Part II covers China's CDM potential and an impact assessment of CDM on China's socioeconomic development, which covers the results of Task 3, as well as conclusions and recommendation.

Study Partners

The China CDM Study was primarily conducted by Chinese experts from the leading institutions in cooperation with the international experts designated by the World Bank/GTZ Germany/SECO Swiss under the general guidance of a Steering Committee, consisting of MOST of China (Chair) and supported by other concerned agencies, including the GTZ of Germany, the Government of Switzerland, the World Bank, and the SICP of Italy.

The national expert team is divided into three task teams responsible for the three tasks. Recommended by the Steering Committee, the Global Climate Change Institute (GCCI), Tsinghua University, is designated as the National Project Coordinator (NPC) unit, and the GCCI, INET, and 3-E institutes of Tsinghua University are selected as the executing agencies responsible for Tasks 1, 2, and 3, as well as for the organization of the national expert teams in cooperation with other local institutions and industries. Therefore, the GCCI represents a role as an association, involving several competent institutions and industrial experts within and outside Tsinghua University under the project framework, as shown in Annex VIII on the CD-ROM. The domestic experts could thus fully use their interdisciplinary expertise and knowledge in the association coordinated by the NPC. The role of the international experts is to provide advisory suggestions, relevant information, and necessary technical assistance, as stipulated by the TOR and requested by the project coordinator. The list of the national and international experts team can be found in Annex VIII on the CD-ROM.

The role of the Steering Committee was to guide the project team, perform overall monitoring of the study activities, make decisions regarding essential components of the study, and adopt the inception report, the progress reports, and the final report. The member list of the Steering Committee is also in the Annex VIII on the CD-ROM.

In addition, a Technical Advisory Group consisting of three Chinese and two international experts performed an in-depth, on-site peer review of the draft final report, and international experts, the World Bank, and the German GTZ also reviewed and provided comments at various stages of report preparation. Representatives of several Chinese Government ministries provided comments on key elements of the report before it was finalized.

Endnote/Reference

1. Italy joined the World Bank/GTZ Germany/SECO Swiss China CDM Study Project later, but its work is separately developed.

Technical Summary

The China CDM Study was supervised by the Ministry of Science and Technology of the Chinese Government and supported by the Swiss Government, the German Agency for Technical Cooperation (GTZ), and the World Bank. The objectives of the study were to:

- Project China's CDM supply potential and prioritize under different scenarios the technology options for CER supply
- Estimate the size of the global CDM market and factors influencing China's market opportunities, as well as the likely range of economic benefits
- Contribute to a better understanding of the methodological issues related to application of CDM under China's national circumstances
- Build capacity and experience in CDM project development through investigation of six case studies from the electrical power and the renewable energy sectors
- Assess the impacts of CDM on China's economic development and related barriers
- Identify policy implications of CDM and frame recommendations for policymakers accordingly.

METHODOLOGICAL GUIDELINES AND INSTITUTIONS FOR CDM

In the first part of the study, a series of methodological issues were investigated. There are various stages and studies that are required for a project to realize revenues from the CDM market. The correct application of these methodologies will ensure that a proposed CDM project activity results in real, measurable, and long-term greenhouse gas emission reduction benefits. A better understanding of methodological and technical issues related to CDM projects (in particular baselines and additionality) would provide guidance for case studies conducted at the sectoral level. The findings in this study will help CDM project proponents in the country make well-informed decisions at various stages of project development and implementation.

Table T.1 provides a brief overview of the most important terms in the CDM process and their definitions by the Conference of the Parties or—if not defined by UNFCCC bodies—the definition used in this study. Following that, the methodological results of the study are presented.

Project Boundary and Leakage

A rational project boundary is essential to accurately measure the emission reduction benefits of a CDM project activity and to mitigate leakage. Leakage can be caused by activity shifting, which happens when people (or capital) change location; changes in product price; life-cycle emissions shifting, such as an

TABLE T.1 Key Methodological Terms in the CDM Process

Project boundary
". . . shall encompass all anthropogenic emissions by sources and/or removals by sinks of greenhouse gases under the control of the project participants that are significant and reasonably attributable to the CDM project activity."

Leakage
"Net change of anthropogenic emissions by sources of greenhouse gases which occurs outside the project boundary, and which is measurable and attributable to the CDM project activity."

Baseline
"The baseline for a CDM project activity is the scenario that reasonably represents the anthropogenic emissions by sources of greenhouse gases that would occur in the absence of the proposed project activity. A baseline shall cover emissions from all gases, sectors and source categories listed in Annex A within the project boundary."

Additionality
"A CDM project activity is additional if anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the registered CDM project activity."

Project-based incremental emission reduction cost
Based on economic theory, the calculation method of project-based emission reduction cost for a CDM project depends on the cost allocation options among the domestic benefits (such as products and/or service) and the CER benefits from different points of view; that is, the cost could be defined as an incremental cost for achieving the CERs or for achieving domestic benefits. The CDM is designed to provide benefits for both project investor and host. It should help non-Annex I (developing) countries achieve sustainable development, and help Annex-I (industrialized) countries fulfill their quantitative obligations under the Kyoto Protocol. According to this share of benefits, there has to be a subsequent cost-share arrangement. Since it is easy to measure the project costs and complicated to measure the benefits, this study views this issue from the cost perspective; that is, CDM project developers will bear additional costs other than those that occur in the baseline scenario.

upstream or downstream emissions increase caused by the project; and change in GHG fluxes resulting from ecosystem-level changes in surrounding areas.

Four principles are useful in identifying emission sources and sinks that should be included in the project boundary: (1) comprehensiveness of the boundary, or balancing the comprehensiveness in boundary definition and the accompanying cost; (2) control over emissions and maintenance of proper incentives; (3) avoidance of double counting (credits can only be issued once for a project activity); and (4) materiality of emission, or setting a threshold for "significant".

Taking these principles into account, leakage can be mitigated by various means:

- *Rational project selection and design.* A developer can evaluate the likely impacts of the project on the existing supply of and demand for goods and services, and seek to change this supply/demand or meet this supply/demand through alternative actions. Using project design to avoid leakage is more difficult when economic goods (e.g., energy or timber) are involved.
- *Extension of project boundary.* Tracking household energy use after installation of a more efficient appliance, for example could catch leakage resulting from homeowner perceptions that energy has become less expensive. Some observers have carried this argument further, asserting that global energy models should be run on individual projects to identify their net global impacts. Unfortunately, the impacts of individual projects, however real, will rarely, if ever show up at the level of aggregation associated with a global model.

- *Development of non-project specific leakage benchmarks or coefficients.* This approach would create and apply a series of project-level national or international leakage coefficients that can be used to adjust the estimate of project benefits in a more standardized way to account for leakage.

Baseline

Project-specific baseline methodologies have been used most widely in past AIJ projects, in both China and elsewhere. A project-specific baseline implies low costs for data collection in the short term, less data collection work, and universal applicability, while it implies less transparency and in the long term a high cost of data collection. Standardized baselines have opposite implications. Standardized baselines would be suitable for new construction projects, projects with simple and easy-to-measure output, and projects with single technologies. A project-specific baseline is suitable for technical retrofit projects, projects that focus on better management to improve energy efficiency, and projects with diversified output. In practice, project-specific baselines are used most commonly.

Baselines can also be categorized as either static, quasi-dynamic, or dynamic. Dynamic baselines may be necessary considering factors such as technological progress, energy efficiency improvements, or changes in the regulatory or legal environment, fuel price, fuel availability, or product structure.

Although various baseline methodologies have been proposed by different sources and discussed in this study, it does not necessarily mean that all of them could be appropriate choices for CDM projects hosted by China. Some conclusions include:

- *A balanced choice of baseline is an important prerequisite for project integrity.* To choose the most appropriate baseline methodology for a CDM project activity, one needs to strike a good balance among different considerations, such as the real situation, transparency, accuracy, verifiability, and transaction cost.
- *National baselines are not appropriate.* China is a large country with significant differences between regions, so baseline methodologies based on national average data are not an appropriate choice. If the project boundary permits, those based on regional data could strike a good balance among different considerations as a default value.
- *Project-specific baselines are the best option.* Most projects adopted project-specific baselines, in part because of the lighter workload for data collection compared to multi-project baselines, as well as the fact that baseline data were easier to get because there were currently existing similar projects under construction or under design in the same region, and because of the low cost of data collection.

Project proponents planning to undertake CDM projects in China should take these observations into account.

Additionality

Additionality assessment is important in the sense of safeguarding the environmental integrity of the Kyoto Protocol. Various institutions are involved in the additionality assessment process. Cooperation among these institutions is a necessity to reduce costs and increase the accuracy of additionality assessment. Technically, the additionality of a CDM project activity can be demonstrated from various aspects, including emissions aspect, financial aspect, investment barrier, technology barrier, or other barriers. Based on the methodological analysis, this study makes the following recommendations for additionality assessment:

- *Meeting of efficiency criteria.* They should reflect as much as possible specific circumstances of the project to be assessed, and reflect to some extent general situations of a specific sector/region where the project is to be located. In addition,

they should have rational or even limited data requirements, very limited system errors, relatively low uncertainties, acceptable transaction cost, and very limited subjective judgment.
- *Use of integrated approaches.* The results of assessment from different aspects for a same project activity could be different, so the additionality should be assessed from an integrated point of view.

Although various additionality criteria have been proposed, this does not mean that all the criteria could or should be applied in a proposed CDM project activity, nor does it mean that a project activity should pass all the assessments before it could be viewed as additional.

Project-based Incremental Costs for Emission Reduction

One of the objectives of a CDM project is to generate emission reduction benefits compared to the baseline project. The incremental costs for emission reduction (ICER) only cover the costs going beyond the baseline project, such as a coal-fired power plant that would be replaced by a gas generation unit under the CDM. The CDM is intended to help Annex I countries fulfill their quantitative obligations toward the Kyoto Protocol and at the same time to help non-Annex I countries to achieve sustainable development. The cost-sharing arrangement may follow this share of benefits. From the methodological point of view, this study considered the following:

- *Generally, the above-mentioned cost sharing approach means that the incremental costs are borne by the project investor.* Additionally, assuming adequate data availability, the calculation method of incremental emission reduction cost per unit of CERs is preferred, as discussed below and applied in the case studies.
- *The ICER method is applied in this study.* This study uses the incremental cost for emission reduction (ICER) method to calculate GHG emission reduction costs. It identifies the major parameters necessary for the calculation. This cost serves as one of the criteria for project proponents to determine whether or not to accept an offered price for CERs.
- *Depending on the evaluation of the circumstances, other methods are possible.* Based on the distribution of risks and benefits, other cost-sharing arrangements could be applied.

Transaction Costs

CDM provides an opportunity for project developers to sell certified emission reductions (CERs) that are generated when the project commences operation. It primarily provides revenue streams for a project activity that need to be contracted on or around the time of financial closure of the project. In its simplest form, CDM thus does not provide financing for projects.

In the context of CDM, transaction costs refer to all expenditures made by buyers and sellers of CERs to complete a transaction for exchange of CERs. The transaction cost associated with a CDM project activity includes project search cost; project document development cost; negotiation cost; validation cost; registration cost; monitoring cost; verification and certification cost; and share of proceeds. Methodologically, the following recommendations regarding the transaction costs should be taken into account by project proponents:

- *Since the economic impact of transaction costs is considerable, the concept should be clear.* Given the complexity of CDM projects, it is important to understand the components and significance of any possible transaction costs that are likely to be involved in the initiation and implementation of CDM projects. As part of a market process, the costs of CER generation and associated transaction costs will—to a large extent—influence the CDM market.
- *The main factors affecting transaction costs have to be observed closely.* In general, transaction

costs depend on the volume of CER trade, which depends on the project size; the number of parties and project sites involved in a project; the enabling environment within the host and the investor countries; and CDM methodological, contractual, or project financing issues.

A case study project involving power generation and the anaerobic treatment of effluent provides an example of estimating the transaction cost, and the estimated transaction cost is about \$0.8/t-CO_2 equivalent currently. These costs in the mid-term future may be reduced to about \$0.6/tCO_2 equivalent, but do not fully account for the cost of time inputs by the project developer and the investor. Transaction costs associated with prevailing low prices for carbon offsets will act as a significant barrier for potential CDM project deals to reach the market.

FINDINGS OF PROJECT CASE STUDIES

The study has conducted case studies that could lead to CDM deals. This effort in capacity building was undertaken in order to achieve the following objectives:

- To learn how to identify and select promising CDM projects in the electric power and renewable energy areas by applying eligibility criteria and procedures for the CDM project selections
- To build up capacity and experience in the development of CDM projects in the whole project cycle by carrying out several CDM project case studies in the selected areas
- To demonstrate the applicability of the CDM methodology and operation procedures based on China's real circumstances
- To establish a pipeline of promising CDM projects and prepare feasible CDM project design documents.

The case studies selected were intended to present a relevant distribution of projects, both in terms of geographical coverage and in terms of project types. The study outline targeted the energy sector. Further, given the emphasis on capacity building and the agreed focus on the power sector and project development, the study team also endeavored to consider projects for which the methodological basis is relatively less developed. Guided by the steering committee and findings from previous studies, a long list of possible CDM cases was developed for the fossil-fuel-based power generation and renewable energy sectors in China, which have substantial potential for CDM activities. Eligibility criteria and indicators were then evaluated for the long list, resulting in six CDM case studies. Their key features are displayed in *Table T.2.*

A case study report was developed for each case addressing baseline, additionality, crediting period, and local environmental and socioeconomic impacts, as well as stakeholders' comments, perceived barriers, and risks, (see annex AI on the CD-ROM). Six project design documents were prepared, (see annex AII on the CD-ROM). In general, the case studies are in compliance with the methodologies regulated by the Executive Board of CDM, while specific measures are taken to consolidate the quality of the study, such as:

- The latest decisions made by the CDM Executive Board are reviewed and adopted as appropriate
- New methodologies and PDDs published at the UNFCCC web site are studied and taken as references
- Intensive inter-task communication contributed to make the six cases robust and consistent with each other
- Rules and good practices for economic assessment (as issued by concerned governmental agencies) were followed
- Close interaction and technical training provided to the industries involved contributed to building capacity in terms of project development and future implementation of such CDM activities.

The case studies applied state-of-the-art methodologies for design of CDM projects in

TABLE T.2 Key Data on the Investigated Case Studies

Case study	Installed capacity	CO_2-equivalent emission reduction per year (1000t)
1. Huaneng-Qinbei Supercritical Coal-Fired Power Project (Phase II)	1136 MW	876
2. Beijing Dianzicheng Gas-fired Combined Cycle Tri-generation Project	128 MW	534
3. Gas-Steam Combined Cycle Power Project (Phase II) in Beijing No. 3 Thermal Power Plant (BJ3TPP)	404 MW	650
4. Shanghai Wind Farm Project (Phase II)	20 MW	36
5. Anaerobic Treatment of Effluent and Power Generation in Taicang Xin Tai Alcohol Co. Ltd.	4 MW	27
6. Landfill Gas Recovery Power Generation Project in Zhuhai, Guangdong Province	1.7 MW	72

the power sector. The main methodological findings were as follows:

- *Physical project boundary is preferred.* It is shown in the case studies that the physical boundary CDM project is usually a good choice to set the project and system boundary for GHG calculation. Leakages in these CDM cases could be omitted because of the lesser quantity compared to direct emissions, although different potential sources of leakages might be in existence.
- *Baseline determination is critical.* Baselines typically vary according to different technology and project design characteristics. The following issues should be considered:
  - A PDD offering a portfolio of possible baseline options is important and necessary. The conservative principle, stipulated by the Marrakech Accords and relative decisions made by EB, usually is the most important criteria in selecting an appropriate baseline and in calculating emission reductions. While the approaches defined in 48(b) and 48(c) of Decision 17/CP7 are followed more frequently than that in 48(a), two methodologies are incorporated in the determination of baselines in the case studies: "operating margin" and "built margin."
  - Based on the real circumstances in China, approach 48.a) is not appropriate as a power baseline for China's fast growing economy.
  - The operating margin is the most appropriate baseline methodology in the case of small renewable energy power generation—depending on the requirements for a predictable, and reliable power supply.
  - The built margin is the most appropriate baseline methodology for large-scale projects.
- *Additionality is the key parameter determining CDM market potential.* Additionality can be justified in terms of technology, financial performance, and other factors. The case studies show that those advanced technologies with higher electricity generation cost and lower market share could be qualified CDM choices, as not accepted broadly in the business as usual.

The technology assessment presented in *Table T.3* intends to promote further discussion among all stakeholders on the findings of the case studies. The development of a larger project pipeline would take into consideration parameters such as concentration on projects perceived as "low" risk and technological advancement in the respective sectors. Also important is the assessment of mitigation cost; the assessment of the project developer's risks associated with demonstration of additionality; the related technological and financial risks; as well as stakeholders' views based on such criteria and other barriers. *Table T.3* shows the perceived interaction of risks and costs. Through wider analysis of results obtained by different groups of project proponents, a more consistent assessment of technology priority for CDM could be established.

The six CDM case studies investigated in this study cover a total annual reduction potential of about 2.5 $MtCO_2$ equivalents. The incremental cost for emission reduction (ICER) ranges between \$3.60 and \$50/tCO_2. The economic incentive available from a CER price in the range of \$5.20 to \$6.50/tCO_2 will not be sufficient to make renewable energy projects such as wind power a commercially viable technology option.

- High fuel prices (e.g. natural gas for gas turbines), higher capital costs, and less operation hours (e.g. for wind generation units) result in an ICER in four of six cases significantly above the \$10/tCO_2 threshold. Comprehensive financing packages and efforts to make the CDM project cycle shorter and the transaction cost lower would be needed to make some renewable CDM options more attractive.
- Besides substantial benefits of emission reduction, these CDM projects will create beneficial impacts on the local environment and socioeconomic system and thus make contributions to the sustainable development of the hosting area and the hosting country.

CDM POTENTIAL IN CHINA

Addressing global climate change poses a significant challenge to China's policymakers for strategically assessing the opportunities of the emerging carbon offset market at the macro and micro levels. What are the economic, social, and environmental benefits of participating in the CDM regime? The potential supply and demand for CERs in the global carbon market, carbon price trends, and how best bring to the market Chinese CERs are questions pursued in Part II of the study. What are the priority areas for carbon investments, especially in the energy-related sectors? To answer these questions, an energy-economy model framework was developed that consists of energy technology models (IPAC-emission and IPAC-AIM technology), a carbon market equilibrium model (CERT), and a computable general equilibrium model (IPAC-SGM). The model system works out future carbon emission projections and generates marginal abatement cost curves for different regions in the world. It addresses equilibrium carbon quota prices in the world carbon market and the possible carbon trade, and then examines carbon reduction

TABLE T.3 Cost and Priority Ranking of Project Types

	Barriers and associated risk for demonstrating additionality		
Abatement cost	**Low risk**	**+/-**	**High risk**
Medium to high cost > 10 USD/t CO_2	• Wind power • Biogas	• Biomass gasification • Tri-generation • Fuel switch: Gas combined cycle	
Low cost < 10 USD/tCO_2	• Landfill methane gas recovery	• Energy efficiency in industry	• Supercritical coal

potentials by major sectors as well as technology priorities for CDM in China.

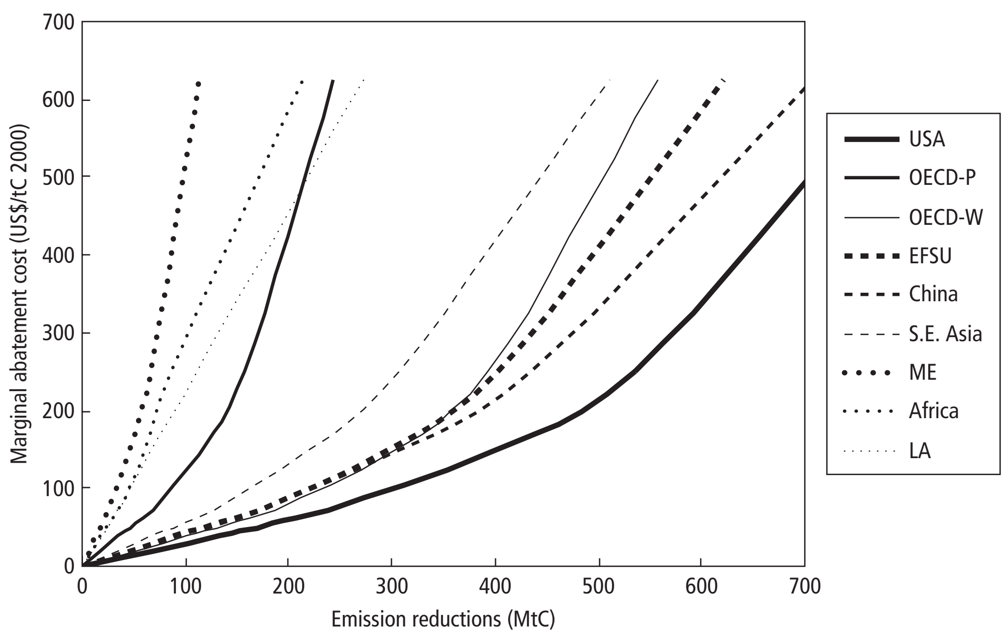
The model system's results provide the policy implications for CDM potential in China, and the impact of CDM on China's economy. It would be helpful for China's climate change policymakers to formulate appropriate CDM strategy and policy for China.

The reference scenario used in this study was developed based on results of related studies and projections up to 2010. World carbon emissions from fossil fuel combustion are by 2010 expected to grow by 36.5 percent from the 1990 level. By 2010, renewable energy may account for 7.8 percent of total primary energy demand globally. The annual average energy efficiency improvement rate is assumed as 1.18 percent from 2000 to 2010. In a reference scenario, the greenhouse gas emissions from China's energy sector were projected to increase from 3080 $MtCO_2$ in 2000 to 4000 $MtCO_2$, with coal contributing a significant share to the increasing demand from the power and industry sectors.

Marginal abatement cost curves were calculated by the IPAC emission model for nine regions of the world by introducing progressively higher carbon taxes (*Figure T.1*). Other top-down studies such as EPPA and GTEM have projected a significantly flatter MAC curve for China than the IPAC emission model does. Factors contributing to this are more efficient technologies entering the built margin during the 1990s, and further efficiency gains contributing to reduce the growth trend for GHG emissions up to 2010. In IPAC, China has a relatively low reference carbon emission projection.

Based on the IPAC emission model projection, the Annex II countries' reduction requirement is estimated on the order of 1371 $MtCO_2$, taking into consideration forest management sink credits and the assumed voluntary U.S. participation in the carbon offset market (10 per-

FIGURE T.1 MACs for Carbon in 2010 from IPAC-Emission Model



cent participation rate). The projection for potential hot air supply from countries with economies in transition (EITs) is 800MtCO_2. Through application of the results for both, the emission projection and MACs from the IPAC emission model feeding into the CERT model, the CDM market size in 2010 is estimated in the base scenario to be 164 MtCO_2. These results were obtained assuming a limited scale of 10 percent voluntary U.S. participation[1] in the global carbon offset market, price leadership of EFSU, 30 percent CDM implementation rates for all non-Annex I Parties, 50 percent supplementarity for the EU, and \$0.54/tCO_2 transaction cost associated with CDM deals. Price leadership of EFSU and hence the Russian ratification of the Kyoto Protocol is the main factor leading to a significant CDM market size as well as carbon offset price in projected range. *Table T.4* shows the results of this study, comparing them with findings of other WB-NSS completed since 2001 as well as with the outcome of selected carbon offset market studies completed in 2003.

Based on three market scenarios, this study estimated China's energy-related CDM market potential[2] in the year 2010 at between 24.9-111.6 MtCO_2, based on an equilibrium certificate price of \$5.20 to \$6.50/tCO_2. Under all three scenarios, China captures nearly 50 percent of the total market CDM demand (estimated at between 52-240 MtCO_2). The largest share of the carbon offset market goes to JI and hot air. A number of Eastern European countries use hot air to trade ERUs under JI. The disaggregated information is shown in *Figure T.2.*

Figures T.2 and *T.3* highlight that China's share in the global carbon market is 11 percent, and around 50 percent in the CDM market. China's CDM potential of 79.2 MtCO_2 for 2010 is, however, still substantial. Supplying this amount of CERs would require a significant number of newly built larger power projects (300MW-600MW) registered as CDM projects, as well as several dozen to as many as 100 renewable power projects put into operation by 2006–07. It is important to note that besides reductions in CO_2 from electricity generation, CDM potentials from other energy end-use and from abatement of other gases and other source and sink categories must also be taken into account in estimating China's total CDM potential and its impact on market dynamics.

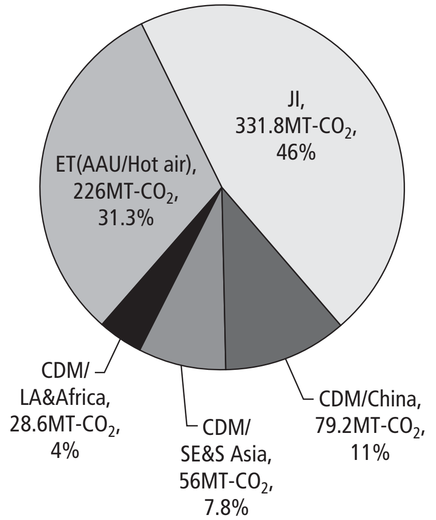
Sensitivity analysis performed on the base scenario resulted in an even wider range of estimates. Chinese CDM potential is estimated at 0–211 MtCO_2, with an equilibrium price estimated at \$0–7.30/tCO_2. This can be attributed

TABLE T.4 Annex II Countries GHG Reduction Demand, Market Share by KP Mechanisms and Their Domestic Actions, and Estimated CER Price Range

	Annex II reduction requirement Mt CO_2 (2010)	CDM market size MtCO_2 (2010)	CER price range USD/CO_2
IPAC Emission model, without U.S.	1243	0–161	0–6
IPAC Emission model, US voluntary participation (10%)	1371	0–164	0–7
Grubb 2003	415–1250**	50–180	0–13.8
Selected WB-NSS* studies completed since 2001	1300–(3000)	300–(2000)	1.7–(10)
EU Trading Scheme study (Criqui and others 2003) **	1140[2]	330–360	6–12

* Vietnam, Peru, Indonesia
** assuming 50 percent of reduction requirement met by domestic action in EU 15

FIGURE T.2 Annex II Countries ER Demand Under the KP and the Market Offset Share by Three Kyoto Mechanisms

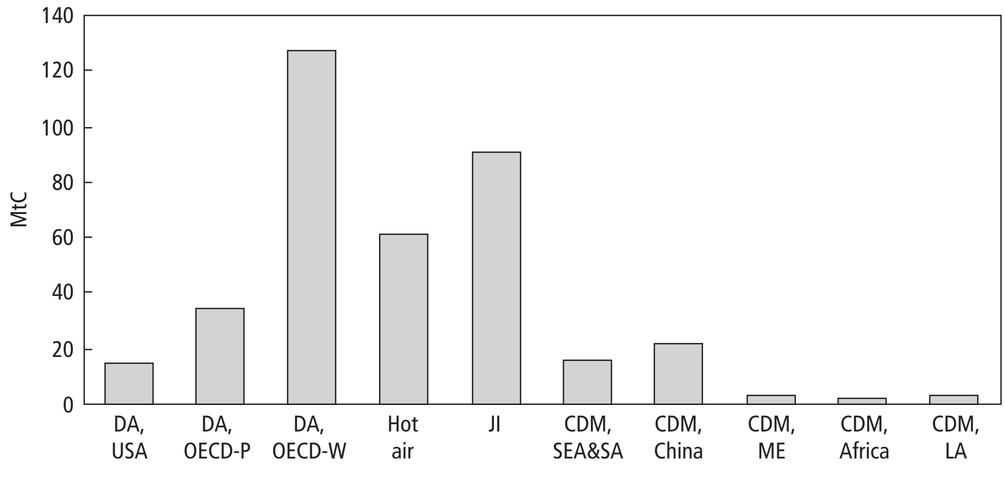


to uncertainty in the following factors (in order of importance): business-as-usual emissions projections (demand side and supply of hot air) and marginal abatement costs of potential buyers and sellers; the market structure (competition vs. price leadership); the fraction of CDM potential that is actually realized by 2010 (implementation rate); the assumed participation rate of the United States; the way in which countries choose to operate supplementarity; and the level of transaction costs.

The present early CDM market is buyer-dominated. The preference of investors for "high quality" and "low risk" projects is likely to shape the market for carbon offsets. In reality, there will be no one uniform carbon price for different transferable emission units (RMUs, CERs, ERUs, and AAUs). Relevant market observers see evidence for a likely price differentiation between the project-based mechanisms JI and CDM on the one hand and ET (trading AAUs) on the other. In the real world, the global CDM market may be smaller than the projected 164 Mt-CO_2/year, while the CER price could, considering the prevailing uncertainties about the ratification of the Kyoto Protocol, also be higher than projected by CERT, if the Protocol is ratified late and falls into the \$7 to \$12 /tCO_2 range.

By applying the bottom-up IPAC-AIM technology model, a significant carbon reduc-

FIGURE T.3 Distribution of Carbon Emission Reductions among Domestic Action (DA), JI, ET, and CDM under the Base Scenario

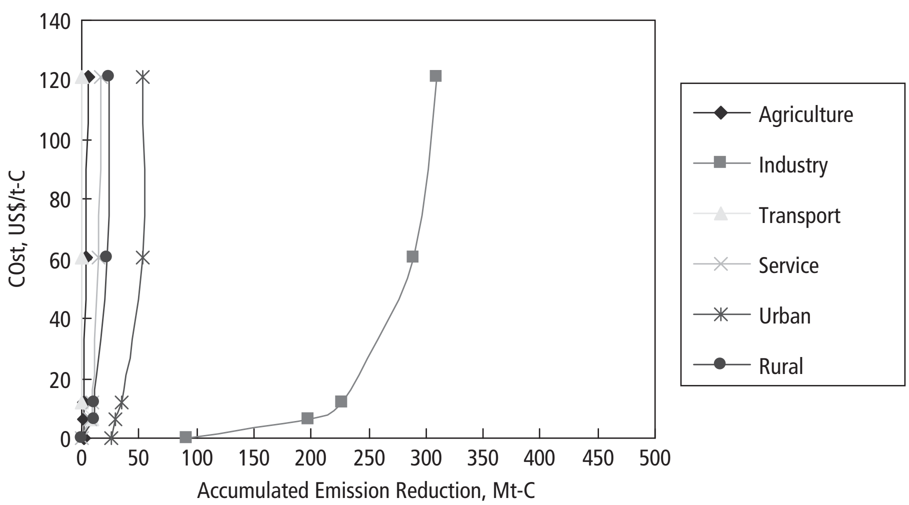


tion potential (760 $MtCO_2$/year) was identified by sectors in the \$13.60/tCO_2 range, consistent with China's sustainable energy development strategy. The efforts undertaken in this study to link the top-down projected CDM potential for China of 79 $MtCO_2$ with sectors and technologies for CDM did underscore the significant role that barriers such as deal size, transaction cost, and time lag play in a project-based mechanism. The evaluation of consistency between the two models applied revealed that MAC curve-based approaches estimating the CER supply potential at a given CER price would substantially overestimate the potential CDM deal flow. A significant amount of abatement measures are economically feasible at (for example) \$5/tCO_2 from small-scale industry. The commercial and residential sectors are unlikely to reach the CDM market due to high transaction costs associated with smaller trade volumes.

The marginal abatement cost (MAC) analysis by sectors (*Figure T.4*) displays that the industry/power generation sector has a relatively flat marginal abatement cost curve compared with other sectors, like the rural/urban commercial and residential or transportation sectors. Based on expert judgment, the power generation sector could account for around 50 percent of total CDM potential in China. China's power generation sector contributed 24 percent of the total carbon emissions of the energy sector in 2000, and is still expected to contribute 26 percent by 2010. Considering the options for demonstrating technology additionality and cost effectiveness, significant CDM potential also exists in various other sectors: steel making and the cement sector (10 percent); the chemical industry such as ammonia production, calcium, soda ash (5 percent); industries such as glass sector, brick production, aluminum, copper, zinc&lead, paper making, ethylene, transport, service sector, urban and rural residential (15 percent); and projects abating non-CO_2 GHGs in the industrial sector (10 percent).

The advanced technologies for mitigation in the power sector were identified as fuel-switching to combined cycle gas power plants; wind power; landfill gas conversion to power; and hydropower.

FIGURE T.4 Marginal Abatement Cost Curves by Sectors



Note: The industry sector, displaying the flattest MAC, includes the power sector

Technologies that may prove to have significant potential and other environmental benefits but could not be covered within the methodology of this study are coal-bed methane recovery; biomass-based cogeneration; biogas from agricultural, industrial, and urban waste; power generation from municipal solid waste; and non-CO_2 emission abatement technologies (methane, HFCs).

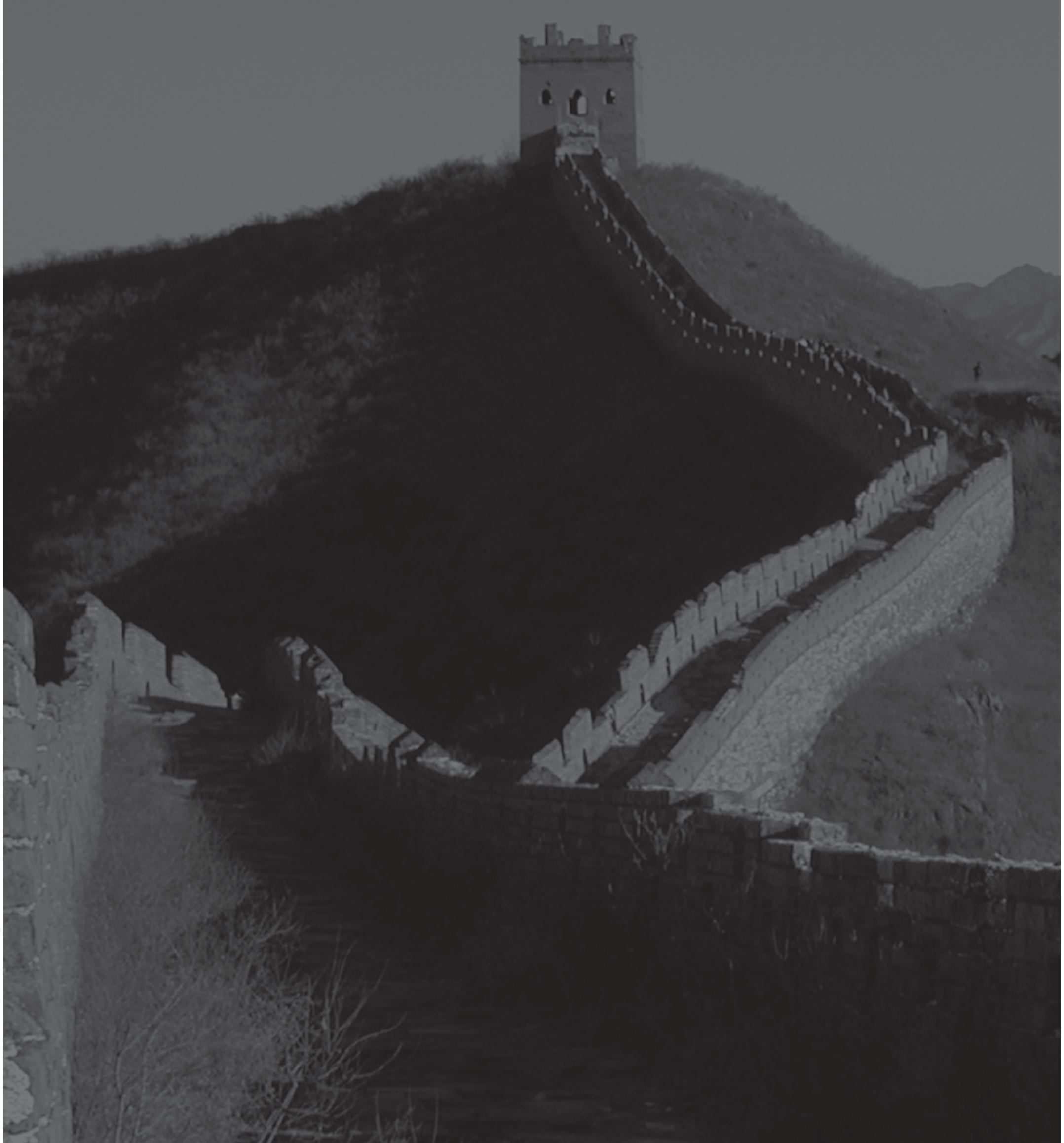
As might be expected, the study showed that the Clean Development Mechanism will not have a significant impact on overall economic growth in China in the timeframe considered (up to 2010–2020). The profits from the estimated range of CER sales (25 to117 $MtCO_2$) would be $77 million to $311 million per year. They are small and have essentially no significant effect on GDP Growth. CDM implementation, however, will be beneficial for energy project proponents and relevant stakeholders in China, who will be able to familiarize themselves with an emerging market, strengthen investment portfolios, technology progress and environmental side benefits, and contribute to regional and local sustainable development.

Endnotes/References

1. The climate change strategy of the United States announced by President Bush on February 14, 2002, sets a voluntary target for the nation to achieve an 18 percent reduction in emissions *intensity* between 2002-12, which will allow *absolute* emissions to increase 13 percent over the same period. Under the Bush plan, emissions in 2012 would be 29 percent above the 1990 level and 36 percent above the U.S.'s Kyoto target. The corresponding business as usual levels would be +15 percent, +31 percent, and +38 percent, respectively. If the voluntary target is achieved, the "implementation rate" would be 5 percent ((38-36)/ 38)*100). There is a significant uncertainty in BAU projections across Annex I countries, which also influences the availability of hot air.
2. Source: Criqui, P. and others 2003; external trading enlarged EU 128 $MtCO_2e$; external trading rest of Annex B 242 $MtCO_2$, EU internal trade with 10 new EU states 36 $MtCO_2e$, domestic action Annex B 734 $MtCO_2e$

I

CDM METHODOLOGY AND CASE STUDIES



1

Objectives, Methodologies, and Approach of Part I

OBJECTIVES

The main focus of this study is to identify the prerequisites and existing barriers to development and implementation of the Clean Development Mechanism in China, as well as to analyze the need for capacity building based on the partner country's special circumstances and interests.

The provisions of the Kyoto Protocol, as well as the relevant decisions of the Conferences of the Parties, prescribe various preconditions to be met for projects to be eligible as a CDM activity. To meet these preconditions, methodological and technical issues for CDM include:

- Learning how to develop appropriate baseline methodologies by applying the baseline approaches set out in the CDM modalities and procedures in the Marrakech Accords and the relevant clarifications and guidance by the CDM Executive Board
- Understanding and applying dynamic baselines to determine the crediting period of a CDM project activity from the options provided in the Marrakech Accords
- Determining project boundaries by using appropriate principles and approaches, and identifying and estimating the leakage of a CDM project activity
- Developing an approach to assess and test the additionality of proposed CDM projects in China, taking into account the recent guidance and clarifications given by the EB
- Learning how to estimate the incremental emission reduction cost of CDM projects, and estimating how the revenues from CER trading could improve the financial performance of the CDM project.

In order to build practical experience with respect to technology options and CDM methodological issues, the analysis includes six case studies in the power and renewable energy sectors. These studies will help build the capacity of Chinese stakeholders to participate in CDM project activities—within the context of the provisions of the Marrakesh Accords and subsequent decisions, as well as China's current priorities and long-term goals for sustainable development.

The CDM project case studies are intended to help:

- Learn how to identify and select promising CDM projects in the electric power sector and the renewable energy field by applying eligibility assessment criteria and procedures for the CDM project selections

- Build capacity and experience in the development of CDM projects through the whole project cycle
- Demonstrate the applicability of the CDM methodology and operational procedures based on China's real circumstances
- Establish a pipeline of promising CDM projects and prepare CDM project design documents.

In Chapter 1, the study develops a suitable methodological approach and addresses a series of key issues for the implementation of CDM in China.

METHODOLOGICAL APPROACH

CDM has primarily two objectives: (1) assisting non-Annex I Parties in achieving sustainable development; and (2) assisting Annex I Parties in realizing their quantified emission limitation and reduction commitments. Each CDM project activity is intended to result in real, measurable, and long-term greenhouse gas emission reduction benefits that are additional to any that would occur in the absence of the project activity. To assess whether a proposed CDM project activity could meet these requirements, several methodological issues need to be addressed. Against the background of the needs for capacity building, and based on China's special circumstances and interests, the subsequent methodological approaches of this study are (a) to develop methodological guidelines for CDM project development in China; and (b) to use case studies to assess these methodological guidelines.

In the following section, we will describe these two components.

Development of Methodological Guidelines for CDM in China

The development of guidelines for specific methodological and technical issues includes the description of the concept, the analysis of its application under specific circumstances in China, and recommendations either for the CDM process in general or its application in China. The methodological guidelines reflect the most important prerequisites and methodological issues for CDM in China, including baseline, project boundary and leakage, additionality, and project-based emission reduction costs. The methodological approach of the study (a) follows official documents, especially relevant decisions adopted by the CDM Executive Board; (b) reviews currently available achievements; (c) combines a theoretical study with practical application in case studies; and (d) considers China's specific circumstances.

Official documents released by the Conference of the Parties and its subsidiary bodies provide basic rules for the CDM regime, which are the basis and starting point for this research. This study fully follows the Kyoto Protocol, the Bonn Political Agreements, the Marrakech Accords, and the CDM Executive Board decisions. For instance, when discussing the dynamic baseline issue, we understand that the Marrakech Accords provide for such possibilities. When discussing the possible criteria for additionality assessment, we are aware that the international agreements provide very limited specific guidance on this issue. The host-country governments may have their own criteria, and the opinions of different governments may diverge. Furthermore, great efforts have been made in this study to reflect all relevant decisions adopted by the CDM Executive Board.

As a result of various efforts, there have already been significant achievements in our understanding of CDM methodological issues; and they serve as a good basis for this study. Review and understanding of the current achievements can make the discussion more pertinent and instructive, save time and effort, and avoid discussing issues that are already generally settled. For example, the baseline section includes a comprehensive review of the literature and summarizes their major findings, including possible baseline determination methods, their pros and cons, and their applicability.

As part of the efforts to make the recommendations as practical and sound as possible, the study combines theoretical analysis with practical application of methodologies in selected case studies. To achieve the aims of this methodological approach, various analytical instruments are used, such as (a) decision trees for the baseline determination; (b) flow charts for the project boundary consideration; (c) uniform overview tables for the description of the case studies; and (d) standardized calculation formulas for the calculation of the incremental costs of emission reductions.

To make the study more useful, China's specific circumstances are fully considered in the discussion and methodology development.

Assessment of the Methodological Guidelines by Case Studies

The assessment of the methodological guidelines will apply the methodology to the real circumstances of the case studies—taking their regional and site-specific conditions into account. The findings will be based on different instruments, including:

- Sensitivity analysis, which assesses the impact of changes in exogenous factors on the eligibility of the project, GHG emission reductions, incremental costs, or other important dimensions
- Standardized comparison of the case studies, environmental impact assessments, and estimation of uncertainties within different monitoring activities.

On the basis of the analysis of the case studies and comparison with the results of other ongoing CDM studies, the study presents recommendations regarding the policies and measures that should be undertaken to tackle the perceived challenges, as well as the likely benefits.

KEY ISSUES

Based on the objectives of the study, Chapters 2 and 3 below are expected to facilitate a better understanding of CDM methodological issues by Chinese experts and government officials. Chapter 2 presents a general analysis of the key CDM methodological issues and analyzes the applicability of different methodologies under China's specific circumstances. Chapter 3 applies some methodologies to selected case studies, and includes some recommendations on the appropriate choice and application of methodologies.

Several key methodological issues are addressed in Chapter 2, including:

Baseline

According to the Marrakesh Accords, the baseline for a CDM project activity is the scenario that reasonably represents the anthropogenic emissions by sources of greenhouse gases that would occur in the absence of the proposed project activity. A baseline should cover emissions from all gases, sectors, and source categories listed in Annex A within the project boundary. To define the baseline scenario, which does not actually exist and thus could not be observed, three approaches have been put forward based on different considerations. To use these approaches, different baseline methods have been proposed. They vary greatly in terms of integration or standardization, and have their own advantages and disadvantages. In this part, different baseline determination methods are assessed. Dynamic baselines are also discussed in detail, and we make some recommendations on the selection of appropriate methods based on China's real circumstances.

Project boundary and leakage

The project boundary refers to a project's spatial scope and should encompass all anthropogenic emissions by sources of greenhouse gases under the control of the project participants that are significant and reasonably attributable to the CDM project activity. Leakage is the net change of anthropogenic emissions by sources of greenhouse gases that occurs outside the project boundary and is measurable and attributable to the CDM project activity. This part identifies possible direct and indirect sources of leakage and their categories; discusses methods to design a rational project boundary to effectively address leakage; and discusses possible approaches to deal effectively and reasonably with the leakage issue.

Additionality

Additionality refers to the concept that any emission reductions to be ascribed to a CDM project activity should be additional to those that would occur in the absence of the proposed CDM project activity. It is prescribed in the Marrakesh Accords that a CDM project activity is additional if anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the registered CDM project activity. This part analyzes the concepts of evaluating additionality from different aspects, based on different considerations, and assesses the characteristics of proposed additionality assessment criteria.

Project-based emission reduction cost

To achieve GHG emission reduction benefits, CDM project participants will bear additional costs other than those that occur in the baseline scenario (incremental costs of emission reduction, ICER). Such costs serve as one of the criteria for the host-country entity to determine whether or not to accept an offered price for CERs. This part identifies major components of project-based reduction costs; discusses the incremental cost approach for GHG emission reduction benefits; identifies major parameters used in the reduction cost calculation; identifies the components of transaction costs; and estimates a case study's transaction cost.

Chapter 3 presents the findings from the case studies. An introductory section presents the basic considerations for selecting the power sector as an appropriate field for the case studies. The following section selects the case studies within the power sector. To make the selection approach transparent, the chapter elaborates on the selection criteria and the selection procedure. Among a long list of 25 possible projects, we select the six most appropriate cases (*Table 1.1*).

The chapter briefly describes the six case studies, using a uniform description to help the reader compare the six case studies. It discusses the results and findings from the case studies regarding baseline, project boundary and leakage, additionality, project-based reduction costs, and the major findings from the stakeholder consultation. The results and findings from the case studies are cross-compared with results from other CDM studies.

Based on this analysis, we consider supply barriers and risks. So far, the key issues assessed here reflect the main chapters of a CDM Project Design Document. At the end of Part I, we present conclusions and recommendations.

TABLE 1.1 Selected Case Studies

Case study 1:	Huaneng-Qinbei Supercritical Coal-Fired Power Project (Phase II)
Case study 2:	Beijing Dianzicheng Gas-fired Combined Cycle Tri-generation Project
Case study 3:	Gas-Steam Combined Cycle Power Project (Phase II) in Beijing No. 3 Thermal Power Plant (BJ3TPP)
Case study 4:	Shanghai Wind Farm Project (Phase II)
Case study 5:	Anaerobic Treatment of Effluent and Power Generation in Taicang Xin Tai Alcohol Co. Ltd.
Case study 6:	Landfill Gas Recovery Power Generation Project in Zhuhai, Guangdong Province

2

Institutional Framework and Methodological Guidelines for CDM

As a sequel to the United Nations Conference on Environment and Development (UNCED) in 1992, the Clean Development Mechanism process and subsequent methodology was developed from the provisions in Article 12 of the 1997 Kyoto Protocol, the subsequent Marrakesh Accords, and decisions of the CDM Executive Board.

To help support capacity building in China and provide a transparent analytical framework for the assessment of the case studies, this chapter provides some methodological background and guidance to the case studies. For example:

— We provide an overview of the CDM-related institutional framework to help readers who are not familiar with the CDM terminology and process
— We analyze the relevant methodological issues for implementing the CDM in China
— We describe the institutional arrangements provided by the Chinese Government to facilitate CDM in China.

This chapter could be used as a handbook for the practical application of the CDM in China.

RELEVANT INSTITUTIONS AND CDM PROJECT CYCLE

The international CDM regime is complex, involving organizations at different levels. An overview of the institutional framework in *Figure 2.1* shows the essence of some methodological issues, as well as how these issues have and could be addressed at the international level.

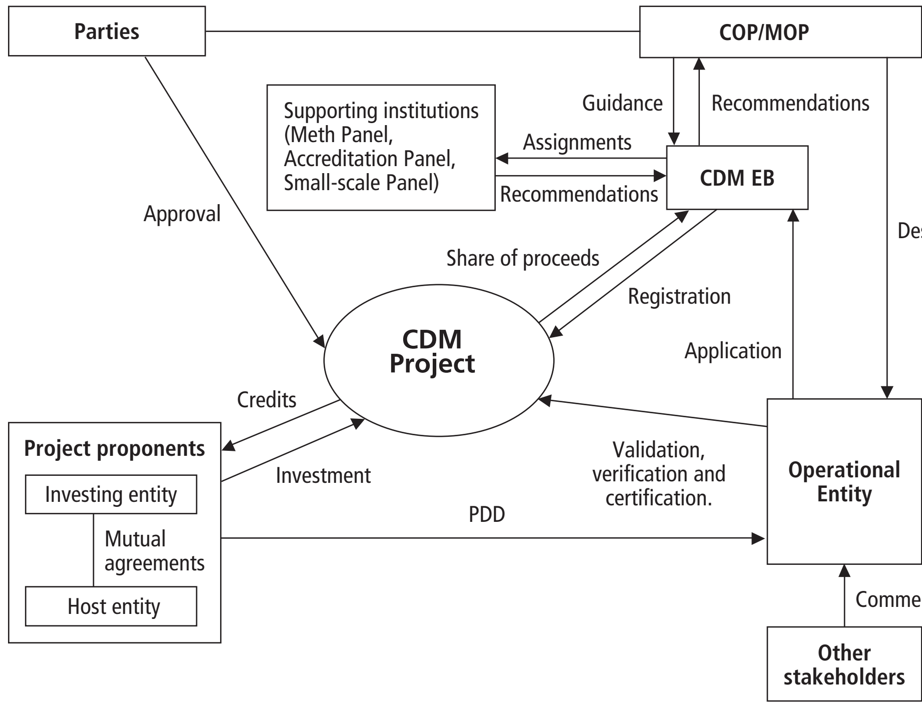
There are a number of milestones in the international community's efforts to address global climate change, including the 1992 United Nations Framework Convention on Climate Change (UNFCCC), the 1997 Kyoto Protocol, and more recently the 2001 Bonn Agreement and the 2001 Marrakech Accords.

The UNFCCC is the fundamental basis for international cooperation on climate change. It set an objective for the international community and outlined the principles to guide actions taken by the Parties to achieve the objective.

The Kyoto Protocol sets quantitative emissions limitation and reduction commitments for Annex I Parties. The Protocol's Article 12 establishes the Clean Development Mechanism (CDM). The CDM has two purposes: (1) to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the UNFCCC; and (2) to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3.

The Bonn Political Agreements and the Marrakech Accords marked the completion of the Buenos Aires Plan of Action and the end of four

FIGURE 2.1 CDM Institutions



years of international negotiations on the principles, guidelines, and rules for the Kyoto Mechanisms, including the CDM, which are crucial to the entry into force of the Kyoto Protocol. At the 7th Conference of the Parties, the CDM Executive Board was established. According to the Marrakech Accords, institutions involved in the international CDM regime include project proponents, COP/MOP, the CDM Executive Board, operational entities, Parties, supporting institutions, and other stakeholders.

There are different participants at different levels in the CDM process. The first level includes the primary participants in the investing country and the host country (project proponents such as private companies, national governments as the UNFCCC-Parties), who are carrying out the project or are directly involved in national project approval. The UNFCCC bodies and institutions (COP/MOP, CDM Executive Board) and other stakeholders (industry, nongovernmental organizations etc.) provide comments on the proposed project and act as an intermediary between the investor and the host of the CDM project.

At the second level, institutions are acting on behalf of the primary participants, such as the operational entities contracted by project developers for validation and certification purpose, supporting institutions of the Executive Board, technology suppliers and contractors, or brokers and traders (Oberheitmann 1999). A detailed description of the relevant institutions can be found in the Annex.

There are various stages and studies that are required for a CDM project. The main steps in the process are (a) preparation of a project design document, a baseline study, and the monitoring plan; (b) validation; (c) negotiation of project arrangements, construction, and startup; (d) registration;

(e) monitoring, verification and certification; and (f) issuance of CERs.

The project cycle in *Figure 2.2* describes the manufacturing process for CDM/JI emission reductions. A detailed description of the shown CDM project cycle can be found in the Annex 3.

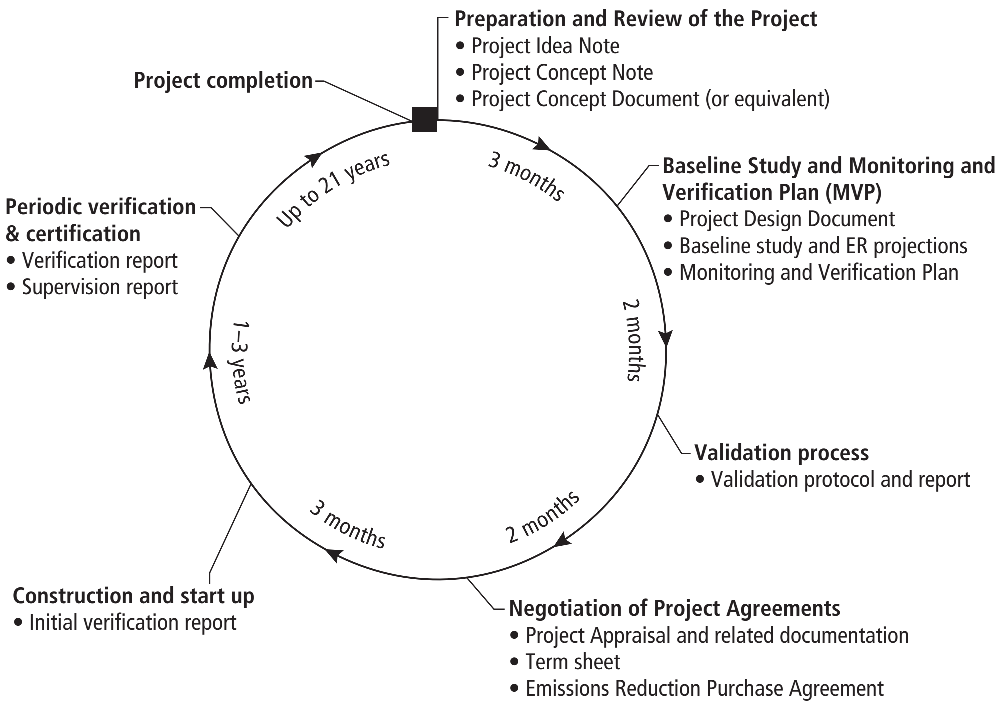
Based on the experience of the Prototype Carbon Fund (PCF), it can take up to three and a half years from the preparation and review of a project to the certification of project emission reductions. In other words, a project beginning in 2004 might not reach the certification stage until 2007 or even 2008. Such a long time scale puts considerable time pressure on the Chinese Government to develop a project pipeline and the necessary institutions for implementing the CDM in China to assure that a reasonable time is left for implementing a project within the first commitment period. The time frame presented is only an average; single projects can be completed in less time.

PROJECT BOUNDARY AND LEAKAGE EVALUATION

When a CDM project is being designed, one of the most important tasks is to set a reasonable boundary for the project to determine the project's emissions and possible leakage. Otherwise, given a reasonable amount of determination costs, the emission reductions or other environmental benefits of the project could be overestimated.

This chapter includes a description of the concept and regulations, leakage sources and leakage treatment, and subsequent recommendations.

FIGURE 2.2 Manufacturing Process for CDM/JI Emission Reductions



Source: Carbon Finance Strategy of the World Bank, a presentation by Michael Rubino at KfW Conference. Berlin, May 21, 2003.

Concept, Rules, and Regulations; Leakage Sources and their Categories

A project boundary is defined in the UNFCCC documents for the reduction purposes of estimating the project's net GHG reduction impact. It encompasses all anthropogenic emissions by sources and/or removals by sinks of greenhouse gases under the control of the project participants that are significant and reasonably attributable to the CDM project activity (UNFCCC 2001b). To some extent, the possibility of leakage is a function of the size of the project boundary; the larger the boundary, the greater the likelihood that all impacts will be accounted for. Hence, one approach to mitigate leakage is to set an acceptably large project boundary.

Leakage is defined as the net change of anthropogenic emissions by sources of greenhouse gases that occurs outside the project boundary, and that is measurable and attributable to the CDM project activity (UNFCCC 2001b).

Leakage concerns have arisen most prominently with forest protection activities. However, the basic concept extends to all types of carbon mitigation activities, since they invariably affect the demand for or supply of products that emit or sequester GHGs. A shift in either the demand for or supply of a GHG emitting product such as coal will, in an unhindered market, affect the product's price. These altered market prices will affect the level of product consumption outside the project boundary. The fundamental challenge is to determine under what conditions this "price effect" is significant and warrants accounting. In December 2003, COP 9 dealt with the project boundary and leakage issues in the LULUCF context. More complex definitions of project boundary and leakage are described in the rules and procedures for afforestation and reforestation CDM project (UNFCCC 2003a).

The magnitude of leakage is determined by many factors, such as changes in relevant regulations and laws, the trend in autonomous efficiency improvements, and changes in other basic variables such as development of markets for a project's products.

Leakage can be caused by (Schwarze and others 2002):

Activity shifting. A project or policy can displace an activity or change the likelihood of an activity outside the project boundary. One example of negative activity-shifting leakage would be a high-efficiency boiler project that displaces old low-efficiency boilers, which are then used in other places.

Market effects. A project or policy can alter supply, demand, and the equilibrium price of goods or services, causing changes in emitting activities elsewhere. For example, a boiler efficiency project that decreases coal consumption could result in a slight downward shift in coal prices, which could then stimulate an increase in coal consumption.

Market-driven leakage is caused by a change in the price of goods, whereas activity shifting happens when human or other capital changes location. These two leakage types may in some cases be inversely related. If a project displaces people and activities to adjacent areas, market leakage may diminish. This is because activity-shifting leakage moves economic activity, while market leakage occurs through net changes in production for a given regional distribution of activities.

Two other types of leakage also bear mentioning.

Life-cycle emissions shifting. Mitigation activities may increase emissions in upstream or downstream activities. For example, a renewable energy power project will not include the emissions caused by the production of equipment.

Ecological leakage. This refers to a change in GHG fluxes caused by ecosystem-level changes in surrounding areas. The ecological leakage generally occurs in sink projects.

There are currently no explicit CDM Executive Board decisions on project boundary and leakage.

Reasonable Project Boundary and Leakage Treatment

To avoid leakage and ensure GHG emissions reduction performance, it is important to identify a reasonable project boundary before undertaking the CDM project design. All direct GHG emissions in both the CDM and the baseline cases should be covered in the project boundary. Theoretically, it is essential to define a project boundary that is large enough to form a GHG "bubble" system, so that all upstream and downstream indirect effects on GHG emissions are covered in the project boundary in both the CDM project and baseline cases [Liu Deshun 2000].

In practice, such exercises are often not feasible, especially when projects are affected by microeconomic pressures, have possible macroeconomic effects, or may conflict with territory principles. The project boundary is usually defined as the physical site of both the CDM project and the baseline project in a project-specific manner. In some cases, when the CDM project activities are associated with mutually connected energy networks or pipeline systems—for example, electric power grids and natural gas distribution systems—the project boundary should be extended to them, in order to avoid easily definable leakage. *Figure 2.3* gives an example of project boundary setting with the life cycle analysis approach. Current CDM rules and procedures do not require that all upstream and downstream effects are included in the leakage analysis of a proposed CDM project activity.

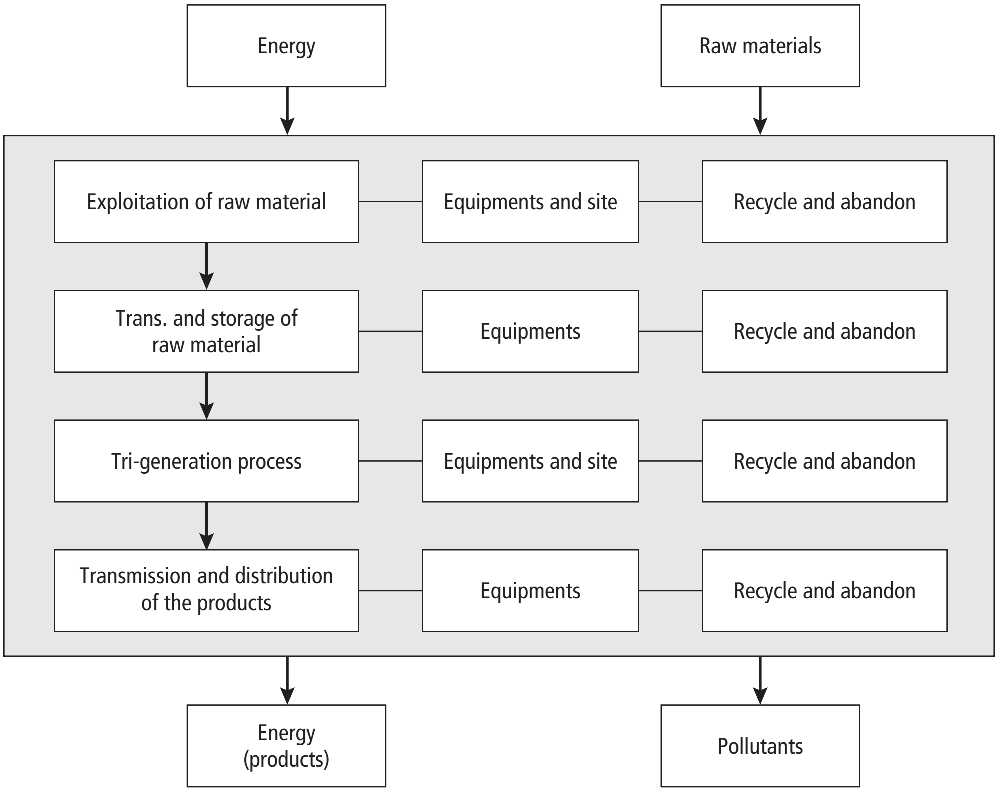
In order to set a reasonable boundary and determine leakage, the following issues should be considered.

Comprehensiveness of the boundary. The wider the boundaries, the more complete the accounting of a project's emissions impacts, but the greater the costs. Several options could be considered for helping proponents resolve the tension between cost and comprehensiveness in boundary definition. The first option is to simply exclude projects whose emissions impacts cannot be quantified because the necessary measurement, monitoring, and verification would be prohibitively expensive. A second option is to establish a cost limit beyond which the proponent is not required to further expand the project boundary—for example, if measurement, monitoring, and verification costs exceed 10 percent of total project costs. However, if important uncertainties regarding indirect or off-site emissions still remain, it may be questionable as to whether the project should proceed. A third option, where potential significant boundary effects cannot be readily addressed through acceptable, cost-effective methods, is to request that proponents hold in reserve a fraction of their claimed reductions subject to the future development of adequate monitoring and verification methods (Lasco, Michealowa, and Miline 2001).

Control over emissions. All the controllable emissions should be involved inside the system boundary. By including those emissions over which the proponent can exercise control, project boundaries can provide opportunities and incentives to achieve emissions reductions whether on-site or off-site. For example, narrow boundaries could create perverse incentives if credits were claimed for activities that simply outsource emissions (for example, by replacing on-site with grid electricity generation that was not accounted for). Control over emissions can be defined in two ways.

The first option is to equate control with proponents' ownership or management of facilities. This interpretation implies that a consumer (of a fuel, electricity, commodity, or other product) has no control over the off-site emissions resulting from the production, processing, transport, disposal, etc, because those stages in a product's lifecycle are out of control. The second option is "control over whether or not emissions occur." This interpretation is consistent with life cycle or "footprint" analysis, implying that consumers of a product control off-site emissions to the extent that those emissions are a consequence of the amount of product consumed.

FIGURE 2.3 Project Boundary Considering the Whole Life



The second definition more effectively conveys the proper incentives for mitigation activities and might be more appropriate in the context of a credit trading regime. The "ownership/management" definition might be preferable in the context of an anticipated allowance trading regime.

Materiality of emissions. According to the definition of leakage, emissions sources and sinks should be analyzed only if they will significantly affect the project's total GHG emission impacts. "Significant" can be indicated by "materiality." For example, a guideline could be issued to state that impacts must be included that present a 50 percent or greater likelihood of accounting for more than 5 percent of the project's total claimed reductions. Such a materiality threshold might assist proponents in knowing which effects could be neglected, but it might be difficult to apply in practice without simple estimates, access to default data, or expert judgment.

Avoidance of double counting. Multiple proponents should not get credits for the same emissions reductions. This is an important problem in determining leakage. For a simple example, one proponent switching a boiler from coal to biomass use might claim upstream benefits for reducing coal-bed methane emissions, while a second project developer might claim credits for methane capture at coal mines.

The potential for double counting could be dealt with in several ways. The simplest would be to exclude off-site emissions from consideration, thereby eliminating most of the potential for project boundaries to overlap. Important effects could thereby be neglected, however. A second option would be to require proponents to review potential project activities that might affect reported indirect emissions estimates. Double counting will be avoided if the baseline is consistent with the project. Good project registration across various incentive programs, as is being designed for green power program, could greatly assist in this task. A third option is to ensure monitoring and verification of claimed off-site and indirect emissions reductions.

Generally, there are three methods to reduce leakage:

Mitigate leakage through project design. Leakage sometimes can be addressed in project selection and design. For example, a developer can evaluate the likely impacts of the project on the existing supply of and demand for goods and services, and seek to change this supply/demand or meet this supply/demand through alternative actions. Using project design to avoid leakage is more difficult when economic goods such as energy or timber are involved.

Extend the project monitoring boundary. Expanding the project boundary can sometimes catch potential leakage. Tracking household energy use after installation of a more efficient appliance, for example, could catch leakage resulting from homeowner perceptions that energy has become less expensive. Some observers have carried this argument further, asserting that global energy or timber models should be run on individual projects to identify their net global impacts. Unfortunately, the impacts of individual projects, however real, will rarely (if ever) show up at the level of aggregation associated with a global model.

The developer can attempt to predict where leakage is likely to occur, monitor leakage impacts over time, and adjust the estimate of project benefits accordingly.

Develop non-project specific leakage benchmarks or coefficients. This approach would create and apply a series of project-level national or international leakage coefficients that can be used to adjust the estimate of project benefits in a more standardized way to account for leakage (IPCC, 2000). Its applicability is premised on a condition that project-specific leakage assessments are almost impossible to perform. Although in some sense less site-specific than a project-level leakage review, the benchmarking approach would be much easier to apply at the project level, and could avoid the potentially overwhelming analytical problem of being called upon to expand projects' boundaries further and further to deal with leakage concerns.

In a specific project, the following steps can be followed to address the leakage issue.

First, the possible emissions outside the project boundary should be determined. As stated above, they may be caused by activity shifting, market effects, life cycle effects, or ecological effects.

Second, adjust the project boundary according to the controllable principle. The project boundary should also be adjusted if there are double counting problems. Hence, the leakages involved in the case are known.

Third, identify the cost-effective solutions for each type of leakage. Generally speaking, leakage caused by activity shifting can be determined through the tracing of the project activities; leakage caused by market effects can be omitted, since it is generally too small to be considered; and leakage caused by life-cycle effects should be dealt with according to the real situation.

Fourth, the leakage emissions and then CERs can be determined.

Recommendations

To reduce possible leakage, it is very important to set a proper project boundary. Furthermore, leakage of certain types of activities is more significant than others. However, the identification and calculation of leakage is usually very complex, so it is not very cost-effective to calculate leakage on a project-by-project basis. It is very necessary and useful to develop leakage coefficients for certain types of project activities, so that leakage could be estimated easily and cost-effectively. Leakage factors for certain types of activities should be developed based on the Chinese situation. However, in the case that Chinese data are not available, data from other sources such as the IPCC could be used.

Whether or not a source of emissions constitutes leakage depends on whether or not it is "significant," so it is important to set a benchmark for "significant." With this benchmark, the project proponents could judge clearly whether or not a specific source of leakage could be omitted, and whether or not a project's emission reduction benefits should therefore be adjusted accordingly.

BASELINE SETTING

Baseline setting is of fundamental importance to every CDM project activity. It has direct and significant impacts on almost every aspect of a project, since it describes the situation without the project activities. Hence, the baseline is the yardstick for the calculation of the project-related emission reductions. This study provides a description of the concept, rules and regulations, an assessment of different baseline methods, the applicability of different methods, a detailed study of dynamic baselines, and recommendations.

Concept, Rules, and Regulations

There have been various definitions of baseline in the past (Matsuo 2000; Ellis 1999; NVROM 2001). The Marrakech Accords established a clear definition of baseline: "The baseline for a CDM project activity is the scenario that reasonably represents the anthropogenic emissions by sources of greenhouse gases that would occur in the absence of the proposed project activity. A baseline shall cover emissions from all gases, sectors and source categories listed in Annex A within the project boundary." (Annex A of the Kyoto Protocol lists the greenhouse gases that are considered in the Protocol—CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6—and the sectors/source categories of greenhouse gases, including energy, industrial processes, solvent and other product use, agriculture, and waste.) Since 2001, the CDM Executive Board has formulated a series of decisions regarding baseline setting for CDM projects (see Annex 1). If a CDM project is applying a new baseline method, it has to be submitted by the project proponents to the Executive Board for approval. Prior to the thirteenth EB meeting held in March 2004, nine methodologies—including landfill gas recovery and biogas cogeneration—had been approved. Further information on baseline and monitoring methodologies approved and/or under consideration can be obtained on the UNFCCC website http://cdm.unfccc.int/methodologies.

A baseline is actually an emissions trajectory in the baseline scenario, and a function of such variables as time, product of output, and emissions intensity. An ideal baseline should be environmentally credible, transparent and verifiable, simple and inexpensive to determine, and provide a reasonable level of certainty regarding credits for investors. In practice, any baseline determination is likely to involve a trade-off among these criteria.

Baseline setting is a key step in the process of identifying emission reductions of a CDM project activity. A higher emissions baseline is more attractive to both CDM project hosts and investors because of the larger amount of CERs and higher return on investment.

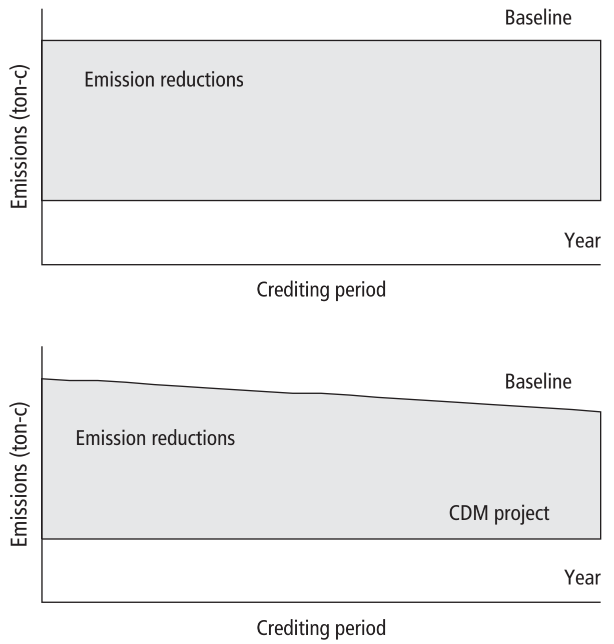
There are several ways to describe the baseline in terms of emissions. *Figure 2.4* shows the possible baselines and GHG emissions of a proposed CDM project activity along with the project lifetime. Shapes of the baseline trajectory are determined by the characteristics of baseline scenarios and could be represented by different types of time functions. The first figure illustrates a scenario under which the baselines stay unchanged during the whole crediting period. The second figure illustrates a scenario under which the baseline emissions change during the crediting period.

Assessment of Different Baseline Settings

Emission reductions expected from a proposed CDM project could be calculated by subtracting project emissions from the baseline. The Marrakech Accords provide three general baseline approaches for a CDM project activity: (1) existing actual or historical emissions, as applicable; (2) emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment; or (3) the average emissions of similar project activities undertaken in the previous five years in similar social, economic, environmental, and technological circumstances, and whose performance is among the top 20 percent of their category. People have various interpretations of these approaches, and the possibility is still open to choose different methodologies based on the real circumstances. The following methods are often discussed:

- Project-specific baseline methods
- Multi-project baseline methods
- Technology benchmark baseline methods
- "Top-down" sectoral baseline methods
- "Top-down" nationwide baseline methods
- Hybrid baseline methods

FIGURE 2.4 Possible Baseline Trajectory and Emission Reductions of a CDM Project Activity



Classification of baseline methods

Different baseline methods have different indications for application. In general, project-specific baselines present non-standardized and disaggregated characteristics, while benchmark baselines could be designed and applied at different levels of project aggregation, such as one technology category in several similar projects, in one sector, in one region, or even in one country.

From a standardization point of view, baseline methods could be classified as either standard-oriented or project-oriented. Multi-project baseline methods, technology benchmark baseline methods, sector-level or "top-down" sectoral baseline methods, and nationwide baseline methods can be viewed as standard-oriented. Hybrid baseline methods are actually a combination of project-oriented methods and standard-oriented ones. With standard-oriented methods, baselines are developed using some standardized parameters, such as the average emissions intensity of a specific electric power grid or the technical parameters of a specific type of technology. In the case of project-specific methods, baselines are developed with specific parameters of a relevant project activity. For example, when a gas-fired power plant replaces a coal-fired one, the coal-fired plant could be taken as the baseline project. Thus, such specific parameters of the project as energy efficiency, load curve, load factors, operation hours, type of coal delivered, and even combustion condition have to be considered in baseline development.

Table 2.1 compares project-specific base-line methods and standardized ones (Lazarus 1999).

TABLE 2.1 The Spectrum of Baseline Methods

Benchmark methods	Project-specific methods
"perfectly standardized"	"completely un-standardized"
Same baseline for each project	Different baseline for each project
Uniform, rigid	Tailored, ad hoc
Additionality test reflects only emission intensity	Additionality test reflects emissions intensity and level of activity
Based on category-wide information	Based on site-specific information
Aims to be credible for family of projects	Aims to be credible for individual projects

The aggregation level of a baseline is usually in parallel with its standardization level; that is, the more standardized, the more aggregated, and *vice versa.* A project-specific baseline is the least aggregated type, while multi-project and technology benchmark baselines seek to standardize emission levels or rates and are applicable to multiple projects of a similar type. Between these two types of baseline, there is a gray area called hybrid baselines that would be more aggregated and standardized than project-specific baselines, while less aggregated and standardized than multi-project (benchmark) baselines (Ellis 1999).

Standardized baseline approaches seem to be attractive to many people and organizations (IEA, OECD, 2000; Ellis and Bosi 1999) and some of them are even advocating sector-level, area-level, or industry-level baselines (Baumert 1998; Hargrave and others 1999). While acknowledging some possible merits of these approaches, we are not of the view that sector-level, area-level, or industry-level baselines would be a good choice for CDM projects—at least for some project types to be hosted by China, considering the scale and complex structure of China's industries and very different situations in different areas. Furthermore, the Chinese government is also of the view that the baseline should be set on a project-specific basis. *Table 2.2* lists some of the pros and cons of different baseline methods.

TABLE 2.2 Variation in Calculated Carbon Offsets under Different Baselines

Offsets under different baselines (t CO_2)	Project type: Fuel switch	Project type: Cogeneration
Project-specific	175,000	41,000
Technology-based	430,000	43,000
Sectoral-based	180,000	21,000
Top-down	195,000	22,000

Source: Adapted from Basler 1999

Baseline experience

The UNFCCC secretariat listed 95 AIJ projects (UNFCCC, 1998) in its second synthesis report on activities implemented jointly, most of which have used project-specific baselines (Ellis 1999).

The US/Russia Rusafor Project (Michaelowa 1998) used a hybrid baseline with both site-specific data and technology-based data. An AIJ project—hosted by the Czech Republic and funded by the Government of Switzerland—used four baseline approaches (Basler 1999) and two types of projects—fuel switching (coal to biomass) and energy efficiency improvements. *Table 2.2* shows the significant difference in results with different baseline methods.

Table 2.3 reveals that assumptions have significant effects on the emission reduction benefits of a specific project. For example, in the case of fuel switching, emission reduction benefits of the project could vary by a factor of 2.5 when different baselines (technology-based baseline vs. project-specific baseline) are used. However, we cannot draw a simple conclusion from the table regarding which type of baseline is the most conservative. The Marrakech Accords provide clear guidance on baseline determination.

The Center for Clean Air Policy (CCAP) also conducted a qualitative analysis on the impacts of

TABLE 2.3 Pros and Cons of Different Baseline Methods

Baseline method	Pros	Cons
Top-down nationwide baseline methods	• Low cost for long-term data collection • Easy to get the data • High transparency of data • Easy to estimate emission reductions of following projects	• High cost for data collection in short-term • Poor reflection of the specific circumstances • Not acceptable from political point of view
Project-specific baseline methods	• Low cost for data collection in short term • Easy to get the data • Applicable to every project • Good reflection of specific situations	• High cost for data collection in long term • Less transparency for data collection • Difficult to verify data • Difficult to estimate credits from the project activity at the design stage
Multi-project baseline methods	• Low cost for data collection in long term • More transparency regarding data collection • Easy to estimate credits from the following project activities	• High cost for data collection at the beginning stage • Not easy to get data • Difficult to verify data • Not applicable to every project activity
Technology benchmark baseline methods	• Low cost for data collection • Easy to get the data • Transparent regarding data collection • Easy to estimate credits from the relevant project activities	• Application limited to projects with a single technology • Poor reflection of the project-specific situations
Sector-level baseline methods	• Easy to get the data • Low cost for data collection in long-term • Transparent regarding data collection • Easy to estimate credits from the relevant project activities	• Possible high cost for data collection at the beginning stage • Poor reflection of the project-specific situations
Hybrid baseline methods	• Easy to get the data • Medium cost for data collection in long term • Transparency of some data used • Emission reductions from following project activities could be roughly estimated from the beginning • A good balance between reflection of the specific circumstance and transparency	• High cost for data collection in short term • Less transparency for project-specific data • Complex from technical point of view

different baselines on an AIJ project in Decin, Czech Republic (CCAP 1999). Results show that different baseline assumptions can significantly affect the amount of credits to be generated—sometimes by a factor of three.

More and more projects now are using multi-project baselines, in which the assumptions diverge based on the specific sectors and nations.

Multi-project baselines, based on existing electricity capacity and recent capacity additions, are also used in a study focusing on projects in the power sectors of Brazil, India, and Morocco (Bois 2000). Recent capacity additions included such items as all source and only fossil fuels, source-specific, sub-national, and load-specific. The implications of different assumptions, in terms of stringency, are different for different countries. The source-specific multi-project baseline, particularly in the case of coal, may result in perverse incentives, but might promote a cleaner use of coal reserves. Developing a separate multi-project baseline for peak-load electricity may be desirable, as those plants are typically different from base-load plants.

Similar studies have also been conducted in the fields of transportation (Salon 2001) and energy efficiency improvement (Violette 2000). The former study set up a sub-sector technical baseline for a transportation project and considered the modification of the historical baseline to allow a mode-shifting project. A single-region transportation baseline and worldwide regional baseline were also discussed. Taking lighting and motors as examples, the energy efficiency study analyzed data needs, quality, and availability for baseline calculation. Based on seven cases, the study discussed the issues of determining standard baseline performance, standard calculation and data protocols, and of standardizing operating and performance parameters.

Two conclusions can be drawn from the above-mentioned cases in terms of applicability of different baseline methods.

Multi-project baseline methods are suitable for projects with the following characteristics: (a) a new construction project; (b) output that is simple and easy to measure; and (c) adoption of a single technology.

Project-specific baseline methods are suitable for projects with the following characteristics: (a) technical retrofit projects; (b) energy efficiency improvement through better management; and (c) output that is diversified by using multiple processes and energy flows.

Applicability of Different Methodologies Under China's Circumstances

A survey was conducted to review baseline development practice in China. The information for 10 cases was collected and is summarized in *Table 2.4*. *Table 2.5* shows the relationship between baseline methods and types of project.

The following observations could also be made from the investigation.

- No case study in China adopted a nationwide baseline because of the significant disparities in socioeconomic development, technical level, natural resources, and weather conditions among different regions and sectors. If the project boundary permits, regional baselines could be an option as a default value (e.g. the average CO_2-factor of the regional grid).
- Only a small portion of projects adopted multi-project baselines because of the huge data collection demands.
- Most projects adopted project-specific baselines for the following reasons: (a) lighter workload for data collection compared to multi-project baseline; (b) easy-to-get baseline data because of the currently existing similar projects under construction or under design in the same region; and (c) low cost for data collection.
- For some types of projects, a technology benchmark baseline could be the best choice considering data collection and cost reduction.
- For energy efficiency projects, identifying the appropriate project boundary is a difficult point

TABLE 2.4 General Information about CDM/AIJ Project Case Studies in China

		number of projects
Project sector	Power generation	3
	Heat supply	3
	Energy efficiency improvement	4
Baseline method	Project-specific (P)	5
	Multi-project baseline (M)	2
	Hybrid baseline	
	Technology benchmark baseline (T)	1
	Sector-level baseline (S)	3
	Regional/national-wide baseline	
Workload of data collection from the case study team perspective	Small	
	Medium	8
	Large	1
	Huge	1
Main difficulties in the case studies from the study team perspective	Baseline method	4
	Data collection	5
	Cooperation from project developers	3
	Assessment of additionality	1
	Identification of reference technology	1
	System boundary identification	1
	Technical factor identification	1

TABLE 2.5 Project Types and Corresponding Baseline Methods

		Baseline method			
Case No.	**Type of Project**	**P**	**M**	**T**	**S**
1	Energy saving by implementation of ground-source coupled heat-pumps & aquifer thermal energy		×		×
2	Wind power				×
3	Municipal waste incineration for heat recovery	×			
4	PFBC power generation			×	
5	Municipal waste incineration for power generation				×
6	Energy efficiency improvement for cement industry		×		
7	Energy efficiency improvement for ferroalloy refining industry	×			
8	Switching coal-fired boiler to gas-fired boiler for space heating	×			
9	CFBC/CHP	×			
10	Coke dry quenching	×			

Note: P—Project-specific baseline method M—Multi-project baseline method
T—Technology benchmark baseline method S—Sector-level baseline method

because most such projects consume secondary energy.

- For projects with GHG emissions besides CO_2, the lack of related research makes it difficult to calculate the emissions and identify technical factors.
- Workload for data collection is one of the decisive factors affecting the choice of baseline approaches.
- Constrained by budget, data availability, and time schedule, etc., only one case study adopted more than one kind of baseline methods.

A decision tree for baseline setting is shown in *Figure 2.5.*

Dynamic Baseline

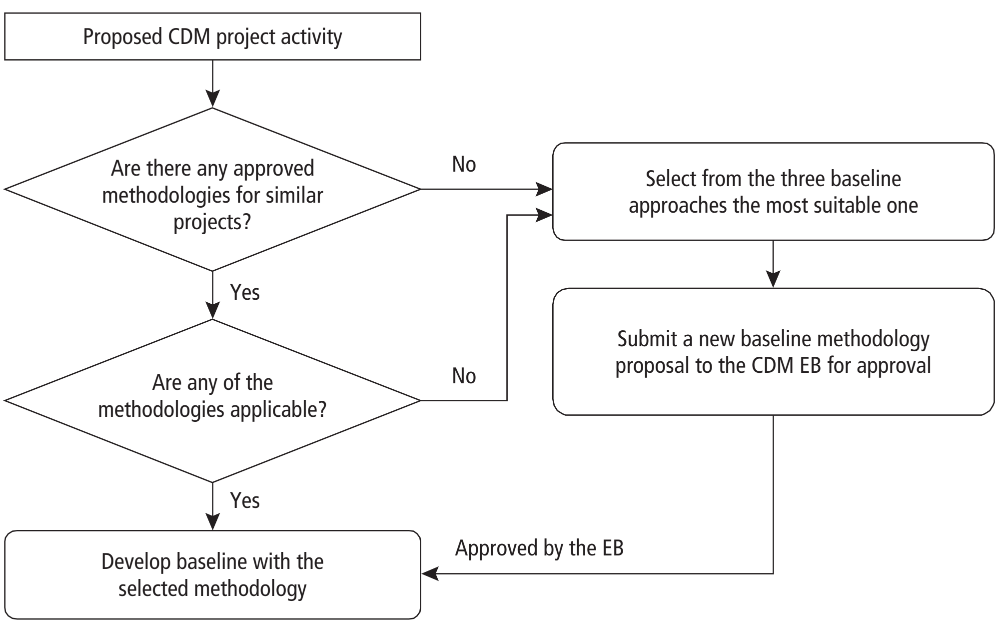
Concept

Baselines, according to whether or not they are fixed during the crediting period of a proposed CDM project activity, could be classified as either static/constant/fixed or dynamic. However, there are no commonly accepted definitions of static and dynamic, and the views diverge.

Some researchers (Michaelowa 1999) believe that a baseline is static if either constant emissions or a constant emissions benchmark are assumed throughout the crediting period of the project, and that a baseline is dynamic if only changing emissions (not due to changes in activity levels) or a changing benchmark are assumed. Some prefer a broader dynamic definition, which include a baseline with changing emissions caused by the changes of output level. And some others (Ellis and Bosi 1999; Chomitz 1998) would like to see an even narrower definition, which includes only a baseline that is revised during the lifetime of the project activity without specifications at the outset on how the revision(s) will be made.

Baselines with changing emissions could also be divided into dynamic and quasi- dynamic. For a dynamic baseline, either the emission lev-

FIGURE 2.5 Decision Tree for Baseline Determination



els change for other reasons than changes in activity levels or a changing benchmark is used, while the changing rate is not pre-specified. A quasi-dynamic baseline varies through time with a trend indicator that would be specified from the beginning of the project. To be more accurate and to help the analysis, this study classifies baselines into three types: static, quasi-dynamic, and dynamic. Although in some cases, emissions in a dynamic baseline could rise due to specific reasons, it is likely that in most cases the emissions will decrease.

Desirability

Static and dynamic baselines have their own advantages and disadvantages. Which type to choose in a specific project depends on the specific circumstances and main considerations of the project developers. In some cases, dynamic baselines could better reflect the real situation than static ones and thus are more suitable. Chomitz (1998) argues that dynamic baselines are especially desirable in two circumstances: (1) in replacement/retrofit projects, when retirement of the existing facility is sensitive to unpredictable changes in prices or interest rates; or (2) when emissions are volatile because of variable and unpredictable facility loads.

Willems (2000) suggests that it may be important to use a dynamic baseline in sectors where the rate of change in performance is relatively high; where the baseline is inherently dynamic (e.g. in the case of a reforestation project on land where the carbon stock is naturally regenerating, but at a lower rate); or where the crediting period and/or the time between setting and revising a baseline is relatively long.

According to the Marrakech Accords, a baseline methodology should be selected from (a) existing actual or historical emissions; (b) emissions from a technology that is economically attractive; or (c) the average emissions of similar project activities undertaken in the previous five years, in similar circumstances, and whose performance is among the top 20 per cent of their category. The Accords also provide two options for crediting period: (1) a maximum of seven years, which may be renewed at most two times, provided that for each renewal a designated operational entity determines and informs the executive board that the original project baseline is still valid or has been updated, taking account of new data where applicable; or (2) a maximum of 10 years, with no option of renewal. With the change of environments, the economic performance of technologies and thus the average emissions of projects will change. Therefore, the latter two options imply the possibility and necessity of dynamic baseline emission rates. Besides, the variation in output of a CDM project activity could also cause a change in baseline emissions during the crediting period.

At its ninth meeting, the CDM Executive Board decided that for an electricity generation CDM project, the baseline emission rates could be calculated ex post provided that (a) proper justification was provided; and (b) baseline emission rates calculated ex ante were reported explicitly in the draft CDM-PDD.

Most of the experience obtained to date regarding baseline determination comes from the AIJ pilot phase. Although static baselines are used in most of the AIJ projects, dynamic ones are also available. The France/Czech cement production project in Cizkovice uses a baseline that will be revisited after the first five years of project operation, and many AIJ projects supported by the Government of Switzerland revised their emission baselines between the first and subsequent reports to the UNFCCC.

Factors causing the change of baseline emissions

Many factors could possibly cause the change of baseline emissions of a CDM project activity. Generally speaking, most factors will make the baseline emissions decline with time. Therefore, the emission reduction benefits of a CDM project activity, when measured against a dynamic baseline, usually shrink with time.

Technologies evolve continuously in their own way and are not necessarily associated with GHG mitigation considerations. However, in most cases, autonomous technology development could improve the energy efficiency and thus reduce the carbon intensity of some technologies, installations, sectors, and/or industries. This will inevitably make baseline emissions change with time. For example, during the lifetime of a CDM project activity, the old equipment or technology, which is used in the baseline case, could be replaced by new equipment or technology even without the incentives from CDM. Therefore, the baseline should be re-estimated. A dynamic baseline would more accurately reflect what the emissions will be without the project activity.

Energy efficiency improvements could happen autonomously with time and thus reduce the emissions intensity of related products or services. This is not necessarily associated with technology development. The improvement in management and the optimization of load and operation could also result in higher energy efficiency. Energy efficiency improvements will reduce the emissions in a baseline scenario; a dynamic baseline is necessary, especially in case of a high changing rate. Otherwise, excess credits will be issued and environmental integrity undermined.

A change in the regulatory or legal environment—such as a renewable energy development plan, a new environmental policy, or new environmental standards—could change the BAU scenario, and thus make dynamic baselines a necessity. For example, a wind energy project is carbon free and usually should be eligible to generate emission reduction credits at lease for a period of 10 years, which is allowed by the Marrakech Accords. If the host country government already has a plan to develop a wind energy project in the same site as the wind CDM project—perhaps five years later—the CDM project activity is eligible to generate credits for only five years. Subsequently, it should become a baseline project.

In most cases, project operators could choose the most suitable fuel type from several available types. Cost is always an important consideration. Changing fuel prices could change the economic competitiveness of different types of fuels and thus the decision of project operators on fuel type. In the same manner, it could possibly cause the change of energy consumption structure in certain industries/sectors, especially the energy-intensive industries/sectors. Different fuels could be obviously different in emissions intensity, so the baseline or the emissions benchmark could also change with fuel price. Fuel switching always means additional equipment or retrofit investment, so little price change may not cause significant fuel switching. However, when fuel price changes happen, the baseline should be revisited and possibly reassessed.

Even in the case of no fuel switching, a change in fuel prices could also cause a change in baseline emissions. For example, in the case of low energy prices, project operators may be unwilling to implement an energy conservation plan because the organizational cost might be higher than the benefits from energy conservation. With the increase in energy prices, the situation may change. Economic benefits from energy saving may accelerate the technological retrofitting process in some factories, sectors and/or industries, and thus change the baseline scenario.

Changes in resource availability sometimes may also make it necessary to set a dynamic baseline. For example, in an area where the only available fuel is coal, the reference fuel for energy conservation projects should be coal, and thus the baseline should be emissions from the energy utilization of coal. If other fuels such as natural gas or diesel oil are available, the energy consumption structure of the area will change, and thus the reference fuels should be different. The possible differences between the carbon intensities of different fuels could therefore change the baseline.

When new technologies are available, they would compete with conventional ones in the same market, and thus could possibly change the technology structure of that market. If conventional technologies and new ones have different emissions intensities, the emissions benchmark of specific industries and/or sectors will change. It is also possible that new technologies become the new conventional technologies, and the old conventional ones are phased out.

Different products could differ in emission intensities, and therefore the change of product structure could possibly change the overall emissions feature of certain industries, sectors, and/or regions, and thus the baseline.

These are some of the external macro factors that could cause a change in the baseline. Micro inherent factors could also cause a change of baseline. For example, it is likely that the longer a boiler has been used, the lower its energy efficiency. Therefore, when this boiler is used to represent the baseline scenario, the emissions will likely change with the boiler's service time.

Characteristics of dynamic baselines

Dynamic baselines need to be re-estimated at certain intervals if some significant changes relevant to the project activity have taken place during the crediting, and thus could reflect more precisely what will happen in the baseline scenario than static ones. In cases such as improved energy efficiency or stricter environmental regulations, the baseline could be adjusted downwards and thus fewer credits would be issued. This could help to safeguard a project's environmental integrity.

However, compared with static baselines, dynamic ones usually mean more baseline estimation work, more validation work, and a heavier monitoring, reporting, and data collection burden. All of these will inevitably increase a project's transaction costs.

If a static baseline is used in a proposed project activity, the investors could know in advance the amount of credits they would get from that project, and thus could make their decisions with some certainty. In the case of a dynamic baseline, the investors could not know the amount of credits in advance, as they could not know what would possibly happen during the lifetime of the project activity and thus how the baseline would be adjusted. This will increase uncertainty for investors and make a CDM project less attractive.

In most circumstances, dynamic baselines mean that the baseline will decrease with time. However, it is possible that the emissions may rise in specific cases. For example, in an area where nuclear power accounts for a large part of total electricity production, the average carbon intensity of electricity production in that area may rise if the nuclear power is phased out while renewable energy could not fully satisfy the demand gap. The Marrakech Accords allow a baseline that includes a scenario where future emissions are projected to rise above current levels. *Table 2.6* illustrates such a scenario, under which the average carbon intensity of power generation is used as the baseline.

TABLE 2.6 Carbon Intensity Scenarios

		Renewable sources	Fossil fuel sources	Nuclear	Average carbon intensity of power generation
Carbon intensity of power generation		0	300 gC/kWh	0	
Composition of the power generation (%)	Original	10	50	40	150 gC/kWh
	Changed	20	60	20	180 gC/kWh

Source: GCCI calculation.

For simplicity, imagine that electric power in a certain area comes from three types of sources: renewable sources, fossil fuel sources, and nuclear sources, and related carbon intensities are also given. Under the original market structure, the average carbon intensity of power generation in that area is 150 gC/kWh. If the share of the fossil sources increases, the average could increase to 180 gC/kWh.

Set dynamic baselines in an affordable way

In the Marrakech Accords, two alternative approaches are provided for crediting period selection: (1) a maximum of seven years, which may be renewed at most two times; or (2) a maximum of ten years with no option of renewal. If the seven-year period is selected, the baseline will be revisited at the interval no longer than seven years during the crediting lifetime of the project activity, and there is the possibility that a dynamic baseline will be developed.

When updating the baseline for a project activity, all the above-mentioned factors should be taken into consideration to make the revision more precise. Failing to do so may potentially inflate the baseline, whereas a too rigorous process may mean more transaction costs and uncertainties for investors and could thus hinder their decision at the beginning. Too-short updating intervals may create similar concerns for investors. A trade-off has to be made between different considerations.

Quasi-dynamic baselines and mixed ones could be good choices. In the case of quasi-dynamic baselines, the baseline will change during the crediting lifetime of the project activity, while the rate is specified at the very outset. This could accommodate both the environmental concern and the desire of some certainty by investors. There are two options for the mixed baselines. One option is that the baseline will be re-estimated at a predefined interval, while between two estimations the baseline is fixed. The other option is that during two estimations, the baseline is not a fixed one, but a quasi-dynamic one.

One of the major challenges of using this approach is how to update the baseline. First of all, there should be a careful study of related legal and regulatory environments to see if any significant changes have already taken place. If there have, the baseline shall be updated accordingly. Secondly, the market should be analyzed to see whether the baseline technology could still represent the most attractive choice for investors or whether the situation has changed. If it is still attractive, the baseline could remain unchanged. Otherwise, a new baseline should be developed. This process is actually similar to developing a baseline at the outset.

Another significant challenge lies in the difficulty of defining a rational changing rate for the baseline. If a clear historical change trend can be observed in a sector, area, and/or industry, this trend may serve as a reference for the future change. Otherwise, a subjective trend will have to be set. Actually, technological progress often happens unexpectedly, so subjective judgment is unavoidable in this process.

Dynamic baselines are not always a good choice. Where a large investment has been avoided and the lifetime of the project could be much longer than the crediting period, such as the power plant, it is unlikely that a newly built one will be replaced in a short term. Therefore, a static baseline is more rational than a dynamic one.

Recommendations

Although various baseline methodologies have been proposed by different sources and discussed in this chapter, it does not necessarily mean that all of them could be appropriate choices for CDM projects hosted by China. Choosing the most appropriate baseline methodology for a CDM project activity requires striking a balance among different considerations, such as the real situation, transparency, accuracy, verifiability, and transaction cost.

Theoretically, the higher or broader the level at which the baseline methodology is determined, the more transparent the methodology and the result because it is much easier to get and verify aggregated rather than disaggregated data. However, such a choice also usually means a higher initial baseline determination cost, a lower cost for following projects, and a lower average cost in the case of a large number of CDM projects.

China is a large county with significant differences between different regions in aspects such as natural resources, technology development, and socioeconomic development. Baseline methodologies based on national average data could overestimate the GHG emission reduction benefits of projects to be implemented in economically and technologically advanced areas, while underestimating the benefits for potential projects in other areas. Therefore, such methodologies are not appropriate for CDM projects in China.

Baseline methodologies based on regional data could reflect to a large extent the real situation where the project is to be implemented, reduce to a certain extent the transaction cost of baseline determination, and retain an acceptable level of transparency. They are thus an attractive option.

A baseline associated with the average emissions of similar project activities whose performance is among the top 20 per cent in its category is not an attractive and appropriate choice for some types of CDM project activities, at least under China's current situation. Take power projects as an example. In China's current power market, some high-efficiency projects, such as natural gas-fired projects, are to be built as demonstrations. However, in a specific area, there are only a limited number of newly planned or built power plants, and one such project could account for a large portion of the newly added capacity in that area. Baseline methodology based on this approach could possibly underestimate the baseline and thus not provide enough incentives to CDM project proponents. Furthermore, the CDM Executive Board decided at its 8th meeting that: "Project participants wishing to use this approach and a related approved methodology shall assess the applicability and use the most conservative of the following options: (a) The output-weighted average emissions of the top 20 per cent of similar project activities undertaken in the previous five years in similar circumstances; (b) The output-weighted average emissions of similar project activities undertaken in the previous five years under similar circumstances that are also in the top 20 per cent of all current operating projects in their category (i.e. in similar circumstances as defined above)." Such an exercise requires a large amount of data about the whole market. However, most of the data are considered confidential/internal and are not publicly available in China. This will inevitably increase the transaction cost and restrict the transparency and verifiability of the methodologies.

Data availability will be one of the most serious challenges that project developers have to face during baseline determination in China, because of the poor statistical basis of the country, limited publicly available information, and less transparent statistical data.

In comparison with static baselines, dynamic baselines usually mean more data requirements and less transparency. Furthermore, such methodologies also mean more uncertainties for project proponents and thus are not currently attractive and appropriate when the CDM is still in its infancy. In the case of a dynamic baseline, the amount of available historical data will have obvious effects on the projections of future scenarios and thus the emissions baseline to be used in the project. However, more historical data would not necessarily mean a more rational representation of the current trend.

ADDITIONALITY ASSESSMENT

This section discusses three points about additionality: the concept, the assessment criteria, and the procedures for additionality assessment. Additionality represents the environmental benefit of the project by proving the project mandate is fulfilled with regard to the baseline and generating the unit of economic transaction, i.e. certified emissions reductions (Oberheitmann 1999). Hence, it is a core element of the CDM. Here we describe the concept of additionality, its assessment criteria, and recommendations.

Concept and Importance of Additionality

Concept, rules and regulations

According to the Marrakech Accords, "a CDM project activity is additional if anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the registered CDM project activity" (UNFCCC 2001b). Based on that, the CDM Executive Board has (as of December 2003) formulated further decisions on how to demonstrate the additionality of a proposed CDM project activity (see below; for details refer to Annex 1).

Assessing whether a proposed CDM project activity is additional involves two issues: (1) identifying the baseline scenario in the absence of the proposed project activity; and (2) explaining why the project's emissions will be reduced below the baseline, or why the emission reductions to be achieved by the proposed CDM project activity will not otherwise happen.

Significance of additionality

Additionality assessment is a very important step in assuring that the proposed CDM project activity will result in real, measurable, and long-term GHG emissions reduction benefits, and that these reductions are additional to any that would occur in the absence of the certified project activity. It has two particularly significant aspects.

Safeguard integrity of the Kyoto Protocol. Once specific criteria have been established, an additionality test becomes an effective instrument to manage the operation of CDM projects. With related assessment criteria, designated operational entities could distinguish clearly and more easily between projects with real and additional reductions in emissions and those without, and thus assure that CERs are awarded only to eligible project activities and safeguard the integrity of the Kyoto Protocol.

Spill-over benefits to the host country. CDM project activities that have passed the additionality assessment could really promote sustainable development of the host countries and thus create spill-over benefits to those countries, such as improvement of local environmental quality, transfer of environmentally sound technologies from developed countries, more public or private investment from developed countries, and the elimination of market barriers in host countries.

Additionality Assessment Criteria

Generally speaking, ideal criteria for assessing the additionality of a proposed CDM project activity should reflect as much as possible specific circumstances of the project to be assessed; reflect to some extent general situations of a specific sector/region where the project is to be located; require rational or even limited data; have limited system errors; have relatively lower uncertainties; have acceptable cost; and have limited or even no subjective judgment.

Until now, there is no consensus by the international community on specific criteria for additionality assessment. Some guidance has already been provided by the COP and the CDM Executive Board.

In the Marrakesh Accords, paragraphs 43 and 44 stipulate that:

43. A CDM project activity is additional if anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the registered CDM project activity.

44. The baseline for a CDM project activity is the scenario that reasonably represents the anthropogenic emissions by sources of greenhouse gases that would occur in the absence of the proposed project activity. A baseline shall cover emissions from all gases, sectors and source categories listed in Annex A within the project boundary. A baseline shall be deemed to reasonably represent the anthropogenic *emissions by sources that would occur in the absence of the proposed project activity if it is derived using a baseline methodology referred to in paragraphs 37 and 38 above.*

At its 9th meeting, the CDM EB required that project participants should refrain from providing glossaries or using key terminology not used in the COP documents and the CDM glossary (environmental/investment additionality).

At its 10th meeting, the EB provided further clarification on additionality:

1. As part of the basis for determining the baseline scenario an explanation shall be made of how, through the use of the methodology, it can be demonstrated that a project activity is additional and therefore not the baseline scenario.
2. Examples of tools that may be used to demonstrate that a project activity is additional and therefore not the baseline scenario include, among others:
   (a) A flow-chart or series of questions that lead to a narrowing of potential baseline options; and/or
   (b) A qualitative or quantitative assessment of different potential options and an indication of why the non-project option is more likely; and/or
   (c) A qualitative or quantitative assessment of one or more barriers facing the proposed project activity (such as those laid out for small-scale CDM projects); and/or
   (d) An indication that the project type is not common practice (e.g. occurs in less than [<x%] of similar cases) in the proposed area of implementation, and not required by a Party's legislation/regulations.

Project participants could use these four tools provided by the EB and other tools they deem necessary to demonstrate the additionality of a proposed CDM project activity. Terminologies that were once widely used in the past—such as emissions additionality and technology additionality—will be avoided in this report. However, it is still necessary to demonstrate various aspects of the project's additionality. Therefore, we propose and discuss a series of additionality assessment criteria, though they are not necessarily suitable for every project. These criteria deal with emissions aspects, financial aspects, investment barriers, technology barriers, and other barriers.

Emissions aspects. Paragraphs 43 and 44 of the Marrakech Accords provide a clear indication regarding how to demonstrate additionality from the emissions perspective.

It is widely agreed that an emissions-related criterion is most important because of its direct and quantitative characteristics as well as universal applicability. The comparison between emissions of a CDM project and the baseline gives a clear and quantitative understanding of the emissions reduction benefits of a proposed CDM project activity, and this comparison can and must be undertaken for any CDM project to be implemented in any sector and country.

The index to scale the emissions level is rather simple: the amount of GHG emissions. But it is sometimes more convincing to calculate the GHG emissions rate (i.e. tCO_2/GWh) instead of the total amount (e.g. tCO_2). This is also a requirement put forward by the EB at its 8th meeting. For example, in the case of a thermal power plant, two possible indexes—CO_2 emissions per unit of electricity supply, or CO_2 emissions per unit of heat supply—could be used to assess the project's additionality from an emissions perspective.

Data requirements for an emissions-based additionality assessment are relatively simple: only technical data are necessary, while data regarding cost, investment, revenues, and market barrier are not necesssary. And when necessary, CO_2 emissions associated with electricity or heat production could even be estimated, with formula and default emissions factors recommended by relevant organizations such as the IPCC.

Financial aspects. From a financial point of view, additionality requires that public funding for CDM project activities from developed country parties should be clearly additional to the financial obligations of Annex I parties under the Convention and the Kyoto Protocol, as well as not result in the diversion of official development assistance (ODA). Therefore, funds from ODA should not be used to finance the acquisition of CERs. However, public funds could be used for capacity building in both the public and private sectors of the host countries, with a focus on creating an enabling environment for CDM project activities.

However, it is actually very difficult to implement this criterion for additionality assessment because it is almost impossible to set a baseline for any international funds. Judgment of a project's additionality from the financial perspective is thus actually a process of political negotiation and judgment.

Investment barriers. From an investment point of view, a proposed CDM project activity is additional only if it is less attractive from the investor's viewpoint compared with the baseline project, when revenues from the emission reduction credits are not taken into consideration. Otherwise, the proposed project will happen anyway, regardless of the incentives from the CDM, and thus will be the baseline case.

To measure and compare the attractiveness of the baseline project and the proposed CDM project, and thus assess quantitatively the additionality of a proposed project from the investment point of view, some indicators should be used. Indicators often used to describe the economic performance of a project activity—including internal rate of return (IRR), payback period, net present value (NPV) and project cost—could be used to evaluate the additionality of a proposed CDM project activity from the investment aspect. The specific criterion is that the economic performance of the proposed project activity should be worse than that of the baseline project.

Assessing the additionality from the investment aspect requires substantial financial data regarding both the baseline project and the proposed CDM project. These data in many cases will be considered confidential by the project proponents. This is especially true for large-size projects. Therefore, such an assessment will inevitably encounter many practical difficulties, which makes it even more necessary to assess the additionality of a proposed CDM project activity from other perspectives.

Technology barriers. Technologies used in CDM projects must be environmentally safe and not commercially available or viable in the host country market. This is to ensure that CDM projects will lead to the transfer of high-quality technologies to host countries, not the dumping of old, second-hand technologies into these countries' markets. The transfer of technologies under the CDM should also be additional to the technology transfer obligations of Annex II countries in other areas.

The technological assessment process should include:

- An assessment of commercially available relevant technologies in order to determine the emissions intensity of the technology to be used in the baseline scenario
- An assessment of the market penetration of relevant technologies in the region.

The evaluating indices for technological evaluation are a comprehensive system, in which some indices are quantitative, while others are qualitative. Three types of indices should be noted for assessment of additionality from a technological point of view: (1) indices describing technological characteristics; (2) indices describing economic characteristics, including fixed cost, investment of infrastructure, and price of product or output; and (3)indices describing other characteristics, such as imperfect markets, special laws or regulations, or environmental barriers.

The most notable drawback of such an assessment may be its high cost. Furthermore, some required data are usually viewed as confidential by related stakeholders and thus are not publicly available. In addition, the rate of technological advancement is very rapid, so it is necessary to update periodically the database of conventional technologies, which is actually a difficult exercise.

Other barriers. To assess whether a project would have occurred anyway, one has to identify barriers a CDM project may face as completely as possible, and then assess how these barriers would influence the implementation of the project. Because the identification of barriers is sometimes a difficult and subjective process, the program-related assessment criteria are not applicable to any project. In fact, it could be considered as the base for other assessment criteria on condition that there is sufficient information.

The following aspects need to be considered when assessing the additionality of a proposed CDM project activity:

- Regulatory check: Does the project meet all the existing legal/regulatory requirements?
- Economic performance check: Without financial incentives from emission reductions, how competitive is the project in the local market?
- Barrier removal and market transformation check: Does the project introduce innovative financing, raise awareness regarding new products, technologies and practices, increase demand, or increase competitive pressure for technological change in the local market?

Table 2.7 summarizes the characteristics of additionality assessments.

Recommendations

In choosing the most suitable additionality assessment criteria, it is necessary to strike a balance between safeguarding environmental integrity and practicability.

Although various criteria have already been proposed to assess the additionality of a proposed CDM project activity, this does not mean that all these criteria could or should be applied in a proposed CDM project activity, nor does it mean that a project activity should pass all these assessments before it could be viewed as additional.

The availability of data, especially economic and financial data, will be one of the most serious challenges in the process of assessing the additionality of a specific project activity, because detailed data are usually viewed as confidential by the project developers.

The results of an assessment from different aspects for the same project activity could be dif-

TABLE 2.7 Characteristics of Additionality Assessment from Different Aspects

Criteria characteristics	Emission aspect	Investment barrier	Financial aspect	Technology barrier
Applicability	H	L	L	H
Quantitative	H	H	M	M
Qualitative	L	M	M	M
Accuracy	H	M	L	M
Uncertainty	M	M	H	M
Dynamic	H	L	M	H
Cost	M	L	M	H
Data needs	M	H	M	H
Index amount	M	M	M	H

Note: H: to a high extent M: to a medium extent L: to a low extent ferent, so additionality should be assessed from an integrated point of view. It is useful to reach an agreement with the international community regarding which types of additionality assessment are necessary and which are not.

PROJECT-BASED EMISSION REDUCTION COST CALCULATION

The calculation method for project-based emission reduction costs for a CDM project depends on the cost allocation options among the domestic benefits (such as products and/or service) and the CERs benefits; that is, the cost could be defined as an incremental cost for achieving the CERs or for achieving domestic benefits.

The CDM is designed to provide benefits for both project investor and host. It should help non-Annex I countries to achieve sustainable development, and help Annex-I countries fulfill their quantitative obligations under the Kyoto Protocol. Given this sharing of benefits, there has to be a subsequent cost-sharing arrangement. Since it is easy to measure the project costs and complicated to measure the benefits, this study views this issue from the cost perspective. One of the objectives of a CDM project is to generate environmental benefits that exceed the baseline. The incremental costs for emission reduction (ICER) only cover the costs that are greater than the baseline project; for example, a coal-fired power plant would be replaced by a biogas electricity generation unit under the CDM. Generally, this means that the incremental costs are borne by the project investor. Owing to data availability, we prefer the calculation method of incremental emission reduction cost per unit of CERs, as discussed below and applied in the case studies. If the cost-sharing option is based on an ICER calculation, the investors from Annex-I countries will obtain much of the total social surplus from the CDM project transaction. Applying the Nash bargaining solution would result in a different allocation of risks and benefits (He and Su 2004).

The CERs price is not the same as the project-based incremental emission reduction cost. The price of CERs is determined by the market equilibrium process, which is affected by demand and supply and by the market structure. The carbon market is fragmented. On the supply side, there is a considerable competition among CERs, ERUs, sink credits, and inexpensive AAUs from Russia and the Ukraine. On the demand side, U.S., participation in the Kyoto process, as well as a further increase of GHG emissions in Europe over their AAUs (Spain, Netherlands, etc.), would significantly increase the CER market (Oberheitmann 2003).

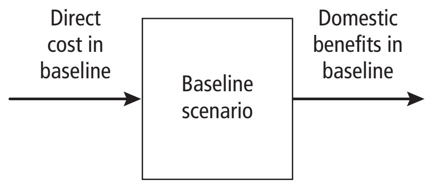
In very limited cases, the GHG abatement cost in developing countries may be the market price. Thus there are net benefits from the CDM project. The share of the benefits mainly depends on negotiation power and the attitude of different project participants toward risk. In the next section we discuss the method for project-based reduction calculations, including major components of project-based reduction costs, the major parameters for the ICER calculation, the assessment of proposed calculation approaches and procedures, and recommendations. The application of the method is illustrated in the case studies in Chapter 3.

Major Components of Project-based Reduction Cost

For a CDM project, investors from Annex I countries who claim the CERs as a return and the project's hosting entity are the two main players. They cooperate to produce domestic socioeconomic and environmental benefits, and at the same time global environmental benefits in the form of CERs from the project activity.

With the incremental cost for emission reduction (ICER) method, the incremental cost for CER benefits can be calculated using formula (2-1), as illustrated in *Figures 2.6 and 2.7.*

FIGURE 2.6 Output and Input in Baseline Scenario



$$ICERT = \left(C_{cdm}DCT - C_{bsl}DCT\right) + CTRN \quad (2\text{-}1)$$

in which

ICERT represents the present value of the total incremental cost of CER benefits for a CDM project over the project cycle (calculation period);

$C_{cdm}DCT$ represents the total discounted direct cost of the CDM project activity, i.e.

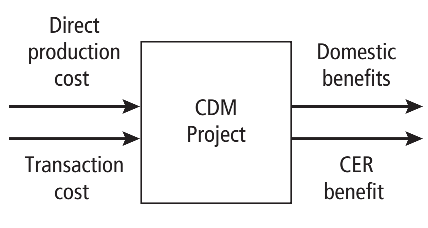
$$C_{cdm}DCT = \sum_{i=1}^{N} \frac{C_{cdm}DC_i}{(1+r)^i} \quad (2\text{-}2)$$

where $C_{cdm}DC_i$ is the annual direct cost of the CDM project activity in the i^{th} year, using the discount rate *r,*

$C_{bls}\,DCT$ represents the total discounted direct cost of the baseline scenario, i.e.

$$C_{bsl}DCT = \sum_{i=1}^{N} \frac{C_{bsl}DC_i}{(1+r)^i} \quad (2\text{-}3)$$

FIGURE 2.7 Output and Input of CDM Projects



where $C_{bsl}DC_i$ is the annual direct cost in the baseline scenario in the i^{th} year.

CTRN represents the total discounted transaction cost of the CDM project, which normally would take place during the whole CDM project cycle. Because the transaction costs are only calculated in the biogas case study (#6), the CTRN term does not occur in formulas 2-5 to 2-8.

N is the calculation period. Determination of N depends on the crediting period of project activity and the lifetime of the main infrastructure or equipment components. From a practical point of view, it can be the crediting period, or the lifetime of the main infrastructure or equipment components.

Major Parameters for ICER Calculation

Parameters related to direct cost components

The ICER for per unit of GHG emission reductions accruing from the CDM project activity can be derived as follows in a bottom-up manner (King 1995):

Defining ER_i as the GHG emission reductions[1] produced by the CDM project activity in the ith year, i.e.

$$ER_i = EMBSL_i - EMCDM, \text{ and} \quad (2\text{-}4)$$

define $ICER_i$ as the incremental cost for the unit of GHG emission reductions in the i^{th} year, i.e.

$$ICER_i = \frac{\left(C_{cdm}DC_i - C_{bsl}DC_i\right)}{ER_i} = \frac{\left(C_{cdm}DC_i - C_{bsl}DC_i\right)}{\left(EMBSL_i - EMCDM_i\right)} \quad (2\text{-}5)$$

thus, the present value of the total incremental cost for CERs benefit for a CDM project could be represented as;

$$ICERT = C_{cdm}DCT - C_{bsl}DCT$$

$$ICERT = \sum_{i=1}^{N} \frac{\left(C_{cdm}DC_i - C_{bsl}DC_i\right)}{(1+r)^i}$$

$$= \sum_{i=1}^{N} \frac{ICER_i \times ER_i}{(1+r)^i} \qquad (2\text{-}6)$$

If we define *ICER* as the average of $ICER_i$ over the lifetime of the CDM project in the sense that the present value of the total incremental cost for CER benefit for a CDM project would keep (⁇) equivalent (formula 2-7),

$$ICER = \frac{\left(C_{cdm}DCT - C_{bsl}DCT\right)}{ER} \qquad (2\text{-}7)$$

thus we have

$$ICERT = \sum_{i=1}^{N} \frac{ICER \times ER_i}{(1+r)^i}$$

$$= ICER \times \sum_{i=1}^{N} \frac{ER_i}{(1+r)^i}$$

$$= ICER \times ER \qquad (2\text{-}8)$$

in which *ER* is the discounted total GHG emission reduction between the baseline scenario and CDM project over the lifetime of the project. It is relevant to note that if the crediting period is shorter than the lifetime of the project, the quantity of ER_i can be zero for i larger than the length of the crediting period. The incremental costs are only calculated throughout the crediting period and affect the cost-effectiveness of the CDM project for the project investor within this period. For the same purpose, the project owner may annualize the incremental costs over the whole life cycle beyond 2012, as his planning horizon is much longer.

The concept of ICER is the uniform basis for all six case studies, while the specific calculation methods may slightly differ according to their special circumstances. *Table 2.8* gives an overview of the yearly incremental costs for emission reduction (ICER) and net present value of the total ICER (ICERT) calculation in the six case studies. Five of six case studies use the general concept. The tri-generation case study, however, has to apply an arithmetical mean concept as there is a different baseline for power generation and for the heat generation in winter and cooling generation in summer.

The ICER calculation method is based on the normal project financial analysis method rather than the economic analysis of a project. In this context, some external benefits and costs, such as social and local environmental costs and benefits which may be available qualitatively only, are not estimated in the calculation of project-based incremental emission reduction cost, while these benefits could be taken into account in the economic analysis of a project. This is also because that the cost associated with emission reductions is calculated from the project proponents' perspective, while in China, most of the external benefits achieved by a project activity could not be internalized, due to the lack of necessary market or administrative measures.

ICER can provide some important information related to the cost effectiveness of a CDM project to both project developers and policymakers, although the ICER is not always the most important consideration for CDM project developers. The parameters related to the direct cost components can be presented as following:

$C_{cdm}DCT$, the total discounted direct cost of the CDM project activity can be broken down into initial capital investment cost and operational cost. The operational cost can be further broken down into sub-components, including energy cost, maintenance cost, labor cost, and other operational cost, as defined in the formula (2-9)

$$C_{cdm}DCT = \sum_{i=1}^{N} \frac{\begin{pmatrix} C_{cdm}INV_i + C_{cdm}ENE_i \\ +C_{cdm}MNT_i + C_{cdm}LAB_i \\ +C_{cdm}OTR_i \end{pmatrix}}{(1+r)^i} \qquad (2\text{-}9)$$

in which

$C_{cdm}INV_i$ represents annually averaged capital investment cost of the CDM project in the i[th] year;

TABLE 2.8 Calculation of ICER and ICERT in the Case Studies

No.	Case Study	ICER	ICERT	Approach
1	Qinbei Supercritical Coal-Fired Power Plant	$ICER = \frac{(C_{cdm}DCT - C_{bsl}DCT)}{ER}$	$ICERT = \sum_{i=1}^{N} \frac{(C_{cdm}DC_i - C_{bsl}DC_i)}{(1+r)^i} = \sum_{i=1}^{N} \frac{ICER_i \times ER_i}{(1+r)^i}$	General approach
2	Beijing Electronic City Tri-generation[1]	$ICER = \sum_{j=1}^{2} \frac{(C_{cdm}DCT_j - C_{bsl}DCT_j)}{ER}$	$ICERT = \sum_{j=1}^{2} \sum_{i=1}^{2} \frac{(C_{cdm}DC_{i,j} - C_{bsl}DC_{i,j})}{(1+r)^i} = \sum_{i=1}^{2} \sum_{j=1}^{N} \frac{ICER_{i,j} \times ER_{i,j}}{(1+r)^i}$	Arithmetrical mean approach
3	Beijing No.3 Thermal Power Plant	$ICER = \frac{(C_{cdm}DCT - C_{bst}DCT)}{ER}$	$ICERT = \sum_{i=1}^{N} \frac{(C_{cdm}DC_i - C_{bsl}DC_i)}{(1+r)^i} = \sum_{i=1}^{N} \frac{ICER_i \times ER_i}{(1+r)^i}$	General approach
4	Shanghai Wind Farm	$ICER = \frac{(C_{cdm}DCT - C_{bsl}DCT)}{ER}$	$ICERT = \sum_{i=1}^{N} \frac{(C_{cdm}DC_i - C_{bsl}DC_i)}{(1+r)^i} = \sum_{i=1}^{N} \frac{ICER_i \times ER_i}{(1+r)^i}$	General approach
5	Taicang Xin Tai Alcohol Co. Ltd.[2]	$ICER = \frac{(C_{cdm}DCT - C_{bsl}DCT)}{ER}$	$ICERT = \sum_{i=1}^{N} \frac{(C_{cdm}DC_i - C_{bsl}DC_i)}{(1+r)^i} = \sum_{i=1}^{N} \frac{ICER_i \times ER_i}{(1+r)^i}$	General approach
6	Zhuhai Landfill Gas Recovery	$ICER = \frac{(C_{cdm}DCT - C_{bsl}DCT)}{ER}$	$ICERT = \sum_{i=1}^{N} \frac{(C_{cdm}DC_i - C_{bsl}DC_i)}{(1+r)^i} = \sum_{i=1}^{N} \frac{ICER_i \times ER_i}{(1+r)^i}$	General approach

1) Generation of heat in winter and cool in summer.
2) In the biogas case study, the transaction costs been taken into account. For the calculation of the ICER and ICERT, the formula has to be extended by the respective CTRN term.

$C_{cdm}ENE_i$ represents energy cost of the CDM project in the ith year;

$C_{cdm}OTR_i$ represents other operational cost in CDM project in the ith year;

$C_{cdm}MNT_i$ represents maintenance cost of the CDM project in the ith year;

$C_{cdm}LAB_i$ represents labor cost of the CDM project in the ith year; and

r represents real discounted rate;

i represents the *i*th year in the life time of the CDM project.

Similarly the total discounted direct cost of the baseline scenario can be broken down as defined in formula (2-10)

$$C_{bsl}DCT = \sum_{i=1}^{N} \frac{\begin{pmatrix} C_{bsl}INV_i + C_{bsl}ENE_i + \\ C_{bsl}MNT_i + C_{bsl}LAB_i \\ +C_{bsl}OTR_i \end{pmatrix}}{(1+r)^i} \quad (2\text{-}10)$$

in which the sub-components are defined as the same as in the formula (2-3) but with footnotes for the baseline scenario.

Formula (2-9) and (2-10) show that the energy cost will affect the direct cost for a CDM project and the baseline scenario. If the energy price is subsidized, the application of the distorted energy price in the calculation will affect the result of project-based incremental emission reduction costs. Generally speaking, if the fuel price in the baseline scenario is subsidized, the incremental reduction cost will be overestimated. On the other hand, if the fuel price in the CDM project is subsidized, the project reduction cost will be underestimated. So the sensitivity analysis would be very useful to assess the impact of the key price parameters on the competitiveness of a CDM project.

Parameters related to transaction cost components

Several NSS country studies and UNFCCC reports on AIJ and CDM have identified transaction costs as one of the major obstacles to access the potential benefits from a CDM project. The process to develop simplified modalities and procedures for a small-scale CDM project also supports the above argument.

The transaction cost is a commonly used economic term to measure the costs incurred during the business trade process. It may involve different components in different business contexts. From a practical point of view, in a CDM project the transaction cost could include those costs incurred during the whole CDM project cycle for the purpose of the CERs transaction, such as project search cost (CSER), project documents development cost (CPDD), negotiation cost (CNEG), validation cost (CVAL), registration cost (CREG), monitoring cost (CMON), verification and certification cost (CVER), and share of proceeds for adaptation (SOPA).[2] Therefore, the total transaction cost for a proposed CDM project can be calculated as in formula (2-11)

$$\begin{aligned} CTRN &= CSER + CPDD + CNEG \\ &\quad + CVAL + CREG + CMON \\ &\quad + CVER + SOPA \end{aligned} \quad (2\text{-}11)$$

"Anaerobic Treatment of Effluent and Power Generation in Taicang Xin Tai Alcohol Co. Ltd." project was taken as an example to estimate the transaction cost of a CDM project activity.[3] The estimation of the transaction cost was mainly based on results of a questionnaire survey among the technical experts involved in this project. The results are listed in *Table 2.9.*

The result shows that the transaction cost for even this small- to medium-sized project is still rather high, at least currently—about \$0.80/tCO_2e at current value. However, it is expected that the transaction cost will decrease with more experience in the future, and will be reduced to about \$0.60/t-CO_2 e for this kind of project.

The transaction cost associated with a CDM project activity depends on various factors, including the scale of the project (Michaelowa and others 2003), the specific technology applied, and whether suitable approved methodologies are already available. Considering that this case

TABLE 2.9 Estimation of Transaction Cost of CDM Project Activity (US$)

Item		Present Cost level (US $)	expected cost level in 2008–2012 (US$)
Once	Project search cost	35,000	15,000
	Project documents development cost	33,000	20,000
	Negotiation cost	30,000	10,000
	Validation cost	22,000	15,000
	Registration cost	10,000	10,000
Annual	Monitoring cost	50,00	5,000
	Verification and certification cost	8,000	8,000
	Share of proceeds for adaptation	2,000*	2,000
Discounted total transaction cost		225,203	165,203

Source: GCCI estimates. This is estimated with the assumption of a price of \$3.6/t-CO_2 e.

is a rather small CDM project, the transaction cost estimate may not be suitable for projects of other types or scales. It is clear that transaction cost will be one of the significant barriers for CDM project development, and that the transaction cost of CDM projects will decrease with time, experience, and the availability of more approved methodologies. It should be noted that the transaction cost considered in this component is not exhaustive, and some elements associated with the transaction cost (such as host country approval cost) are not discussed here.

Assessment of Proposed Calculation Approaches and Procedures

The calculation method for the incremental cost of the emission reduction of a CDM project can be traced back to the incremental cost approach developed by the Global Environment Facility (GEF).

To design the financial mechanism, GEF financed a program called PRINCE, or the Program for Measuring Incremental Cost for the Environment. The incremental cost approach is applied in cost-benefit analysis and project economic analysis when environmental benefits are achieved. Based on the PRINCE work, GEF developed an incremental cost approach for GHG emission reductions (Mintzer 1993).

The incremental cost approach for GHG reductions has been applied to GEF-funded projects since 1993. In a working paper, King (1995) pointed out that "international financing for only the net incremental cost of a project with both domestic and global benefits is the cost allocation rule that requires the lease amount of international finance."

Participants in AIJ projects also applied the incremental cost approach for GHG emission reductions during the AIJ Pilot Phase (AIJPP).

There are various GHG emission reduction cost calculation methods, with different pros and cons, but the incremental cost method (ICER) is straightforward, practical, financially workable, and widely used by the project developers and investors in the CDM project evaluation. Whichever method is used, revenue from CERs trading is mainly determined by carbon market prices.

The procedure for calculation of the ICER could be summarized as following:

- Calculate the total direct production cost of the proposed CDM project

- Determine the reasonable baseline scenario, keeping in mind that the baseline scenario should provide the same production/service level as the CDM project activities
- Calculate the total direct production cost in the baseline case
- Calculate the GHG emission reductions over the lifetime of the project
- Calculate the incremental cost associated with the production of emission reductions for the proposed CDM project over its lifetime
- Calculate the averaged incremental cost per unit of the emission reductions for the proposed CDM project
- Estimate the transaction cost for the proposed CDM project.

Recommendations

Using an appropriate method to calculate the cost of the emission reductions accrued from CDM project activities is critical to measure the cost effectiveness of CER trade. We recommend using the ICER method. The ICER method combined with other financial indicators—such as NPV, IRR, payback period, and CERs price—could provide key messages on the financial performance of the CDM project and its attractiveness to CDM investors. In particular, these financial indicators could show the competitiveness of the proposed CDM project compared with the baseline scenario, which is helpful to demonstrate the additionality of the CDM project activity.

CDM project activities may be parts of a large project, with the other parts having nothing to do with GHG emission reductions. In this case, the project boundary should be well defined to exclude those non-CDM parts of the large project, and the domestic cost and benefits of those parts are also excluded from ICER calculation.

Although there are many uncertainties in the estimation of the transaction cost, the analysis and the current exercise show that there are many factors existing in the CDM project cycle that may result in high transaction costs, considering the complexity of the CDM regime. We recommended that the CDM methodologies should be simplified and standardized in order to reduce the transaction cost.

The marginal abatement cost (MAC) approach is also used in Chapter 4 to analyze the incremental cost of GHG emission reductions. The MAC approach is at a macro level, whereas the ICER approach is at the project level, and the results gained from these two approaches are different and not comparable. It is worthwhile to understand the differences between them. They use (a) data from different sources and levels; and (b) different cost components for MAC and ICER, thus leading to the different estimates. In addition, they are used for different purposes and have different policy implications.

INSTITUTIONAL ARRANGEMENTS FOR FACILITATING CDM IN CHINA

In order to engage in the CDM, certain institutional prerequisites should be put in place, most notably a designated national authority (DNA) for the approval of CDM project activities. In addition, the policies, procedures, and regulations under which the DNA will operate should be specified.

The CDM market is currently a “buyer’s market” and is expected to remain so for the foreseeable future (see Part II for further information). If it were to seize the opportunity to experiment with the CDM and ultimately play a significant role in this emerging market, China could actively promote the CDM by:

- Ensuring an attractive climate for CER purchase agreements or CDM investment
- Keeping transaction costs as low as possible
- Facilitating the development of viable CDM projects.

This, in turn, may require steps to improve cross-sectoral policy integration across ministries; to adopt conditions (e.g., laws, incentives, standards, training) for the market uptake of advanced technologies, in particular renewable power generation; to provide clear operational procedures for project developers; and to build capacity among the range of societal groups that are part of the CDM process (government, enterprises that emit greenhouse gases, local stakeholders, and financial services companies).

Institutional Prerequisites for the CDM

Countries that wish to engage in CDM projects must have ratified the Kyoto Protocol and appointed designated national authority for the CDM. As part of the required CDM validation process, the DNA of each country involved in the CDM project must provide the project participants written approval of voluntary participation; in the case of host countries, this approval must confirm that the project activity assists the country in achieving sustainable development. It is the prerogative of the host country to select an appropriate DNA and to establish the necessary institutional framework, procedures, and regulations for approval of CDM project activities. Considerable general guidance is available on the criteria, requirements, and process for designating the national authority (see, for example, IISD 2002).

The Chinese Government approved the Kyoto Protocol in August 2002. To facilitate CDM project activities in China, Chinese government agencies have already formulated *Interim Measures for the Management of CDM Project Development.* It is expected that these measures will be published during the first half of 2004.[5] According to this proposal, various agencies will be involved in the management of CDM in China. In general, three levels of responsibility are foreseen:

(1) National Coordination Committee for Climate Change (“the Committee”)

The NCCCC is a high-level, inter-agency Committee, comprised of representatives of 15 government agencies.4 This committee was founded in 1990, reorganized in 1998, and is responsible for the formulation and coordination of China’s important climate change-related policies and measures at the strategic level. Currently, the chairman of the National Development and Reform Commission (NDRC) serves as the head of the committee, and the committee office is located in NDRC. With respect to CDM, the committee is responsible for the review and coordination of important CDM policies and measures, which, according to the Interim Measures includes:

- Review of China’s national policies, criteria, and standards on CDM project activity
- Approval of members of the National CDM Project Board (see below)
- Review of other issues, when necessary.

(2) National CDM Project Board (“the Board”)

Under the authority of the NCCCC, the National CDM Project Board has the following main responsibilities:

- Review CDM project proposals and approve CDM projects
- Report to the Coordination Committee on the implementation of CDM project activities and make recommendations
- Put forward China’s rules and procedures for CDM project activities.

The NDRC and the Ministry of Science and Technology (MOST) function as co-chairs and the Ministry of Foreign Affairs (MFA) serves as vice-chair of the Board, which includes four additional government agencies.[6]

(3) Designated National Authority for the CDM (DNA)

According to the proposed measures, NDRC will be designated as the Chinese national authority for the CDM and thus provide official written approval of CDM project activities on behalf of the Chinese Government. However, the NDRC can only issue DNA approval for projects that have been recommended by the Board. Acting as the DNA for the CDM in China, the NDRC is responsible for:

- Acceptance of the CDM project proposal
- preliminary screening of the CDM project proposal
- Approval of CDM project activities, together with the MOST and MFA, according to the review result of the Board
- Issuance of official DNA approval for CDM projects on behalf of the Chinese Government
- Addressing other related foreign affairs.

Interim Procedures for CDM Project Development in China

General requirements

According to the proposed interim measures, China has the following general requirements on CDM project activities to be hosted by China:

- They shall conform to China's sustainable development strategy and policies, as well as the general requirements of economic and social development programs.
- The implementation of CDM project activities in China shall result in no new obligations for China other than those under the Convention and the Protocol.
- They must be approved by the Chinese Government.
- Funds used in CDM project activities from developed country Parties shall be additional to the current ODA and other financial obligations under the Convention.
- They shall promote transfer of environmentally friendly technology.
- Implementation shall ensure transparent, efficient, and traceable responsibilities.
- Currently, the priority areas for CDM cooperation are energy efficiency improvement, renewable energy development, methane recovery, as well as coal bed methane uses.

Application and Approval Procedures

The proposed interim measures stipulate that each potential CDM project shall adhere to the regular Chinese project approval process, in accordance with China's related laws, rules, and regulations. In addition, potential CDM project activities proposed by a project developer are subject to a domestic CDM project approval cycle to obtain official Chinese DNA approval. The approval process includes the following:

a) The project developer submits application for approval of proposed CDM project activity to NDRC, directly or through related agencies and local governments, and also delivers CDM PDDs together with other required materials.
b) NDRC will invite external experts to evaluate the proposed project activities and submit a report to the Board for its approval.
c) The National CDM Project Board reviews CDM project proposal and informs NDRC of eligible projects.

NDRC, MOST, and MFA approve jointly the project activity, and then NDRC issues official approval of the activity and notifies the decision to the project developer. The provisional rules stipulate that the project developer must subsequently sign a contract with a designated operational entity (OE) for independent validation of the proposed project activity. Furthermore, when the project developer receives the registration notice from the CDM Executive Board, it shall notify the government for record-keeping purposes.

According to the proposed measures, the developer of a CDM project to be hosted by China is obligated, inter alia, to:

a) Submit to the NDRC an application for CDM project cooperation, including a CDM PDD and other required materials
b) Report on the construction of the project
c) Implement the CDM project activity, and compile and implement a greenhouse gas emissions monitoring plan and ensure the CERs generated from the project are real, measurable, and additional
d) Provide the necessary material and monitoring records for record-keeping
e) Assist the NDRC and the Board in investigating related issues
f) Protect state secrets and confidential business information.

Implementation and monitoring of CDM project activity

The interim rules further stipulate that, during implementation and monitoring of the CDM project activity: (a) NDRC supervises the implementation of the CDM project activity to improve implementation quality; (b) the CDM project developer shall submit project implementation and monitoring reports; and (c) the NDRC records the CERs issued by the CDM Executive Board to CDM project activities.

Endnotes

1. As in the biogas case study, the average CO_2 intensity of the grid was used, for the calculation of the emission reductions (ER_i) the on-site emissions were denominated with $EMELEC_{bsl,,i}^{on}$, and the emissions in the CDM project denominated with $EMELECC_{cdm,i}$.
2. In this study we have not discussed the transfer cost and registry cost related to CERs trading, which have been discussed by Michaelowa and others (2003) as well as Michaelowa and Jotzo (2003).
3. Since transaction cost is quite uncertain, we just estimate the transaction cost for this case as an example.
4. The agencies are: National Development and Reform Commission, Ministry of Commerce, Ministry of Science and Technology, China Meteorological Administration, Ministry of Foreign Affairs, State Environmental Protection Administration, Ministry of Finance, Ministry of Construction, Ministry of Communications, Ministry of Water Resources, Ministry of Agriculture, State Forestry Administration, Chinese Academy of Sciences, State Oceanic Administration, and Civil Aviation Administration of China.
5. The final interim measures that were adopted by the Chinese Government and went into effect on 30 June 2004 are contained in Annex 4.
6. State Environmental Protection Administration, China Meteorological Administration, Ministry of Finance, and Ministry of Agriculture.

3

Findings from CDM Case Studies

Chapter 3 discusses the six case studies that were part of the China CDM study. Based on the results of the case studies, we make recommendations to facilitate the process of CDM project development in China.

BASIC CONSIDERATIONS: THE POWER MARKET

Current Status of the Power Sector in China

China's installed power capacity in the year 2001 was 338.6 GW, with an annual power generation of 1483.8 TWh. During the 2000–01 period, capacity increased by 6.0 percent and power generation by 8.4 percent. The Government of China is aiming for long-term sustainable development with an average annual growth rate of the economy slightly above 7 percent. It is estimated that the electricity demand growth rate in the future will vary between 5.5 percent and 6 percent annually. Until 2010 the growth rate could be as high as 6.5 percent to 7 percent per year.

China's power sector has been growing rapidly in recent years. The real growth rate of power generation was 9 percent in 2001 and 11.7 percent in 2002. This rate is much higher than the one estimated in the 10th Five-Year Plan. In the summer of 2003, about 20 provinces faced a shortage of electricity, including Guangdong Province, Shanghai City, Jiangsu Province, and Henan Province. Government managers of the power sector are revising the power development plan by adding an extra 30 GW capacity by 2005, which will result in a total generation capacity of 430 GW.

The construction of transmission lines of 35 kV and higher voltage levels reached 7.8×10^5 km in 2001, 7.67 percent greater than 2000. The corresponding transformer capacity rose to 1.1×10^9 kVA, a 12.2 percent increase compared to the year 2000.

In 2001, 81 percent of China's power was generated in coal-fired power plants. The fuel generation mix in each of the areas with potential CDM project activities is given in more detail in *Table 3.1*.

In these areas, coal is the dominant fuel in the power sector. Moreover, there are only a few applications of advanced technologies such as clean coal, nuclear, super-critical coal-fired units, as well as high-voltage DC transmission. The absence of new renewable power generation in the table is due to its very small share within the power generation mix.

The coal intensity and thermal efficiency of coal-fired power generation in these areas (and the respective loss rate for electricity transmission) are shown in *Table 3.2*. The difference between exist-

TABLE 3.1 Shares of Installed Power Capacity and Power Generation in the Provinces where Potential CDM Project Activities are Located (2001)

	Installed Capacity					Annual Generation	
Area	Hydro (%)	Thermal Total (%)	Coal (%)	Gas (%)	Diesel (%)	Hydro (%)	Thermal (%)
North China	6.2	93.8	93.6	0.2	0.0	1.2	98.8
Shanghai	0.0	100	95.1	4.9	0.0	0.0	100.0
Jiangsu	0.2	99.8	99.5	0.3	0.0	0.1	99.9
Henan	13.7	86.3	85.9	0.4	0.0	4.5	95.5
Guangdong	23.0	77.0	53.2	8.4	15.4	14.9	85.1
Average	8.6	91.4	85.5	2.8	3.1	4.1	95.9

Data source: State Power Corporation, Statistics of the Power Sector 2001.

ing thermal efficiency and advanced technology is measurable; for example, a 45 percent efficiency rate for state-of-the-art super-critical thermal generation technology compared to 35.1 percent in the Shanghai area. Transmission losses are 2 to 3 percent higher than those in developed countries.

Power Market Initiatives

China's power sector is presently undergoing an institutional reform that was launched at the end of 2002. Power generation assets, which used to be owned by the former State Power Corporation, are now being separated and assigned to five nationwide operating power generation companies. The grid facilities for electricity transmission and distribution are assigned to the State Grid Corporation and China South Grid Corporation.

Unbundling of power generation from electricity transmission and distribution has provided incentives for the power generation companies to invest in conventional coal-fired power plants. This technology has competitive advantages such as lower fuel costs, a shorter plant construction period, availability of reliable domestic technology, and standard management. The five national-level operating power generation companies have been competing against each other and investing in coal-fired plants all over the country.

Early in 2003, the State Electricity Regulatory Commission (SERC) was set up to shape and oversee the new power market. SERC is charged with:

- Issuing market rules
- Submitting suggestions on price adjustments to the respective governmental pricing departments
- Issuing and managing licenses for power businesses and monitoring the compliance of quality standards
- Resolving disputes between the participants in the power market

TABLE 3.2 Efficiency of Thermal Power Generation and Power Transmission Losses

Area	Coal Intensity (gce/kWhe)	Thermal Efficiency (%)	Transmission Loss Rate (%)
North China	384	32.0	6
Shanghai	350	35.1	7
Jiangsu	378	32.5	8
Henan	410	30.0	7
Guangdong	363	33.8	7
Average	377	33.0	7

Data source: State Power Corporation, Statistics of the Power Sector 2001.

- Monitoring the enforcement of social policy obligations.[1]

SERC also has the leading role for the implementation of the overall power reform and has just completed an initial draft of regional market rules. The Northeast Power Grid and the East Power Grid are the first two pilot grids to establish regional power markets. It is anticipated that—at the national level—separating power generation from the electricity grid will be achieved during the 10th Five-Year Plan (that is, by 2005). The set-up of regional power markets will follow thereafter.

According to the market rules, power generating companies will compete on the basis of merit order in the power market. Government subsidies are considered discriminatory interventions that could injure the fairness of the market. For renewable energy, such as wind farms, the removal of the subsidy will place an additional financial burden on the investor; that is, higher power production costs would lead to higher marginal abatement costs for a CDM project activity. Competition will also be a big challenge for natural-gas-fired power plants because of the present high price level of natural gas.

Technological Upgrade Priorities

To meet increasing electricity demand, while at the same time dealing with the challenges of protecting the domestic and global environment, options exist to increase the share of less-polluting power generation technologies and improve the efficiency of power generation, transmission, distribution, and consumption. The government plans to optimize the structure of thermal plants with respect to unit mix, technology, and geographic distribution and to support technological upgrades and rehabilitation.

The number of small coal-fired power units will be reduced. The current policy is aiming for a total reduction of 25 GW. Conventional small thermal units are controlled strictly in order to improve the share of large units with better characteristics. Active promotion of cogeneration and multi-purpose generation will help to improve the urban environment and energy efficiency. Additional power plants will be 300 MW and larger units with high parameters, efficient, and quality performance. Power plants located close to mines will be constructed in Shanxi, Inner Mongolia, and other energy bases in northwest China. These plants will transmit power to the east and coastal provinces, optimize resource allocation in a broader domain, and facilitate national wide interconnection. The government will introduce super critical units as well as clean coal generation projects, such as Circulating Fluidized Bed Combustion (CFBC) and other technologies. Introduction and digestion of external advanced technologies will speed up the pace of domestic industrialization of CFBC boilers and desulphurization equipment.

Major Characteristics of the Power Sector Relevant for CDM

Based on present knowledge and the likely development of the power market, *Table 3.3* provides some major findings and conclusions regarding promising starting points for CDM project activities. The case studies in this report help to validate these preliminary findings and conclusions.

SELECTION OF CASE STUDY PROJECTS

Approach

The case study projects were selected in four steps:

1. Compilation of a long list with potential CDM projects. The respective projects were selected by expert recommendations from the power and renewable sector, and are also based on suggestions from governmental authorities and CDM experts. Furthermore, the results of

TABLE 3.3 Major Characteristics of Power Sector Relevant to CDM

Findings	Conclusions
Coal dominates as fuel for power generation. Gas as a fuel at present (2004) is about three times more costly.	Gas as fuel for power generation is most likely not to be baseline. However, there are some natural gas fired power plants. Therefore, natural gas may be part of a baseline in specific cases, e.g. because of dispatch arrangements or political incentives.
Several different companies are in charge of the operation of power generation plants as well as electricity transmission and distribution.	The new ownership arrangement within the power sector may make the coordination of future CDM project activities more challenging. On the other hand, the entry of private sector participants may also be an opportunity for CDM.
Power grids are increasingly interconnected nationwide.	Baseline definition and displaced power emission factors have to take into account inter-provincial and maybe national interconnections, not only local power generation facilities.
Removal of subsidies for renewable energy in the power market will result in higher power generation costs for renewables and higher prices for the respective electricity.	In terms of CDM, this would lead to higher abatement costs for renewable energy, but it would also mean a higher probability for renewable energies to qualify for CDM, i.e. to qualify as additional.
Because of the ongoing new organization of the power market (unbundling, more companies) and the not-yet established market rules, it is for the time being difficult to predict the behavior of market stakeholders.	For an interested international investor these uncertainties may be perceived as risk and provide a barrier until stable, more predictable circumstances exist. Also, the projection of ex-ante electricity emission factors may be more difficult.
The reform of the power market may lead to more competition between power generation companies. This means an increased focus and incentive for cost-effective power generation. At present, this favors coal-fired power plants (coal-fired power plant technology is proven, domestically available, and offers comparatively low fuel costs).	There is a high probability that coal-fired power plants will be a baseline for the coming years. However, this may differ from province to province, depending mainly on the local availability of coal as fuel. Therefore, the priority for potential CDM project activities might be switching to cleaner fuels (natural gas) in conventional power generation or to new renewable power generation technologies such as small hydro, wind farms, biomass digestion etc.
According to the current policy, additional power plants will be based on 300 MW and larger units. The number of existing small coal-fired power units will be reduced.	Small- and medium-sized power generation units, e.g. for renewable power plants, have a good probability not to be baseline and to qualify as additional.
In recent years power demand has rapidly increased in response to the rapid growth of the economy. A strong increase in power demand is also expected in the coming years.	New, additional power plant capacity will be needed and built. Therefore, CDM approach 48.a seems not to be the appropriate baseline approach.

former research work, such as country studies and ALGAS, have been taken into account.
2. Uniform description of the CDM project activities on the long list. Data and information were gathered to compare the projects.
3. Development of a set of criteria to assess potential CDM projects.
4. Evaluation of potential CDM projects by applying the selection criteria. The 25 projects were rated by applying a set of criteria. The projects were evaluated and rated by 15 experienced experts. The ranking of the projects is based on professional judgment, the defined (weighted) criteria, and takes into account China's specific conditions.

Long List for the Identification and Selection of CDM Case Study Projects

The 25 possible CDM projects are listed by their technology categories in *Table 3.4*. The three categories are:

1. *Power generation by gas-steam combined cycle technology.* Gas-steam combined cycle plants can achieve efficiencies up to 60 percent, the highest in the power sector today. In most cases, natural gas will be used as fuel. If such plants replace coal-fired power plants, CO_2 emissions are further reduced due to the lower carbon content of the fuel. The investment

TABLE 3.4 List of 25 Potential CDM Project Activities by Technology Category

No.	Project	Project Site	CDM Project Activity Characteristics	Range of Abatement Costs[1)] [US\$/CO_2]	Replication Potential until 2012[2)]
I. Gas-Steam Combined Cycle for Power Generation Projects					
1	The Second Phase of Gas-Steam Combined Cycle for power generation project in Beijing Third Thermal Power Plant	Yungan, Changxindian, Beijing	2×300 MW Gas-Steam CC Generating, Units 1×300 MW unit will be built in the first phase, with the annual gas consumption of 2.67×10^8 Nm^3	15	3
2	Beijing "Electronic City" CHP tri-generation project	Jiuxianqiao, Chaoyang District, Beijing	2×42 MW gas turbine generating units	25	3
3	Beijing Caoqiao Gas-Steam Combined Cycle for Power Generation	Caoqiao Village, Flower Township, Fentai District, Beijing	2×200 MW Gas-Steam CC Generating units	10–20	3
4	Lanzhou Gas-Steam Combined Cycle for Power Generation project	Lanzhou of Gansu province	Total installed capacity will be 1.2 GW, 4×300 MW gas-steam combined cycle generating units will be installed	10–18	3
5	Gas-Steam Combined Cycle for Power Generation project of Tianjin First Thermal Power Plant	Tianjin 1st Coal Gas Plant	1×300 MW gas-steam combined cycle generating units	10–20	3

(*continued*)

TABLE 3.4 List of 25 Potential CDM Project Activities by Technology Category (*Continued*)

No.	Project	Project Site	CDM Project Activity Characteristics	Range of Abatement Costs[1)] [US\$/CO_2]	Replication Potential until 2012[2)]
6	Xiaoshan Zhejiang Gas-Steam Combined Cycle for Power Generation	Xiaoshan City, Zhejiang Province	2 × 300 MW gas-steam combined cycle generating units	10–20	3
7	Zhengzhou-Henan Gas-Steam Combined Cycle for Power Generation	Zhengzhou Thermal Power Plant	2 × 300 MW gas-steam combined cycle generating units	10–20	3
8	Qinzhou-Guangxi Gas-Steam Combined Cycle for Power Generation	Qinzhou, Guangxi Province	1.4 GW gas-steam combined cycle generating units	10–20	3
9	Jingbian-Shaanxi Gas-Steam Combined Cycle for Power Generation	Jingbian, Shaanxi Province	2 × 300 MW gas-steam combined cycle generating units	10–20	3
II. Coal-Fired Super-Critical Power Generation Projects					
10	Second Phase of the Huaneng-Qinbei Super-critical Power Plant	Jiyuan City, Henan Province	2 × 600 MW coal-fired super-critical power generating units will be installed in two phases	8.5	4
11	Wangqu Super-Critical Coal-fired Power Generation	Changzhi City, Shanxi Province	2 × 600 MW super-critical generating units will be installed in the first-phase project	12–20	4
12	Nanyang-Henan Yahekou Super-Critical Thermal Power Plant	Yahekou, Nayang County, Henan Province	2 × 600 MW super-critical coal-fired power generation	8–18	4
13	Suizhong-Liaoning Super-Critical Thermal Power Plant	Suizhong, Liaoning Province	3.2 GW, 2 × 800 MW super-critical generating units will be installed in the first phase	12–20	4
III. Renewable Energy Case Projects					
14	Beijing Chaoyang Garbage-incinerating Power Generation	Gaoantun, Chaoyang District, Beijing	Garbage disposal amounts to 1600 tons/day in the first-phase project, a 25 MW generating unit. The annual electricity supply to the grid is 225 GWh.	25–40	4

(*continued*)

TABLE 3.4 List of 25 Potential CDM Project Activities by Technology Category (*Continued*)

No.	Project	Project Site	CDM Project Activity Characteristics	Range of Abatement Costs[1)] [US$/$CO_2$]	Replication Potential until 2012[2)]
15	Harbin Garbage-incinerating Power Plant	Harbin City, Heilongjiang Province	Garbage disposal amounts to about 3,500 tons/day in the second phase	25–40	4
16	Kunming Urban Garbage-incinerating Power Generation	Kuming City, Yunnan Province	Garbge disposal amounts to 1,000 tons/day; annual electricity generation amounts to 70 GWh	25–40	4
17	Shijiazhuang Urban Garbage-incinerating Power Generation	Shijiazhuang City, Hebei Province	The plant occupies an area of 6.26 ha, the garbage disposal capacity can amount to 450 tons/day in the first-phase project, and the annual electricity generation will be 61.20 GWh	25–40	4
18	Nanhui and Chongming Wind Farm	Nanhui County and Chongming County of Shanghai	Capacity 20–40 MW, annual electricity generation is 46 to 92 GWh	50	3
19	Biogas Electricity Generation in Taicang Alcohol Production Company	Taicang City, Jiangsu Province	Biogas production is 45,000 m^3/day and electricity generation is 26 GWh	22	3
20	Guangzhou gasification based biomass power generation	Guangzhou City of Guangdong Province	10 MW (a package of five 2 MW projects), annual electricity generation is 46 to 92 GWh	15–22	3
21	Haikou Anaerobic Digestion of Pig Breeding Farm Waste for Power Generation	Haikou City of Hainan Province	700 kW, annual electricity generation is 4.75 GWh	20–28	4
22	Heilongjiang Gasification Based Biomass Power Generation	Heilongjiang Province	4 MW (a package of four 1 MW projects), annual electricity generation is 20 GWh	28–36	3
23	Guangdong Bagasse Cogeneration	Guangdong Province	Sugar Mill Capacity 3,000 tons/day	20–40	3

(*continued*)

TABLE 3.4 List of 25 Potential CDM Project Activities by Technology Category (*Continued*)

No.	Project	Project Site	CDM Project Activity Characteristics	Range of Abatement Costs[1] [US$/$CO_2$]	Replication Potential until 2012[2]
24	Xingfeng of Guangdong Landfill Methane Recovery for Power Generation	Guangdong Province	20 × 0.97 MW Landfill methane recovery for power generation	8–20	4
25	Landfill Gas Recovery for Power Generation	Zhuhai City, Guangdong Province	2 × 0.97 MW Landfill methane recovery for power generation	5	4

1) Estimated range of abatement costs based on present state of knowledge and on the results of the case study projects considering different, site-specific conditions. Each specific, potential CDM project activity has to be looked at separately and the specific abatement costs may differ from those stated above.
2) 4 very high replication potential, 3 high replication potential, 2 medium replication potential, 1 low replication potential

cost of combined cycle plants is lower than the cost of coal-fired plants with the same capacity, which makes this technology economically attractive.

2. *Power generation by coal-fired super-critical technology.* Advanced super-critical hard-coal-fired steam power plants are still built and in operation with net efficiencies of up to 46 percent depending on site-specific conditions, including environment protection measures. Further improvement potential is expected by applying ultra super-critical live steam parameters (over 30 MPa and 700°C, double reheating). As hard-coal is (and will be) the main primary energy carrier in China in the future, in particular for large power plants, increasing the efficiency of coal-fired power plants has significant benefits in terms of environmental protection and CO_2 emission reductions.
3. *Power generation by renewable energy technologies.* One main characteristic of renewable energy power plants is that CO_2 emissions and fuel costs in most cases are zero. Municipal solid waste incineration plants use the energy in the waste to generate power and help save land resources by reducing the need for landfills. Centrally located municipal solid waste incineration plants can be built as power generation plants only, as well as cogeneration plants for district heating. Renewable energy power plants based on wind, photovoltaic, biomass, and landfill gas are of small capacity in comparison to fossil fuel-fired power plants, and therefore are normally not centrally located. The power generation costs are mainly determined by investment costs, the lifetime of the plants, and the operational hours. In the case of photovoltaic and wind plants, the operational hours are determined by the solar irradiation and the wind situation.

Criteria for the Evaluation of Projects on the Long List

For the compilation of the project pipeline as well as for the selection of the case study projects, we applied a multi-factor methodology. The criteria focused on those projects that could a) qualify for CDM; b) get the support of national authorities and stakeholders; c) interest international investors; and d) be good candidates for case studies. The respective criteria are given in *Table 3.5.*

Selection of Promising CDM Projects from the Long List

Table 3.6 provides the result of the CDM project activity evaluation. The selection is basically the result of domestic expert judgment. The consulted experts are experienced and have taken into account China's specific conditions for their judgment.

As mentioned above, the ranked projects on the long list are also the basis for the selection of the projects for the case studies. The first six CDM projects are taken for case studies.

Major Findings

In the course of identifying promising CDM project activities and their subsequent evaluation, there were several challenges.

- *Provincial- and city-level authorities are not yet fully aware of CDM opportunities.* Most energy generation projects have to be approved by public authorities such as the SDRC. In their decision process on projects, authorities do not take into account the possibility of additional revenues through the generation and selling of CERs. Therefore, projects that become viable only with the inclusion of CER revenues are not approved because public authorities are unaware of the additional revenue streams from CDM. This significantly reduces the number of candidate CDM projects in China.
- *It is difficult to obtain essential data to describe and evaluate potential CDM projects.* In order to have a sound basis for the project description, specific information and data are needed that usually only the potential project host can provide. For several reasons, this was difficult. First, since the Kyoto Protocol has not yet entered into force, some of the stakeholders prefer to wait and see if CDM will take off. Second, some of the potential project hosts prefer an earlier return on their up-front investment. The time between the revenues from CER and the initial investment is considered too long. Third, the CDM project cycle is regarded as very complex, requiring much effort and high transaction costs.
- *Close cooperation with the project host is mandatory.* Contact and cooperation with possible project hosts is a prerequisite to get adequate information and data needed for the identification of possible CDM project activities or its validation. In order to build up a reasonable and representative portfolio of candidate projects, industry and technology providers have to be informed of the opportunities for additional revenue streams from the CDM.
- *Knowledge of CDM within China is concentrated in major cities on the east coast.* CDM activities, related know-how, and awareness are concentrated in eastern cities. Moreover, CDM at present is mainly a topic within national-level institutions; there is little discussion at the provincial and local levels. This reduces the potential for dissemination of CDM project activities in the country.
- *Using synergies among ongoing CDM activities has significant potential for capacity building and the transfer of knowledge.* At present, many CDM activities are taking place in China involving many institutions and foreign donors. There is great potential in coordinating and using synergies among these activities to share know-how and lessons learned. Establishing a regulatory process would provide a much stronger basis for CDM project development in China.

BRIEF DESCRIPTION OF THE SIX CASE STUDY PROJECTS

This section describes the main characteristics of the case study projects. For more detailed infor-

TABLE 3.5 Set of Criteria for the Evaluation of Promising CDM Projects

ID	Criteria	Notes
I. CDM Eligibility		
1	GHG emission reduction	CDM case project activities should bring about real, measurable, and long-term reductions in GHG emissions. The GHG emission reductions of the CDM case project activity must be justified as additional to what would occur in the absence of the CDM project activity.
2	Investment barrier	The financial performance of the CDM case project investment is not competitive with the baseline, unless the additional investment from CDM investors is involved with CERs as a return. The CERs are not funded by ODA or GEF funds.
3	Market penetration of the technology in China	The technology to be applied in the CDM project activity is internationally proven technology but has not yet been commercialized and is not prevalent in China.
II. National Perspective		
4	Suitability to national sustainable development strategy[1]	The CDM project technology should be compatible and supportive of the priority strategy of sustainable development for the power sector or/and other sectors.
5	Significant GHG emission reduction potential	The CDM project technology should have a large replication and market potential in China, as well as a significant GHG emission mitigation potential.
6	Technology and know-how transfer	The CDM project activity should be a demonstration to promote technology transfer and its localization in China.
7	Local environmental benefits	The CDM project activity should generate strong local environmental benefits, such as a reduction in emissions of SO_2, NOx, and TSP, and the conservation of natural resources like land and water.
8	Local social benefits	The CDM case project activities should contribute to social acceptance and development through the creation of jobs, amelioration of working conditions, as well as safety, training, and capacity building.
III. International Investors' Perspective		
9	Low marginal incremental reduction costs	One important factor to attract interest from the side of international investors is competitive marginal incremental abatement costs of GHG emission reductions and CER prices.
10	Creating a good image	The CDM project activity should put international investor in a positive light. The engagement in CDM project activities can be used for communication in order to create a good image, especially in the present early phase of the emerging CDM market.
11	Low project risk	In order to get a CDM deal, the risk perception of interested international stakeholders is a key issue. The project should have a high probability to actually generate the expected amount of CERs. This risk includes aspects such as reliability of the technology, capability of management and operation staff, and financial status of the project host.
IV. Project Developer's Perspective		
12	Project progress status	Those projects that have normally received preliminary approval by the state governing body.
13	Project developer's interest	The preliminary information on technological and economic aspects of the projects should be available; developers would like to provide this information for CDM assessment.

1) Sustainable strategy according to the 10th Five-Year-Plan (2001-2005): i) Adhering to the basic state policy on family planning. ii) Protecting natural resources and using them properly. iii) Improving ecological conservation and strengthening environmental protection.

TABLE 3.6 The Ranked Projects and the Pipeline of CDM Project Activities

Ranking	No.	Project Name	Project Description	Score
1	2	Beijing "Electronic City" CHP	2 × 42 MW Natural gas-steam combined cycle tri-generation	5.00
2	18	Nanhui and Chongming Wind Farm	20 MW wind farm	4.92
3	1	Second phase of Beijing Third Thermal Power Plant	1 × 300 MW Natural gas-steam combined cycle	4.90
4	25	Landfill Power Generation in Zhuhai City	2 × 0.97 MW landfill methane recovery for power generation	4.88
5	19	Biogas Power Generation in Taicang Alcohol Production Company	4.1 MW biogas power generation	4.85
6	10	Second phase of Huaneng-Qinbei Thermal Power Plant	2 × 600 MW coal-fired super-critical power generating units	4.78
7	22	Heilongjiang biomass gasification for power generation	4 MW (4 × 1 MW) biomass gasification for power generation	4.72
8	3	Beijing Caoqiao Gas-Steam Combined Cycle for Power Generation	2 × 200 MW gas-steam combined cycle power generation units	4.70
9	4	Lanzhou Natural Gas-Fired Power Plant	4 × 300 MW gas-steam combined cycle power generation units	4.70
10	21	Haikou anaerobic digestion of pig breeding farm waste for power generation	700 kW; annual power generation is 4.75 GWh	4.66
11	5	Tianjin First Thermal Power Plant	1 × 300 MW gas-steam combined cycle generating units	4.60
12	20	Guangzhou biomass gasification for power generation	10 MW (5 × 2 MW); annual electricity generation is 46–92 GWh	4.52
13	6	Xiaoshan, Zhejiang Gas-Steam Combined Cycle for Power Generation	2 × 300 MW gas-steam combined cycle generating units	4.50
14	24	Guangdong Landfill Methane Recovery for Power Generation	20 × 0.97 MW landfill methane recovery for power generation	4.48
15	23	Guangdong Bagasse Cogeneration	Sugar Mill Capacity 3'000 tons/day	4.46
16	7	Zhengzhou-Henan Gas-Steam Combined Cycle for Power Generation	2 × 300 MW gas-steam combined cycle generating units	4.40
17	8	Qinzhou-Guangxi Gas-Steam Combined Cycle for Power Generation	1.4 GW gas-steam combined cycle generating units	4.40
18	9	Jingbian-Shaanxi Gas-Steam Combined Cycle for Power Generation	2 × 300 MW gas-steam combined cycle generating units	4.40
19	15	Second phase of Harbin Garbage-incinerating Power Generation	Waste disposal quantity 3'500 tons/day for power generation	4.38
20	16	Kunming Urban Garbage-incinerating Power Generation.	Waste disposal quantity 3'000 tons/day for power generation.	4.38
21	12	Nanyang-Henan Yahekou Thermal Power Plant	2 × 600 MW super-critical coal-fired power generation	4.29
22	17	Shijiazhuang Urban Garbage-incinerating Power Generation	Waste disposal quantity to 450 tons/day (1. Phase); power generation will be 61.20 GWh/a	4.28
23	13	Suizhong-Liaoning Thermal Power Plant	2 × 800 MW super-critical generating units	3.99
24	14	Beijing Chaoyang Garbage-incinerating Power Generation	Waste disposal quantity 1300 tons/day (1. Phase), 25 MW generating unit, Power generation 136 GWh/a.	3.56
25	11	Wangqu Super-Critical Coal-fired Power Generation	2 × 600 MW super-critical generating units will be installed in the first-phase project	3.37

mation, see the case study reports in Annex 1 on the CD-ROM. The six case study projects are:

- *Case 1. Huaneng-Qinbei Supercritical Coal-Fired Power Project (Phase II).* In case 1, the super-critical coal-fired generators are used to replace common sub-critical generators. Emission reductions are caused only by increasing generating efficiency. Therefore, the declining fuel rate is the key measure to increase CERs.
- *Cases 2 and 3. Beijing Dianzicheng Gas-fired Combined Cycle Tri-generation Project; Gas-Steam Combined Cycle Power Project (Phase II) in Beijing No.3 Thermal Power Plant (BJ3TPP).* In cases 2 and 3, coal-fired generators will be replaced by gas-fired generators with low carbon fuel. These two CDM projects realize emission reductions through fuel switching and efficiency increases.
- *Case 4. Shanghai Wind Farm Project (Phase II).* Case 4 uses wind as renewable energy for power generation to substitute coal to reduce CO_2 emissions. For renewable energy generation CDM projects, the annual full load operating time is one of the most important impact factors affecting emission reductions.
- *Case 5. Anaerobic Treatment of Effluent and Power Generation in Taicang Xin Tai Alcohol Co. Ltd.* Case 5 uses biogas as renewable energy for power generation to substitute coal to reduce CO_2 emissions. For renewable energy generation CDM projects, annual full load operating time is one of the most important impact factors affecting emission reductions.
- *Case 6. Landfill Gas Recovery Power Generation Project in Zhuhai, Guangdong Province.* Case 6 is a project that captures CH_4 produced in a landfill. The CH_4 is used as fuel for power generation. This power will replace coal-fired electricity and therefore reduce CO_2 emissions. In this project, developing advanced CH_4 recovery technology can increase CERs.

Huaneng-Qinbei Super-Critical Coal-Fired Power Project (Phase II)

Project information. This project is a coal-fired super-critical steam power plant with an installed capacity of 2×600 MW and a net efficiency of 41.37 percent. The main steam pressure and temperature are 24.2 MPa and 566°C respectively. It is a copy of the Phase I plants, which are still under construction. The Phase I plants will be erected partly by imported technology with the assistant of foreign companies, whereas the Phase II plants will be erected by domestic industry completely. Sulfur oxide as well as nitrogen oxide reduction facilities are not applied. Besides a further increase of the live steam parameters to around 30 MPa and 610°C (up to efficiencies of about 45 percent), the application of environmental protection measures provides the potential for further improvements. For more information, see the case study report in Annex 1.

Baseline setting. For a fair comparison with the state-of-the-art technology in China, we used a sub-critical coal-fired power plant with a net efficiency of 35.4 percent that could currently be erected by domestic industry.

Crediting period. Due to the expected rate of enhancement of the power plant capacity and uncertainty of the rate of improvement in technology in China, we chose a crediting period of 3 × 7 years. This provides flexibility to readjust the annual amount of CO_2 emission reductions and the incremental cost of emission reductions.

Major parameters and results are shown in *Table 3.7*.

Monitoring plan and activity. In this project the monitoring process will be based on measurements. Therefore, the annual coal input and the net electricity generation will be measured and specified. Furthermore, uncertainties concerning the coal quantities and the accuracy of the measurements will be analyzed and evaluated. The monitoring process will be conducted by the technical staff of the plant.

Other useful notes. The possible stakeholders encompass several parties in relation to this super-critical power plant, including governments at both central and local levels, coal vendors, and banks, as well as local residents. In general, they have responded positively to the construction of this interesting project, but local residents prefer to keep the land for current use rather than converting it into other nonagricultural purposes. This could create potential barriers to the implementation of the project. Fortunately, the proposed CDM case entails a smaller land occupation than the baseline project. This project also features low technical and financial risks if the technological localization progresses rapidly and is successful.

Beijing Dianzicheng Gas-Steam Combined Cycle Tri-Generation Project

Project information. This project involves a gas-steam combined cycle for tri-generation of heat, cooling, and electricity to displace 98 conventional coal-fired boilers in Beijing. It is supposed to greatly enhance energy efficiency and improve the capital's environmental quality. With Beijing's rapid socioeconomic development, energy demand for residential heating in winter, cooling in summer, and industrial use will continue to increase over the coming decade. The commissioning of this project could help meet both the current thermal load and future demand in 2005 for the extended heating zone in a more environmentally sound way.

Baseline setting. The baseline consists of two parts: (1) the North China Power Grid for thermal electricity generation over the crediting period between 2006 and 2015; and (2) a mix of existing coal-fired heating boilers (347 GWh_{th}/year) for current heat supplies, and four sets of 52.5MW gas-fired boilers (528 GWh_{th}/year) for newly increased loads.

Crediting period. Coal-fired boilers and cogeneration plants for heating service will eventually cease to exist with more stringent enforcement of urban environmental standards in Beijing. Natural gas-based heat supplies are expected to increase

TABLE 3.7 Major Parameters for Huaneng SC

Huaneng-SC	Unit	Baseline Project	CDM Project
Technical Data			
Installed net-capacity	MW	1136	1136
Full load operation time	h/year	5500	5500
Electricity generation	GWh/year	6250	6250
Fuel consumption	GWh_f/year	17649	15107
Net efficiency	%	35.4	41.37
Economic Data			
Capital Investment	Mill.Yuan	5460.72	6331.01
Specific Investment	Yuan/kW	4805	5571
Fuel costs	Yuan/kWh_f	0.018	0.018
Discount rate	% p.a.	8	8
Crediting period	years		3×7
Lifetime	years	25	25
Depreciation time	years	15	15
O&M costs	Yuan/kW_e p.a.	283.26	247.81
Environmental Data			
Coal-CO_2 emission factor			
—measure in kWh_f equivalent	g CO_2/kWh_f	345	345
—measure in kWh_e equivalent	g CO_2/kWh_e	973	833
Other GHGs as CO_2-equivalents	g CO_2/kWh_f	—	—
CO_2 emission reductions per kWh of electricity generation	kg CO_2/kWh_e	—	0.140
CO_2-emission reductions over a 3 × 7-year crediting period	Mt-CO_2	—	12.264
CO_2 emission reductions per year	Mt-CO_2/a	—	0.876
Incremental cost per kWh of electricity generation	Yuan/kWh_e	—	0.010
CO_2 emission reduction costs	Yuan/t CO_2	—	70.04
	US$/t CO_2	—	8.47
Year (for technical, economic data):			2000

Notes (these notes apply to all six comparative tables):
1/:kWh_f: thermal value of fossil fuels measured in kWh equivalent.
kWh_e: unit of electricity generation.
kWh_{th}: unit of heat generation measured in kWh equivalent.
2/:fuel cost is measured per unit of its thermal value.
3/:emission factor of fossil fuels is measured per unit of its thermal value.
4/: operational cost includes the labor cost.
5/: default exchange rate = 8.27 RMB/US$.
6/:if 3×7 years of crediting period is applied, it refers to the first 14 years.

TABLE 3.8 Major Parameters for GSCC TriGen

GSCC-TriGen	Unit	Baseline Project	CDM Project
Technical Data			
Installed net-capacity	MW	128	128[/a]
Full load operation time	h/year	4281	4281
Power generation:	GWh/year		
Electricity		548	548
Heat		875	875
Total		1423	1423
Fuel consumption:	GWh_f/year		1883
Coal-fired boilers		694	
Natural gas boilers		551	
Coal for power grid		1566	
Total		2811	
Net efficiency:	%		67
Electricity generation		33.7	
Heat supply		70	
Total		56	
Economic Data			
Capital Investment	mill.Yuan		734.72
Electricity		675	
Heat		114	
Total		789	
Specific Investment	Yuan/kW	5104	5754[/a]
Fuel costs	$Yuan/kWh_f$	0.038	0.143
Discount rate	% p.a.	8	8
Crediting period	years	—	10
Lifetime	years	25	25
Depreciation time	years	15	15
O&M costs	$Yuan/kW_e$ p.a.	333	1258
Environmental Data			
Fuel-CO_2 emission factor	$g\text{-}CO_2/kWh_f$	349	201
Other GHGs as CO_2 equivalents	$g\text{-}CO_2/kWh_f$	—	—
CO_2 emission reductions per kWh	$kg\text{-}CO_2/kWh_e$ $kg\text{-}CO_2/kWh_{th}$	—	0.686 0.183
CO_2 emission reductions over a 10-year crediting period	$Mt\text{-}CO_2$	—	5.3585
CO_2 emission reductions per year	$Mt\text{-}CO_2/a$	—	0.53585
Incremental cost per kWh of electricity and heat generation	Yuan/kWh	—	0.2017
CO_2 emission reduction costs	$Yuan/t\text{-}CO_2$ $\$/t\text{-}CO_2$	— —	206.29 24.94
Year (for technical, economic data):		—	2000

Note:

[a/] The capacity is 133 MW, the self service rate is 4 percent

[b/] The specific investment costs are 5524 RMB/kWe, the self service rate is 4 percent

and displace these plants, so a fixed 10-year crediting period was chosen for the project.

Major parameters and results are shown in *Table 3.8.*

Monitoring plan and activity. The following data and information should be recorded to verify the GHG emission reductions (*Table 3.9*).

For part of the baseline reference, we gathered some key information related to the North China Power Grid, including the CO_2 emission per unit power generated over the crediting period (2006–2015). In the case study, specific CO_2 emissions are extrapolated (based on the coal consumption trend) to be 999.39 g-CO_2/kWh. This number can be checked against the actual data logged in the monitoring process.

For the heating baseline of the original coal-fired small boilers, average CO_2 emissions per unit of heat supply over the crediting period of 2006 to 2015 should be well monitored.

Other useful notes. The possible stakeholders involved in this CDM project include the State Developing and Planning Commission, PRC; Beijing Municipal Commission of Development Planning, PRC; CDM project investors; The Power Design Institute of North China; The North China Power Grid Company; the Beijing Natural Gas Company; and commercial banks.

The stakeholders all support this proposed project, since each of them can benefit from the CDM project. The only perceived risk is the prohibitively high price of natural gas, which is

TABLE 3.9 Data and Information to Verify GHG Emission Reductions

Items	Unit
Net electricity generation to North China power grid	MWh/yr
Net heat supply to heat-users	TJ/yr
Total natural gas consumption	Mm^3/yr
Carbon content of natural gas	%
Caloric value of natural gas	MJ/m^3

now being negotiated with relevant government agencies for a better solution.

BJ3TPP Gas-Steam Combined Cycle (Phase II)

Project information. With the current pace of economic growth, load demand and the peak-valley gap keep increasing in part of the Beijing-Tianjin-Tangshan power grid. For example, between 1992 and 1997, the peak load increased by 8 percent annually, while the peak-valley gap widened by 10 percent per year. It is expected that the lowest load rate will be 55 percent in 2005. So it is necessary and important to install some new peak-load generating units to improve the performance of the local power grid and help boost the capital's economic growth and environmental preservation. This new BJ3TPP project is a 300 MW class gas/steam turbine combined cycle plant to be commissioned in the near future.

Baseline setting. The planned BJ3TPP gas-steam combined cycle project will replace a coal-fired thermal power plant that would have otherwise been built, so the most likely baseline would be an advanced 300MW coal-fired technology plant. For a more in-depth analysis of possible alternative situations, four baseline scenarios were developed for further discussion. The most reasonable and realistic scenario was chosen.

Crediting period. It is reasonably believed that gas-fired power plants may still remain an advanced option beyond the current baseline ranges and could produce additional environmental benefits. Nevertheless, there are many uncertainties regarding natural gas use for electricity generation in the near future, including supply sources, pipeline access, gas pricing, competition from alternative fossil fuels, and environmental legislation and enforcement. A 3 × 7-year crediting period was chosen in order to have the possibility for adjustment.

Major parameters and results are shown in *Table 3.10.*

Monitoring plan and activity. This project needs to be monitored to verify the actual CO_2 emissions in the implementing process. The following data related to the baseline project is based on the technical specifications, while the data about the running CDM project should be recorded and checked during the operation period. As shown in *Tables 3.11 and 3.12,* the following data can be found from the domestic standard technical spec-

TABLE 3.10 Major Parameters for BJ3TPP-GSCC

BJ3TPP-GSCC	Unit	Baseline Project	CDM Project
Technical Data			
Installed net-capacity	MW	404.3	404.3
Full load operation time	h/year	3500	3500
Electricity generation	GWh/year	1413.6	1413.6
Fuel consumption	GWh_f/year	4038.8	2425.42
Net efficiency	%	35	57
Economic Data			
Capital Investment	mill.Yuan	1,454.40	1,600.75
Specific Investment	Yuan/kW	4,848	4,106
Fuel costs	Yuan/kWh_f	0.03563	0.116–0.143
Discount rate	% p.a.	8	8
Crediting period	years	—	3 × 7
Lifetime	years	25	25
Depreciation time	years	15	15
O&M costs	Yuan/kW_e p.a.	141.22	131.74
Environmental Data			
Fuel-CO_2 emission factor	g-CO_2/kWh_f	326	198.66
Other GHGs as CO_2-equivalents	g-CO_2/kWh_f	—	—
CO_2 emission reductions per kWh of electricity generation	kg CO_2/kWh_e	—	0.460
CO_2 emission reductions over a 3 × 7-year crediting period	Mt-CO_2	—	9.1
CO_2 emission reductions per year	Mt-CO_2/a	—	0.65
Incremental cost per kWh of electricity generation	Yuan/kWh_e	—	0.086
CO_2 emission reduction costs	Yuan/t CO_2	—	124.08
	\$/t CO_2	—	15.00
Year (for technical, economic data):			2000

TABLE 3.11 Standard Technical Specifications for 300MW Thermal Power Plant

Parameter	Unit
Annual operational hour	hour/year
Annual electricity generation	kWh/year
Operational efficiency	%
Calorific value of coal	MJ/t
Annual coal consumption	t

ifications for a typical 300MW thermal power plant. These data have to be checked against the technical specifications.

With the availability of those critical data listed in the table, total annual CO_2 emissions can be rigorously calculated.

Other useful notes. The stakeholders in this project include the State Planning and Development Commission (SDPC); Beijing Municipal Planning and Development Commission (BJMPDC); State Environmental Protection Agency (SEPA); Beijing Municipal Environmental Protection Bureau (BJMEPB); Beijing Municipal Water Resource Administration (BJMWRA); Beijing No. 3 Thermal Power Plant; natural gas companies; Bejijng-Jingfeng Thermal Power Co., Ltd; international vendors for gas turbines; and domestic partners for cooperation.

TABLE 3.12 Data to be Recorded and Gathered for the CDM Project

Parameter	Unit
Annual operation time	hour/year
Annual electricity generation	kWh/year
Annual natural gas consumption	m^3/year
Operational efficiency	%
Compositions of natural gas	

All of these stakeholders support this gas-steam combined cycle case study and are willing to set this CDM project in motion. With the transfer of advanced international gas turbine technology, the only risk for implementation is the prohibitively high operational and maintenance costs and localization of the imported technologies. However, with the clean development mechanism up and running, the CER-based revenues are expected to help bring down the O&M costs. With the progress of Sino-foreign technical cooperation, the technologies could become more localized and well adopted with a good prospect of wider application in China.

Shanghai Wind Farm Project (Phase II) (SH-Wind Farm)

Project information. Wind power is a promising opportunity to switch to clean energy use. Shanghai is China's largest city, but 64.5 percent of its energy mix comes from coal. Such an energy structure causes serious local environmental stress, and undermines its status as an international city. Shanghai is favorably located on the Yangtse River, the biggest river of China, and is adjacent to the sea. It boasts huge potential for wind power; theoretical capacity is rated at 3000MW, with enough local space for generator installation. The Shanghai municipal government is pushing forward with technological development for new energy to sustain the region's rapid economic.

Baseline setting. To justify the selection of the most conservative and reasonable baseline for this wind-farm CDM case project, six scenarios were developed for an in-depth comparative analysis.

The final choice is scenario-6—"Coal Baseline on the Future Shanghai Power Grid" (48b). This is a mix of existing and increased coal-fired electricity from the future Shanghai power grid to be replaced by the output from this wind-farm project.

Crediting period. A period of 3×7 years has been chosen as the crediting period. It is assumed that wind power will not be the baseline for power generation for a long time, and so will qualify as additional and generate CERs.

Major parameters and results are shown in *Table 3.13.*

Monitoring plan and activity. The output per minute from each wind turbine will be logged at the control center by the computer system, which can be automatically processed to provide statistical data on the annual generation of electric power. The Shanghai Power Company will be responsible for keeping the output record.

Other useful notes. Important stakeholders include the national and municipal governments, Shanghai Wind Generation Co. Ltd., Shanghai Power Co. Ltd., foreign investors, and local residents.

Most stakeholders support the implementation of this proposed CDM project. Some power companies prefer that wind farms be part of the grid connection.

TABLE 3.13 Major Parameters for SH Wind Farm

SH-WindFarm	Unit	Baseline Project	CDM Project
Technical Data			
Installed net-capacity	MW	—	20
Full load operation time	h/year	—	2000
Electricity generation	GWh/year	—	40
Fuel consumption	GWh_f/year	—	N/A
Net efficiency	%	—	N/A
Economic Data			
Capital Investment	mill.Yuan	—	182.57
Specific Investment	Yuan/kW	—	9128
Fuel costs	$Yuan/kWh_f$	0.0467	—
Discount rate	% p.a.	—	8
Crediting period	years	—	3×7
Lifetime	years	—	25
Depreciation time	years	—	15
O&M costs	$Yuan/kW_e$ p.a.	—	193.24
Environmental Data			
Coal-CO_2 emission factor	g-CO_2/kWh_f	327	0
Other GHGs as CO_2 equivalents	g-CO_2/kWh_f	—	—
CO_2 emission reductions per kWh of electricity generation	kg-CO_2/kWh_{el}	—	0.91
CO_2 emission reductions over a 3×7-year crediting period	Mt-CO_2	—	0.5082
CO_2 emission reductions per year	Mt-CO_2/a	—	0.0363
Incremental cost per kWh of electricity generation	$Yuan/kWh_{el}$	—	0.372
CO_2 emission reduction costs	Yuan/t CO_2 $/t CO_2	— —	411.73 49.79
Year (for technical, economic data):			2000

Anaerobic Treatment of Effluents for Power Generation (Taichang-Biogas)

Project information. Wastewater control and treatment have long been a difficult challenge across the country. Despite all the efforts made so far, there is still a long way to go to achieve the established targets, particularly for small private enterprises in China. Taichang Xintai Alcohol Co. Ltd. is an alcohol producer in Taicang City, Jiangsu Province. The plant is supposed to be the biggest water polluter in the city. The wastewater discharged from the plant contributes approximately 70 percent of the city's total COD concentration. The main river is severely polluted by the untreated effluents, affecting both the quality of life of local people and the city's investment environment.

With the introduction of the anaerobic fermentation technology, the treated wastewater would meet local environmental standards, and the biogas can be used for power generation. So this project could help integrate environmental protection with waste resource utilization. The project consists basically of a biogas reactor, a gas engine power generation system, and a power transmission system connected with the local power grid.

Baseline setting. Seven baseline scenarios were developed for an analysis of alternative situations, as shown below:

- Scenario-1: GHG emissions based on existing or historical power production (48a)
- Scenario-2: Built margin single plant or single specific technology (48b)

TABLE 3.14 Major Parameters for Taicang Biogas Project

Taichang-Biogas	Unit	Baseline Project	CDM Project
Technical Data			
Installed net-capacity	MW	—	4.0
Full load operation time	h/year	—	7680
Electricity generation	GWh/year	29.1	29.1
Fuel consumption	GWh_f/year	82.9	
Net efficiency	%	35.1	27.53
Economic Data			
Capital Investment	mill.Yuan	—	45
Specific Investment	Yuan/kW	—	11250
Fuel costs	Yuan/kWh_f	0.228	0.392
Discount rate	% p.a.	—	8
Crediting period	years	—	10
Lifetime	years	—	20
Depreciation time	years	15	15
O&M costs	Yuan/kW_e p.a.	—	1180
Environmental Data			
Coal-CO_2 emission factor	g-CO_2/kWh_f	327	
Other GHGs as CO_2 equivalents	g-CO_2/kWh_f	—	
CO_2 emission reductions per kWh of electricity generation	kg CO_2/kWh_e		0.921
CO_2 emission reductions over a 10-year crediting period	Mt-CO_2		0.2676
CO_2 emission reductions 0.02676 per year	Mt-CO_2/a		
Incremental cost per kWh of electricity generation	Yuan/kWh_e		0.165
CO_2 emission reduction costs	Yuan/t CO_2 \$/t CO_2		179.2 21.67
Year (for technical, economic data):			2000

- Scenario-3: Built margin mix of power plants (48b)
- Scenario-4: Operating margin (48b)
- Scenario-5: Mixed coal operating margin (48b)
- Scenario-6: East China grid coal operating margin (48b)
- Scenario-7: Best recent addition (48c)

Since the size of local coal-fired power plants is rather small, with higher coal intensity than in the East China Power Grid, and currently 83 percent of the electricity on the Taicang Power Grid comes from the East China Power Grid, scenario 6 was considered more conservative and the most appropriate choice.

Crediting period. The control measures and environmental standards on water pollution will apparently be intensified over the coming years in China, and local governments will be more serious about implementing the regulations. The crediting period is fixed for 10 years starting from January 2005, since the biogas installation is more likely to become normal (like the Taicang Alcohol Company) in 10 years.

Major parameters and results are shown in *Table 3.14.*

Monitoring plan and activity. For part of the CDM project, the project output will be monitored and recorded on-site at the control center by a computer system, and can also be checked against the electricity purchase invoice.

With regard to the baseline, the following parameters will be needed for emission calculations: (a) total electricity generated from the coal-fired power plants on the East China Power Grid each year, and (b) total coal consumption by the coal-fired power plants on the East China Power Grid each year.

Other useful notes. The most important stakeholders include the Jiangsu province government, Taicang city government, Taichang Xin Tai Alcohol Co. Ltd., Taicang Power Company, international investors, and local residents.

Most stakeholders support the implementation of this proposed CDM project. Some power companies prefer the reliability of grid connection. In addition, the perceived financial risks are closely related to the alcohol market situation and company business performance, while the technical risks may encompass gas quality for reliability and special skills for production and maintenance.

Zhuhai Landfill Gas Recovery for Power Generation Project

Project information. This is a renewable energy case study that explores the potential of landfill gas recovery for power generation. The project's other benefits include urban environmental protection, fugitive gas capture for energy reuse and land-use improvement, and methane (CH_4) mitigation. Such an LFG recovery project is of particular importance for China, where cheap and large quantities of CH_4 are discharged from urban landfills. The methodological study in this project is expected to shed more light on similar cases across the country.

Baseline setting. At present, three types of GHF emission baselines are considered: (1) LFG recovery baseline, which assumes the current situation, 100 percent of methane emissions from the landfill site; (2) power generation fuel substitution baseline, which assumes the GHG emissions when generating the sam electricity quantity from the power grid; and (3) flaring baseline, which assumes zero flaring of LFG. Compared to the emission reductions from LFG recovery, those from the fuel substitution for power generation are so small in amount as to be negligible; only the parts from the LFG recovery and flaring are of great account.

Crediting period. Since the landfill gas in this case could be recovered as long as the coming decade, a 10-year period has been fixed for the crediting of this project starting from January 2005.

Major parameters and results are shown in *Table 3.15.*

Monitoring plan and activity. The following elements should be well monitored for verification of GHG emission reduction acquired from the proposed CDM project: (a) emission reductions from methane combustion in flares; and (b) emission reductions from methane combustion in generators.

Other useful notes. Important stakeholders include the Zhuhai municipal government,, Zhuhai New Fangzhou Environment Technic Corporation (Project Owner), Guangzhou Yufeng Energy Environment Technic Corporation (Project Designer), Zhuhai Power Company, and state banks and foreign investors.

TABLE 3.15 Major Parameters for Zhuhai LFG Project

Zhuhai-LFG	Unit	Baseline Project	CDM Project
Technical Data			
Installed net-capacity	MW	—	1.74
Full load operation time	h/year	—	5000
Electricity generation	GWh/year	—	8.7
Fuel consumption	GWh_f/year	24.22	16.41
Net efficiency	%	35	34.42
Economic Data			
Capital Investment	mill.Yuan	—	23.20
Specific Investment	Yuan/kW	—	13333
Fuel costs	Yuan/kWh_f	—	0
Discount rate	% p.a.	8	8
Crediting period	years	—	10
Lifetime	years	10	10
Depreciation time	years	10	10
O&M costs	Yuan/kW_e p.a.	—	824.7
Environmental Data			
Coal-CO_2 emission factor	g-CO_2/kWh_f	910	0
Other GHGs as CO_2 equivalents	g-CO_2/kWh_f	4361.78	4042.87
GHGs as CO_2 equivalents reductions per kWh of electricity generation	kg-CO_2/kWh_e	—	8.33
CO_2 emission reductions over a 10-year crediting period	Mt-CO_2	—	0.7247
CO_2 emission reductions per year	Mt-CO_2/a	—	0.072
Incremental cost per kWh of electricity generation	Yuan/kWh_e	—	0.30
CO_2 emission reduction costs	Yuan/t CO_2	—	32.61
	\$/t CO_2	—	3.94
Year (for technical, economic data):			2000

In general, they all support launching this useful project, with multiple benefits expected for each participant. The only partners to be affected would be some power companies, but such impacts would be negligible due to the small size of this project. Some technical and financial risks may still exist, including the technical maturity and localization as well as the prohibitively high upfront costs. CDM may serve as an important vehicle to overcome these uncertainties.

DISCUSSION OF RESULTS FROM SIX CASE STUDIES

Baseline Setting

General procedure and steps of baseline setting in the six case studies

The procedure and main steps for setting the baseline followed the decisions and guidance provided by the CDM Executive Board. The mains steps were:

- Clarification of the baseline system boundaries, taking into account the limits and scope of the CDM project activity
- Compilation and analysis of main determining factors that influence the baseline
- Definition of possible baseline scenarios
- Consultations with experts
- Evaluation and selection of the most appropriate baseline approach
- Identification and description of possible baseline methodologies
- Evaluation and selection of the most appropriate baseline methodology, including the calculation of baseline GHG emissions.

Overall comparison of the baseline setting over six case studies

The major data on the baseline setting for each case study is stated in *Table 3.16*.

The baseline setting takes into account the latest definitions and guidelines. At the time of the CDM Case Study, they were:

- The **baseline** for a CDM project activity is the scenario that reasonably represents the anthropogenic emissions by sources of greenhouse gases that would occur in the absence of the proposed project activity.
- A **baseline approach** is the basis for a baseline methodology. The Executive Board agreed that the three approaches identified in subparagraphs **48 (a) to (c)** of the CDM modalities and procedures be the only ones applicable to CDM project activities.
- A **methodology** is the application of an approach (as defined in paragraph 48 of the CDM modalities and procedures) to an individual project activity, reflecting aspects such as sector and region.

Also used in the context of the baseline setting were the methods of "operating margin" and "built margin." These can be defined according to "OECD, IEA: Practical Baseline Recommendations for Greenhouse Gas Mitigation Projects in the Electric Power Sector. May 2002." as follows:

- The **operating margin** method presumes that a CDM project's activity predominant effect is to modify the operation of existing power plants.
- The **built margin** method makes a "best guess" as to what type of power facility would have otherwise been built had the project not been implemented, or built sooner, insofar as GHG mitigation projects are likely to delay rather than displace other new plants, respectively.

Major findings and lessons learned on baseline setting from the case studies

Baseline approach 48.a is not appropriate as the power baseline for fast-growing economies such as China. China's economy is expected to keep growing at around 8 percent annually. Power demand increases with the growth of GDP. Therefore, additional power plant capacity is needed. At the same time, new power generation technology is likely to develop, resulting in higher energy efficiency rates, a shift in fuel mix, or changes in the use of renewable energies. The future mix of operated power plants and the resulting GHG emissions will differ from the current period. Therefore, 48.a is not the appropriate approach for setting the power generation baseline. Accordingly, the baseline approach 48.a has not been chosen as the power baseline.

Baseline approach 48.b was selected as the power baseline in all six case studies. Data requirements are a barrier for baseline approach 48.c. The results of the baseline settings show that—for the power

TABLE 3.16 Baseline Setting of the Six Case Study Projects

Case Name	Huaneng-SC	GSCC-TriGen	BJ3TPP-GSCC	SH-Wind Farm	Taicang-Biogas	Zhuhai-Landfill gas
CDM Project Activity (as additional information)						
Location of the CDM project	Jiyuan City, Henan Province	Beijing	Beijing	Shanghai	Taicang City, Jiangsu Province.	Zhuhai City, Guangdong Province
Type of technology	Super-critical coal-fired for power generation	Gas-steam combined cycle, tri-generation	Gas-steam combined cycle for power generation	Wind power generation	Biogas power generation	LFG recovery for power generation
Scale of project	2 × 600 MW	133 MW	300 MW	20 MW	4.1 MW	1.94 MW
Power grid to be connected	Henan Province grid	North China grid	North China grid	East China grid	East China grid	Guangdong province grid
Selected Baseline						
Baseline components	1. power	1. power 2. heating coal 3. heating gas	1. power	1. power	1. power	1. landfill 2. torch
Baseline Approach	48 b)	1. 48 b) 2. 48 a) 3. 48 b)	48 b)	48 b)	48 b)	1. 48 a), 2. 48 a).
Baseline Methodology	Built margin	Operating margins for all baselines	Built margin	Operating margin	Operating margin	

(*continued*)

TABLE 3.16 Baseline Setting of the Six Case Study Projects (*Continued*)

Case Name	Huaneng-SC	GSCC-TriGen	BJ3TPP-GSCC	SH-Wind Farm	Taicang-Biogas	Zhuhai-Landfill gas
Description of Baseline Scenario	Existing 600 MW sub-critical coal-fired power plants in similar power grids.	1. Electricity baseline: Operating margin or averaged thermal electricity mix in the North China power grid. 2. Heating baseline1 Existing coal-fired heating boilers for original heating load provided by the coal boilers; 3. Heating baseline2 Gas-fired heating boilers for expanded heating capacity.	Economically attractive 300 MW coal-fired thermal power technology for peak load.	Average GHG emissions from the mix of thermal power plants operated in the East China grid	Average GHG emissions from the mix of thermal power plants operated in the East China grid	1. Landfill baseline: LFG emitted from the landfill with no recovery; 2. LFG Flaring: none

baseline only—approach 48.b was the most appropriate. Baseline approach 48.c was also a valid option, but the data requirements for this approach are difficult. Power plant utilities were often reluctant to assist or provide the necessary data. This may be because of the uncertainties regarding the development of a CDM market according to the Kyoto Protocol, lack of information on CDM, or because of other priorities. Furthermore, in the case of large-scale fossil fuel power plants, not many similar projects were undertaken in the previous five years in similar social, economic, environmental, and technological circumstances.

Operating margin is regarded as the most appropriate baseline methodology in the case of small, renewable energy power generation projects. The key issue is the standard set for a reliable power supply. For all three cases with renewable power generation, the operating margin methodology was selected as most appropriate. In the Shanghai wind farm case, the power generation depends on the wind situation. In the case of the alcohol plant, the power generation is related to the produced alcohol quantity, or to the resulting COD content in the effluent. In the case of the landfill, the power generation is mainly dependent on the disposed waste quantity and quality, as well as on the degradable process determined by temperature and humidity. As a result, the power supplied to the public grid will be unreliable and difficult to predict. In order to have a reliable and predictable power supply, which generally is expected on the demand side, a back-up of (nearly) the same conventional power generation capacity has to be built and be available to compensate for the volatile power supply of the renewable energies. Therefore, neither built margin nor combined margin was considered appropriate, since there won't be a delay or an impact on new power plant capacity additions.

In a power grid system with relatively new power plants, the type of baseline approach and baseline methodology has a limited impact on the baseline emissions. The wind farm project is an example. The results of the calculation for different baseline approaches and methodologies are stated in *Table 3.17.*

TABLE 3.17 Impact of Different Baseline Approaches on CO_2 Emission Reduction

	48.a Historical and present data				48.b Attractive technology	
	(Static)		(Dynamic)			
	Shanghai regional sectoral baseline	National sectoral baseline	Shanghai regional sectoral baseline	National sectoral baseline	Shanghai prevailing technology	National prevailing technology
Power generation (GWh_{el}/yr)	40	40	40	40	40	40
Fuel intensity of net generation (gce/kWh_{el})	351	392	346.7	361.1	344	360
Fuel consumption (GWh_{th}/yr)	114.3	127.6	105.9	109.4	112.0	117.2
Rate of fuel combustion (%)	94.4	94.4	94.4	94.4	94.4	94.4
CO_2-emissions factor of Baseline (kg-CO_2e/kWh_{el})	0.938	1.048	0.927	0.965	0.919	0.962
CO_2-emission reduction (t-CO_2/yr)	37,520	41,902	37,049	38,287	36,771	38,482
(%)	102.0	114.0	100.8	104.1	100	104.7

Note: Base year for technical data is 2000. CO_2e = CO_2 equivalents.

The prevailing power generation technology in the Shanghai power grid (as well as in the national power grid) is 600 MW or 300 MW coal-fired units. The regional sector baseline is defined as the average fuel intensity of the power grid in Shanghai, and the national sector baseline as national average fuel intensity. The CO_2 emissions from wind power generation are zero. The results show that CO_2 emissions reductions in the Shanghai grid are higher than the ones in the national grid, i.e. the coal-fired power generation technology level of Shanghai is advanced compared to the national level. Over the 2010–2030 period, the similar CO_2 emissions reductions of prevailing technology and dynamic baseline between Shanghai and the national level is due to the same sector technology policy, which will even out differences over time.

BOX 3.1 Baseline Setting and "Power Shortage"

Due to China's economic growth and the time-consuming erection of new power plants, in the future China is likely face severe power shortages. These power shortages may go far beyond most CDM project's crediting period. For the time being, there is no adequate baseline approach or methodology that takes into account such long-term power shortage conditions. The condition of additionality cannot exist, since these potential CDM project activities do not displace the power from another power plant. There is a need to develop a (simplified) baseline methodology that can be applied to these specific situations.

Additionality Assessment of the CDM Case Studies

Basis for the additionality assessment and overview of results

The guiding principles for assessing additionality have been primarily laid out in Article 12, paragraph 5(c), of the Kyoto Protocol, as well as in paragraphs 43–44 of the Marrakesh Accords and in the 9th and 10th EB meetings. The relevant approaches and assessment methods have been applied to these six case study projects. The additionality check for a CDM project activity should verify whether the prospective project meets the requirements of the "reductions in emissions that are additional to any that would occur in the absence of the certified project activity."

Based on the assessments and analyses in line with the established criteria or principles, all the selected case study projects meet the additionality criteria (*Table 3.18*).

Major findings within the additionality assessment

Impact of governmental strategies and development plans on additionality. It is a normal practice for the Chinese government to map out, or update on a regular basis, a five-year plan and long-term development programs. The plans state goals for science and technology development, covering energy supply schemes and advanced or efficient energy technology, R & D projects, transfers, and applications. These initiatives are aimed at pushing ahead the technological progress of energy supply and efficiency improvements, as well as meeting increasing energy demand and supporting national economic growth in a more sustainable way.

Projects listed in the "five-year plan" will arguably be built anyway, even in the absence of CDM. Projects or programs listed high on the development agenda generally are the top priorities set out by the central authorities for the near future, but that does not necessarily mean these projects will eventually be implemented. A potential CDM project listed in the plan may face a variety of barriers or hit a snag in the implementing process due to insecure financing resources or emerging technological challenges.

It is important to note that the five-year planning process is more directive than mandatory. In other words, the planning makes clear the priorities and willingness of the government, or the development target, which may not constitute the obligations for actors in the sector. Especially,

TABLE 3.18 Additionality Assessment Summary for Six Cases

Six Cases	GHG emission reduction (Mt-CO_2/a)	Investment barrier	Technological barrier	Other barriers	Not Common Practice
Case-1: **Huaneng-SC**	0.876	Higher investment costs	Low market share, higher performance risk	Strong incentives remain to be well established	Very few plants in operation; subcritical power plants are common
Case-2: **GSCC-TriGen**	0.536	Relatively competitive upfront costs	Low market share, higher performance risk	Prohibitively high cost of natural gas	Very few plants in operation; subcritical power plants are common
Case-3: **BJ3TPP-GSCC**	0.65	Relatively competitive upfront costs	Low market share, higher performance risk	Prohibitively high cost of natural gas	Very few plants in operation; subcritical power plants are common
Case-4: **SH-Wind**	0.036	Comparatively high up-front costs	Low market share, higher performance risk	Hardly predictable power supply	Very few plants in the capacity range > 1MW per turbine
Case-5: **Taicang-Biogas**	0.02676	Comparatively high up-front costs	Higher performance risk due to volatile gas quality	Hardly predictable power supply	Not yet, encouraged by legal regulations expected after 2010
Case-6: **Zhuhai-LFG**	0.072	Investment cost are higher than in baseline case	Higher performance risk due to volatile gas quality	Institutional barriers	Common practice is not to capture the landfill gas at all

BOX 3.2 Five-Year Power Development Planning in China

The Chinese government maps out five-year plans on a regular basis in all sectors, including the electric power industry. The general process can be summarized as follows:

The practice of formulating a five-year economic development plan has been adopted in China since the 1950s, particularly during the period when the economy was centrally planned. Long-term development programs and five-year plans are normally in line with the blueprints mapped out at the National Congress of the Communist Party of China (CPC).

The NDRC (former SDPC) will organize the drafting of the next five-year socioeconomic plan. In the specific development plan for the electric power industry, the growth rate, priority technologies, and some important projects could be proposed for consideration or implementation.

After being subject to review and debate, the draft plans will be submitted to the National Development and Reform Commission(NDRC) for consolidation, then to the State Council for further deliberations, and then to the National People's Congress (NPC) for final approval.

Once the national five-year bill is through the NPC, sector-specific plans will be subject to updating or revision, and then made public as guidelines for the electric power sector.

the projects listed in the planning document may be or may not be developed in reality, depending on whether the necessary resources are available or not. Taking the super-critical technology as an example, being listed as one of the priority areas in the five-year planning document means it is supported by the government, but there is no guaranteed financial assistance or other aid.

Early action needed in order to take advantage of CDM. The projects that are submitted to the government for their approval are in most cases at an early stage and still need to secure external (financial) resources and technical assistance. However, if the proposed projects get officially approved, then this generally implies that the financial resources for implementation could have been promised or secured. On the other hand, the project proposal could be possibly turned down even with the availability of financing sources, due to the problems of technological choices or regional balance.

It is therefore important to identify potential CDM project activities that are in line with the government's priorities—by, for example, being listed in the Five-Year-Plan—and are at the time of project development not (yet) economically feasible. The identification of those projects should occur before the submission of a project to government authorities for approval. Furthermore, projects that are not economically viable at first sight may improve their economic performance with CDM, and hence have a higher probability to be approved by the government.

Power tariffs or fuel price have an important impact on additionality. Power tariffs and fuel prices play an important role in the context of additionality. In many cases, renewable and advanced energy technologies, which either have unaffordable O&M costs or entail prohibitively higher upfront investments, would appear economically uncompetitive with other conventional options. For instance, the front-end investments for launching the BJ3TPP Gas-Steam Combined Cycle and the Beijing Dianzicheng Gas-Steam Trigeneration projects are supposed to be roughly equal or even lower than their coal-fired counterparts. However, the overall economic performance of GSCC power plants turns out to be less competitive, with the current price of natural gas three times that for coal (even considering the favorable terms granted by the Beijing municipal government). The common practice is therefore to choose a coal-fired power plant rather than a too-expensive GSCC installation, which requires additional capital to cover the running cost.

Newly installed environmental regulations and legislation can remove a project's additionality, depending on the region; early action is needed to make use of a longer crediting period and higher amount of CERs. With China's rapid socio-economic development, the importance of environmental protection has been increasingly recognized. The National People's Congress (NPC) of China has made great efforts in environmental legislation in order to improve air quality and stem the increasing nationwide environmental degradation. This is particularly true in many large cities and environmentally fragile regions.

In Beijing, for example, more stringent environmental codes and standards have been imposed by the municipal government in the lead-up to the Olympic Games in 2008. As part of this effort, coal-derived CO_2 emissions and other pollutants have been strictly controlled. The Olympic Action Plan has been formulated to develop response measures for clean air quality. This initiative is only one of many government-sponsored efforts to push the use of those advanced and energy-efficient technologies. Therefore, the opportunity to launch certain CDM project activities is limited until they are common practice; that is, the baseline case.

Dilemma of data availability vs. additionality or "the chicken and egg challenge" in the context of CDM in China. In the course of the work on the case studies, it has sometimes been difficult to get the data needed to prepare a PDD. However, the PDD is essential for CDM since the EB is going to approve or reject a potential CDM project activity based on the PDD. On the other hand, each large new (or retrofit) power plant project must also be handed in to the NDRC to get official approval. Once officially approved by the NDRC, the project planning can go ahead with all required pre-feasibility studies fully prepared and the financial resources in place. In short, no pre-feasibility study or technical preparation would have been carried out before the normal approval procedure, leaving the necessary data for a complete PDD (for a third party) unavailable.

Emission Reduction and Abatement Costs

Overview of the main data regarding emission reduction and abatement costs

In *Table 3.19,* we present the main data for the six case study projects regarding emission reductions and the calculation of incremental costs of emission reductions (ICER).

In case 1, investment per kW is 5571Yuan/kW, which is 15 percent higher than the baseline project, and the supply cost for generating is 0.01Yuan/kWh higher. But since the efficiency has been improved, the decline in fuel use will make up for the increase in the supply cost in the CDM project. *Table 3.19* shows that ICER for case 1 is 8.47US$/t CO_2, comparatively low in the 6 cases.

After analyzing cases 2 and 3, the combined cycle steam power plants, it is obvious that the higher price of natural gas compared to coal causes CDM project costs to increase significantly. In Beijing, the price of gas is 1.4Yuan/m^3 (0.154Yuan/kWh) and coal is 0.29Yuan/kgce

TABLE 3.19 Major Emission Reduction and ICER Data of the CDM Case Studies

Case Study Data	Case 1. Huaneng-SC	Case 2. GSCC-TriGen	Case 3. BJ3TPP-GSCC	Case 4. SH-Wind Farm	Case 5. Taicang-Biogas	Case 6. Zhuhai-Landfill
Total CO_2 equiv. Emission Reduction over the Crediting Period (t CO_2 equiv.)	12,264,000	5,358,500	9,099,650	508,200	267,760	724,700
Average Annual CO_2 Emission Reduction over the Crediting Period[1)] (t CO_2/a)	876,000	535,850	649,975	36,260	26,760	72,470
Emission Reduction per kW (t CO_2/kW)	1.08	4.03	2.17	1.8	7	459.3
Total CO_2 Emission Reduction Costs over the Crediting Period (Mill, RMB)	858.97	1105.4	1129.08	209.24	47.9	23.632
Average Annual CO_2 Emission Reduction Costs over the Crediting Period (Mill, RMB/a)	61.36	110.54	121.75	14.93	4.79	2.363
Average Incremental Cost of Emission Reductions (ICER) or Average Specific CO_2 Emission ReductionCosts (US$/t CO_2)	8.47	24.94	15.00	49.79	21.67	3.94

[1)]In the case of a crediting period of 3×7 years, the annual emission reduction is multiplied by 14 for the calculation of the total emission reduction. In the case of a 10-year crediting period, the factor is 10.

(0.03536Yuan/kWh). The coal price is just 23 percent of the gas price. In the CDM project, fuel cost accounts for 52 percent of the total generation cost; in the baseline project, the percentage is only 38 percent. Therefore, the generation cost per kWh of the CDM project is 72 percent higher than that of the baseline project. However, the low initial investment of the CDM project—4106Yuan/kW, compared to a baseline cost of 4848Yuan/kWh—can to some extent counteract the high ER cost. The ICER of case 3 is \$15/t CO_2.

Case 4 is phase II of the 20MW Shanghai wind farm project. As is shown in *Table 3.19,* the average specific CO_2 emission cost of case 4 is \$50/tCO_2. The main reason why the ICER is so high is because of the high initial investment, reaching 9128Yuan/kW. The data was obtained from the phase I Shanghai wind farm project. With the rapid development of the wind power generation market, investment per kW has declined to around 7,000Yuan, 23 percent lower than the data used in calculation. Similar to case 5, the key factor in declining incremental abatement cost is to decrease initial investment. Another important factor is the annual operating hours of the wind farm. In Shanghai, 2,000 hours of full-load electricity is connected to the grid, which is less than the 2,300 to 2,500 hours in Inner Mongolia and Sinkiang. The less annual supply, the less CO_2 ER, and ICER will increase.

Case 5—a renewable energy generation project—deals with the anaerobic treatment of effluent and power generation at the Taicang Xin Tai Alcohol Co. The capacity of this CDM project is only 4MW, but the initial investment is as high as 45 million Yuan. Its specific investment is 11,250Yuan/kW, much higher than former cases, because effluent treating equipment has been involved as well as biogas generating equipment. In addition, the operating cost of effluent treatment is also very expensive, about 4.5 million Yuan yearly. After combining these two parts, the biogas generating cost reaches 0.392 Yuan/kWh, 56.8 percent higher than average cost of the grid, which is 0.25Yuan/kWh. The case 5 ICER is \$21.67/tCO_2, a little higher than that of cases 2 and 3. Analysis shows that decreasing initial investment and operating costs are the key factors in the declining incremental abatement cost of such projects.

Case 6 concerns landfill methane recovery for power generation in Zhuhai City. The main part of the emission cost is the initial investment, 23.2 million Yuan, and investment per kW can reach 13,300Yuan. Key factors to decrease ICER are designing reasonable recovery systems and lowering investment. Total emission cost in this case is about 23.20 million Yuan, and annual CO_2 emission saving is 72,470 t because of the large greenhouse effect of CH_4. The ICER is then a comparatively low \$3.94/tCO_2.

Analysis of driving factors on incremental cost of emission reductions

Impacts of crediting period on ICER. Cases 2, 5, and 6 have selected a fixed crediting time of 10 years. Cases 1, 3, and 4 have selected a renewable crediting period of 3 × 7 years. The longer the crediting period, the higher the total emission reductions and profits from the CDM project activity. However, long crediting periods also bring some problems, such as uncertainty, especially to the cases that take the average fuel rate of the grid as baselines. In the coming 20 years, China's GDP will about 7 percent annually, so electrical generation will grow at about the same rate. Clean coal technology, fuel replacement, and renewable energy generation will be developed mainly in order to protect the environment. Furthermore, out-dated mid-sized and small coal-fired plants will be phased out rapidly. It can be anticipated that the fuel structure on the grid in China will change significantly in the future, which causes uncertainty for CERs.

Impacts of coal prices and gas prices on ICER. The coal price in China is lower than the world market price. China has an abundance of coal resources. Coal takes 67 percent of primary energy in China, and is more than 80 percent of fuel fired for electrical generation. Because of the low coal price, when CDM projects choose the average fuel rate of the grid as baselines, ICER results will be relatively high. Cases 1, 2 and 5 are located in Henan province, Beijing, and Shanghai, where coal prices are \$24.9/toe, \$53.4/toe and \$65.3/toe respectively. But in Japan, England, and the OECD, the prices are \$110.2/toe, \$97.76/toe, and \$61/toe (Data from IEA Energy Prices and Taxes). The average international market price is at least 20 percent higher than the price in China. In case 3, when the OECD coal price serves as an opportunity cost in the sensitive analysis, the result shows that if the price is 34 percent higher, the ICER will be 39 percent lower, changing from \$25/toe to \$15.3/toe. On the contrary, natural gas prices in China are higher than world market price. Data from IEA Energy Prices and Taxes reveals that price of gas in China is \$0.17/m^3 (1.40Yuan/m^3), almost twice the American price of \$0.09/m^3. Case 3 also provides sensitive analysis in this direction. If the gas price declines from 1.4Yuan/m^3 to 1.13Yuan/m^3, the ICER will change from \$30/tCO_2 to \$15/tCO_2, decreasing 50 percent. After analyzing this, it is clear that coal and natural gas prices have a big impact on ICER.

Relevance of power purchase agreement (PPA) for ICER. Many countries have set regulations and policies to promote the development of renewable energy generation. For example, in Germany, PPAs with public utilities provide higher tariffs for green power supplied into the grid, such as for wind parks. Although the Chinese government has not announced such regulations, some documents have been developed to promote renewable energy. In 2003, the NDRC approved two 100 MW wind farms in Rudong county, Jiangsu province and in Huilai county. Guangdong province would invite public bidding to construct the plants. The owner of the wind farm and local power company could also negotiate a favorable fixed price (this is PPA). In the near future, 10 wind farms will be constructed. The availability of higher price PPAs and bidding may decrease the ICER considerably, and may render wind projects more competitive compared to other technologies.

Findings and Conclusion

After analyzing the most important driving factors on ICERs in the six cases, the main findings and conclusions are as follows:

- Due to high natural gas prices and low carbon prices in China, the ICER in fuel-switching CDM project activities is rather high.
- ICERs in renewable energy generation CDM project activities could be reduced if the initial investment is lower and the full-load operating hours of the plant higher.
- Improving the landfill methane capturing rate in the respective CDM project activity may decrease ICERs.
- If CDM projects choose the average fuel rate on the grid as a baseline, the coal price will have a significant impact on ICERs.
- Power purchase agreements (PPAs) will help to improve the economic performance of renewable energy generation projects, as well as decrease their ICERs.
- As a potential CDM activity, advanced coal-fired generator technology provides a high amount of CERs and low ICER.
- Renewable energy generation projects have high potential emission reductions, while their initial investments are very high. However, with policy support (such as PPA) such projects are promising.
- With lower gas prices in China, fuel switching may become an interesting CDM project activity.

CDM: CHANCES, BENEFITS, BARRIERS, AND UNCERTAINTIES

Chances and Benefits for China Deriving from CDM

Besides the obvious reduction of greenhouse gas emissions and the mitigation of climate change, CDM has other benefits for China. Based on the six case studies, *Table 3.20* lists the chances and benefits. The right side of the table provides selected examples from the case studies. (For more detailed information, refer to the separate case study reports in Annex 1 on the CD-ROM.)

The benefits derived from CDM and CDM itself fits and supports all three major objectives of China's energy policy; that is, to reduce the environmental impacts of coal fired generation by 1) diversifying the fuel mix; 2) promoting energy efficiency and clean coal technologies; and 3) promoting renewable energy.

Barriers for the Preparation and Implementation of CDM and Respective Mitigation Measures

In the course of the elaboration of the case studies, different barriers were encountered. These barriers represent the present status at the end of 2003. However, there also exist a set of measures to tackle and overcome the barriers, given the commitment of the government and all other involved stakeholders (*Table 3.21*).

TABLE 3.20 Summary of Chances and Benefits from CDM Based on the Findings of Six Case Studies

Chances and Benefits from CDM for China	Selected examples from the Case Study Projects
Economical Chances and Benefits	
Increase in tax revenues	17% VAT for power sale, business tax for project implementation (5% of turnover), 33% income tax for employees
Transfer of state-of-the-art technology to China that would stimulate scientific and technological progress	Gas engine and turbine for biogas use for the effluent treatment Taicang Alcohol plant coming from the United States
Additional revenues coming from CER improve the financial performance of a project	All case studies
Help to start up new domestic industry sectors	Manufacturing of wind turbines larger than 1 MW (e.g. by franchising system)
Expand employment	All case studies
Ecological Benefits	
Reduction of GHG emission and mitigation of climate change	In all case studies
Improvement of local air, water, and groundwater quality	a) Reduction of SO_2 emissions, NOx emissions and particulates. b) Improvement of water quality of Taicang river
Diversification of electricity generation sources	Fuel switch from coal to natural gas, renewable energies such as wind, biomass
Saving natural resources by the use of renewable energies	Power generation by landfill gas, gas from anaerobic digestion and wind
Support and help to accelerate the development of renewable energies	Wind, landfill gas
Social Benefits	
Creation of new jobs	In all six case studies
Awareness raising for environmental challenges at the local level	Information and education center on site of the wind power plant in Shanghai
Improving household living standards	Switch from coal to gas for heating boiler in households in the case study project #3

TABLE 3.21 Overview of Perceived Barriers and Suggested Mitigation Measures based on the Six Case Studies

Challenge, Barrier	Mitigation Measure
Stakeholder Barriers	
The central government (NDRC, MOST, SEPA, MOA, MOF, MOFA, China Meteorology Bureau, MOT etc.) is familiar with CDM. However, on the provincial and city level, knowledge and awareness of CDM is low.	Information and promoting CDM at the provincial and local level. These can be done by several means, such as by workshops, or carrying out of CDM pilot projects.
Improving the energy efficiencies of power plants and enlarging the share of renewable energies are stated objectives, but governmental support has not been provided.	a) Governmental incentives, e.g. lower value-added tax for renewable energies (for example, a 6% VAT for small-scale hydropower instead of 17%). b) Binding and favorable regulation on tariffs of electricity purchased by power companies when the electricity is coming from renewable energies.
Since the Kyoto Protocol has not entered into force, the designated national authority hasn't been established yet.	Establish DNA and provide guidance for the CDM procedure in China.
Local residents near future large power plants may be worried about the increase of air pollution or the loss of land.	Suitable financial subsides for inhabitants.
Financial–Technical Challenges	
The level of transaction cost of the (potential) CDM project activity (costs for negotiation, validation, monitoring, and verification) is expected to be high, above all for small-scale CDM project activities.	a) Bundling of small-scale CDM projects b) Enabling unilateral CDM projects, i.e. the project is developed, financed, and implemented by the project host only
Some CDM project activities may involve technology transfer from abroad. Other CDM project activities will work with fuel of varying quality. Therefore, some time could be needed to sustain reliable operation of the respective plants.	a) Introduce experienced technicians (including introduce technicians from foreign countries) b) Strict quality control during manufacturing of equipment and erection of plants c) Thorough commissioning of the plant, documentation and training of the designated operations staff.
Environmental Challenges	
Methane leaks in the natural gas pipeline.	. . .

Stakeholders Perspective on Requirements to Facilitate CDM in China

An important uncertainty is whether and when the Kyoto Protocol will enter into force. Another uncertainty is how the EB may consider baseline and monitoring methodologies proposed for larger-scale energy efficiency and large fossil-fuel-based projects. By 2007–8, the opportunity to start larger-scale CDM projects may have passed because of the uncertainty regarding the 2nd commitment period, since by then less then 7 years would fall into the first commitment period. A commercial bank in this situation would prefer to finance projects that are economically viable. Larger-scale no-regrets projects would in turn face difficulties in demonstrating additionality.

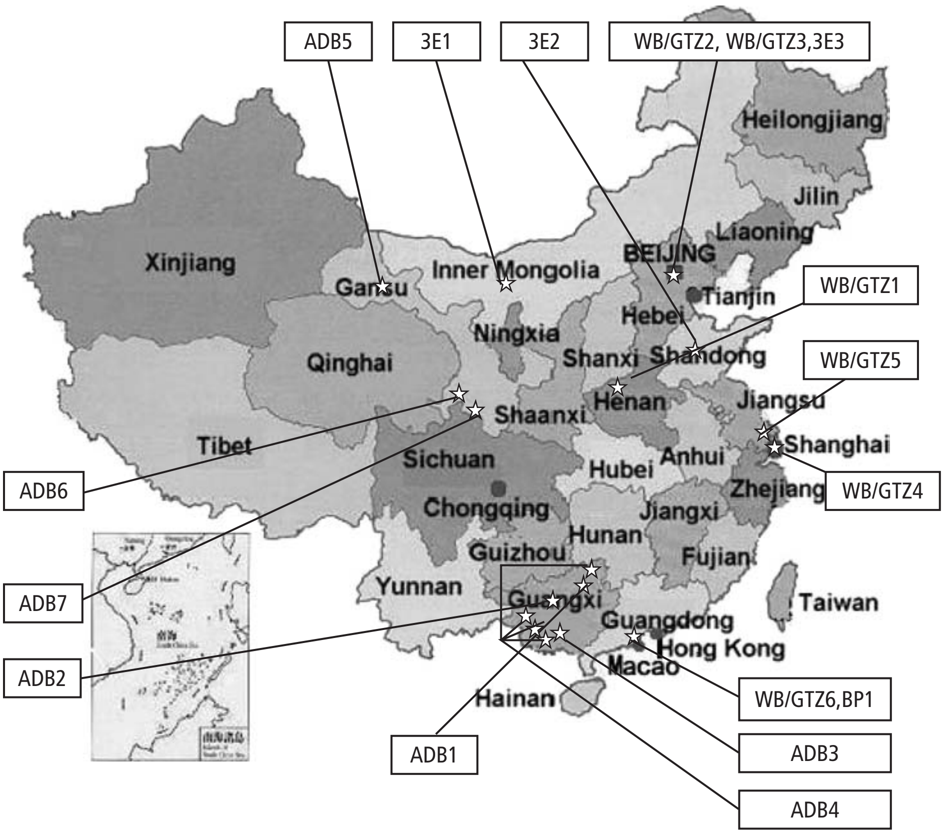
Based on the stakeholder assessment and focusing on the CDM potential in the first commitment period, the subsequent main requirements are as follows:

- Transparent, simple, and straight-forward CDM procedures for project developers
- Maximum certainty regarding the amount of CERs and approval by the EB
- Short time between preparing PDDs, the official approval of the CDM project activity by the EB, and the CER revenues
- Assessment and minimization of risks associated with CDM project activities.

CROSS COMPARISON OF FINDINGS WITH RESULTS FROM OTHER STUDIES

Figure 3.1 and *Table 3.22* provide an overview of CDM Case Study projects in China. On one hand, there are the six case studies that have been conducted within the present study; on the other hand, there are case study projects from other studies. These further case studies are the BP-1 project (sponsored by British Petrolium) the ADB-1 to ADB-7 case studies (sponsored by the Asian Development Bank), as well as the 3E1, 3E2 and 3E3 case studies (sponsored by New Energy and Industrial Technology Development

FIGURE 3.1 Location of China's CDM Project Activities with Case Studies



Note: status at the end of 2003

Organization NEDO, Japan). All together, 17 case studies have been considered. One is based on coal, four are based on natural gas, and the other 12 are based on renewable energy and waste. Two of the waste utilization processes are related to industrial processes.

Figure 3.2 shows the specific investment costs of the case studies with available data.

The first four case studies are based on fossil fuels; the others are renewable energy power generation projects. The average specific investment costs of the fossil-fuel projects are about half of the investment costs of the renewable energy projects. This is mainly due to the much higher capacities of the fossil power generation projects. In the case of the renewable energy projects, the operational costs are very low due to the fact that the fuel costs are (almost) zero.

Figure 3.3 shows the emission reductions and the costs of CO_2 emission reductions of the case studies. (Note that we did not check the data from the other case studies.) The figure is divided into the sectors A, B, C, and D. In sector "A," the project case studies with high CO_2 emission reduction quantities and low ICER are indicated. Projects within this sector have the highest priority as CDM projects. In this sector, you can find the BP-1 project, a fuel-switching natural gas combined cycle power plant; the WB/GTZ1 project, a coal-fired super-critical steam turbine power plant; and the 3E3 project, a plant related to an industrial process. No renewable energy-based project is in sector "A."

The case studies in sector "B" are characterized by relatively low CO_2 emission reduction quantities and low ICER. This sector includes an industrial-process-related plant (3E2) and a small landfill gas-to-energy power plant (WB/GTZ6). The landfill gas plant has very low ICER, but the specific investment costs are the highest of all case study projects as shown in *Figure 3.3.*

In sector "C," there is only one project (3E1), a natural gas-fired combined cycle.

Sector "D" projects have relatively high ICER and at the same time a relatively low emission reduction potential. In sector "D" there are two natural-gas based projects, a cogeneration project (WB/GTZ2), a combined cycle project (WB/GTZ3), and two renewable-based projects. The wind project (WB/GTZ4) has the highest ICER of all case studies shown and simultaneously a low quantity of CO_2 emission reduction potential.

Generally speaking, renewable-energy-based projects have a comparatively low CO_2 emission reduction potential as a single project, but a very high replication potential. The large-scale fossil fuel power plants have a comparatively higher potential for CO_2 emission reductions.

CONCLUSIONS AND RECOMMENDATIONS

Based on the application of the CDM methodologies in the selected six case studies in the electric power sector and the renewable energy fields (for power generation), the major conclusions and recommendations are as follows.

The Applicability of CDM Methodology under the Specific Conditions of China

Project system boundary and leakages

All case studies selected the physical boundary of the projects as defined in the CDM Glossary. For most cases, the one-step upstream and downstream leakages were evaluated. The results show that normally in comparison with total emissions during the project lifetime, the leakage could be neglected. These findings could be applicable in most other projects as a simple and workable approach to deal with the on-site direct project emissions reductions within the project boundary and leakage issues.

Baseline setting

There are three kinds of baseline approaches identified by the Executive Board, paragraphs 48a to 48c, which build the basis for baseline methodology. In a fast-growing economy like China's,

TABLE 3.22 Overview and Summary Table Comprising Other CDM Project Case Studies

		WB/GTZ1	WB/GTZ2	WB/GTZ3	WB/GTZ4	WB/GTZ5	WB/GTZ6	BP-1
Project Name		Huaneng-Qinbei	Beijing Dianzicheng	BJ3TPP	SH-Wind Farm	Taichang-Biogas	Zhuhai-LFG	Zhuhai II
Project Location	[City, Province]	Wulongkou Jiyuan, Henan	Beijing	Beijing	Shanghai	Taichang, Jiangsu	Zhuhai City, Guangdong	Zhuhai City, Guangdong
Sector	[According to IPCC]	energy	energy	energy	energy	waste	waste	energy
CDM Project Activity	[Brief description]	Super-critical coal-fired power generation	Gas-fired Combined Cycle Tri-generation	Gas-Steam Combined Cycle Power	Wind power generation	Power from the anaerobic treatment	Landfill Gas for Power	Combined Cycle Power Generation
Baseline Approach	[48.a; 48.b; 48.c]	48 b)	1.48 b) 2.48 a) 3.48 b)	48 b)	48 b)	48 b)	1.48 a) 2.48 a)	48 a)
Crediting Period	[years]	Renewable 3×7	Fixed 10	Renewable 3 × 7	Renewable 3 × 7	Fixed 10	Fixed 10	Fixed 10
Capacity	[MW_e]	2×600	133	400	20	4.1	1.74	3×700
Energy Generation	[GWh_e/a] [MWh_{th}/a]	6,250	548 875	1413.6	40	29.1	8.7	8400[1]
CO_2-Reduction	[Mt CO_2/a]	0.88	0.536	0.65	0.036	0.027	0.072	3.70[1]
Investment	[Mil. US$]	765.54	88.84	193.56	22.08	5.44	2.81	914.87[3]
ICER	[US$/t CO_2]	8.47	24.94	15.0	49.79	21.7	3.94	11.62[4]

Default exchange rate = 8.27 RMB/US$
1/ medium scenario, annual operating time:4000hr, in 2010.
2/ CO_2-emission reduction/Energy Generation, calculated by Zheng Zhaoning
3/ static investment costs
4/ medium scenario, annual operating time:4000hr. discount rate: 8%
5/ calculated by Zheng Zhaoning based on the CO_2 emission intensity per unit electricity generation

additional power plant capacity is needed, while at the same time autonomous development in technology by means of higher efficiencies is expected. The 48a approach is consequently not chosen for the power baseline of the six case studies under investigation. For approach 48c, the data requirements are too much and the uncertainties regarding improvements in technology over the crediting period—as well as the development of a CDM market according to the Kyoto Protocol—are very high.

Operating Margin is regarded as the most appropriate baseline methodology in the case of small, renewable energy power generation projects. The key issue is the standard set for a reliable power supply.

In a power grid system with relative new power plants, the type of baseline approach and baseline

ADB-1	ADB-2	ADB-3	ADB-4	ADB-5	ADB-6	ADB-7	3E1	3E2	3E3
Guilin MSW	Guangxi Bio-organic	Guitang Bagasse	Biogas Digesters	Gansu Yumen	Luertai Hydropower	Niaojiaga Hydropower	Baotou CC	Laigang-TRT	Liulihe Cement
Guilin City, Guangdxi	Laibin, Liuzhou, Guangdxi	Guigang City, Guangdxi	Nanning, Guilin Baise in Guangxi	Yumen, Gansu	Lintan County, Gannan Tibetan, Gansu	Diebu County, Gansu	Baotou, Inner, Mongonia	Laiwu, Shaidong	Beijing
waste	waste	waste	waste	energy	energy		energy	Industrial Processes	Industrial Processes
municipal waste to generate energy	organic fertilizer	treat waste water	anaerobic digester	Wind Power generation	Hydropower generation	Hydropower generation	Gas-Steam Combined Cycle	Power generation from TRT	Waste gas power generation
simplified	simplified	simplified	simplified	simplified	simplified	simplified	48 c)	simplified	simplified
Fixed 10	Fixed 10	Fixed 10	Fixed 10	Fixed 10	Fixed 10	Fixed 10	Renewable 3×7	Fixed 10	Fixed 10
12				15	12.2	12.9	2×300	3	3
64				41.65	49.55	49.79	3791	14.8	14.9
0.13163	0.04284	0.01553	0.01797	0.03023	0.13374	0.17855	0.965	0.98	1.9
12.04	1.02	4.12	0.91	14.22	13.28	13.28		3.02	8.9
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

methodology has a limited impact on the baseline emissions.

Due to the economic growth in China and the time requirements for building new power plants, it can be expected that China will face severe power shortages in the future. These power shortages may last beyond the crediting period of most CDM project. For the time being, there is no adequate baseline approach or methodology available that takes into account such long-term power shortage conditions. The expected power shortages, however, do not allow CDM projects to replace power. To derive additionality for these specific situations, there is a need to develop a (simplified) baseline methodology. Standardized baselines, which should be adjusted from time to time for the grids in China and could be used for all CDM projects, can sig-

FIGURE 3.2 Specific Investment Costs of the CDM Case Studies in China

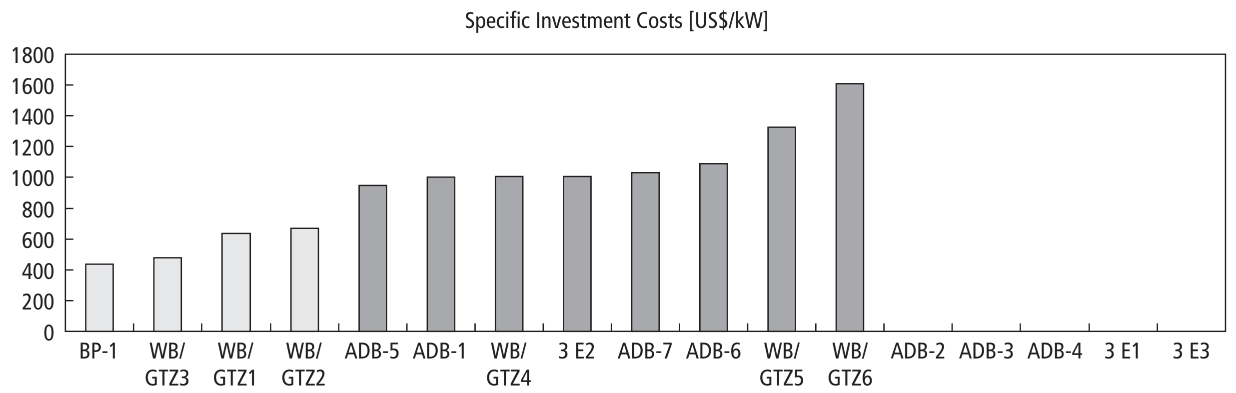
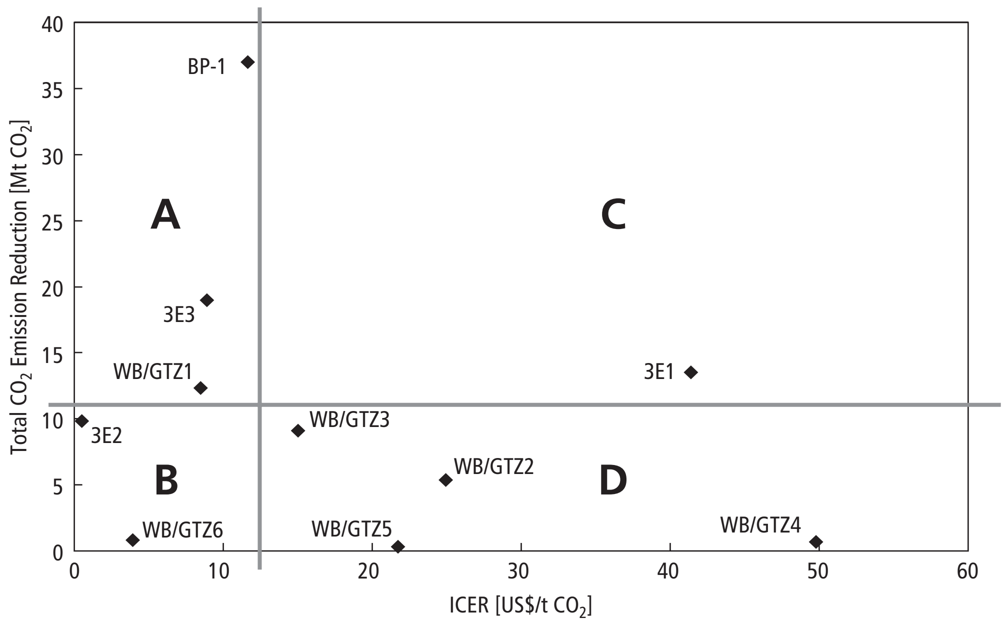


FIGURE 3.3 Total CO_2 Emission Reductions Related to the Incremental Costs of Emissions Reduction (ICER) of the CDM Case Studies



nificantly reduce the work load for setting up CDM projects.

Additionality

One might argue that projects listed in the Five-Year-Plans will be built anyway, even in the absence of CDM. For a potential CDM project that is listed in the plan, it has to be shown that the project would not receive the necessary financing, even though it is part of the Five-Year-Plan (This may be a criteria of exemption from the project pipeline).

Early action is needed in order to catch the opportunities provided by CDM. Therefore, it is necessary to identify potential CDM project activities that are in line with the government priorities listed in the Five-Year-Plan, and are at the time not (yet) economically feasible for project development. These projects should be identified before the submission of a project to the government authorities for approval. Furthermore, projects that are not economically viable at first sight may improve their economic performance with CDM, and hence have a higher probability to be approved by the government.

Benefits from CDM and Barriers for its Implementation

Benefits from CDM to China

Beside the obvious goals of CDM project activities—the reduction of GHG emissions and mitigation of climate change—there are other significant benefits for China. These include the a) transfer of state-of-the-art technology to China that will stimulate scientific and technological progress; b) additional revenues coming from CER that will improve the financial performance of a project; c) help to start up new, domestic industry sectors; d) improvements in local air, water, and groundwater quality; e) diversification of electricity generation sources; f) support and help to accelerate the development of renewable energies; and g) creation of new jobs.

The benefits derived from CDM support all three major objectives of China's energy policy within the 10th Five-Year Plan; that is, to reduce the environmental impacts of coal-fired generation by 1) diversifying the fuel mix; 2) promoting energy efficiency and clean coal technologies; and 3) promoting renewable energy.

Barriers for the implementation of CDM in China

The barriers and possible risks for CDM implementation in China have been analyzed systematically. There are potential barriers at different levels.

For the stakeholders, important barriers include the following: a) the central government is knowledgeable about CDM, but there is relatively little awareness of CDM at the provincial and local levels; b) the government has stated its objectives to improve the energy efficiencies of power plants and enlarge the share of renewable energy, but has not yet provided the needed support; c) power utilities are crucial in order to get the data to create a solid baseline, but the utilities only benefit from CDM when it involves their own plants.

The present prevailing uncertainty concerns the date when the Kyoto Protocol will enter into force. Since the Kyoto Protocol has not yet entered into force, the DNA (designated national authority) hasn't been established yet. There is a need for transparent, simple, and straight-forward CDM procedures for project developers.

Different factors affect the financial performance of a CDM project activity. Some of them are perceived as risk, such as uncertainties about technology performance, electricity tariffs, and additional revenues from CER. In addition, the level of transaction cost of the CDM project activity is expected to be high, especially for small-scale CDM project activities.

CDM Project Activity Opportunities for China

The incremental costs of emission reduction (ICER) of the six cases are \$3.94/t CO_2 for

TABLE 3.23 Cost and Priority Ranking of Project Types

	Barriers and associated risk for demonstrating additionality		
Abatement cost	**low risk**	**+/-**	**higher risk**
Medium to high cost ≥ 10 US$/ t CO_2	Wind power Biogas	Biomass gasification Trigeneration Fuel switch: Gas combined cycle	
Low cost < 10 US$/ t$CO_2$	Landfill Methane gas recovery	Energy efficiency in industry	Supercritical coal

Zhuhai-Landfill gas, $8.47 for the Huaneng super-critical power plant, $15 for the gas-steam combined cycle trigeneration, $21.67 for Taicang biogas, $24.94 for BJ3TPP-GSCC, and $49.79 for the Shanghai wind farm. The case studies show that the low ICER results from either large GWP of methane or high efficiency improvement. On the other hand, high ICERs result from high initial investment costs, comparatively short annual operation hours of a plant, or high natural gas prices.

In general, it seems that most of the ICER is higher than that the current market price and anticipated level of abatement cost in China. However, the current low market price of CERs does not reflect the future CER market price, given the uncertainty of the Kyoto Protocol's entry into force. On the other hand, sensitivity analysis shows there may be some room for decreasing ICERs, since the value of some parameters is expected to decline, such as natural gas prices or longer crediting periods.

This study has investigated 6 CDM case studies from the power sector with a total reduction potential of about 2.2 MtCO_2 equivalent annually at the weighted average ICER of $15/t-$CO_2$eq. The technology assessment presented in *Table 3.23* intends to facilitate further discussion among all stakeholders on the findings of this investigation.

The development of a larger project pipeline would take into consideration the parameters such as concentration on projects perceived as "low" risk as well as technological advancement in the respective sectors. Other important issues include the assessment of abatement cost; assessment of the project developer's risks associated with demonstration of additionality; the related technology and financial risks; and stakeholders' views based on the above mentioned criteria. *Table 3.23* shows the interaction of risks and costs. Through wider analysis of results obtained by different groups of project proponents, we could establish a more consistent assessment of technology priorities for CDM. The table is specific to this WB/GTZ-aided project only, not a generic conclusion.

Recommendations to Facilitate CDM in China

These recommendations are based on the findings of the six case studies and the lessons learned from the interactions with different stakeholders. The recommendations should facilitate CDM in China by making opportunities provided by CDM more visible, removing perceived barriers, and setting incentives that support CDM.

Regulations, incentives. Provide lower, preferable taxes on electricity sales to the public grid from renewable energy sources.

Issue a directive for power utilities that a certain share (e.g., 5 percent) of their power generation has to come from renewable energy sources.

Tools. Generate a power baseline for regions with high potential for CDM project activities. Investigate and generate simplified baselines for power shortage situations

Information, communication. Promote CDM in target provinces and cities through workshops, case studies, and training courses to improve knowledge and know-how about CDM. Establish a roundtable to make use of experiences gained from the different ongoing CDM activities, with a focus on case studies.

Institutional arrangements. Integrate CDM into the existing application and approval cycle of power plant projects in China, taking into account the opportunities of CER from CDM to improve the economic viability of a project at an early stage.

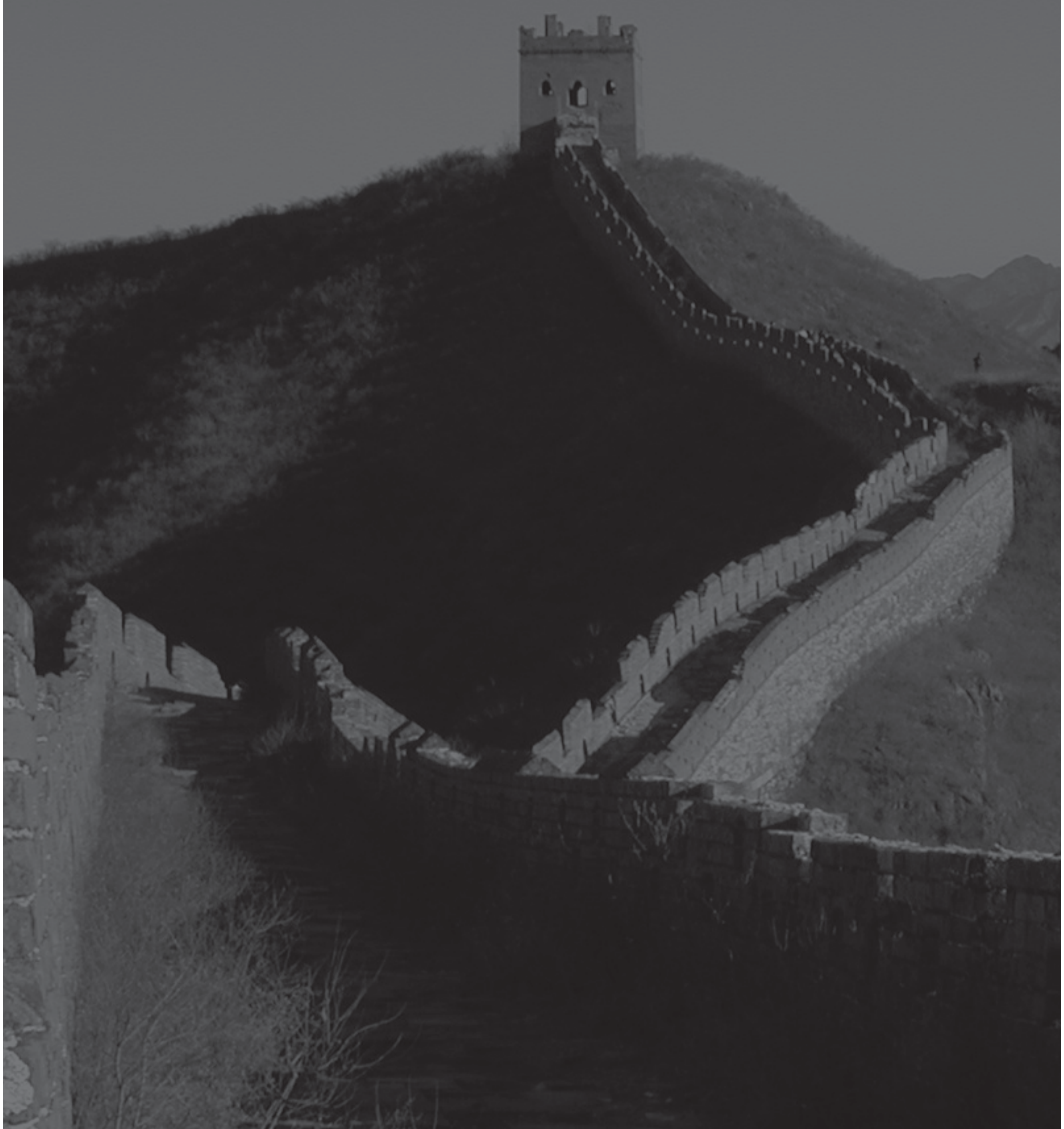
Set up an arrangement for power utilities to get the data and information needed for a solid baseline.

Endnotes/References

1. E.g. monitor that also remote areas are going to be supplied with electricity, not only urban areas.
2. Sustainable strategy according to the 10th Five-Year-Plan: i) Adhering to the basic state policy on family planning. ii) Protecting natural resources and using them properly. iii) Improving ecological conservation and strengthening environmental protection.

II

CHINA'S CDM POTENTIAL



4

Objectives, Methodologies, and Approach in Evaluating China's CDM Potential

OBJECTIVES

In Part II, we assess the potential supply of CERs in China and their marginal abatement cost curve (MAC) in view of the supply and demand potential in the world carbon market. This analysis is intended to improve our understanding of the opportunities and the economic benefits for China provided by participating in the CDM regime.

The specific objectives are as follows:

- To assess global carbon trading supply and demand based on selected scenarios under the Kyoto Protocol
- To determine the potential supply of CERs from CDM projects in China under different scenarios
- To assess the impacts of CDM implementation on China's economic development and identify opportunities and economic benefits created by CDM in China
- To make recommendations on key CDM policy implications for China
- To build capacity in the application of analytical methods and modeling tools in China for CDM carbon trade economics and policy assessment.

THE CHALLENGE

An important challenge for China's policymakers is to understand at the macroeconomic level the opportunities and economic benefits of participating in the CDM regime; that is, understanding the potential supply and demand for CERs in the world carbon trade market, price trends, how to better use and manage potential Chinese CDM projects, and how to promote technology transfer and sustainable development, especially in the energy sector. To answer these questions, this study employed several energy-economy models, including two energy technology models (IPAC-Emission model and IPAC-AIM/Technology model), a carbon market equilibrium model (CERT), and a computable general equilibrium model (IPAC-SGM). The model system will project future carbon emissions and generate marginal abatement cost curves for different regions in the world; address the possible carbon trade and equilibrium carbon quota price with a view to better understand the role of CDM in the world carbon market; examine carbon reduction potential by major sectors; and identify technology priorities for CDM in China. The model system will also provide insights into the policy implications of CDM in China and the impact of CDM on China's economy. Since there have been few comparable studies, using these modeling tools to analyze CDM price, potential, and impact is a difficult challenge.

The 7th Conference of the Parties adopted a package of decisions on Kyoto Protocol issues, especially on CDM. These decisions are documented in the Marrakech Accords. This political achievement should pave the way for Annex I Parties to ratify the Kyoto Protocol and thus bring it into force soon. Under the political agreement, the CDM regime was elaborated in principle at the technical and procedural levels, which will enable CDM to become operational when the Protocol enters into force. Other emerging post-COP7 issues include the impact of the United States' withdrawal, the offsetting effect of carbon sequestration in Russia's forests on Russia's target emissions, the potential for the development of carbon sink projects, the participation rate of the major developing countries, and possible CDM market structures. Some of these issues, which are critical for China's interests, can be addressed by using the modeling approach in this study.

BRIEF DESCRIPTION OF METHODOLOGICAL FRAMEWORK AND APPROACH

The IPAC Emission Model

The IPAC emission model was a global model developed for greenhouse gas emission scenarios. It divides the world into nine regions: (1) the United States (US); (2) Pacific OECD (OECD-P); (3) Europe OECD and Canada (OECD-W); (4) Eastern Europe and the former Soviet Union (EFSU); (5) Middle East (ME); (6) China; (7) other Asia (Southeast Asia); (8) Africa; and (9) Latin America (LA). Major emission sources—including energy activities, industries, land use, agriculture, and forests—can be simulated in the model framework. The model consists of three modules: a macroeconomy module, end-use module, and land-use module, as shown in *Figure 4.1.* The macroeconomy module was developed based on the Edmonds-Reilly-Barns (ERB) model (Edmonds and others 1983), a macroeconomic partial-equilibrium model that forecasts long-term energy demand. It uses GDP and population as future development drivers, combined with other energy-related parameters to forecast energy demand based on the supply and demand balance. The end-use module is originally a part of the Asian-Pacific Integrated Model (AIM), a bottom-up energy-technology model that was developed by the National Institute for Environment Studies and Kyoto University of Japan. The land-use module was developed from the Agriculture Land Use Model developed by Pacific-Northwest National Lab (PNNL) to estimate GHG emissions from land use.

The macroeconomy module calculates future energy service demand for three end-use sectors—industry, commercial/residential, and transport—based on exogenous future potential GDP growth. The end-use module calculates energy technology efficiency and final energy demand from the current period to 2030. After 2030, the macro economy module calculates energy demand for the three energy end-use sectors and energy reserve and its relative cost. In the long term, technology progress is the main basis of energy demand.

The IPAC-AIM Technology Model

The IPAC-AIM technology model is a single-region model for China. It includes three modules: (1) an energy service demand projection module; (2) an energy efficiency estimation module; and (3) a technology selection module. It is a typical bottom-up type model. The structure of this model is given in *Figure 4.2.* The demand sector is divided into industrial, agricultural, service, residential, and transportation. These sectors are further divided into sub-sectors (*Table 4.1*). For both the demand and supply side, more than 400 technologies are considered, including existing as well as future technologies (*Table 4.2*). Future sector output services (such as steel output) are a key driver. In order to provide these output services, a group of technologies will be selected. Energy demand could then be calculated for these technologies. The model searches for the least-cost technology mix to

FIGURE 4.1 Framework of IPAC Emission Model

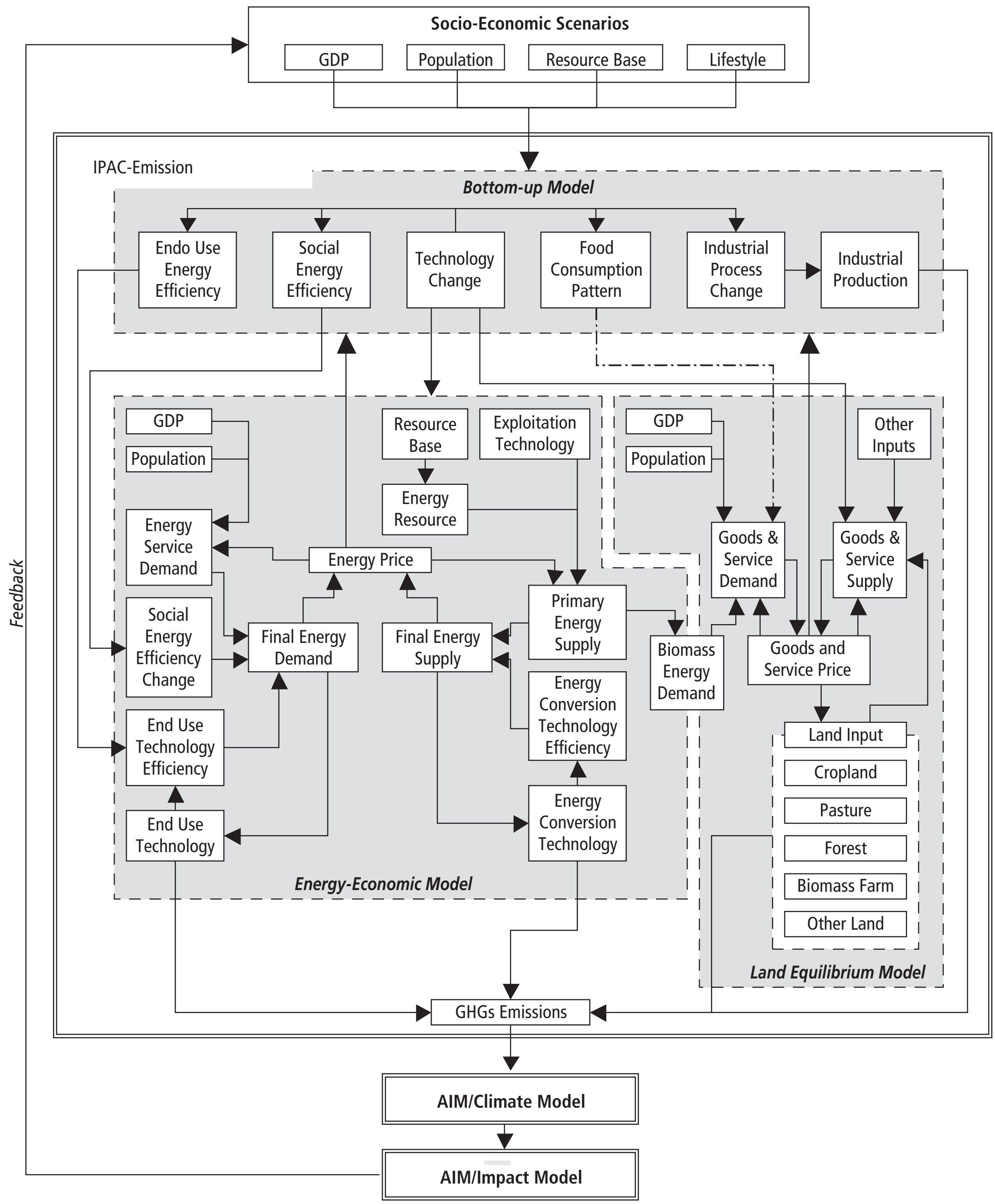


FIGURE 4.2 Structure of IPAC-AIM Technology Model

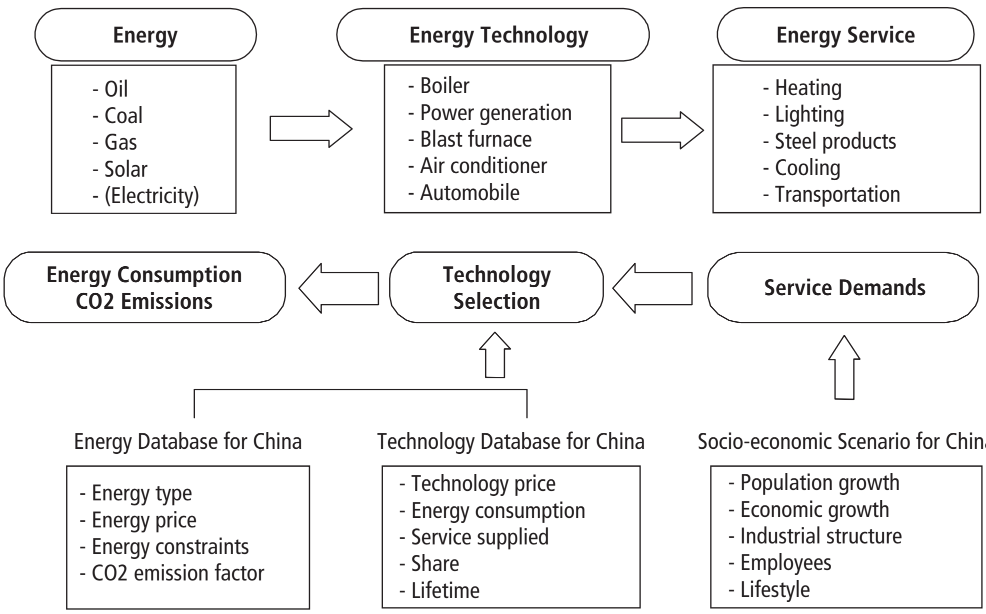


TABLE 4.1 Classification of Energy End-use Sectors and Subsectors

Sectors	Sub-sectors
Agriculture	Irrigation, farming, agricultural products processing, fisheries, animal husbandry
Industry	Iron & steel, non-ferrous, building materials, chemical industry, petrochemical industry, papermaking, textiles
Household	Urban: space heating, cooling, lighting, cooking and hot water, household electric appliance
	Rural: space heating, cooling, lighting, cooking and hot water, household electric appliance
Service	Space heating, cooling, lighting, cooking and hot water, electric appliance
Transportation	Passenger: railway, highway, waterway, airway
	Freight: railway, highway, waterway, airway

meet the given energy service demand. Policies and countermeasures for technology selection, progress, and energy price could be simulated in the model. Data for these technologies were collected from reports, journals, and publications, and by consulting experts. The data is continuously updated to include new information.

The CERT Model

The CERT (Carbon Emission Reduction Trading) model was developed in 2001 by Grütter Consulting together with ETH Zürich on behalf of the World Bank (Kappel and others 2002). CERT is a partial equilibrium model to simulate the emerging market of GHG emission reductions. It uses inputs of GHG emission projections and marginal abatement cost curves from other models.

For whatever market considered, CERT adds up the quantities (x-axis) potentially supplied and

TABLE 4.2 Major Technologies Considered in the Model

Classification	Technologies (equipment)
Iron & steel	Coke oven, sintering machine, blast furnace, open hearth furnace (OHF), basic oxygen furnace (BOF), AC-electric arc furnace, DC- electric arc furnace, ingot casting machine, continuous casting machine, continuous casting machine with rolling machine, steel rolling machine, continuous steel rolling machine, coke dry quenching, coke wet quenching, electric power generated with residue pressure on top of blast furnace (TRT), coke oven gas, OHF gas and BOF gas recovery, cogeneration
Non-ferrous metal	Aluminum production with sintering process, aluminum production with combination process, aluminum with Bayer, electrolytic aluminum with upper-insert cell, electrolytic aluminum with side-insert cell, crude copper production with flash furnace, crude copper production with electric furnace, blast furnace, reverberator furnace, lead smelting-sintering in blast furnace, lead smelting with closed blast furnace, zinc smelting with wet method, zinc smelting with vertical pot method
Building materials	Cement: Mechanized shaft kiln, ordinary shaft kiln, wet process kiln, lepol kiln, ling dry kiln, rotary kiln with pro-heater, dry process rotary kiln with pre-calciner, self-owned electric power generator, electric power generator with residue heat Brick & Tile: Hoffman kiln, tunnel kiln Lime: Ordinary shaft kiln, mechanized shaft kiln Glass: Floating process, vertical process, Colburn process, smelter
Chemical industry	Synthetic ammonia production: Converter, gasification furnace, gas-making furnace, synthetic column, shifting equipment of sulphur removing Caustic soda production: Electronic cell with graphite process, two-stage effects evaporator, multi-stage effects evaporator, rectification, ion membrane method Calcium carbine production: Limestone calciner, closed carbine furnace, open carbine furnace, residue heat recovery Soda ash production: Ammonia & salt water preparation, limestone calcining, distillation column, filter Fertilizer production: Organic products production, residue heat utilization
Petrochemical industry	Atmospheric & vacuum distillation, rectification, catalyzing & cracking, cracking with hydrogen, delayed coking, light carbon cracking, sequential separator, naphtha cracker, de-ethane separator, diesel cracker, de-propane cracker, residue heat utilization from ethylene
Papermaking	Cooker, distillation, washing, bleaching, evaporator, crusher, dewatering, finishing, residue heat utilization, black liquor recovery, cogenerator, back pressure electric power generator, condensing electric power generator
Textile	Cotton weaving, chemical fiber, wool weaving & textiles, silk, printing & dyeing process, garment making, air conditioner, lighting, space heating

(*continued*)

TABLE 4.2 Major Technologies Considered in the Model (*Continued*)

Classification	Technologies (equipment)
Machinery	Ingot process: cupola, electric arc furnace, fan Forging process: coal-fired pre-heater, gas-fired pre-heater, oil-fired pre-heater, steam hammer, electric-hydraulic hammer, pressing machine Facilities for heat processing: Coal-fired heat processing furnace, oil-fired heat processing furnace, gas-fired heat processing furnace, electric processing furnace Cutting process: Ordinary cutting, high-speed cutting
Irrigation	Diesel engine, electric induct motor
Farming works	Tractor, other agricultural machinery
Agricultural products process	Diesel engine, electric induct motor, processing machine, coal-fired facilities
Fishery	Diesel engine, electric induct motor
Animal husbandry	Diesel engine, electric induct motor, other machines
Residential space heating	Heat supplying boiler in thermal power plant, district heating boiler, dispersed boiler, small coal-fired stove, electric heater, brick bed linked with stove (Chinese KANG)
Residential cooling	Air conditioner, electric fan
Residential lighting	Incandescent lamp, fluorescent lamp, kerosene lamp
Residential cooking & hot water	Gas burner, bulk coal-fired stove, briquette-fired stove, kerosene stove, electric cooker, cow dung-fired stove, firewood-fired stove, methane-fired stove
Electric appliance	Television, cloth washing machine, refrigerator, others
Space heating in service sector	Heat supplying boiler in the thermal power plant, district heating boiler, dispersed boiler, electric heater
Cooling	Central air conditioner system, air conditioner, electric fan
Lighting	Incandescent lamp, fluorescent lamp
Cooking & hot water	Gas burner, electric cooker, hot water pipeline, coal-fired stove
Electric appliance	Duplicating machine, computer, elevator, others
Passenger & freight transport	Railway (passenger & freight): Steam locomotive, internal combustion engine locomotive, electric locomotive Highway (passenger & freight): Public diesel vehicle, public gasoline vehicle, private vehicle, large diesel freight truck, large gasoline vehicle, small freight truck. Waterway (passenger & freight): Ocean-going ship, coastal ship, inland ship. Aviation (passenger & freight): Freight airplane, passenger airplane
Common technologies	Electric motor, frequency adjustable electric motor, coal-fired boiler, high efficiency coal-fired boiler, natural gas-fired boiler, oil-fired boiler
Power generation	Low parameter coal-fired generator, high pressure critical coal-fired generator, super critical coal-fired generator, PFBC, IGCC, natural gas-fired generator, NGCC, nuclear generator, wind turbine, hydropower, solar power generation, oil-fired generator, biomass power generation, landfill power generation

those potentially demanded at each price (y-axis) across the constituent regions. As one varies the price, the demand and supply curves for this market are described, and their intersection indicates the market clearing price on the y-axis (Kappel and others 2002). The market is cleared for the first commitment period in 2008–2012, and the year 2010 is taken as a representative value for that period.

CERT incorporates a variety of switches, such as implementation rate, transaction cost, supplementarity, participation rate of the United States, and market structure to analyze the impact of different factors on the market.

The implementation rate is the percentage of CERs actually implemented by non-Annex I countries. An implementation rate below 100 percent means that not all possible projects (MACs) will be realized. If the implementation rate is set over 100 percent, then banking of projects prior to the period 2008–2012 is assumed. The calculation of the implementation rate is performed by calculating a proportional upward or downward shift in the supply curve (Kappel and others 2002).

Transaction costs are added to the cost of the credits (Kappel and others 2002).

Supplementarity is modeled as an import ceiling (restrictions to the amount an Annex B country can import to comply with its reduction commitment). Supplementarity means an Annex B country can import a certain percentage of the reduction requirement. In this case, the demand curve of the market would be changed.

The U.S. withdrawal from the Kyoto Protocol would significantly shrink the carbon market. States such as California might use the three mechanisms defined in the Kyoto Protocol—JI, CDM, and ET—to help realize some of their domestic air quality regulations. The participation rate of the United States could be simulated in CERT 1.3. Limited participation by the United States leads to a corresponding reduction in the BAU-Kyoto target; the parameters of the MAC for the United States are adjusted accordingly (Kappel and others 2002).

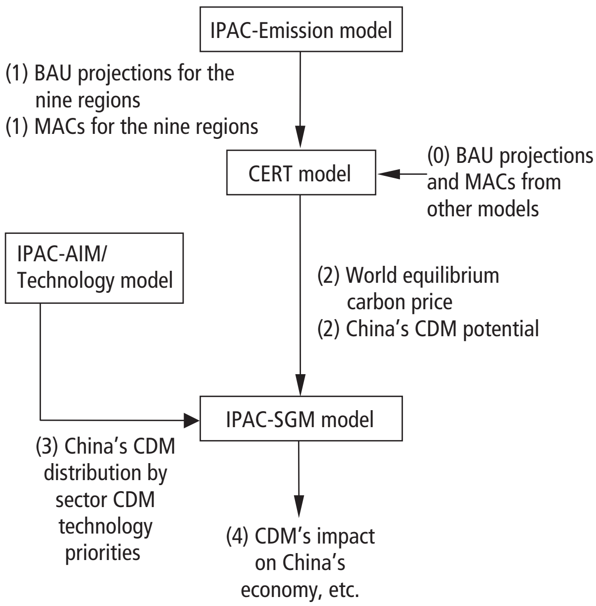
Three kinds of market structures could be simulated in CERT 1.3: perfect competition, monopoly, and price leadership. In the perfect competition market, all countries' marginal abatement cost would be equal to the equilibrium price, which would reflect the lowest cost of global emission reductions. For example, since economies in transition (EITs) have sufficiently large amounts of greenhouse emissions to control the market price, the model could simulate an EIT monopoly. The calculation is made by maximizing revenues for EITs plus non-Annex B nations. However, if EITs restrict their offer to control the price, a trade-off problem would develop in which a high price would lead to a large quantity of free-riders who sell at this price, thus enlarging the offer and limiting the sales and the income of EITs. While a working cartel is not expected—too many countries are involved and partial interests are diverse—an oligopolistic situation or some form of price leadership is much more probable (Kappel and others 2002).

In the CERT model, the world is grouped into 12 regions: six for Annex I parties, including the United States, Japan (JPN), European Union (EEC), other OECD countries (OOE), the former Soviet Union (FSU), and other Economies in Transition (EIT); and the other six for non-Annex I Parties, including China (CHN), India (IND), Brazil (BRA), Energy Exporting countries (EEX), dynamic Asian Economies (DAE), and the rest of the world (ROW). When applying the carbon emission projections and marginal abatement cost curves from the IPAC emission model in CERT, the world can be easily regrouped to be consistent with the regional division in the IPAC emission model.

Linkages Between Models

The IPAC emission model generates reference emission scenarios for the year 2010 and MACs for the nine regions. With the reference emission scenarios and MACs from the IPAC emission model and other models, the CERT model

FIGURE 4.3 Linkage Framework of the Models



calculates the world carbon price, China's potential CERs supply volume (referred to as CDM potential in the following text), and profits from selling CERs when demand and supply reaches equilibrium in the world carbon market. Research results from the IPAC-AIM technology model are used to provide a picture of China's CDM potential by sectors, and technology priorities by assuming various technologies for CDM based on the study for emission reduction potential in China. China's profits from CDM (from the CERT model) are passed to the IPAC-SGM model (introduced in chapter 6) to analyze the impact of CDM on China's economy.

Because CDM is a project-based trading mechanism, it is a challenge to simulate CDM in the overall analysis. So far there is no good model to cover all the issues targeted in this study. So we used several models for this purpose. We faced challenges to maintain good consistency among these models, because there is no hard link among them and the models have different purposes. There are no specific parameters for CDM in these models. Simulation for CDM in these models is given by assumptions for CDM. Another difficulty concerns the differences in model methodology and the structure of the models. This caused the difference in the baseline scenario in the IPAC emission model, IPAC-AIM technology model, and IPAC-SGM model, even though similar assumptions were used for these models. Therefore the modeling study tries to understand limited aspects of CDM. The IPAC-AIM technology model is weakly linked with other models used in this study because of differences in model characteristics and structure. The IPAC-AIM technology model is only used to identify the potential distribution of CDM projects by sector. In the IPAC emission model, 1990 is the base year, while data for 2000 was harmonized to follow actual data.

Figure 4.3 displays the linkage framework of the models.

5

Analysis of China's CDM Potential

MARGINAL ABATEMENT COST CURVES

Reference Emission Scenarios

The reference scenario used in this study was developed from the results of related studies and projects up to 2010. Results from the AIM project—a collaboration among various Asian countries, including Japan, China, India, Korea, Indonesia, and Thailand—were used in the IPAC emission model. Other sources of information—including national communications to UNFCCC, the International Energy Agency's *World Energy Outlook,* and the U.S. Department of Energy's *International Energy Outlook*—were used to prepare a reference scenario. The quantified key scenario drivers and assumptions for the world and nine regions are listed in *Tables 5.1 and 5.2.*

Data used for the model were also collected from several other sources, including the International Energy Agency's energy statistics yearbook, the United Nations Food and Agriculture Organization's agricultural statistics yearbook, the World Bank's population forecast, the International Institute of Applied Systems Analysis GDP forecast, and national statistical yearbooks.

The modeling results for the reference scenario of energy demand and carbon emissions (from fossil fuel combustion only) from the IPAC emission model are shown in *Tables 5.3 and 5.4.* By 2010, world carbon emissions from fossil fuel combustion are expected to grow 36.5 percent from the 1990 level. For Annex I Parties, growth is forecast to be 5.5 percent. By 2010, renewable energy is forecast to account for 7.8 percent of total global primary energy demand. Energy efficiency is expected to improve at an annual average rate of 1.18 percent from 2000 to 2010. In China, coal's share declines from 71 percent in 2000 to 62 percent in 2010, suggesting a shift from coal to natural gas and oil.

Note: Since most references for the modeling work in this chapter apply *tons Carbon* (tC) rather than *carbon dioxide* (CO_2), the tC unit will be applied throughout the chapter. Since the Technical Summary uses the conventionally applied CO_2, the equivalent CO_2 value is added in a bracket behind the tC value. CO_2 values can be converted to C values by multiplying the CO_2 value by 12/44 (the ratio of the molecular weight of C to CO_2).

Marginal Abatement Cost Curves

Using the IPAC emission model, marginal abatement cost curves (MACs) are derived by introducing progressively higher carbon taxes on the basis of the reference emission scenario and

TABLE 5.1 Population of the Nine Regions

Population (billions)	1990	2000	2010
OECD total	0.86	0.92	0.94
USA	0.25	0.28	0.30
Europe OECD and Canada	0.46	0.48	0.49
Pacific OECD	0.14	0.15	0.15
Eastern Europe and Former Soviet Union	0.41	0.42	0.42
Pacific Asia	1.14	1.29	1.35
China	1.14	1.29	1.35
South and south-east Asia	1.56	1.86	2.13
Rest of World	2.75	3.38	4.02
Middle East	0.13	0.17	0.22
Africa	0.63	0.83	1.09
Latin America	0.43	0.51	0.58
World	**5.16**	**6.00**	**6.73**

recording the resulting quantity of abated emissions. The MACs from the IPAC emission model could be represented as:

$$MC = aQ^2 + bQ$$

Where MC is marginal abatement cost for the year 2010, in 1990$/tC, and Q is the abatement amount in MtC. The coefficients of a, b, and R^2 are given in *Table 5.5.*

TABLE 5.2 GDP of the Nine Regions

GDP (Trillion $, 1990$)	1990	2000	2010
OECD total	16.30	21.07	24.47
USA	5.50	7.52	8.95
Europe OECD and Canada	7.58	9.50	11.03
Pacific OECD	3.28	4.05	4.49
Eastern Europe and Former Soviet Union	1.08	0.96	1.36
Pacific Asia	0.47	1.23	2.31
China	0.47	1.23	2.47
South and south-east Asia	1.03	2.06	3.64
Rest of World	2.96	4.73	7.69
Middle East	0.45	0.62	0.92
Africa	0.39	0.53	0.86
Latin America	1.08	1.52	2.28
World	**20.87**	**27.99**	**35.98**

Figure 5.1 displays the results for the MACs in the nine regions for the year 2010.

Because of their high reference emissions, China and the United States have the flattest marginal abatement cost curves. The Middle East, Africa, and Latin America have the steepest marginal abatement cost curves. The Middle East, where oil and gas are the dominant energy sources, and Latin America, where relatively clean energy sources such as hydropower and biogasoline are widely used in countries such as Brazil, show higher reduction costs and less reduction potential.

Comparison of MACs from Different Sources

The MAC curves for different regions in the world could also be observed from several other models, like the Emission Prediction and Policy Assessment model (EPPA) model developed by MIT's Joint Program on the Science and Policy of Global Change, and the Global Trade and Environment model (GTEM) developed by the Australian Bureau of Agricultural and Resource Economics (ABARE). Both the EPPA and GTEM models are recursive computable general equilibrium models of the world economy (Ellerman and others 1998; Tulpule and others 1998).

Figures 5.2, 5.3, and 5.4 display the MACs curves for different regions from EPPA for CO_2 only, from GTEM for both CO_2 only and all GHGs respectively based on the formula and coefficients given in Annex 3.

Figures 5.5, 5.6, and 5.7 compare the MACs for the United States, OECD other than the U.S., and EFSU from different sources. For the United States, the MAC from the IPAC emission model is quite close to that from EPPA when the reduction amount is less than 550MtC (2,017 $MtCO_2$), but becomes steeper than that from EPPA when the reduction amount is larger than 550MtC. The GTEM model results in the steepest curve for the United States. For OECD without the U.S., the IPAC emission model provides the flattest MAC. For EFSU, when the reduction amount is less than 350MtC (1,283 $MtCO_2$) the MACs from IPAC emission, EPPA, and GTEM are very close. When the reduction amount is larger than 350MtC, the MACs from IPAC emission and EPPA are still very close, while GTEM's is much steeper.

Figure 5.8 compares the MACs for China from different sources. The MAC from the IPAC emission model is much steeper than those from GTEM and EPPA.

BAU emission projections are the basis for deriving MACs from models. In the IPAC emission model, China's 2010 BAU emissions are projected to be 1094MtC (4011 $MtCO_2$)—assuming some abatement countermeasures such as energy efficiency improvements, hydropower development, nuclear development, and efficiency improvements. These improvements are consistent with China's energy development strategy. EPPA projects BAU emissions as high as 1792MtC (6571 $MtCO_2$) for China. To further reduce emissions from a relatively low BAU would elevate abatement costs. But even with similar BAU projections, the MACs generated from various models could also be different.

The main reasons for the disparity in MACs generated from different models could be summarized as follows:

Differences in modeling approach and model structure. EPPA and GTEM are top-town CGE models, while IPAC emission is a partial general equilibrium model with a focus on energy systems. In CGE models, the revenues from carbon taxation are normally recycled to the economy. In addition, trade and income effects are taken into account, while the energy system models consider only the adjustment achieved in the energy system. Although MACs from energy system models don't take into account the full range of impacts of reduction policies, they will be close to abatement costs incurred at a microeconomic level.

Different basic assumptions. Different basic assumptions for factors such as GDP growth,

TABLE 5.3 Reference Primary Energy Demand for the Nine Regions from IPAC Emission Model (EJ)

	1990	2000	2010
USA	69.5	82.7	89.5
Pacific OECD	66.1	70.1	73.4
Europe OECD and Canada	22.1	24.5	25.5
Eastern Europe and Former Soviet Union	69.3	53.9	60.6
China[1]	28.2	38.4	54.4
South and Southeast Asia	17.1	25.7	45.5
Middle East	10.6	15.4	21.0
Africa	7.9	10.4	14.9
Latin America	14.1	18.1	22.5
World	**304.9**	**337.5**	**408.6**

TABLE 5.4 Reference Carbon Emissions from Fossil Fuel Combustion for the Nine Regions (from IPAC Emission Model) (GtC)

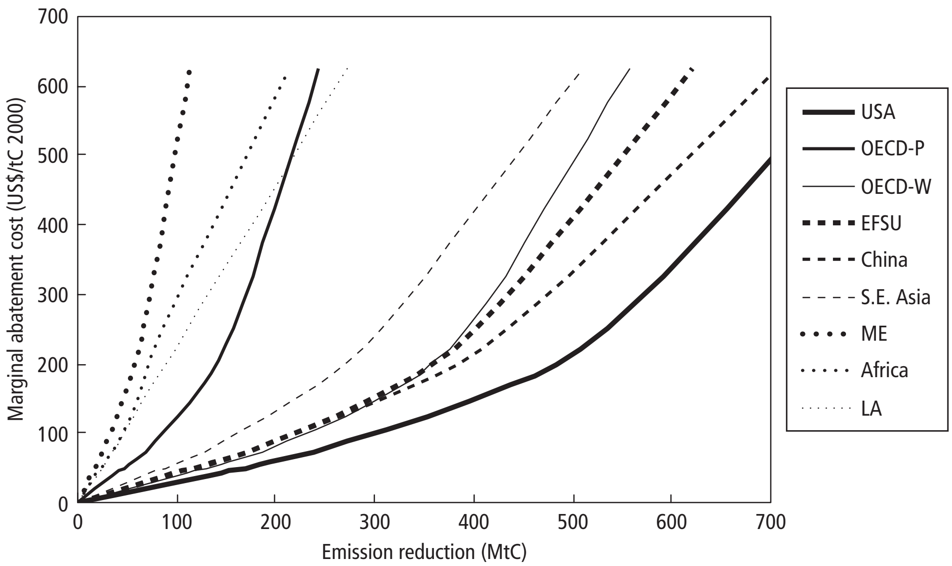
	1990	2000	2010
USA	1.33	1.50	1.62
Pacific OECD	0.47	0.46	0.47
Europe OECD and Canada	1.11	1.20	1.24
Eastern Europe and Former Soviet Union	1.25	0.95	1.06
China	0.66	0.84	1.09
South and Southeast Asia	0.33	0.49	0.86
Middle East	0.18	0.26	0.36
Africa	0.15	0.20	0.28
Latin America	0.22	0.29	0.37
World	**6.02**	**6.68**	**8.22**

TABLE 5.5 MACs Approximation of Coefficients for CO_2 (from IPAC Emission Model)

	USA	OECD-P	OECD-W	EFSU	—
a	0.0008	0.0075	0.0017	0.0012	—
b	–0.0079	0.2223	–0.0841	0.0773	
R^2	0.9913	0.9963	0.9892	0.9959	

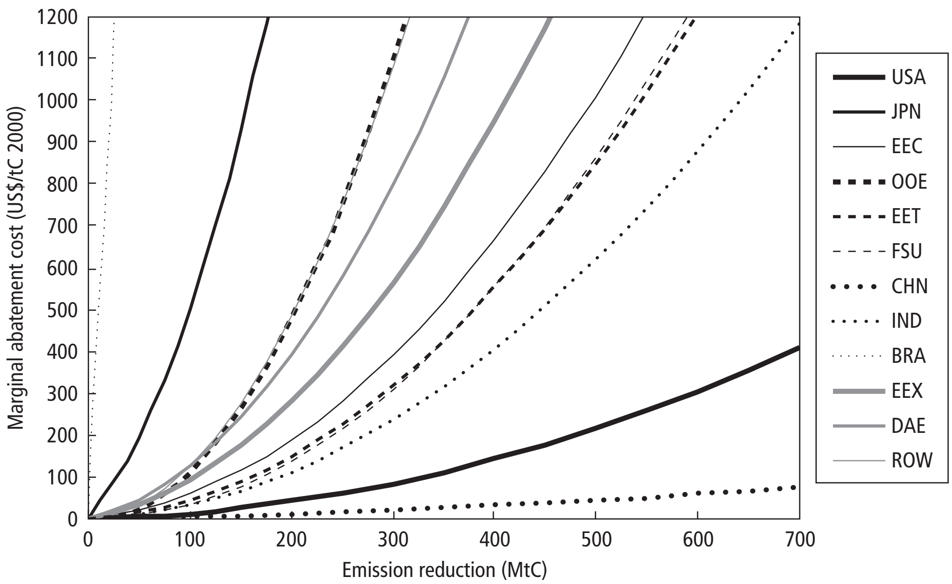
	China	S.E. Asia	M.E.	Africa	L.A.
a	0.0008	0.0014	0.0265	0.0018	0.0003
b	0.1596	0.2358	1.4692	1.9744	1.7344
R^2	0.9972	0.9988	0.999	0.9975	0.9

FIGURE 5.1 MACs for carbon dioxide in 2010 (from IPAC emission model)



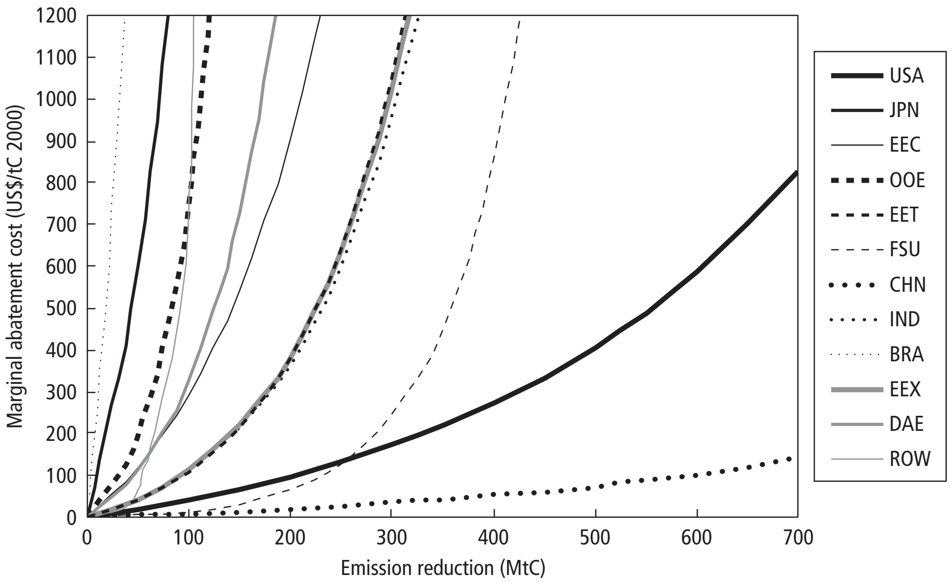
Note: The original results from IPAC emission model are expressed in 1990 $/tC, but converted into 2000 $/tC using deflators of 1.196 for 1990 and 1.495 for 2000. This allows easier comparison with the results from different models.

FIGURE 5.2 MACs for carbon dioxide in 2010 (from EPPA)



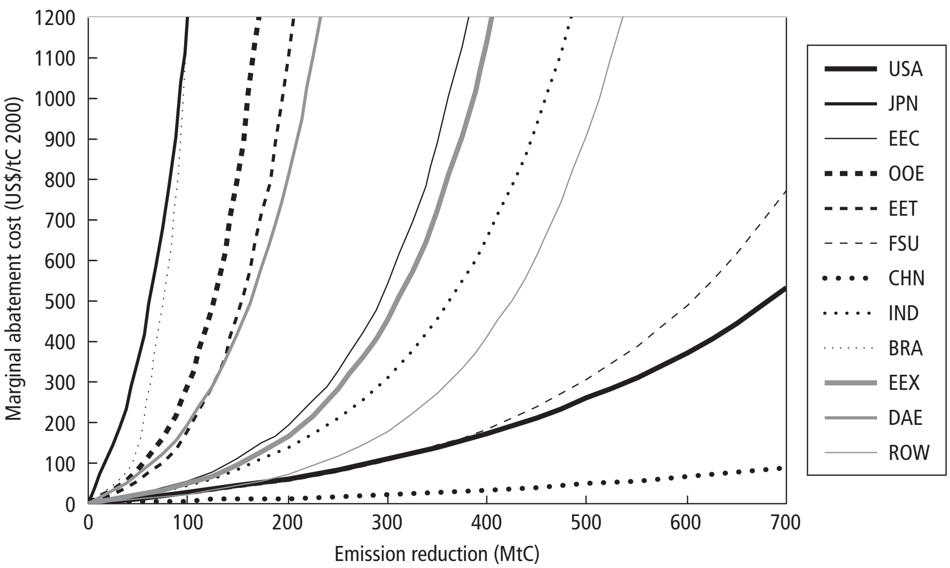
Note: The original results from EPPA are expressed in 1985 $/tC but converted into 2000 $/tC using deflators of 1 for 1985 and 1.495 for 2000. This allows for easier comparison with the results from different models.

FIGURE 5.3 MACs for carbon dioxide only in 2010 (from GTEM)



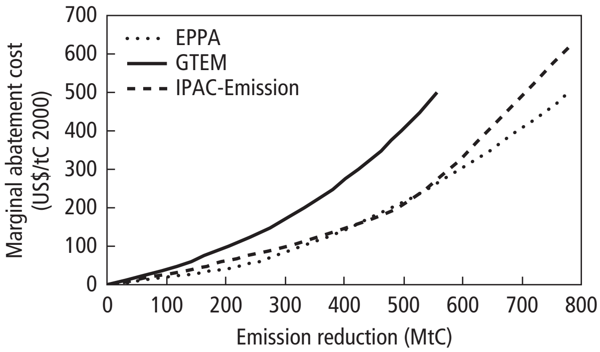
Note: The original results from GTEM are expressed in 1995 $/tC but converted into 2000 $/tC using deflators of 1.36 for 1995 and 1.495 for 2000. This allows for easier comparison with the results from different models.

FIGURE 5.4 MACs for all GHGs in 2010 (from GTEM)



Note: The original results from GTEM are expressed in 1995 $/tC but converted into 2000 $/tC using deflators of 1.36 for 1995 and 1.495 for 2000. This allows for easier comparison with the results from different models.

FIGURE 5.5 Comparison of MACs for the U.S. from Different Sources (carbon dioxide only)



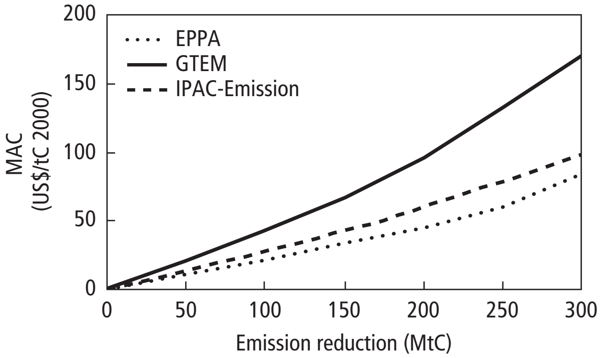
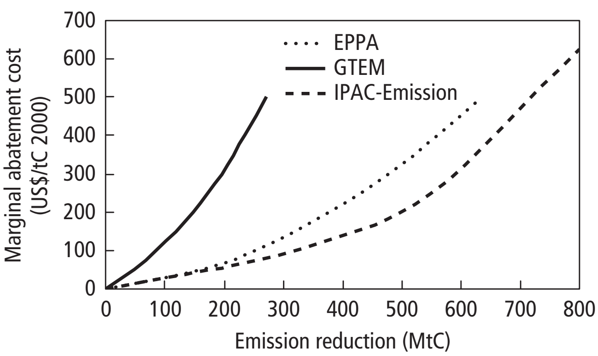


FIGURE 5.6 Comparison of MACs for OECD (without U.S.) from Different Sources (carbon dioxide only)



population growth, and GDP structure lead to diverse reference scenario emissions and thus disparate MACs.

Diverse mitigation measures. Diverse no-regrets mitigation measures, including lower cost and even some high-cost mitigation measures are considered in the reference scenario in different models. The more mitigation measures considered in the reference scenario, the lower the reference scenario emissions and the higher MACs. For example, in the IPAC emission model's reference scenario nuclear power capacity in 2010 is 10 GW and hydropower 110GW, which contribute to relatively lower reference emissions. In addition, energy conservation policies were emphasized in line with the energy conservation rate over the last 20 years in China. Other factors contributing to the steeper MAC curves for China in the IPAC emission model are more efficient technologies entering the built margin during the 1990s, which are reflected in 2000 energy statistical data for China. Accordingly, IPAC projects a lower growth trend for GHG emissions up to 2010 compared to EPPA or GTEM.

Different energy substitution possibilities. Different energy substitution possibilities are assumed in each model. The higher possibility for energy substitution, the lower MACs would be.

Different cost assumptions. Different cost assumptions for technologies in various models. The higher cost assumptions would result in higher MACs.

Different abatement opportunities. Different abatement opportunities, as represented by the estimated MACs in various models.

GLOBAL CARBON MARKET ANALYSIS UNDER DIFFERENT SCENARIOS

Analysis of Emission Reduction Requirements

The Kyoto Protocol set binding quantified reduction commitments for a basket of six greenhouse gases (CO_2, CH_4, N_2O, SF_6, PFCs, and HFCs) for the Annex I Parties during the period 2008 to 2012. Each Annex I Party has its own reduction target ranging from an 8 percent reduction to a 10 percent increase from the 1990 base year. The average reduction commitment is 5.2 percent for all Annex I Parties.

Table 5.6 shows the Kyoto target using total emissions of the six GHG gases in 1990, while *Table 5.7* shows the Kyoto target using CO_2 emissions only in 1990. There is a significant difference between applying all GHG emissions or CO_2-only emissions to set the Kyoto target.

Table 5.8 compares BAU projections from different sources for the year 2010, including three scenarios (low, medium, and high) generated by the U.S. Department of Energy's Energy Information Administration in its latest *International Energy Outlook,* the EPPA model, the GTEM model, the second national communications, and the IPAC emission model (EIA/USDOE 2002; Grütter, 2002; UNFCCC 1998).

With the projected carbon emissions and the Kyoto target, emission reduction requirements are calculated in *Table 5.9.* The reduction requirements range from 378 to 641 MtC (1,386-2,380 $MtCO_2$) for the United States, 24 to 85 MtC (88-312 $MtCO_2$) for Japan, 9 to 308 MtC for the EEC, and 53 to 117 MtC (194-429 $MtCO_2$) for OOE. All model results show that the former Soviet Union and other Economies in Transition would have a surplus assigned amount (termed hot air-see the Technical Summary for a discussion of hot air), but the range varies sharply from 42MtC to 397MtC (154-1,456 $MtCO_2$). Total reduction requirements for Annex I countries differ from 387MtC to 951MtC (1,419-3,487 $MtCO_2$), but shrink to 162MtC to 333MtC (594-1,221 $MtCO_2$) after the United States' withdrawal. The minus values indicate that the surplus assigned amount for the Economies in Transition is larger than Annex II Parties' emission reduction requirements, and no emission reduction measure is needed to achieve the Kyoto target. The total reduction requirements from

FIGURE 5.7 Comparison of MACs for EFSU from Different Sources (Carbon dioxide only)

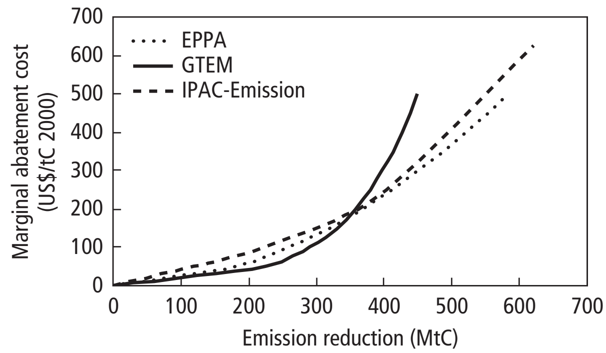


FIGURE 5.8 Comparison of MACs for China from Different Sources (carbon dioxide only)

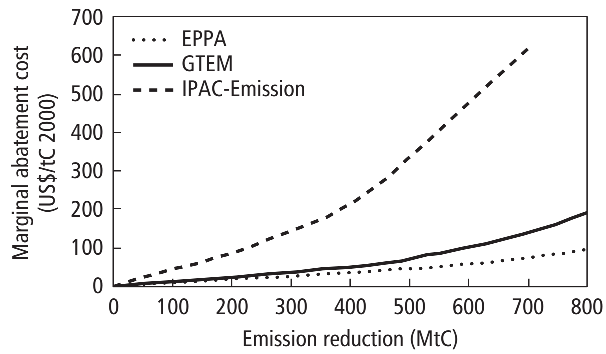


TABLE 5.6 Kyoto Target using all GHG Emissions in 1990 (MtC)

USA	JPN	EEC	OOE	FSU	EET	All with USA	All without USA
1534	311	1056	330	1112	348	4691	3157

(*Note:* 1990 emissions are taken from the second National Communication, and the reduction commitments are taken from the Kyoto Protocol)

TABLE 5.7 Kyoto Target using Carbon Dioxide Emissions only in 1990 (MtC)

USA	JPN	EEC	OOE	OECD-P	OECD-W	FSU	EET	EET	All with USA	All without USA
1246	288	230	834	377	975	865	279	1144	3742	2496

(*Note:* 1990 emissions are taken from the second National Communication, and the reduction commitments are taken from the Kyoto Protocol)

TABLE 5.8 Business-as-usual Projections from Different Models for 2010 (MtC)

	EIA Low	EIA Medium	EIA High	EPPA	GTEM	NC	IPAC-Emission	GTEM all GHGs	NC all GHGs
USA	1795	1835	1887	1864	1870	1669	1624	2060	1946
JPN	312	343	359	373	341	369		385	389
OOE	311	331	347	305	309	286		428	383
EEC	964	1013	1066	1142	951	889		1161	1065
OECD-P							477		
OECD-W							1246		
FSU	540	587	641	735	631	810		810	1029
EET	207	226	243	274	240	292		296	321
EFSU							926		
All with USA	4129	4335	4543	4693	4341	4315	4272	5140	5133
All without USA	2334	2500	2656	2829	2472	2646	2648	3080	3187

Note: All projections are for CO_2-only, except for GTEM and NC, which are all GHGs.

TABLE 5.9 Reduction Requirements to Achieve the Kyoto Target for 2010 (MtC)

	EIA Low	EIA Medium	EIA High	EPPA	GTEM	NC	IPAC-Emission	GTEM all GHGs	NC all GHGs
USA	549	589	641	618	624	423	378	526	412
JPN	24	55	71	85	53	1		74	78
OOE	81	101	117	75	79	56		98	53
EEC	130	179	232	308	117	55		105	9
OECD-P							100		
OECD-W							271		
FSU	–325	–278	–224	–130	–234	–55		–302	–83
EET	–72	–53	–36	–5	–39	13		–52	–27
EFSU							–218		
All with USA	387	593	801	951	599	573	530	449	442
All without USA	–162	4	160	333	–24	150	152	–77	30

TABLE 5.10 Credits from Carbon sequestration for Domestic Action and JI projects, (MtC)

USA	JPN	EEC	OOE	OECD-P	OECD-W	FSU	EET	EFSU	All with USA	All without USA
28	13	13.11	5.17	13.2	18.08	34.83	3.76	39	97.87	69.87

Source: UNFCCC, 2001.

the IPAC emission model are 530MtC (1,943 $MtCO_2$) with U.S. participation and 152MtC (557 $MtCO_2$) without U.S. participation.

The Bonn Agreements (FCCC 2001), Marrakesh Accords, and the Marrakesh Declaration (FCCC 2001) define two categories of eligible activities for sinks under Article 3.3 and 3.4 of the Kyoto Protocol: (1) forests, including afforestation, reforestation, and deforestation; and (2) agriculture, covering revegetation, cropland management, and grazing land management. A specific cap for each Annex I Party to use the credit from carbon sequestration resulting from forest activities from both domestic actions and JI projects is stipulated in the decisions of both COP-6 and COP-7 (Appendix Z), as shown in *Table 5.10.* These sink credits are simulated as zero cost sinks and the reduction requirements for each Annex I countries/regions are deducted by these sink credits in CERT.

Figure 5.9 compares the emission reduction requirements in 2010 for different regions from different sources with sink credits deducted.

Grubb (2003) analyzed supply-demand balance in the Kyoto system and concluded that carbon emissions for the EU, Japan, and Canada might be 84 to 239MtC (308-876 $MtCO_2$) above their Kyoto allocation. Grubb estimated carbon emission credits in the range of 106 to 196 MtC (389-719 $MtCO_2$) for Russia, 67 to 87 MtC (246-319 $MtCO_2$) for the Ukraine, 45 to 75 MtC (165-275 $MtCO_2$) for the Accession 10, and 24 to 36 MtC (88-132 $MtCO_2$) for other EITs. In the Grubb analysis, the total carbon credits provided by EITs ranges from 242 to 394MtC (887-1455 $MtCO_2$), which is close to EIA's projections (260 to 397MtC, or 9,553-1,456 $MtCO_2$) but higher than IPAC emission's projection (218MtC, or 799 $MtCO_2$). Grubb also estimates 30MtC (110 $MtCO_2$) of managed forest allowance for the EU plus Japan and Canada, and 40MtC (147 $MtCO_2$) for EITs. These numbers are very close to the data shown in *Table 5.10.*

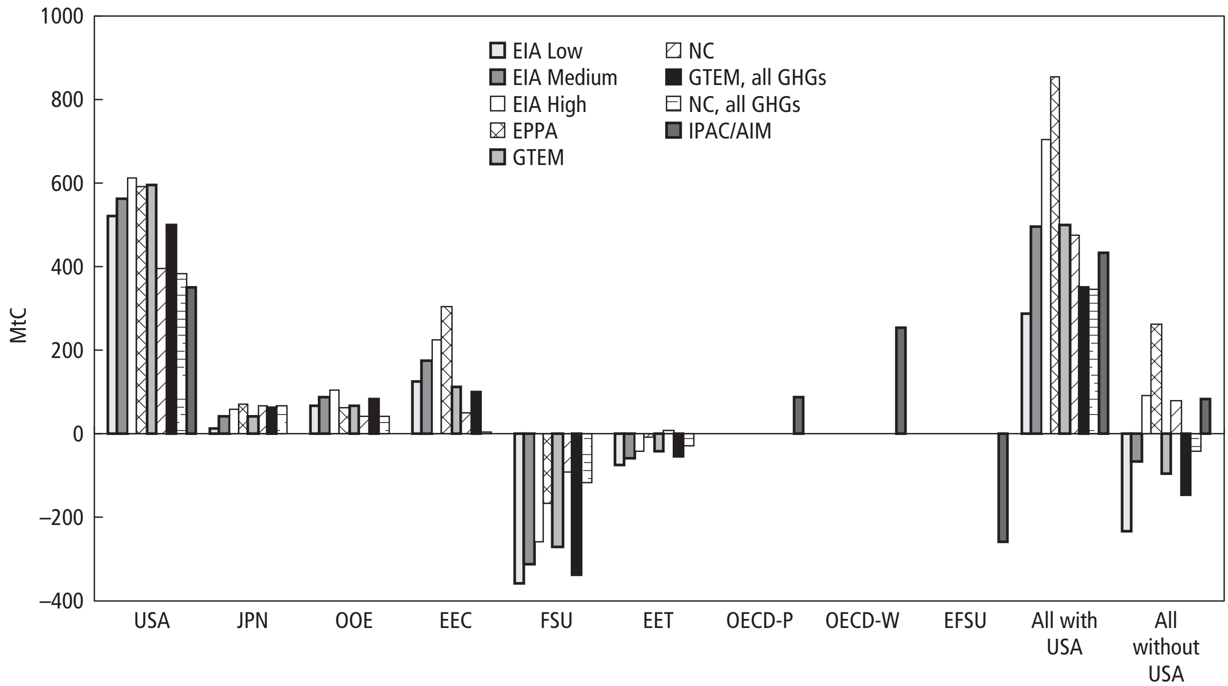
In this study, the emission projection from the IPAC emission model will be used in the base scenario for carbon market analysis.

Global Carbon Market Simulation with Application of CERT

Apart from the BAU projection in each Annex I country/region and MACs for each Annex I and non-Annex I country/region in the year 2010, several other parameters should be set before using CERT to analyze the global carbon market for the first commitment period. A base scenario was designed in this study with the following main assumptions:

- Reference carbon emission and MACs from IPAC emission
- A 2 percent CERs for adaptation fund as stipulated in the Marrakech Accords and Marrakech Declaration.
- Transaction costs of \$2/tC (\$0.54/t-CO_2) for CDM and \$1/tC (\$0.27/t-CO_2) for JI. This is based on the PCF's transaction cost experience for current CDM projects, and assumes that the CDM procedure—including validation and registration, monitoring, verification and certi-

FIGURE 5.9 Comparison of Emission Reduction Requirements in 2010 for Different Regions from Different Sources with Sink Credits Deducted



fication, and issuance—is more complex than JI. (U.S. dollars are in 2000 constant prices.)

- An implementation rate of 30 percent for all non-Annex I countries based on the combined consideration of non-Annex I countries' absorption capacity, the complex procedure for CDM projects, and an early start for CDM projects before 2008.
- A 10 percent participation rate by the United States—considering that various U.S. states such as California, New Hampshire, Massachusetts, New Jersey, Oregon, and Wisconsin would realize their domestic carbon reduction targets through CDM, JI, or ET.
- A 50 percent supplementarity rate for the EU based upon declarations of the EU and various member states—including the Netherlands and Germany—to introduce voluntary supplementarity levels; 0 percent is assumed for other Annex I countries/regions, through this doesn't mean that they will not take any domestic action. In CERT, the percentage of domestic actions in the reduction commitments for these countries will be determined by the marginal abatement cost curves.
- Price leadership of EFSU and price followers for other suppliers.

Moreover, in assessing China's CDM potential this study modeled supply-side competition based solely on differences in national marginal abatement cost curves under perfectly functioning equilibrium market conditions. All developing countries were assigned the same implementation rate (capacity to identify, develop, and implement potential CDM projects); all CDM projects were assumed to have the same level of transaction costs; and no consideration was given to the relative attractiveness of China as a host for CDM projects. In the real world, the attractiveness of China as a CDM host will depend on many factors, not necessarily a theoretical market clearing price, or the aggregate marginal abatement cost or incremental cost of individual Chinese projects.

Table 5.11 shows the marginal abatement cost and total abatement cost for Annex I countries/regions under IPAC emission projections and MACs without CDM, JI, and ET. The reduction requirements are 86MtC (315 $MtCO_2$) for OECD-P, 252MtC (924 $MtCO_2$) for OECD-W, and 35MtC (128 $MtCO_2$) for the U.S. (at a 10 percent participation rate, or 350MtC (1,283 $MtCO_2$) at 100 percent. Sink credits, shown in *Table 5.10,* are deducted from the corresponding number in *Table 5.9.*

The marginal cost was calculated using the formula $MC = aQ^2 + bQ$. The coefficients of a, b are from *Table 5.5;* the dollar deflators are 1.196 for 1990 and 1.495 for 2000. The total cost was calculated using the following formula:

$$TC = \int_0^Q \left(aQ^2 + bQ\right) dQ = \frac{1}{3} aQ^3 + \frac{1}{2} bQ^2$$

For partial U.S. participation, a and b should be adjusted accordingly as follows:

$$a_{\text{adjusted}} = a_{\text{original}} * 1.495/1.196 * (1/\text{participation rate})^2$$

$$b_{\text{adjusted}} = b_{\text{original}} * 1.495/1.196 * (1/\text{participation rate})$$

The marginal abatement cost for the U.S. (10 percent participation rate), OECD-P, and OECD-W is high and in the range of \$93–119/tC (\$23-32/tCO_2). Their total abatement cost is as high as \$12.4 billion.

Table 5.12 and *Figure 5.10* display the modeling results of the carbon market for the base scenario. With the three mechanisms, domestic reduction for U.S. (10 percent), OECD-P and OECD-W would drop sharply from 374MtC (1,371 $MtCO_2$) to only 177MtC (649 $MtCO_2$) due to the cheaper abatement cost in non-Annex I countries and EITs as well as zero cost of hot air. The market price is expected to be \$22/tC (\$6/tCO_2). Thus, the total cost for these three regions to achieve the reduction requirement would decrease to only \$5.5 billion, with cost saving of \$6.9 billion. The amount of hot air used for EFSU would be only 61.6MtC (226 $MtCO_2$),

TABLE 5.11 Reduction, Marginal Cost, and Total Abatement Cost for Annex I without CDM, JI, and ET

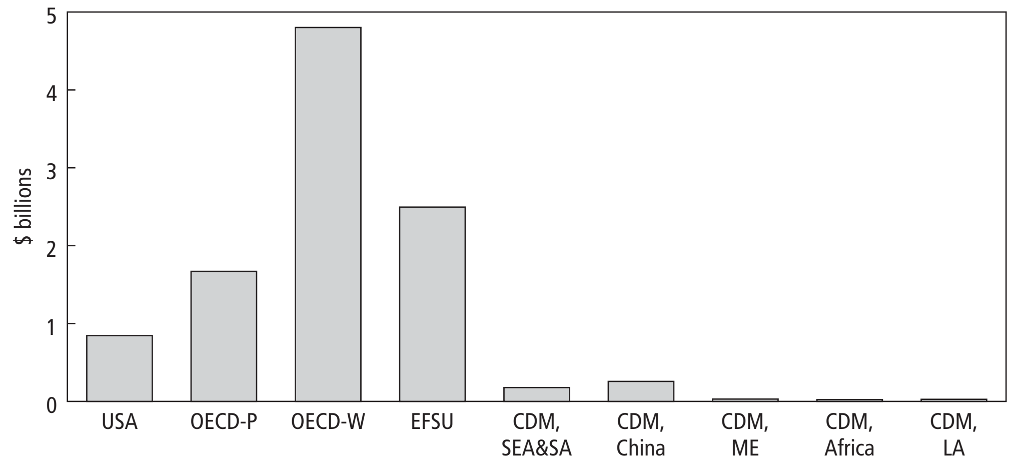
	Reduction (MtC)	Marginal Cost ($/tC, 2000 price)	Total Cost (M$, 2000 price)
U.S. (10%)	35	119	1369
OECD-P	86	93	3015
OECD-W	252	108	7998
Total	374		12382

TABLE 5.12 Modeling Results for the Base Scenario

	Carbon amount (MtC)	Carbon amount ($MtCO_2$)	Profits[a] (MUS$, 2000 price)
Domestic action	**177.1**	**649.4**	
USA	15.0	55.0	845
OECD-P	34.8	127.6	1670
OECD-W	127.3	466.8	4801
Hot air	**61.6**	**225.9**	**2495[b]**
EFSU	61.6	225.9	
JI	**90.5**	**331.8**	
EFSU	90.5	331.8	
CDM	**44.7**	**163.9**	**514**
S.E. Asia	15.3	56.1	178
China	21.6	79.2	257
Middle East	2.7	9.9	30
Africa	2.4	8.8	23
Latin America	2.7	9.9	27
Total	**374.0**	**1371.3**	
Price ($/tC, 2000 price)	22.0		
Price ($/t-$CO_2$, 2000 price)	6.0		

[a]Profits mean cost savings for Annex II countries, and revenues from selling minus abatement costs for EITs and Non-Annex I countries.
[b]This number is the total profits for EFSU from both JI and hot air.

FIGURE 5.10 Distribution of Kyoto Mechanism Profits among Regions ($ Billions, 2000 Prices)



sharing 24 percent of the total, and JI 90.5MtC (332 $MtCO_2$). Both of them would cause as much as a $2.5 billion profit for EFSU, the price leader of the market. The CDM potential would be 44.7MtC (164 $MtCO_2$), with China accounting for 48 percent of the total. One of the main reasons for the smaller CDM potential compared with JI potential is that the implementation rate of 30 percent was assumed for CDM in all non-Annex I countries, while JI is assumed to be 100 percent. The total profit for non-Annex I countries gained from CDM is expected to be $0.5 billion, only 5 percent of that of Annex I countries. China's profit is expected to be $0.26 billion with 21.6MtC ($79.2 $MtCO_2$) of CDM potential.

Table 5.13 and *Figure 5.11* show the impact of different BAU projection and MACs on the carbon market, assuming that all assumptions except the BAU projection and MACs are the same as the base scenario. The resulting carbon prices would fall in the range from $2.5/tC to $22/tC ($0.68-6/tCO_2) with an average of $10.60/tC ($2.90/tCO_2). In the base scenario, with price leadership the highest price results from the IPAC emission model due to a) comparatively steeper MACs for China in the IPAC emission model; and b) emission reduction requirements that differ considerably among different models. Global CDM potential is expected to be in the range of 7 to 95MtC (26-348 $MtCO_2$), with a mean value of 49MtC (180 $MtCO_2$), and the total profit gained from CDM for non-Annex I countries range from $1.5 million to $790 million, with an average of $299 million. China's CDM potential is expected to be in the range of 4 to 57.5MtC (15-211 $MtCO_2$), with a mean value of 30.5MtC (112 $MtCO_2$), while profit is in the range of $0.9 million to $566 million, with an average of $187 million.

The base scenario assumed price leadership of EFSU for the market structure, a 10 percent participation rate by the U.S., 30 percent implementation rates for all non-Annex I countries, $2/tC ($0.55/tCO_2) of transaction cost for CDM, and a 50 percent supplementarity for the EU. However, these factors are uncertain, and sensitivity analysis based on the base scenario (IPAC emission reference emission and MACs)—with one factor (the factor for the sensitivity analysis) changed at one time while keeping the others constant—is needed to analyze these factors' potential impacts on the carbon market.

TABLE 5.13 Impact of BAU Projections and MACs on Carbon Market

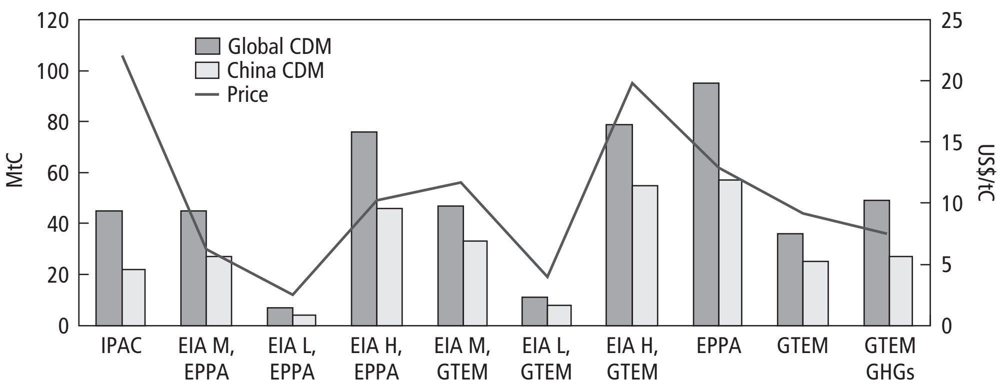
BAU projections	MACs	Price ($/tC, 2000 price)	Global CDM Potentials[a] (MtC)	China CDM Potentials[a] (MtC)	China's profits (M$, 2000 price)
IPAC emission	IPAC emission	22.0	44.7	21.6	256.8
EPPA	EPPA	13.0	95.3	57.5	397.7
GTEM	GTEM	9.2	35.7	25.4	96.2
EIA Medium growth	EPPA	6.2	45.3	27.1	63.9
EIA High growth	EPPA	10.2	76.5	46.1	229.1
EIA Low growth	EPPA	2.5	6.9	4.0	0.9
EIA Medium growth	GTEM	11.8	47.0	33.3	175.6
EIA High growth	GTEM	19.8	79.2	55.2	565.6
EIA Low growth	GTEM	4.0	10.6	7.6	7.4
GTEM, all GHGs	GTEM, all GHGs	7.4	48.9	27.1	76.8
Average		10.61	49.0	30.5	187.0
Standard Deviation		6.36	28.0	18.1	181.6

Note: The BAU projections and MACs are all for CO2-only except the last scenario (GTEM, all GHGs).
[a] CDM potentials derived from CERT are potential traded volumes of CERs when the market is clearing.

If the market structure is perfect competition, and all other parameters remain the same as the base scenario, then the modeling result would provide zero price and zero traded CDM volumes. All available hot air of 257MtC (942 $MtCO_2$) would be used.

CDM's complex operation process or project cycle—from validation and registration, to monitoring, verification, certification, and issuance—would slow CDM implementation speed and lessen CDM credits. However, a prompt start of CDM projects—resulting in banking of CERs prior to 2008—would enlarge CDM potential. In order to analyze the impact of these two factors, as well as the limited absorption capacity of non-Annex I Parties on the carbon market, we com-

FIGURE 5.11 Global and China's CDM Potentials and Price under Different BAU Projections and MACs



Note: EIA L(M, H) means EIA Low(Medium, High) growth.

TABLE 5.14 Impact of Implementation Rate on Carbon Market

Implementation Rate (%)	Price ($/tC, 2000 price)	Global CDM Potentials (MtC)	China CDM Potentials (MtC)	China's profits (M$, 2000 price)
10	24.3	16.3	7.8	108.5
20	22.7	30.6	14.8	185.0
30	22.0	44.7	21.6	256.8
40	20.6	56.1	27.2	294.1
50	18.2	62.3	30.3	277.6

pleted a sensitivity analysis of implementation rates. The result is shown in *Table 5.14.* Increasing implementation rates will lower the equilibrium price, while elevating CDM potential. If all non-Annex I countries' implementation rates decrease to only 10 percent, then the carbon price would go up to \$24.3/tC (\$6.60/tCO_2), but global and China CDM potentials would shrink to only 16.3MtC (60 MtCO_2) and 7.8MtC (28.6 MtCO_2) respectively. If all non-Annex I countries' implementation rates are increased to 50 percent, then the market price would fall to \$18.2/tC, while global and China CDM potentials would rise to 62.3MtC (228.4 MtCO_2) and 30.3MtC (111.1 MtCO_2) respectively. China's share of CDM potential in the total would not change, remaining around 50 percent, if all non-Annex I countries' implementation rates are the same. Under the price leadership of EFSU, the implementation rate has a larger impact on CDM potential than on the equilibrium price. Thus, increasing the implementation rate from 10 percent to 50 percent would increase China's profits from \$108.5 million to \$277.6 million in spite of the lower market price.

The participation rate of the United States will have an important impact on the total reduction requirement and demand for the carbon market, and consequently further influence the price of the carbon market and CDM potential. *Table 5.15* shows the impact of USA's participation rate on carbon market under the price leadership of EFSU. It could be found that participation rate of USA has less impact on the carbon market (price and CDM potentials etc.) than implementation rate does. If the U.S. participation rate varies from 0 to 30 percent, the equilibrium price will be around \$20–22/tC (\$5.5-6/tCO_2), while traded CDM volumes for China are in the range of 19.8–21.6MtC

TABLE 5.15 Impact of U.S. Participation Rate on Carbon Market

U.S. Participation Rate (%)	Price ($/tC, 2000 price)	Global CDM Potentials (MtC)	China CDM Potentials (MtC)	China's profits (M$, 2000 price)
0	21.7	44.0	21.3	247.6
5	21.3	43.3	20.9	238.8
10	22.0	44.7	21.6	256.8
20	19.9	40.8	19.8	208.1
30	21.2	43.1	20.9	236.6

TABLE 5.16 Impact of CDM's Transaction Cost on Carbon Market

Transaction cost ($/tC, 2000 price)	Price ($/tC, 2000 price)	Global CDM Potentials (MtC)	China CDM Potentials (MtC)	China's profits (M$, 2000 price)
1	21.9	46.2	22.3	277.9
2	22	44.7	21.6	256.8
5	21.3	37.7	18.4	173.3

(72.6-79.2 $MtCO_2$). However, if the market structure is perfect competition, the U.S. participation rate will have a large impact on the carbon market; for example, by increasing the U.S. participation rate from 0 to 30 percent, the equilibrium price would increase from 0 to $4.40/tC ($0-1.20 tCO_2).

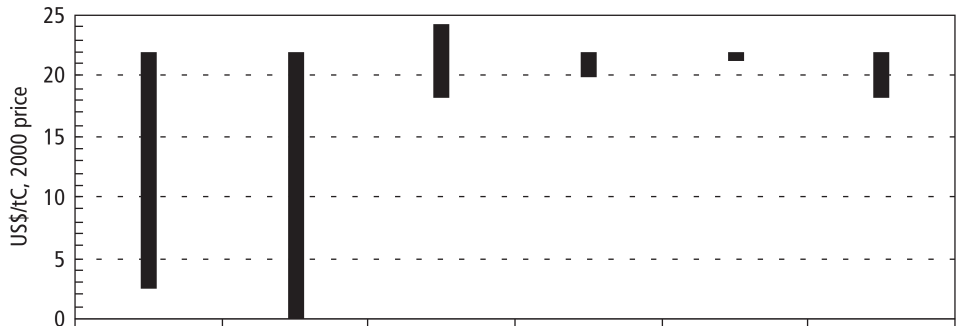
The transaction cost would depend on the executive board's administrative cost, designed operational entities' charge, and the cost for the whole process—including project searching, project design, validation and registration, monitoring, verification and certification, and issuance. Transaction costs can differ according to the specific project. The rule of simplified modalities and procedures for small-scale projects would lessen their transaction costs. *Table 5.16* displays the results of a sensitivity analysis of transaction costs on the carbon market under the price leadership of EFSU. Increasing transaction costs of the CDM will decrease CDM potential. However, the impact of transaction costs on the equilibrium price is limited under the price leadership of EFSU. By varying the transaction cost from $1 to $5/tC ($0.27-1.36/tCO_2), the price almost remains the same, while global CDM potential drops from 46.2MtC (169.4 $MtCO_2$) to 37.7MtC (138.2 $MtCO_2$) and China's CDM potential from 22.3MtC (81.8 $MtCO_2$) to 18.4MtC (67.5 $MtCO_2$).

Although COP-7 decided on no compulsory supplementarity level, various countries are considering introducing voluntary supplementarity levels, especially in the EU. Like various participation rates for the United States, different supplementarity levels for Annex I countries would increase demand for a carbon market, and accordingly effect carbon market prices and CDM potential. The impact of supplementarity on the carbon market is shown in *Table 5.17* under the price leadership of EFSU. If there were no supplementarity for all Annex I countries, then the price would decrease to $18.1/tC ($4.90/tCO_2) and China's CDM potential would decrease to 18.1MtC (49.5 $MtCO_2$). If 50 percent supplementarity is applied to all Annex I countries, then

TABLE 5.17 Impact of Supplementarity on Carbon Market

Supplementarity %	Price ($/tC, 2000 price)	Global CDM Potentials (MtC)	China CDM Potentials (MtC)	China's profits (M$, 2000 price)
EU 50	22.0	44.7	21.6	256.8
All 50	20.9	42.5	20.6	229.1
All 0	18.1	37.1	18.1	168.4

FIGURE 5.12 Impact of Different Factors on Carbon Price



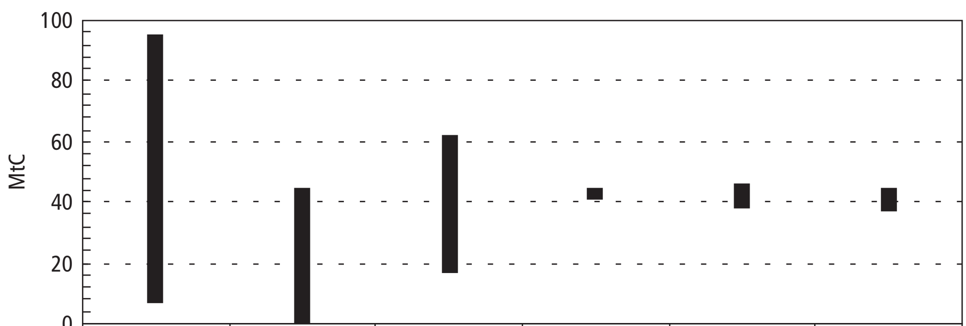
	BAU, MACs	Market structure	Implementation rate	USA participation	Transaction cost	Supplementarity
Lowest	2.5	0.0	18.2	19.9	21.3	18.1
Highest	22.0	22.0	24.3	22.0	22.0	22.0

the price would be \$20.9/tC (\$5.70/tCO_2) and China's CDM potential would be 20.6MtC (75.5 MtCO_2).

Figures 5.12, 5.13, and 5.14 summarize the impact of these factors on the carbon price, global CDM potential, and China's CDM potential.

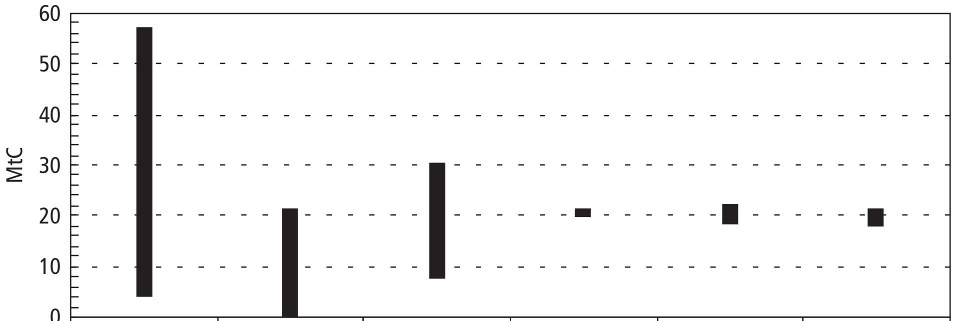
The impact of different factors on the carbon market can be roughly ordered from high to low as BAU projections and MACs, the market regime, the implementation rate, supplementarity, the U.S. participation rate (0 to 30 percent), and transaction costs.

FIGURE 5.13 Impact of Different Factors on Global CDM Potential



	BAU, MACs	Market structure	Implementation rate	USA participation	Transaction cost	Supplementarity
Lowest	6.9	0.0	16.3	40.8	37.7	37.1
Highest	95.3	44.7	62.3	44.7	46.2	44.7

FIGURE 5.14 Impact of Different Factors on China's CDM Potential



	BAU, MACs	Market structure	Implementation rate	USA participation	Transaction cost	Supplementarity
Lowest	4.0	0.0	7.81	9.8	18.4	18.1
Highest	57.5	21.6	30.3	21.6	22.3	21.6

For the equilibrium quota price, global and China CDM potential, the sensitivity analysis estimates are \$0–24.30/tC (\$0-6.60/tCO_2), \$0–95.30/tC (\$0-26/tCO_2), and \$0–57.50/tC (\$0-15.70/tCO_2) respectively. The zero price and zero CDM potential is provided by the case of perfect competition. The highest estimation of global as well as China's CDM potential was derived from EPPA BAU projection and EPPA MACs. One of the main reasons for this is that EPPA projected the lowest available hot air (135MtC, or 495 MtCO_2). The highest price of \$24.30/tC (\$6.60/tCO_2) is provided by the lowest implementation rate assumed in the analysis; that is, 10 percent. Increasing the implementation rate will decrease the equilibrium price, while enhancing CDM potential. The U.S. participation rate and supplementarity are important factors influencing carbon market demand. If the market is characterized by perfect competition, demand will significantly influence the equilibrium price and CDM potential. However, under the price leadership of EFSU, which owns a large amount of hot air, the demand will have limited impact on the market. In the CERT simulation, the transaction cost has a relatively low impact on the carbon market. Since transaction costs are strongly sensitive to project size, the computation in CERT does not accurately display the real impacts of transaction costs on market dynamics.

Apart from the base scenario, the High and Low CDM scenarios were designed to present a reasonable range of China's traded CDM volumes. The reference carbon emission and MACs from the IPAC emission model were also applied to both the High and Low CDM scenarios. All parameters—except transaction cost, implementation rate, and U.S. participation rate—are the same for the three scenarios. *Table 5.18* compares these three parameters for the Base, High, and Low CDM scenarios.

TABLE 5.18 A Comparison of Assumptions for the Base, High, and Low Scenarios

Scenarios	Transaction Cost (\$/tC)	Implementation Rate (%)	U.S. Participation Rate (%)
Base	2	30	10
High CDM	2	50	30
Low CDM	5	10	5

Table 5.19 compares the modeling results for the Base, High CDM, and Low CDM scenarios. The High CDM scenario provides \$19.20/tC (\$5.20/tCO_2) of equilibrium price, lower than the Base, and 31.8MtC (116.6 MtCO_2) of CDM traded volumes for China, around 10MtC higher than the Base. The Low CDM scenario results in the highest equilibrium price of \$23.7/tC (\$6.50/tCO_2), and only 6.8MtC (24.9 MtCO_2) of CDM traded volumes for China. China's profits range from \$76.6 to \$310.8 million, and global traded CDM volumes from 14.1 to 65.5MtC (51.7-240 MtCO_2).

Discussion of Results from Market Simulation with Application of CERT

The IPAC emission model shows carbon reduction requirements of 371MtC (1,360 MtCO_2) for Annex II Parties (without the U.S.), close to EIA's latest medium-growth projection (335MtC, or 1,228 MtCO_2). The projection of hot air carbon supply for EITs from the IPAC emission model is 218MtC (799 MtCO_2), lower than EIA's latest projections (260–397MtC, or 953-1,456 MtCO_2). The IPAC emission model projected that U.S. carbon reduction requirements would be 378MtC (1,386 MtCO_2). This is much lower than EIA's projections, but quite close to the projection based on national communications (423MtC, or 1,551 MtCO_2).

Taking into account sink credits, the IPAC emission model provides reduction requirements of 690 MtC for all Annex II Parties, 340 MtC (1,247 MtCO_2) for Annex II Parties without the U.S., and 374 MtC (1,371 MtCO_2) for Annex II Parties with 10 percent U.S. participation. In total, there are 257MtC (942 MtCO_2) of surplus AAUs and sink credits available from EITs.

GHG emission reduction requirements are the main determining factor for the shape of the future carbon market, followed by the marginal abatement cost curves for both market supply and demand. The IPAC emission, EPPA, and GTEM models all illustrate that China has a relatively flat marginal abatement cost curve (expressed in costs vs. reduction amount) compared with other countries, owing to her large emission base as well as relatively cheap reduction costs. However, the marginal abatement cost curve for China from the IPAC emission model is much steeper than those from EPPA and GTEM. In the IPAC emission model, the relatively low reference carbon emission projection—with a lot of carbon reduction countermeasures, which is consistent with China's sustainable energy development strategy—is one of the main contributors to the discrepancy.

With the reference emission projections and MACs from the IPAC emission model—together with the assumptions of price leadership of the EFSU for the future carbon market structure, a 10 percent U.S. participation rate, 30 percent implementation rates for all non-Annex I Parties, 50 percent supplementary for the EU, and \$2/tC (\$0.55/tCO_2) of transaction cost for CDM—the CERT simulation shows \$22/tC (\$6/tCO_2) for the future equilibrium carbon price; 21.6MtC (79 Mt-CO_2) of China's CDM potential, account-

TABLE 5.19 Comparisons of Future Carbon Market for Different Scenarios

Scenario	Price ($/tC, 2000 price)	Global CDM Potentials (MtC)	China CDM Potentials (MtC)	China's profits (M$)
Base	22.0	44.7	21.6	256.8
High CDM	19.2	65.5	31.8	310.8
Low CDM	23.7	14.1	6.8	76.6

ing for around 50 percent of the total CDM potential; and $0.26 billion profit for China gained from CERs. With the reference emission projections and MACs from the IPAC emission model, the estimation of possible China CDM potential will fall in the range of 6.8–31.8MtC (25–117MtCO_2).

CHINA'S CDM POTENTIAL BY MAJOR SECTORS

China's Carbon Emissions and MACs by Sector

The IPAC-AIM technology model is an energy model for China with a detailed disaggregation of sectors and detailed description of technology. This model identifies carbon emissions, MACs, and carbon reduction potential by sector. The IPAC-AIM technology model was developed in collaboration with Japan's National Institute for Environment Studies. For the last several years this model was used to simulate emission scenarios up to 2030 for China, and identify the contribution from technologies for emission reduction. Policies to promote advanced technologies were also discussed using this model. These results, which identify CDM potential for sectors, are based on the study for emission reduction potential in China in ERI by the IPAC modeling team. Technologies suitable for CDM collaboration were specified in the modeling study. *Tables 5.20 and Table 5.21* display the basic assumptions for future population and GDP growth respectively.

Figure 5.15 provides the modeling results of carbon emissions for three scenarios—technology frozen, market, and policy—from the IPAC-AIM technology model. The Technology Frozen scenario assumed that the future technology mix would stay the same as in 2000 (no technology selection in the model). The Market scenario assumed technology would be introduced based on the market, which means technologies will be selected by model based on least cost. The Policy scenario used a $12.10/tC ($3.30/tCO_2) carbon tax and investment of the carbon tax revenues as subsidies for selected technologies.[2] In the IPAC-AIM technology model, technology fixed costs, energy costs, and other operational costs are included. These emission scenarios were used to identify emission reduction potential by sectors.[3] The CDM potential results for 2010 by sector are given by identifying technologies for CDM projects in each sector.

TABLE 5.20 Assumptions for China's Future Population (million)

	1990	2000	2010
Total	1141	1284	1393
Urban	302	413	531
Rural	840	872	862

TABLE 5.21 Assumptions for China's Future GDP Growth (%)

	1990–2000	2000–2010
GDP Growth rate	9	7.9

FIGURE 5.15 Carbon Emissions for Three Different Scenarios in IPAC-AIM Technology Model

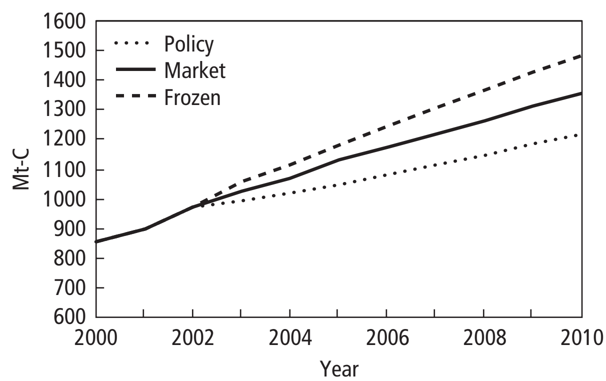
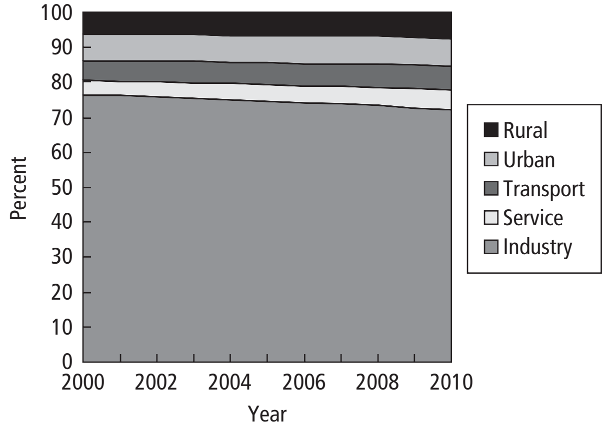


FIGURE 5.16 Share of Carbon Emissions by End-use Sector for the Market Scenario

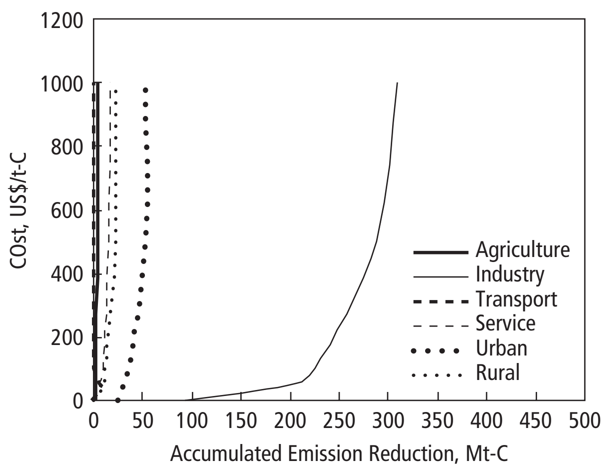


Note: CO_2 emissions from end-use sectors includes emissions from electricity by accounting for energy use in the power generation sector

The market scenario is taken as the base scenario to analyze carbon emissions and MACs by sectors. *Figure 5.16* shows the share of carbon emissions by sector for the Market scenario.

The study based on the IPAC-AIM technology model on cost analysis is given in *Figure 5.17,*

FIGURE 5.17 Marginal Abatement Cost Curves by Sectors



which presents the reduction cost by sectors in China. In this figure, axis Y is the average cost for CO_2 emission reductions. Subsidies in four cost cases are expressed here. Axis X is the accumulated CO_2 reduction from 2000 (when the subsidy begins) to 2010, compared with the market case.

China's Emission Abatement Potential by Sector

The study from the IPAC-AIM technology model identified the potential for CDM projects in various sectors, including steel-making, cement, glass, brick production, ammonia production, calcium, soda ash, aluminum, copper, zinc and lead, paper making, ethylene, transport, services, urban residential, rural residential, and power generation. In contrast to emission reduction potential analysis, this analysis for CDM potential considered technology additionality (advanced technologies, especially technologies that are not mature in China), cost effectiveness, and possible penetration of advanced technologies. Technology additionality is a focal point for CDM project collaboration in China. Advanced technologies are one of the objectives of CDM to support sustainable development in developing countries. Advanced technologies or clean technologies are the key for future GHG mitigation and local air pollutant emission reductions. Widespread adoption of advanced technologies in China could contribute widely to environmental protection and local economic and sustainable development. Compared with technologies already widely used and produced in China, some advanced technologies currently used in the developed world could be much more effective in meeting the objectives of CDM. Therefore a group of technologies suitable for CDM projects was identified in the model. The selection of advanced technologies for CDM projects is based on emission reduction potential and local availability.[4] The methodology used in this model reflects abatement cost only, and does not take into consideration factors such as CER prices or transaction costs, as simulated in the CERT model.

The reduction potential by sector was simulated with a wider cost range of up to \$50/tC (\$13.60/tCO_2). *Figure 5.18* and *Table 5.22* shows emission reduction potential by sectors with costs less than \$50/tC (\$13.60/tCO_2).

The IPAC-AIM technology model results indicate that (in 2010) the difference in carbon emissions between the policy scenario (with carbon tax and investment of revenues as subsidies) and market scenario (the baseline scenario) is 138MtC/a (506 MtCO_2).

TABLE 5.22 Share of Emission Reductions by Sector

Sector	Share (%)
Steel	10.7
Ammonia	4.4
Ethylene	1.2
fertilizer	1.0
Calcium	0.0
Cement	10.4
Brick	6.8
Glass	0.4
Aluminum	0.6
Copper	0.3
Paper	0.4
Commerce	4.4
Transport	7.7
Urban	3.3
Rural	8.1
Power Generation Sector	37.3
Other	2.9

The Influence of Transaction Costs on CDM Potential

The technology-based analysis of emission reduction potential reveals that top-down approaches based on MAC curves estimating the CER supply potential at a given CER price substantially overestimate the potential CDM deal flow. This is largely because a considerable amount of smaller scale carbon offset projects with an abatement potential below 10,000t CO_2/year have been included in this emission reduction potential. But such small-scale projects are not economically viable and are unattractive for foreign investors because of their high transaction cost.

Even if the absolute transaction costs for small-scale CDM projects seem low, the ratio of the transaction cost to the total project cost is very high compared to large-scale projects, as shown in *Table 5.23*.

This section links the top-down CDM potential projected for China (79 MtCO_2, or 21.6 MtC) with priority technologies for CDM. This analysis underscores the significant role transaction costs play in a project-based mechanism. At an assumed CER price of 5 \$/tCO_2, a minimal

FIGURE 5.18 Emission reduction potential by sector

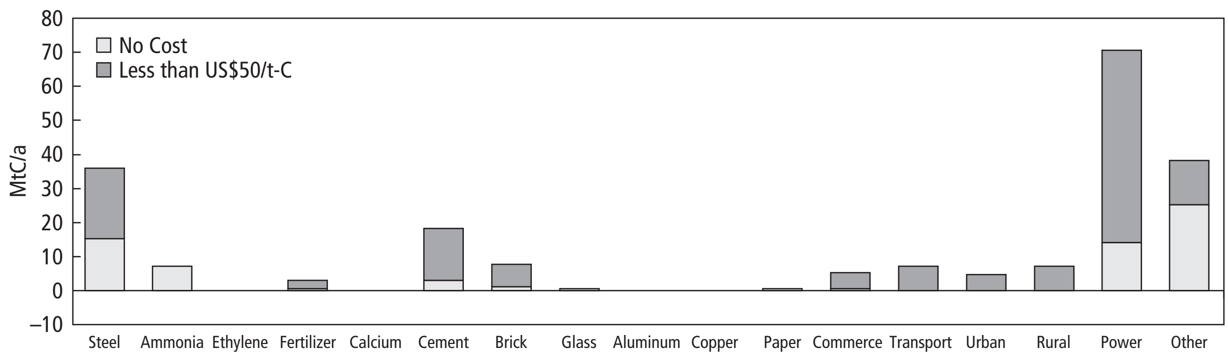


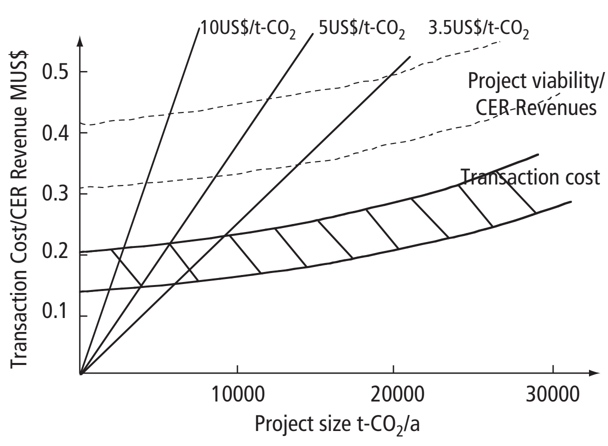
TABLE 5.23 Project Size and Transaction Cost

Project size	Reduction ($t\ CO_2/y$)	Transaction Cost ($\$/t\ CO_2$)
Very large	> 200,000	0.1
Large	20,000–200,000	0.4–1.3
Small	2,000–20,000	13
Mini	200–2,000	130
Micro	< 200	1,300

(*Source:* Michaelowa/Jotzo, 2003)

deal size of close to 10,000tCO_2/year is required to make a CDM project commercially viable. For this, based upon expert judgements and investor views, the discounted total CER revenues should be at least twice the amount of the transaction cost (*Figure 5.19*). The lower band in Figure 5.19 illustrates the range of possible transaction costs for CDM projects related to their project sizes in tCO_2/a (hatched area). The upper band (range between the dashed lines) and above shows the area where CER revenues should be (twice the amount of the transaction costs) for a project to be commercially viable. Given that, a significant number of small-scale CDM projects with less than 10,000 tCO_2 annual abatement potential—

FIGURE 5.19 Impact of Transaction Cost and CER Price on Commercial Viability of CDM Projects



Note: (transaction data source[5]: section 3-6-2, crediting period 7-10 years)

in the industry, transport, rural, urban, and commercial sectors (demand-side management)—would not be commercially attractive as CDM project because the transaction costs will be as high as $2–20/$tCO_2$. Transaction costs for small-size projects makes smaller emission reduction options economically unfeasible, although abatement costs may fall into the CER price range of up to $6/t CO_2 ($22/t C). The deal-size threshold is very sensitive to the CER price, As indicated by *Figure 5.19*.

China's CDM Potential by Sector

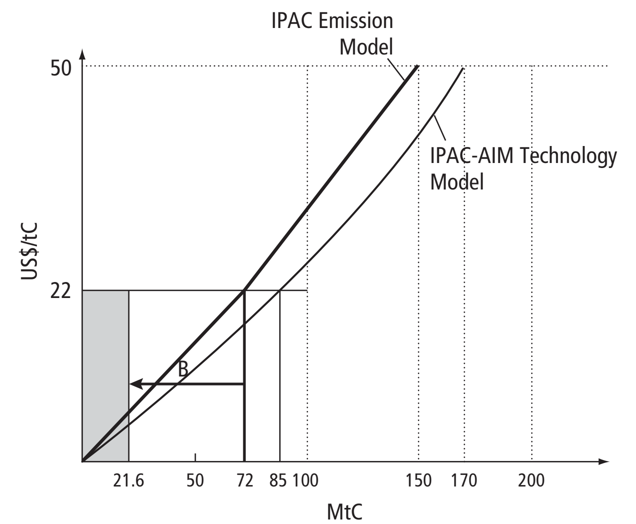
The emission reduction potential by sectors—at a cost of $50/tC ($13.60/tCO_2)—reflects the mitigation potential induced by switching over to advanced lower carbon intensive technologies. The technical abatement potential is estimated at 170 MtC (624 $MtCO_2$) in 2010; however, the CER market potential is substantially less than this for several reasons, including (a) only about 50 percent or 85 MtC/year (312 $MtCO_2$) of the total CO_2 reduction potential can be achieved at costs below $22/tC ($6/tCO_2); (b) it is assumed that transaction costs for smaller projects (<10,000 tCO_2 emission reductions per year) will be prohibitive to their implementation under the CDM at the range of market prices estimated in this study; (c) not all of the emission reduction potential will meet the additionality criterion for CDM approval, and (d) not all of the remaining potentially viable and eligible CDM project opportunities can be implemented to generate CERs by 2010, due to various barriers (such as the time lag from CDM dealmaking until the start of operations, the lack of awareness of CDM opportunities, the failure of the Kyoto Protocol to enter into force so far, and lack of project preparation capacity).

Figure 5.20 compares the results of two models—the IPAC emission model and CERT on the one hand, and the bottom-up IPAC-AIM technology model on the other. As the IPAC-AIM technology model does take into consideration no-regrets options, while the IPAC emission model does not, the MAC curve in the IPAC-AIM technology model is flatter. At \$22/tC (\$6/tCO_2), the IPAC-AIM/technology MAC curve projects an abatement potential of around 85 MtC (312 MtCO_2), while the IPAC MAC projects 72 MtC (264 MtCO_2). In addition, the IPAC-AIM technology model suggests—with some CDM-eligible no-regrets options—the abatement potential would be around 170 MtC (624 MtCO_2). By application of the CERT model using the IPAC MAC curves, and assuming a 30 percent implementation rate of CDM projects, the deal size at \$22/tC has been estimated at 21.6 MtC. The 30 percent implementation rate taken into account is the dimension B in Figure 5.20. Hence, *Figure 5.20* provides evidence that the emission reduction potential identified through the IPAC-AIM technology model (170 MtC/year, or 624 MtCO_2) at \$50/tC cost (\$13.60/tCO_2), and the CDM potential identified by application of the CERT model—21.6 MtC/ year or 79.2 MtCO_2 at \$22/tC (\$6/tCO_2)—seem to be in plausible and consistent relation with each other. This cross-check provides evidence that the 30 percent implementation rate assumed for the CERT base scenario (based on IPAC) is a plausible assumption, also taking into consideration that some no-regrets abatement potential could qualify for CDM.

Table 5.24 gives a preliminary idea of the distribution of CDM potential by sector that is feasible at a cost of \$22/tC (\$6/tCO_2). This estimate relates to the cost of technologies, not to the market price. The study has estimated the share of CDM project potential for selected sectors based on the sectoral distribution displayed in table *Table 5.24.* Sectors contained in the IPAC-SGM model used for impact analysis (see chapter 6) were assessed by expert judgment; the study authors took into consideration criteria such as:

- The price of CERs from the CERT model and the sectoral MAC curves (*Figure 5.17*)
- Size of sector, sector risk, and expression of interest by stakeholders to go for CDM project deals
- The minimal deal size (which would put the small-scale commercial and residential sector at a disadvantage)
- Risks associated with demonstration of additionality of the potential CDM project type/ technology.

FIGURE 5.20 Comparing Bottom-up Emission Abatement Potential (50\$/tC) with Top-down Estimated CDM Potential (22\$/tC), 2010



B = Barriers reducing the share of abatement potential at equilibrium price which is CDM-able (deal size, time lag, demonstration of additionality ect.)

TABLE 5.24 Contribution of Different Sectors to the 21.6 MtC CDM Potential Resulting from CERT Analysis

Sector	Share (%)	Amount (MtC/a) 2008–2012 average
Steel Making	10	2.16
Cement	10	2.16
Chemical Industry	5	1.08
Power Generation	50	10.8
Other sector	15	3.24
Non-CO_2 project	10	2.16
Total	100	21.6

Because project proponents have recently given much attention to the power sector, and the related MAC curve is flatter than the ones for other sectors, the study has allocated a higher share in the power sector. The shares of CDM potential in different sectors are assumed as 50 percent for the power generation sector, 10 percent for both the steelmaking and cement sectors, 5 percent for the chemical industry, and 15 percent for the other industry sectors. Ten percent of China's CDM potential was allocated to non-energy non-CO_2 CDM projects from the industry sector. The calculated distribution of the annual 21.6 MtC (79.2 $MtCO_2$) CDM potential (CERT base scenario) to the various sectors is shown in *Table 5.24.*

The allocation of CDM potential to non-CO_2 projects not covered by the IPAC/AIM technology model is justified as follows: Michaelowa (2003) has estimated the emission reduction potential in methane from gas flaring in China to be 1–2 percent of total CER sales. In addition, China has a significant potential for HFC-23 decomposition, which can be based on methodology AM0001 already approved by the CDM Executive Board. Accordingly, an allocation of 10 percent of China's CDM potential to non-CO_2 projects seems plausible. The sector split as displayed in *Table 5.24* should be seen as tentative. It will require a more detailed analysis that is beyond the reach of the model applied in this study.

Technology Priority for CDM

The major energy and industry sector technologies suitable for CDM and significantly contributing to emission reductions are listed in *Table 5.25.* Within the reduction potential of 85 MtC (312 $MtCO_2$) estimated through the IPAC-AIM technology model (at a reference scenario CER price of \$22/tC or \$6/tCO_2) the total of deals qualifying for CDM is significantly lower because of (a) the transaction cost of such deals; and (b) the consideration of project additionality. Accordingly, the CDM potential in 2010 in China is projected as 21.6 MtC/a (79.2 $MtCO_2$) (*Table 5.25*).

ANALYSIS OF DEMAND-SIDE BARRIERS

The global carbon market size and price is influenced by a whole range of factors. The key factors include the uncertainty of emission projections up to 2010; MACs of countries and sectors; the market regime; the CDM implementation rate, which is influenced by supply-side factors such as the host-county regulatory environment (taxation); expected carbon price and transaction costs; the level of domestic action undertaken by Annex I parties; and the mitigation efforts in Annex I parties not ratifying the Kyoto Protocol (United States and Australia).

The IPAC emission model calculates total reduction requirements for Annex I Parties of 374 MtC (1,371 $MtCO_2$) (based on the reference scenario, with an assumed CDM potential implementation rate of 30 percent, and with 10 percent U.S. participation). The global CDM market size in 2010 is accordingly projected at 44.7 MtC (164 $MtCO_2$), of which China could implement close to 50 percent of the total (21.6 MtC, or 79.2 $MtCO_2$). The CERT sensitivity analysis shows that China's CDM potential would vary from 0 to 57.5MtC (211 $MtCO_2$). The respective CER price would range from \$0 to \$24.30/tC (or \$6.60/tCO_2).

Other recent publications on market and CER price development divert only slightly from the IPAC/CERT model projections made in this study. Grubb (2003) compared different models' estimations for the equilibrium carbon price under Kyoto, and found a price ranging from \$55 to \$190/tC (\$15 to 52/tCO_2) with U.S. participation, and "close to zero" to \$50/tC (\$13.6/tCO_2) without any U.S. participation. In his medium-range estimation, the price falls from \$55/tC (\$15/tCO_2) to \$18/tC (\$5/tCO_2) without the U.S. Depending on CER prices, the estimates of CDM supply spanned a range between

TABLE 5.25 Technologies Contributing to GHG Emission Reductions in the Short and Middle Term

Sector	Technologies
Steel Industry	Large-size equipment (coke oven, blast furnace, basic oxygen furnace), coke dry quenching, continuous casting machine, TRT, continuous rolling machine, coke oven gas, OH gas and blast furnace gas recovery, DC-electric arc furnace
Chemical Industry	Large-size equipment for chemical production, waste-heat recovery system, ion membrane technology, existing improved technologies
Paper Making	Cogeneration systems, residue heat utilization, black liquor recovery system, continuous distillation system
Textile	Cogeneration systems, shuttleless loom, high-speed printing and dyeing
Non-ferrous metal	Reverberator furnace, waste-heat recovery system, QSL for lead and zinc production
Building Materials	Dry process rotary kiln with pre-calciner, electric power generator with residue heat, Colburn process, Hoffman kiln, tunnel kiln
Machinery	High-speed cutting, electric-hydraulic hammer, heat preservation furnace
Residential	Cooking by gas, centralized space heating system, energy-saving electric appliances efficient lighting, solar thermal for hot water, insulation of buildings, energy-efficient windows
Service	Centralized space heating systems, centralized cooling-heating systems, cogeneration systems, energy-saving electric appliances, efficient lighting
Transport	Diesel truck, low energy-use car, electric car, natural gas car, electric railway locomotives
Common Use Technology	High-efficiency boiler, fluid bed combustion technology, high efficiency electric motor, speed adjustable motor, centrifugal electric fan, energy-saving lighting
Power generation	Super critical unit, natural gas combined cycle, pressurized fluid bed combustion boiler, wind turbine, integrated gasification combined cycle, small-scale hydropower, biomass-based power generation

15 and 50 MtC (54 to 180 $MtCO_2$) per year, after the withdrawal of the U.S. By comparison, Haites (1998), the U.S. government (1998), Austin (1998), and Ellermann and others (1998) all provided higher estimates of the size of CDM of 27 to 572MtC (99-2,108 $MtCO_2$), 273 to 723MtC (1,001-2,651 $MtCO_2$), 397 to 503MtC (1,456-1,844 $MtCO_2$), and 100 to 188MtC (367-689 $MtCO_2$) respectively. The lower values in the estimates mainly result from scenarios with supplementarity restrictions (cited in Grubb 2003). Grubb (2003) also indicated that due to the project-based nature of the CDM and various related institutional, legal, and financial barriers, far lower estimates of CDM potential resulted than when generating them from "top-down" assessments based on marginal supply curves of the costs of limiting GHG emissions in developing countries.

The present, early carbon offset market has been shaped by deals affected by the Dutch CERUPT Programme and the World Bank's Prototype Carbon Fund and is buyer-dominated. The pricing is so far largely dependent on the buyers' willingness to pay, the types of projects to generate emission reductions, the price signal in the market, and the risk-sharing between buyers and sellers. Accordingly, the price for CERs is currently in the range of \$10 to \$20/tC (\$2.5 to \$5/tCO_2), which is close to the evaluation based on the IPAC emission model and CERT.

- Through the World Bank's Prototype Carbon Fund, the CERUPT Programme, Japanese

Industries activities, and initiatives by several other market players, about two dozen CDM projects could possibly be registered by the end of 2004.

- The European Emission Trading Scheme (EU ETS) may open for carbon offsets from JI and CDM projects from 2005 onwards. A recent study on the impacts of linking JI and CDM credits to the EU ETS has estimated the market potential for JI and CDM to maximally 100 MtC (360 $MtCO_2$) in 2010 with a CER price of \$43/tC (\$12/tCO_2) (Criqui and Kitous 2003).[6] China is expected to be the largest CDM credit supplier (55 percent of all CERs). But the access of the 10 new EU member states is likely to make JI projects particularly attractive under the EU ETS, as the respective transaction cost seems to be lower under JI than under CDM.
- Some market observers see evidence for a likely price differentiation between the project-based mechanisms JI and CDM on one hand, and ET (trading AAUs) on the other hand (Grubb 2003). There is also a private and public sector demand for "green carbon offsets" emerging from renewable energy CDM and JI projects, some of it complying with the "gold standard" proposed by WWF. On the other hand, Grubb (2003) expects that a significant part of the carbon offset demand from countries such as Canada or Japan would choose the least-cost option; that is, emission trading (AAUs).

The literature research and analysis done by the study team provide ample evidence for a large uncertainty with regard to CDM potentials as well as the carbon offset price. So far, only a small proportion of the potential CDM market size has taken shape yet. The factors influencing the pace at which the carbon offset demand develops further are therefore highly relevant for understanding prevailing market incentives and barriers. Unless the demand for CERs does pick up significantly until 2006 the IPAC-projected global CDM potential in 2010 of 44.7MtC/yr (164 $MtCO_2$/yr) and the projected potential in China (21.6 MtC or 79.2 $MtCO_2$) will be difficult to be realized on an average during the first commitment period. So, in essence, the global CDM market in reality is likely to be smaller than the projected 44.7MtC/yr (164 $MtCO_2$/yr), but the CER price could be higher than projected by CERT and fall into the \$20 to \$40/tC (\$5 to \$10/tCO_2) range.

The following institutional and methodological parameters seem to have a significant influence on buyers' preferences and the actual CER price:

- Crucial for the further development of the CDM market is an early entrance into force of the Kyoto Protocol, as only CDM projects coming into operation before 2006 will benefit from a full 7-year crediting period up to 2012. Some domestic regulations in Annex I countries are still awaiting parliamentary ratification, which is scheduled to follow when the Kyoto Protocol has been ratified by Russia as well. Another decisive factor for a CDM market will also be second commitment period targets (if any), which will influence banking decisions and thereby affect the carbon market during the first commitment period.
- The uncertainty regarding the carbon offset demand and prices emerging under JI and CDM as well as the uncertain availability of assigned amounts (AAU) on the emission trading market make market intermediaries and the financial sector still standing rather aloof with regard to upfront investments. Associated with this is a comparatively low level of involvement and CDM awareness of commercial banks and financial intermediaries. The institutions offering carbon finance services do compete within a still comparatively small market—at least if compared to the requirements of a 44.7MtC/yr (164 $MtCO_2$/yr) CDM market in 2008.
- Considering the considerable size of transaction costs, many potential investors from Annex I countries make carbon trading investments a

second priority and first look for carbon offsets within the enterprise. But Lecoq and Capoor (2003) report an increasing participation of firms in the carbon offset market, in particular from Japan. On the other hand, the business community in Europe is heavily engaged in the discussions on National Allocation Plans for the EU-ETS, and does not share their governments' views that it is beneficial or urgent to get involved in an early action with regard to procurement of CERs or ERU options. The business community thinks that there is still time to make decisions. In most Annex I countries, the Kyoto regulatory framework is still at a stage of voluntary measures. The political process to make it legally binding is ongoing. This largely explains the "we cross the bridge when we reach the river" attitude still prevailing in the corporate sector within key Annex I economies.

- Significant amounts of private non-carbon capital are required to make proposed CDM deals bankable and reach the respective financial closure. As long as the CER-based revenue stream is associated with a significant project risk, the financial sector prefers investments in highly profitable and larger-scale projects. But in such projects, carbon finance risks are perceived as higher and more sensitive due to uncertainty about project completion dates. Important project risks perceived by investors are the regulatory framework, the needed clearances from the legal systems in host countries, transaction costs, and uncertainties about whether CERs will be taxed in China.
- Uncertainty also prevails on how additionality can be demonstrated through appropriate methods in more demanding but attractive sectors for business, such as energy efficiency in industry. For sectors with significant GHG abatement potentials and significant sustainable development benefits—but with more demanding CDM methodological issues, such as demand-side management in commercial and residential buildings, energy efficiency in small-scale industry, rural electrification or transport—public finance is likely be required to get such projects to the market. At present, demand is channeled to renewable energy projects, where additionality can be justified comparatively easily and where a project size of 5 to 50 MW does not pose significant project risks. However, such projects would account for only a small fraction of the GHG abatement potential in large developing economies such as China.

Various groups of stakeholders do apply differing strategies in selecting technologies and prioritizing their project pipeline for CDM investments. The EU emission trading scheme and other national regulations potentially offer additional incentives for private investment in the carbon offset market. Key stakeholders shaping the demand in today's "buyers market" include a) OECD governments, b) large institutional and international agencies, c) the corporate sector, and d) the NGO sector. For example:

- Many EU member states and other OECD governments are in the process of establishing domestic emission trading systems and/or JI/CDM programs.
- Many governments are launching their own ERU and CER procurement programs, including the Dutch CERUPT, the Finish small-scale CDM program, the Danish CDM/JI initiative, the German JI/CDM fund (through KFW), and more recently the programs of Austria, Sweden, and Australia.
- Government and multilateral funds have so far played central roles on the buyer side in potential CDM project transactions. To date, Annex I governments are investing in CDM mainly because of country-level compliance. Governments also are putting aside funds for investment in emerging private undertakings as well, creating public-private-partnerships. This could help attract private investments to carbon funds, and thus support such funds through a difficult introductory phase, when uncertainty about the status of the Kyoto Protocol still puts off many potential CDM investors.

- Institutional buyers such as the World Bank's Prototype Carbon Fund, IFC, the Asian Development Bank, or the EBRD are partly acting on behalf of OECD governments or on behalf of large corporations. They play an important role as market-place facilitators.
- Funds support the development of the market by promoting pilot projects and the acquisition of the first verified and certified emission reductions. By establishing certificate pools for investors and buyers from the public and private sector, such initiatives are important efficiency instruments to reach the Kyoto Protocol's emission reduction targets.
- Large Japanese and European GHG emitters from energy-intensive industries and the power sector are in the process of making direct investments into the emerging CDM and JI market, or are developing their own carbon offset portfolio.
- Multinational corporations, committed to mitigate their carbon risks and demonstrating their corporate responsibility toward environment issues, are in the process of developing their own carbon offset portfolio.
- Commercial banks and large financial sector players are still significantly underrepresented in the market place. They may assess the risk associated with an early involvement as still being too high.
- Project developers and brokers, such as special departments in internationally operating enterprises and specialized consulting companies, together with NGOs are the most active stakeholders in the current global carbon market.

CONCLUSION

The Kyoto Protocol set a GHG emission target for the first commitment period for Annex I Parties. But the real emission reduction to be achieved under the Protocol by Annex I Parties is uncertain due to projected economic development and the related future growth of GHG emissions. GHG emission projections for the year 2010—the year taken as representative of the first commitment period—differ, largely because of differences in modeling approaches, model structures, and assumptions.

Based on the IPAC emission model projection, the Annex II countries' reduction requirements are estimated on the order of 374 MtC (1371 Mt-CO_2), taking into consideration forest management sink credits and the assumed voluntary U.S. participation in the carbon offset market (10 percent participation rate). Through application of the results for both the emission projection and MACs from the IPAC emission model into the CERT model—and assuming EFSU price leadership for the future carbon market, a 10 percent participation rate by the United States, 30 percent implementation rates for all non-Annex I Parties, 50 percent supplementary for EU, and a \$2/tC (\$0.55/tCO_2) of transaction cost for CDM—the CDM market size in 2010 is estimated to be 44.7 MtC (164 MtCO_2). *Table 5.26* shows the results of this study, comparing it with findings of selected other WB-NSS completed since 2001 as well as with the outcome of selected carbon offset market studies completed in 2003.

As shown in *Table 5.27,* China's share in the global carbon market is 11 percent and in the global CDM market around 50 percent. China's CDM potential is 21.6 MtC (79.2 Mt-CO_2) for 2010, which is substantial. Supplying this amount of CERs would require a significant number of newly built larger power projects (300MW-600MW) registered as CDM projects, as well as up to 100 operating renewable power projects by 2006/07. In addition to reductions in CO_2 from electricity generation, projects in other categories—including abatement of other gases and other source and sink categories—should also be taken into account in estimating China's total CDM potential and its impact on market dynamics.

The current market price for carbon offsets certified as per Kyoto rules is in the \$3 to \$5/t CO_2 range. This range is close to the results of the scenario evaluation based on the IPAC emission model and CERT (\$0 to \$7/tCO_2). The price resulting from these models is an equilib-

TABLE 5.26 Annex II Countries Emission Reduction Requirements, CDM Market Size, and CER Price Range Estimated

	Annex II Countries reduction requirement Mt CO_2 (2010)	CDM market size MtCO_2 (2010)	CER price range USD/CO_2
IPAC emission model, 30% CDM implementation rate, without U.S. participation	1,243	0–161	0–6
IPAC emission model, 30% CDM implementation rate, 10% U.S. participation	1,371	0–164	0–7
Selected WB-NSS* studies completed since 2001	1,300–(3,000)	300–(2,000)	1.7–(10)
International Energy Outlook, EIA/USDOE 2002	860–1,540	80–465	—
Supply-demand balance study, Grubb 2003	415–1,250**	50–180	0–13.8
EU Emission Trading Study (Criqui et al, 2003)	1,140[7]	330–360	6–12
Transaction cost study, Michaelowa/Jotzo, 2003	1,105	363	< 4

*Vietnam, Peru, Indonesia
**Assuming 50 percent of reduction requirement met by domestic action in the 15 EU member states

rium price under a ratified Kyoto regime. In reality, there will not be one uniform carbon price for different transferable emission units (RMUs, CERs, ERUs and AAUs), and even not a common price for the same transferable emission units resulted from different kinds of projects in various countries. The preference of investors for "high-quality," "low-risk" projects might affect the price of their credits. Grubb (2003) as well as Criqui and Kitous (2003) for the EU emission trading system tried to assess the effect of a differentiated carbon offset market (*Table 5.26*). Simulations in which European market participants give a clear preference to JI/CDM credits conclude that under such a regime CER prices may increase by up to $6 to

TABLE 5.27 Annex II Countries GHG Reduction Demand and its Market Offset Share among Kyoto Mechanisms and the Domestic Actions by Annex II Countries in Basic Scenario

GHG reduction by:	Mt-CO_2 (2010)	Mt-C (2010)	Allocation (%)
Total reduction requirement	1371.3	374.0	
Domestic action Annex II	649.4	177.1	
Subtotal Kyoto Mechanisms	721.6	196.8	100.0
ET: AAU/hot air with EITs;	225.9	61.6	31.3
JI	331.8	90.5	46.0
CDM	163.9	44.7	22.7
CDM, China's share	79.2	21.6	11.0
CDM, SE&S Asia	56.1	15.3	7.8
CDM, LA & Africa + mid. East	28.6	7.8	4.0

$12/t$CO_2$. Such pricing for CERs would increasingly help to cover the incremental abatement and transaction costs of CDM projects. Negotiations between investors and host countries should target this CER price frame, which does more realistically reflect the on-the-ground abatement cost of robust additional projects.

China's power generation sector contributed 36 percent of the total carbon emissions of the energy sector in 2000. This share is expected to increase to 38 percent by 2010. As the MACs of China's power generation sector (IPAC-AIM technology model) display a relatively flat marginal abatement cost curve compared to other sectors (such as transportation and other industries), it is expected that the power sector will capture a major share of the potential CDM market in China. If the power generation sector accounts for around 50 percent of the projected CDM potential of 79.2 Mt CO_2/a by 2010, supplying this amount of CERs would require a considerable number of newly built larger power projects (registered as CDM projects, assuming the capacity range of new fossil fuel-based power projects is around 300MW-600MW) as well as some 100 operating renewable power projects by 2006/2007. The priority technologies for this sector are identified as:

- Fuels switching to combined cycle gas power plants
- Wind power
- Landfill methane gas conversion to power
- Hydropower.

Technologies that may prove to have significant potential and other environmental benefits but could not be covered within the methodology of this study are:

- Coal bed methane recovery
- Biomass-based cogeneration
- Biogas from agricultural, industrial, and urban waste
- Power generation from municipal solid waste
- Non-CO_2 emission abatement technologies (methane, HFCs).

Besides the power sector, the steel, cement, and chemical industries show the second largest abatement potential. Priority technologies in this sector proposed for further investigation are:

- Equipment for coke dry quenching
- DC-electric arc furnace
- Waste heat recovery systems (chemical industry)
- CFBC-boilers for process heat
- Dry process rotary kiln with pre-calciner (cement industry)
- Biofuels for the transport sector
- Demand-side management, for example using advanced electrical motors.

The scope of this study was confined to the energy sector and related CO_2 emissions; non-CO_2 emissions from the industrial energy sector were not covered under this study. Other non-CO_2 GHG emissions, such as HFCs, may offer significantly lower-cost abatement potential.

References

1. Recent energy data show a rapid increase in energy use and production in China. Some newly developed energy scenarios forecast higher energy demand in 2010 and 2020. This adds uncertainty to the energy demand forecast in China.
2. The effect is roughly equivalent to a carbon tax of $50/tC
3. The carbon emission from the IPAC-AIM technology model is higher than that from the IPAC emission model because of different assumptions about emissions in 2000, technology trends, and scenarios. The scenario used in the IPAC-AIM technology model is not well linked with the reference scenario from the IPAC emission model because of different study purposes. This needs to be improved, especially by following recently published data.
4. In the Kyoto Protocol, there is no specific requirement for technology selection in CDM projects, as this could increase the cost of replacement.
5. The annual part of transaction costs was estimated by expert judgment to be on the order of $1/tCO2 for a project size of 10'000 tCO2/a and fall to $0.5/tCO2 for 30'000 tCO2/a. The annual transaction cost may stabilize for 500'000 tCO2/a at $0.2/tCO2.
6. Additional evidence: The delegates at the Annual General Meeting of the International Emission Trading Association (IETA) on October 30, 2003 estimated the carbon price in 2010 at $14.3/tCO2e (www.carbonpoint.com)
7. The external trading enlarged EU 128 MtCO2e; external trading for the rest of Annex B 242 MtCO2; EU internal trade with 10 new EU states 36 MtCO2e; domestic action Annex B 734 MtCO2e.

6

Impact Assessment of CDM Implementation on China's Socioeconomic Development

METHODOLOGICAL FRAMEWORK OF IPAC-SGM

Framework of IPAC-SGM

In order to analyze the socioeconomic impact of CDM implementation in China, a computable general equilibrium (CGE) model, IPAC-SGM, was selected from the IPAC model family. CGE models play an important role in policy assessment. Many modeling teams use CGE models for simulation of economic activities and policy implementation. IPAC-SGM projects economic activity, energy consumption, and carbon emissions for 12 world regions. To better fit China's circumstances, IPAC-SGM was revised with data for some non-market-based sectors such as biomass, nuclear, and hydropower. It is designed specifically to address issues associated with energy activities and global change, with a special emphasis on providing estimates of the following:

- Environmentally important emissions associated with human activities, especially from energy activities
- The consequences of global environmental change, with particular emphasis on human activities
- The economic consequences of actions to mitigate and adapt to global environmental change.

The model has nine production sectors and eleven consumption sectors. It focuses on energy production, capital stocks, and a suite of anthropogenic greenhouse gases (*Table 6.1*). The model was developed in recognition of the fact that energy production and use is the most important set of human activities associated with greenhouse gas emissions.

Some of the sectors, such as electricity generation, also contain subsectors. Each production sector in the IPAC-SGM model represents a unique product with its own unique equilibrium price. Subsectors within a sector represent different ways of producing the same product. For example, there are many technologies for generating electricity, which are represented by the several electricity subsectors.

Methodology of CDM Implementation Analysis by IPAC-SGM

Because there are few similar studies that assess the impacts of CDM implementation on Chinese economic development, several assumptions were made in using the IPAC-SGM model. For example:

- *Foreign investment increase due to sale of CERs.* A simple assumption was made that total

TABLE 6.1 Production Sectors and Subsectors

Sector No.	Sector	Sub-sectors
1	Agriculture	
2	Other sectors	
3	Crude oil production	
4	Natural gas production	
5	Coal production	
6	Coke production	
7	Products from coal	
8	[Hydrogen fuel]	
9	Heat supply	
10	Wood production	
11	Electricity generation	Oil, Gas, Coal, Biomass, Nuclear, Hydro, Solar/Wind
12	Oil refining	
13	Distributed gas	
14	Chemicals	
15	Cement	
16	Primary metals	
17	Food processing	
18	Other industry and construction	
19	Passenger transport	[by transport mode]
20	Freight transport	[by transport mode]

income from sales of CERs would be a net increase in foreign investment for sectors in IPAC-SGM. Parameters for investment will be changed to include the increase in foreign investment.

- *Technology progress in China due to technology transfer through CDM.* CDM projects lead to transfer of advanced technology to China in the period 2005–10. It was assumed that the CDM investment attracted by the 1st commitment period will be taking place early in order to benefit fully from a 7-year crediting period up to 2012. Technology progress in this period was calculated based on the scale of CDM projects and location of these CDM projects by sectors. We assumed that CDM project investment will promote technology transfer to China, followed by the localization of advanced technology in China. This will therefore impact technology progress after 2010 and could have a larger impact because of much more technology diffusion. Technology diffusion will increase domestic production capacity by applying the localized advanced technology, so as to enhance the competitiveness of China's economy. The impact assessment of the CDM-driven technology transfer on technology progress will be focused on middle- and long-term effects over several decades. The target year of this simulation is 2030.
- *Extension of productivity in the machinery manufacturing sector.* Localization of transferred technologies will increase the production activities for machinery manufacturing in China.

MAIN ASSUMPTIONS AND ENERGY DEMAND

Major assumptions for IPAC-SGM in this simulation include the following:

- *Population growth.* We assumed that the fertility rate, death rate, and birth rate (and future trends) occurring currently in Japan would be similar to that in China by 2030. This population scenario is similar to that in the IPAC

TABLE 6.2 Population Assumed in IPAC-SGM, thousands

Year	Tot.Pop	Working AGE Man	Working AGE Female	Working AGE Total	Employed
1990	1067931	358554	343661	702215	476928
1995	1165023	397988	380687	778675	528857
2000	1244045	426376	407488	833863	566340
2005	1309099	453367	431687	885055	601108
2010	1357580	489652	466795	956446	649596
2015	1399020	514309	489518	1003828	681776
2020	1440727	526122	499638	1025760	696671
2025	1475316	524281	496482	1020763	693278
2030	1495370	529332	500471	1029804	699418

Data source: Energy Year Book 2002, for data from 1990 to 2000.

emission model. *Table 6.2* gives the population scenario in IPAC-SGM.

- *GDP growth.* The government target was basically followed, in which GDP per capita in 2050 will reach the level of developed countries in early 1990. The IPAC model adopted a similar economic growth trend, which is included in IPAC-SGM (*Table 6.3*).
- *Technology progress.* It is assumed that the efficiency improvement trend observed in the past 20 years in China, but—based on research results from other studies—with a declining rate in the future.
- *Energy demand and mix.* Using the above assumptions, a baseline energy demand scenario was developed using the IPAC-SGM model (*Table 6.4*). This provided a baseline energy scenario for this analysis. No large-scale use of biomass and modern renewable energy is assumed.
- *Net foreign investment increase from CDEM implementation.* Selling CDM/CERs to developing countries could bring additional foreign investment funding to China. Here it is assumed that the CDM leads to a net incremental increase in foreign investment[1] compared to the baseline foreign investment (*Table 6.5*). The value for 2010 is the product of the equilibrium market price and China's CDM potential derived from the CERT model. It is assumed that the investment will start to flow

TABLE 6.3 GDP Assumption in IPAC-SGM, million Yuan (in 1990 price)

Year	Consumption	Investment	Government expenditure	Net Export	GDP	GDP Growth Rate	GDP per Capita, 1000 yuan
1990	1000291	473131	61373	218566	1753362		3.218
1995	1351561	804618	214707	218569	2589454	0.081	4.9
2000	2256274	1351287	472525	218560	4298645	0.107	7.59
2005	3624311	1945574	696229	218566	6484680	0.086	10.79
2010	5519115	2621077	1055124	284134	9479450	0.079	14.593
2015	7759009	3245157	1393635	369374	12767175	0.061	18.727
2020	10315084	3958638	1731273	369401	16374397	0.051	23.505
2025	12954654	4710539	2057167	369375	20091735	0.042	28.981
2030	15979505	5773584	2493823	369376	24616288	0.041	35.196

TABLE 6.4 Commercial Primary Energy Consumption (Mtce)

Year	Crude Oil	Natural Gas	Coal	Biomass	Nuclear	Hydro	Other Renewables	Total
1990	164.00	20.64	753.73	0.00	0.03	15.96	0.00	954.36
1995	229.50	27.32	983.40	0.00	0.10	20.15	0.00	1260.47
2000	320.50	32.57	889.55	0.00	0.44	27.32	0.27	1270.65
2005	392.42	40.71	1166.06	0.00	1.13	36.78	0.64	1637.73
2010	484.74	48.52	1301.00	0.00	1.91	46.12	1.25	1883.54
2015	590.33	57.59	1474.87	0.03	2.73	56.09	1.86	2183.49
2020	701.46	65.77	1637.01	0.27	3.31	63.58	3.00	2474.40
2025	814.98	73.70	1781.94	0.58	3.34	62.94	4.12	2741.61
2030	948.70	84.10	1972.43	1.23	3.65	68.07	5.64	3083.82

Note: Traditional biomass use is not included here

from 2005 onwards in order to generate the projected CER volumes in 2010, beginning with incremental CDM investments in 2005 at half the level of 2010. After 2010, it is assumed that the foreign investment in CDM will generally decrease—as other policies that limit emissions (both domestically and internationally) are put in place and decrease the volume of CDM transactions—and will end by 2030. It is also assumed that the CDM will continue to operate after 2010.

- *Technology progress by CDM implementation.* CDM projects will have a positive impact on the technology improvement rate. According to the results from CDM potential analysis by sectors, the power generation sector and energy-intensive sectors will benefit from advanced technology diffusion through technology transfer by CDM projects. The assumption in technology progress rate used in IPAC-SGM is given in *Table 6.6.*
- *Localization of advanced technologies.* In the simulation, advanced technologies transferred through CDM projects could be localized, which is critical for further diffusion in China. Localization of advanced technologies contributes to local economic development and environmental protection. In the IPAC model, it is assumed that localization of technology started five years later than CDM project implementation, and that localization will introduce earlier diffusion of these technologies in the period from 2010 to 2030. The technology diffusion rate will converge to the baseline diffusion rate after 2030. This will increase energy efficiency improvements after 2010 (see Annex 3 in the CD-ROM attachment for assumptions).
- *Productivity increase in the machinery manufacturing sector. Table 6.7* provides an overview of the expenditures for technology imports to the power generation sector. Based on this information, it is assumed that half of the expenditure for technology imports (foreign investment) will be shifted to domestic purchases.

TABLE 6.5 Net Foreign Investment Increase Caused by CDM, (in million US$)

	Net foreign investment increase
2005	237.6
2010	475.2
2015	356.4
2020	237.6

Table 6.8 provides the value added from machinery manufacturing as a share of total industry

(around 10 percent). This added value share will increase from 2010 onwards. In the simulation, it is assumed that capital productivity in the machinery manufacture sector will increase 0.1 percent annually from 2010 to 2030.

IMPACT ASSESSMENT OF CDM IMPLEMENTATION ON GDP

Taking into account the incremental foreign CDM investment, efficiency improvements, and technology localization (which lowers the cost of manufacturing capital goods), the model simulation leads to an increase in GDP of 0.03 percent in 2010, 0.34 percent in 2020, and 0.52 percent in 2030 (*Table 6.9*).

After that, the effects of technology will generally disappear, because technologies transferred by CDM will be introduced into the baseline scenario. The GDP increase peaks in approximately 2030 to 0.52 percent compared with the baseline scenario (*Figure 6.1*). Over the entire 25-year period up to 2030, the CDM leads to a GDP increase of 0.68 percent, compared with the base case without CDM. On an annualized basis, the rate of increase in GDP over this period due to the CDM is 0.022 percent.

The analysis only considers macro-level, aggregate effects of increased CDM investment on GDP. Macroeconomic feedbacks at the sectoral level—such as on competitiveness, structural change, energy costs, or access to capital/capital cost—are not taken into account.

MODEL LIMITATIONS AND CONCLUSION

This study of the economic impact of CDM implementation in China is a preliminary research activity. So far, there are few similar studies. There were limitations in the overall methodology framework, including parameter assumptions for foreign investment, efficiency improvements, and localization of technologies. There were also limits in how the results in the CERT and IPAC-AIM technology models could be applied to the IPAC-SGM model. Given these limits, we made simplified assumptions about the impact of CDM implementation. Critical limitations in the modeling assumptions include:

- *Net increase of foreign investment for CDM implementation.* In this study, we assumes that

TABLE 6.6 Annual Change in Efficiency Improvement Assumption as a Result of CDM in IPAC-SGM

	Base case* 2005 (%)	with CDM 2005+t (%)	% increase due to CDM (%)
Steel Making	4.0	0.2	5.0
Cement	6.0	0.3	5.0
Chemical Industry	4.4	0.1	2.3
Power Generation		0.07	
— gas fired plants	0.8	0.1	12.5
— coal fired plants	0.2	0.06	25.0
Other sector	5.0	0.2	4.0

*This table gives a snapshot of base case efficiency improvements for the year 2005 for comparison with the CDM effect; the full time series for the base case is available in the CD-ROM attachment.

TABLE 6.7 Investment in Power Sector, billion $

	1995	1996	1999	2000
Total Investment	12.6	15.4	22.2	25.7
Foreign investment	0.9	1.4	2.7	2.5

Source: China Year Book 2002.

TABLE 6.8 Value Added in Machinery Sector, billion $

	1997	1999	2001
Total	240.1	261.1	343.0
Machinery (1)	26.1	27.4	36.2

Notes: (1) including ordinary machinery, special purpose equipment, and electric equipment and machinery.

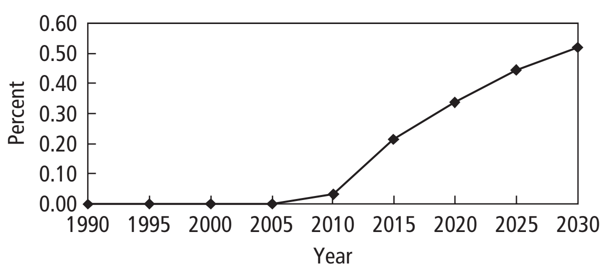
TABLE 6.9 CDM Impact on China's GDP

	GDP base case (B $)	GDP with CDM (B $)	Increase in GDP from CDM (B $)	% GDP increase due to CDM
2005	750.6	750.6		
2010	1109.2	1109.6	0.4	0.033
2020	1965.5	1972.2	6.7	0.34
2030	3025.2	3040.8	15.6	0.52
GDP increase 2005–2030	2274.6	2290.2	15.6	0.68
Annual growth rate increase in GDP for the period 2005–2030				0.022

CDM transactions would result in a net increase in foreign investment. In some cases, there may be tradeoffs between CDM investment and conventional FDI investment, such that CDM investment would not be additional to baseline FDI investment.

- *CDM profit treated as investment.* It is assumed that CDM profits are reinvested in the economy. In reality, profits could be used for other purposes.
- *CDM transactions may take the form of CER sales.* This would put more of the burden for project finance (and risk) on the project owner and may have different economic impacts than CDM investment. This issue requires further study.

FIGURE 6.1 GDP Change by CDM Implementation in China



- *The IPAC-SGM model assumed a technology progress rate.* Because this is a CGE model, there is an indirect linkage between technology progress in the IPAC-SGM model and technology progress in the IPAC-AIM technology model.

Despite analytical uncertainties, some preliminary observations from the study include the following:

- CDM implementation could contribute to China's economic development by extending foreign investment, localization of advanced technologies, and technology efficiency improvement in China. Major contributions from CDM implementation in China to the local economy include a net increase of foreign investment in China by CDM projects, technology efficiency improvements, and localization of advanced technologies.
- CDM implementation could have long-term benefits for China. The results show GDP increases by 0.03 percent in 2010, 0.34 percent in 2020, and 0.52 percent in 2030. This shows the early introduction of technologies and localization effects.
- Further study is necessary to determine the impact of CDM implementation. By reviewing related studies on the impact of CDM projects, we observed ancillary benefits from CDM implementation. Several studies (Jiang and others 1998; Guo and others 2003) present the co-benefits on local air pollution abatement and health impacts from the introduction of clean technology to China. CDM projects could help bring clean technologies to China. This should be further analyzed within the IPAC-SGM model.

Endnote/Reference

1. The prevailing CDM transaction type at present is not direct investment in a CDM project, but the sale of CERs through carbon purchase agreements. This analysis suggests that there are different development implications for these two transaction types.

7

Policy Insights and Recommendations

POLICY INSIGHTS

The Rationale for a Sustainable and Proactive CDM

Based on the knowledge and experience gained through the China CDM study, and considering both the evolution of the international CDM regime and the particular national circumstances of China, this chapter outlines the justification for a Chinese CDM approach that:

- Emphasizes sustainable CDM by ensuring the contribution of CDM project activities to sustainable development in China
- Takes a proactive approach to take early advantage of CDM opportunities during the first commitment period.

Significance of CDM opportunities for China: Local co-benefits

CDM projects will contribute to greenhouse gas emission reductions and help developed country parties meet part of their commitments under the Climate Convention and the Kyoto Protocol. In addition, they will assist China in achieving sustainable development by absorbing additional financial resources and promoting technology transfer.

CDM will not have a significant impact on overall economic growth rates in China in the short to medium term (up to 2010). Assuming the Kyoto Protocol enters into force soon, some positive macroeconomic effects are nonetheless apparent, including:

- An increase in net foreign investment (via CDM deal inflows to China) up to $475 million annually in 2010 (including both incremental abatement cost and profit)
- Higher rates of efficiency improvement in the energy end-use and electricity generation sectors, resulting in greater resource productivity
- A CDM contribution of about 0.5 percent of GDP annually in the year 2030 as a result of CDM investments made from 2005 to 2030, mainly due to the transfer and localization of advanced technology that is not yet mature in China. In the 2005–2010 timeframe, total incremental CDM investments of $1.78 billion (base case) result in a corresponding GDP increase of $2.13 billion. In other words, every dollar invested in Chinese CDM projects boosts the Chinese economy, measured in GDP terms, through 2010 by an additional $0.20 (as a result of technology localization and efficiency improvements). This multiplier effect is expected to increase over time as technology localization advances.

In addition, CDM can have a range of sustainable development co-benefits in line with

China's domestic policy priorities, including positive effects[1] on:

- Local economic development—promoting local economies through technology localization, increasing local tax revenue, creating new (skilled) jobs, and building local capacity
- Resource efficiency—more efficient use of energy and using waste for energy generation
- Local environment—reductions in air pollutants such as sulphur dioxide, nitrous oxide and dust;[2] improved water quality, including reductions in organic oxygen demand; and nature/forest conservation.

Properly selected and designed CDM projects can provide financial leverage to speed technology progress in the electricity generation and energy end-use sectors. The resulting co-benefits can have significant long-term effects on economic growth and China's quality of life. However, not all projects that generate real, measurable, and long-term greenhouse gas reductions also make an unambiguous contribution to local sustainable development, so it is imperative that potential projects be carefully selected to be consistent with China's sustainable development strategy and Action Plan, which is a high priority of the government.

China's critical role in the global carbon market

Three fossil and three renewable case studies that represent a good cross-section of electricity generation options in China were analyzed. Four of them had average specific abatement costs at or above $\$10/tCO_2$, and would likely not be competitive under current market conditions. Taking advantage of synergies with existing government technology progress programs could enhance the financial viability of CDM projects that employ advanced technologies.

The top-down modeling results for the energy sector as a whole, on the other hand, indicate significant potential below the modeled equilibrium price of $\$5.2$ to $\$6.5/tCO_2$. The marginal abatement cost curves for energy end-use sectors used in this analysis are rather preliminary, but some no-cost measures in the industrial end-use sector were identified. Project developers are likely to find many more CDM opportunities in the various end-use sectors that are competitive under prevailing market conditions, but this study only looked in detail at power generation options.

Based on three carbon market scenarios, this study estimated China's energy-related CDM market potential in the year 2010 at between 25 and 117 $MtCO_2$ annually, based on an equilibrium certificate price of $\$5.2$–$6.5/tCO_2$.[3] Under all three scenarios, China captures nearly 50 percent of the total market CDM demand (estimated at between 52 and 240 $MtCO_2$), resulting in CER profits[4] of \$77–\$311 million annually in 2010. If a market structure of perfect competition is assumed, the model results provide close to zero price and CER trade volumes. The estimated CDM potential refers to reductions in CO_2 from electricity generation and energy end-use only (which account for over 80 percent of total CO_2 emissions). CDM potential for other gases (such as HFC 23 decomposition) and other source and sink categories must also be taken into account in estimating China's total CDM potential and its impact on market dynamics.

Sensitivity analysis indicates that the largest sources of uncertainty in these estimates (in order of importance) are (a) the amount of surplus allowances in EIT countries; (b) business-as-usual emissions projections (demand side) and marginal abatement costs of potential buyers and sellers; (c) the level of supply-side competition in the market (competition vs. price leadership); (d) the fraction of CDM potential that is actually realized by 2010 (implementation rate); (e) the trade-off between hot air supply and the amount of carbon offsets reaching the market in the form of JI credits; (f) the assumed participation rate of the United States; (g) the way in which countries choose to operationalize supplementarity; and (h) the level of transaction costs.

In assessing China's CDM potential, this study modeled supply-side competition based solely on differences in national marginal abatement cost curves under perfectly functioning equilibrium market conditions. Future work will have to consider the nature of emerging carbon markets (fragmented, illiquid, non-standardized, risk-averse), the implications of different CDM transaction types (equity investment in CDM projects, forward contracts to purchase CERs, trade in CERs on secondary markets), the differing motivations of market players, and how China can compete successfully under these real-world conditions.

Time pressure to capitalize on CDM opportunity

The shape of the international climate policy regime for the post-2012 period will determine whether CERs generated after 2012 have value for China and other host countries. If the Kyoto Protocol were to enter into force in time, negotiations on commitments for subsequent periods for Annex I Parties—which will take the form of amendments to Annex B of the Kyoto Protocol—would be launched by the end of 2005. If this path is followed, and commitments can be negotiated successfully, the CDM will likely be part of the future policy mix, under a continuation of the Kyoto regime. Otherwise, and this risk is substantial, the validity and value of CERs after 2012 is uncertain.

As a result, investors are only interested at present in making financial commitments to CDM projects for CERs generated through 2012. If we assume that the CDM projects to be implemented by China have a 7-year crediting time, these projects would have to be operational by the end of 2005 to capture the full value of the project's eligible CERs during the first commitment period. As large power projects generally have construction times of several years or more, it is clear that some of the value of the potential CDM projects would not be generated in time to enter into investors' calculations.

To be competitive, therefore, China may have to act rapidly and focus on projects that can be implemented over the next couple of years, have low specific abatement costs, and/or have crediting times that do not extend far beyond 2012. Other strategic options are to use CDM investment (or proceeds from sales of CERs, depending on the transaction model) merely to supplement government initiatives to introduce advanced technologies (clean coal, new and renewable technologies, energy efficiency) without the expectation of full incremental cost recovery.

In order for the Chinese Government to leverage CDM investment/CER proceeds in support of its technology promotion activities, a transparent baseline methodology to demonstrate the additionality of such efforts is required. Identifying CDM opportunities linked to energy sector and municipal infrastructure projects that receive government subsidies to promote technology progress or sustainable development could be one means of rapidly developing viable CDM projects.

To take full advantage of the modeled CDM potential in the power sector, up to several hundred projects—including a considerable number of larger, newly built fossil power projects (i.e., capacity range: 300–600MW), as well as some 100 renewable electricity generation projects—would have to be registered as CDM projects and under operation by 2005/6.

Furthermore, some potential CDM projects, such as the super-critical coal-fired power plant project analyzed as a case study, may lose their CDM eligibility in a rather short timeframe, as the underlying technologies come into widespread use and must be considered in the baseline. In other words, delay in moving forward with CDM implementation can result in irreversible loss of opportunities.

Identification and Removal of CDM Barriers

Chinese enterprises face barriers to CDM implementation in practice

As identified in the course of the case study work and through industry stakeholder consultations (see Annex 7 in the attached CD-ROM), project developers are currently confronted with myriad significant barriers to CDM implementation. Some barriers are faced by all project developers across the world. China alone cannot remove such barriers; including:

- Uncertainty whether and when the Kyoto Protocol will/may enter into force
- Uncertainty about carbon offset prices in the emerging global carbon market for the Kyoto mechanisms, which makes it difficult for enterprises to assess in a robust way the potential net financial benefits from CDM transactions
- Low CER price offers in the current buyer-driven market, which limits the volume of potential projects for which CDM financing actually covers the incremental cost of additional climate protection projects
- Uncertainty regarding international approval procedures
- Complexity of the CDM project cycle. Most enterprises, particularly smaller ones (which are prevalent in China), simply do not have the required capacity; that is, a range of technical/engineering/economic know-how to prepare PDDs, command of English, and experience with monitoring systems.

However, some barriers could be removed, including:

- Institutional and legal systems in China to enable project developers to enter into CDM project activities (such as DNA to give formal approval to CDM projects; transparent and unambiguous rules on project eligibility and procedures for project approval; CDM property rights; CER taxation policy; laws and incentives for renewable energy projects)
- Lack of awareness among decisionmakers in the financial sector and enterprises regarding climate change (greenhouse gas emissions, reduction potentials, Kyoto/CDM framework), plus knowledge and skills to evaluate CDM risks and opportunities (such as taking into account the additional requirements for monitoring, reporting, and verification of CDM projects)
- The challenge of reconciling the need to demonstrate the additionality of CDM project activities within the 5-year planning process
- Lack of incentives for utility participation as crucial stakeholders for power sector CDM deals, as grid-connected power projects require data on the greenhouse gas emissions of the existing power grid (baseline, leakage). However, these enterprises have no financial incentive to deliver the necessary data for CDM project developers, as they are generally not partners in the CDM deal.

Although some potential CDM projects are under development, and some Chinese enterprises are eager to initiate CDM projects, other Chinese enterprises are not fully aware of CDM opportunities or are waiting for additional assistance before launching actual CDM projects, even though there is interest in learning more (capacity building, engaging in pilot projects under low-risk arrangements), even in the period before major uncertainties can be removed and the institutional framework is established. In dialogue with the private sector, the government should explore how to overcome these barriers.

China's actions to facilitate CDM

Whether China will be able to achieve its full CDM potential will depend on China's competitive position in the carbon market. These incentives might include creating attractive investment or carbon purchase arrangements from the perspective of CDM investors or CER buyers; ensuring efficient institutional arrangements and state assistance to lower transaction costs; adopting favorable conditions for the uptake of advanced technologies, in particular, renewables; and providing incentives and capacity building to foster rapid development of CDM projects that can be offered at competitive prices. The current initiatives of the National Peoples Congress to create a law for the promotion of renewable energy and to revise the electricity and energy-saving laws are promising and should offer points of entry for the CDM.

Despite the uncertainties surrounding the Kyoto Protocol's entry into force and CDM costs and benefits, opportunities exist to facilitate the removal of some of the main barriers to CDM implementation, and China is beginning to act on them:

- Several studies and capacity building programs have been carried out in China with international assistance. They have proven beneficial to enhance awareness on climate change and CDM among governmental and industrial audiences, as well as to analyze CDM opportunities.
- Although the DNA of China has not been officially announced, the current "Climate Change Office" in the National Development and Reform Commission has been mandated to perform the tasks of the DNA in the pre-validation phase of CDM project development. A draft interim regulation to formally designate China's DNA and to define the domestic approval procedures for CDM projects is under preparation and expected to be adopted in the first half of 2004.
- The government is also developing additional bilateral cooperation programs with foreign governments and international organizations in facilitating the development and implementation of CDM projects.
- A national CDM website is under development and will be ready soon to provide both domestic and foreign CDM developers the necessary information.
- China has a member on the CDM Executive Board for 2004–06, had an alternate member on the CDM Executive Board for 2001–03, and has a member on the CDM Executive Board's Methodology Panel. These advantages have been used to disseminate relevant information, in particular the updated progress in these two bodies.

Progress is also being made internationally with respect to both institutional arrangements and CDM investment promotion and financing/carbon purchase vehicles. In the recommendation that follow, we propose specific steps that the Government of China could take to facilitate CDM project activities.

Thoughts on Priority Sectors and Project Types

One of the general requirements for CDM project approval under the current Chinese interim arrangements is that the CDM project activity should promote the transfer of environmentally friendly technology. In addition, energy efficiency improvements and new and renewable energy are listed as priority areas for CDM cooperation. In general, the central government's main goals are technology progress (advanced technology, localization) and broader contributions to sustainable development, rather than merely attracting additional foreign investment.

In addition to political priorities, however, CDM potential (volume, price) must also be taken into account in considering priority sectors and project types. Through the IPAC-AIM technology model simulation of the entire Chinese economy, the study concluded that the largest CDM potential would exist in the electric power sector, which attributed to China 50 percent of the total CDM potential of 25–117Mt CO_2 annually per year in 2010. The case studies demonstrate that under prevailing market conditions, the added value of CER sales under current market prices will be insufficient to cover the incremental costs of four of the six power projects analyzed. Only the landfill gas recovery and power generation project ($3.9/t$CO_2$) and perhaps the supercritical coal-fired project ($8.5/t$CO_2$) would appear viable CDM projects on their own.[5]

In the provinces in which the six case study projects are located, the share of thermal power generation ranges from 85 to 100 percent, most of which is coal-fired. As the use of advanced technology can increase the efficiency of coal-fired power generation significantly, it would be logical to seek ways to ensure that new thermal power generation is as efficient as possible. However, at current market prices, the additional financial incentive that could be derived from sales of CERs is simply insufficient to encourage enterprises in the energy supply sector (backed by the incremental cost calculations for the case studies) to reconsider alternative, climate-friendly project designs for mid- to large-scale electric power generation projects, which they would have excluded at the outset of their project design process (due to factors such as lack of access to capital to cover incremental costs, insufficient return on investment, high transaction costs, or high risk). To overcome this dilemma, energy supply companies suggested that CDM financing could be applied in the context of clean and efficient energy demonstration projects that are promoted by the Chinese Government through preferential policy/regulations, financial incentives, subsidies, etc. (see Annex 7 in the attached CD-ROM). It should be possible to demonstrate the additionality of such projects, as the technologies concerned are neither widely implemented nor commercially viable under current national circumstances in China. Such combined incentives could make selected climate-friendly electricity generation projects attractive to project owners, because they would be sufficient to cover both the incremental and transaction costs associated with CDM project activities. CDM alone cannot cover the full incremental costs of most mitigation projects in the energy supply sector. And with additional CDM finance, the limited government financial incentives could have a bigger demonstration impact, also with regard to co-benefits associated with promotion of cleaner technologies.

In addition to the power sector, it is assumed that China's CDM potential is distributed among the steel and cement industries (10 percent of CDM potential each), the chemical industry (5 percent), other industries and end-use sectors (15 percent collectively), and non-CO_2 projects (remaining 10 percent of total potential). Further in-depth analysis of emission reduction potential across sectors and for individual technology options is needed to improve the reliability of these estimates.

Further work is also needed to assess the relative attractiveness of sectors and generic project types. It might be instructive to qualitatively assess factors such as the ease of baseline setting (data availability, complexity of project, grid data), ease of demonstrating additionality, the incremental costs, the total amount of greenhouse gas reductions, project ownership characteristics, the potential for replication, and the contribution to sustainable development for the detailed case studies prepared under this study, as well as for other projects evaluated under other cooperation programs.

RECOMMENDATIONS

China's CDM Strategy, Policy, and Implementation Plans

Based on the current state of advancement of China's CDM strategy, policy and implementation, and the insights gained from the China CDM study, it is recommended that China:

Adopt a proactive and sustainable CDM policy

Sustainable CDM

The main driver for China's participation in the CDM is the promise of local sustainable development benefits in support of China's sustainable development strategy, which is a high priority of the government. This study has shown that properly selected and designed CDM projects can provide financial leverage to speed technology progress (access to advanced technologies, technology localization, and diffusion) in the electricity generation and energy end-use sectors. The resulting co-benefits can have significant long-term effects on economic growth and quality of life in China. Yet not all projects that might be eligible under the CDM make an unambiguous contribution to local sustainable development, so it is imperative that the Chinese Government project approval process encourage this policy coherence, for example, by providing clear guidance on project eligibility to potential project developers.

To achieve sustainable CDM we recommend:

- Defining the desired performance outcome of the approval process as precisely as possible. Initially, some experimentation with the full range of approaches to sustainable development assessment—such as positive or negative technology or project category lists; decision analysis frameworks for multi-criteria analysis of projects; inclusion of SD indicators/performance standards in CDM project MVPs; and application of standards, such as the Gold Standard—could be considered. However, it is important that the performance indicators at the outset take into account such practical issues as transaction costs to government and other stakeholders, human resource requirements, credibility, and replicability/certainty to project developers/investors. So the evaluation system should be transparent, robust, and lean. Based on early experience gained, the government may wish to limit or prescribe acceptable approaches (for example, at the time the CDM Directive is finalized).
- Influencing the international rules for the CDM. As a major player in the CDM market, China has the opportunity to ensure that CDM rules reflect Chinese circumstances and are supportive of domestic policy priorities. One example is the consideration of the additionality of new and renewable power generation or energy efficiency projects that receive financial support from the Chinese Government[6] (see discussion on the application of CDM finance to demonstration projects).
- Building awareness among host country project proponents of the sustainable development implications of benefit-sharing and CER pricing arrangements between buyers and sellers, and promoting the consideration by project proponents of these aspects in their negotiation of CDM deals.
- Integrating CDM into the sustainable development strategy and action planning in the sectors (especially the energy sector and energy intensive industrial sectors). Such initiatives could on one hand ensure maximizing the CDM benefits in achieving the sustainable development, and on the other hand, could ensure not losing the CDM opportunity for China during the first commitment period, which need to prepare and initiate considerable number of CDM projects in the earlier stage. Many relevant energy programs or initiatives (such as clean and efficient energy action plan, renewable energy promotion initiative, fuel switching power projects, localization program of the super critical power technology, etc.) are already in place that could be a source of projects potentially eligible under the CDM. In the absence of the CDM, those demonstration projects, which contribute to climate protection, are dependent on Chinese Government financial support. Until they are widely introduced and as long as they require significant Government subsidies to be financially viable, they could demonstrate additionality under the CDM, but this is a limited window of opportunity.
- Developing a strategy to enhance the contribution of the CDM to advanced technology demonstration in the energy sector. For example, the accelerated introduction of clean coal technologies in the coming decades, including overcoming the substantial barriers to their introduction, is needed. Similarly, renewable energy projects depend on effective regulations that require electricity grid operators to purchase electricity at guaranteed prices, as is already the case in some deregulated markets. Levying lower VAT taxes on electricity supplied to the grid by renewable energy projects could also improve the economic viability of

potential CDM projects. Synergies between the CDM and domestic policy priorities appear to be underutilized by the responsible authorities at present.

Proactive CDM implementation

This study has shown that China must act rapidly to facilitate generation of a substantial pipeline of CDM projects—on the order of hundreds in the power generation sector alone—within the next several years if it is to capture its potential CDM market share. In addition, some attractive CDM opportunities will disappear in the mid-term due to technology localization.

A proactive approach to capture CDM opportunities could involve, for example, the screening of projects during normal project permitting and/or approval procedures by government officials for potential CDM projects and notification of CDM opportunities to the project owners. This would capture CDM opportunities at an early enough stage to make it feasible to integrate additional CDM project preparation and approval tasks in the normal project cycle. It also implies active government efforts to raise awareness of CDM opportunities, build the essential capacity for CDM implementation by governments and enterprises, promote international rules that support China's CDM strategy, and create an institutional and regulatory framework that is effective, but keeps transaction costs to a minimum.

Immediate Steps to Facilitate CDM Transactions

To implement a proactive and sustainable CDM strategy that will allow China to capitalize on CDM opportunities during the first commitment period of the Kyoto Protocol, China will have to develop a comprehensive plan of action that will address the need to:

Provide basic services to allow CDM in China

The Government of China should consider announcing its policy and putting in place its interim regulation soon.[7] The government should also consider establishing the necessary institutional arrangements to allow the official approval of CDM projects, as required for validation under the Kyoto Protocol, and issue procedures for project developers.[8]

Clear rules are one of the major prerequisites for private sector initiative in developing CDM project ideas. Such an institutional framework has already been elaborated, but needs to be officially approved and publicly announced, before projects can be officially processed. It is also essential to create a regulatory framework/legal system for CDM business operation in the carbon credit market. The regulatory framework/legal system should preferably not be separate or independent from the current existing system, but may just add some CDM-related components or terms as a supplementary appendix. Industrial stakeholders insist that given the new nature of the CDM trading business, they are not able to participate in CDM project activities without government documentation to secure their legal interests.

Furthermore, the government must keep informed of CDM developments and build and maintain adequate capacity to approve and regulate the CDM process, as well as to analyze outstanding CDM policy issues from a strategic perspective.

Ensure that critical capacity is developed

Based on the current status of CDM in China, a particularly critical focus at present should be on continued capacity building, including local public awareness, local promotion centers, and intermediate agents. Following up on previous assessments (such as World Bank 2003), the China CDM study identified comprehensive institutional, financial, technological, and human resources needs for capacity building and policy initiatives. Through the case study analysis, which involved cooperation with power plant owners in five different regions, it became evident that knowledge of climate change, the Kyoto Protocol, and the CDM was much lower—or nonexistent—in areas far from Beijing. To build awareness throughout China would be a massive undertaking, and may not be effective or realistic, given time and resource constraints. Instead, training to encourage CDM project preparation efforts should be directed at promising sectors or project technology types.

Given the unique nature and complexity of the CDM, which is still at an early stage, we recommend building a modest CDM "infrastructure" that is aimed at building and/or strengthening local capacity for CDM project development and implementation. This infrastructure should:

- Facilitate the organizational development and networking of CDM technical support centers/ entities, which should be professional and experienced institutions to provide consultant services for identification of eligible CDM projects and PDD development for the project proponents, who could thus avoid doing this complicated job on their own.
- Establish a CDM business center network, which could help project proponents to establish a project pipeline and to carry out CDM business activities in the whole CDM project cycle. Project proponents could thus save significant transaction costs and reduce CDM related risks.
- Bridge foreign investors and local partners. Given that several bilateral or multilateral CDM funds have been or will be in place to provide financial support to the qualified CDM project proposals, we recommend building bridges between foreign investors and local partners to promote promising project options in priority areas with significant GHG emission reduction potential.
- Establish and further improve as soon as possible the critical national capacity to develop high quality PDDs for Executive Board review of methodology.
- Enhance the institutional framework and CDM management at the national and local levels. This would include assistance to design a database for CDM project proposals, to establish a CDM web site, and to build capacity for the negotiation of CDM project deals.
- Build awareness at the strategic level among decisionmakers at state-owned and private enterprises of CDM opportunities, perhaps in collaboration with business associations/ networks.
- Enhance viable CDM project development by local promotion centers and intermediate agents.
- Enhance the CDM financing modality and carbon offset deal-making in the carbon market.
- Elaborate negotiation models for sharing of risks, costs, and benefits of CDM projects with Annex B investors. In addition, enhance negotiation skills to maximize the local benefits of CDM transactions in host countries.

Co-financing options and partnerships for these initiatives could be sought from multi- and bi-lateral development cooperation programs, the local and foreign private sector, and centers of excellence.

Encourage CDM project identification and implementation

Although the case studies for the current China CDM study were originally performed as a means of building understanding of CDM concepts and methods and providing an opportunity for hands-on application of this know-how to real project ideas, they may also provide information that could lead to the rapid identification of demonstration CDM projects. The same may be true of similar study projects analyzed under other cooperation programs.

As suggested above, China should consider how to apply CDM financing in the context of clean and efficient energy demonstration projects promoted by the Chinese Government (at the national, provincial, and municipal levels) through preferential policy/regulations, financial incentives, and subsidies. It should be possible to demonstrate the additionality of such projects, as the technologies concerned are neither widely implemented nor commercially viable under current national circumstances in China. Such projects could be launched without delay and should receive high priority, since rules for such projects are under consideration by the CDM Executive Board.

New CDM proposals initiated by the private sector should also be encouraged. To quickly capture CDM opportunities, we recommend (1) reaching out to international corporate sector key players, who have already announced their interest to go for JI/CDM as part of their company emission trading; and (2) screening through normal project permitting and or approval procedures for potential CDM projects and notifying project owners accordingly. This would raise awareness and capture CDM opportunities at an early enough stage to make it feasible to integrate additional CDM project preparation and approval tasks into the normal project cycle. It would also focus efforts on project ideas that are already well-developed and likely viable for implementation in the 2005– 07 timeframe.

In addition to awareness-raising at the level of decisionmakers and basic CDM skill training for technical experts (see above), a China CDM Business Guide for potential project developers and owners, drafted with their needs and capacities in mind, could help them identify and pursue CDM project opportunities. The CDM is quite complex, and many private sector decisionmakers are overwhelmed. While large companies generally have the resources and can build the skills to devote to project development, smaller companies and institutions might not. Such a guide should provide comprehensive, yet concise information on how to identify, analyze, and develop projects; manage risks; obtain project financing; seek domestic and international project approvals; and implement and monitor CDM projects. It would also lower transaction costs for potential CDM investors/CER purchasers. For this task, China can build on the most relevant material from among similar guides that have already been developed by other CDM host countries, some of which would require only minor modifications to be relevant and appropriate in the Chinese context.[9]

Longer-term Considerations

Consolidate results / enhance synergies across CDM initiatives

As summarized in the previous section, many CDM-related activities are currently ongoing in China, ranging from capacity building, to policy analysis and project development. A great, largely untapped synergy potential thus exists among the various activities that could be further developed, for example, through sharing and disseminating the know-how gained and lessons learned. Studies of CDM potential, such as the present one—which have each tended to focus on a different sector, region, or project type—should be consolidated to ensure consistency of results and to obtain an overall picture of Chinese CDM potential. Appropriate local CDM networks, knowledge management systems, and know-how transfer platforms could foster the desired consolidation and synergies among diverse CDM stakeholders, and would also provide a much stronger basis for CDM project development.

The numerous CDM activities in China involve many institutions, individual experts, foreign donors, and, increasingly, private enterprises. A professional knowledge management system and an outcome-oriented (performance-based) system to manage CDM-related capacity building initiatives could ensure optimal use of scarce resources.

Undertake follow-up analysis on key issues

As is often the case, the research conducted under the China CDM study has raised many additional issues that require further study. Although they may have a long lead time (data requirements, study duration), some of them are quite urgent, as they are linked to CDM implementation issues, and should be initiated as soon as possible. The issues identified over the course of the China CDM study range from work on outstanding domestic and international CDM policy issues to questions of the practical implementation of CDM projects in China, but this list is only indicative:

Policy issues

- Advantages and disadvantages and possible modalities for CDM co-financing of government-subsidized advanced technology and renewable energy demonstration projects.
- International and Chinese CER taxation policy.
- Development and testing of multi-criteria decision-analysis systems to ensure transparent, consistent, and efficient project approval procedures that ensure the consistency of CDM projects with China's sustainable development priorities. Such systems have already been tested by other host countries and could offer a starting point.
- Sustainable development implications of applying the CDM to projects to reduce the emission of greenhouse gases with high global warming potential, such as HFC-23 and N_2O.

Chinese CDM potentials and priorities

- Improve the robustness of (regional and countrywide) marginal abatement cost curves for China. Evaluate results considering up to date international MAC information.
- A combination of capacity building and analysis to work with government officials to establish technology priorities, building on previous cooperation in specific sectors, such as electricity generation, steel, and chemicals. This could lead to CDM handbooks and targeted capacity building for priority sectors and project types.
- Development and application of tools to qualitatively and/or quantitatively evaluate the local sustainable development co-benefits of potential/actual CDM projects.

CDM transaction costs and incentives for enterprises

- Explore opportunities to reduce transaction costs—for example, by developing regional, grid-level baselines for power projects, or baseline methodologies for the most promising large power project types, taking advantage of international donor support.
- Investigate the potential contribution of CDM to project finance under two basic models: (1) up-front investment by CER buyers, combined with Power Purchase Agreements (PPA) on GHG emission reduction credits; and (2) using CDM CERs PPA as a financial guarantee to apply for soft loans from domestic banks.
- Evaluate approaches to effectively bundle smaller-scale climate mitigation projects (energy efficiency, energy-to-waste, and renewable energy projects in power generation; small-scale industry; rural and urban transport; and commercial sectors), for which transaction costs would otherwise be prohibitive to commercial investors.
- Investigate models and develop Chinese strategies for CDM benefit and risk sharing among project partners, considering appropriate price formation modalities, given the volatility in CER prices over time.

Endnotes/References

1. With the exception of GDP effects and carbon dioxide emission reductions, the study did not quantify these important co-benefits at the macro level. Some of the case studies, however, did provide quantitative estimates on reduction potentials in air pollutants such as SO_2, NOx, and dust, and one involved methane emission reductions as the main source of CERs.
2. These emission reductions will also contribute to better health conditions.
3. In the light of the bottom-up analysis, the upper bound of the projected CDM potential of 117 $MtCO_2$ is difficult to achieve, mainly due to the short time span available up to 2010 (time lag associated with technology diffusion) and the constraints in the development of a sufficiently large pipeline of CDM projects.

4. In practice, sharing the producer surplus (which results when the equilibrium price exceeds the incremental abatement cost) between the host country project owner and the CDM investor/CER buyer is a matter of negotiation and will affect the profit achieved by the former and the cost savings to the latter.
5. It is anticipated that the specific abatement costs for supercritical plants will drop in the future, as increased local manufacturing of power plant components reduces capital investment cost.
6. The CDM Executive Board will be considering recommendations from its Methodology Panel (in which China is represented) on avoiding perverse incentives associated with CDM baseline methodologies that would disadvantage or create disincentives for countries that implement domestic policies intended to reduce local environmental externalities in ways that also result in lower GHG emissions. Many of China's energy technology promotion efforts fit this definition and such demonstration projects may represent a viable channel to facilitate rapid CDM project identification and investment in China's energy supply sector, so China should actively contribute to the work of the Methodology Panel on this point.
7. This was already initiated at a side event at the COP9 in Milan in December 2003.
8. Such an institutional framework consists of three main entities: (1) the National Coordination Committee for Climate Change; (2) a National CDM Project Board; and (3) a designated national authority. Similarly, the general requirements for CDM project approval, as well as the approval procedure, have been outlined in detail, but not yet approved.
9. See, for example: Spalding-Fecher, Randall, 2002: *The CDM Guidebook—A Resource for Clean Development Mechanism Project Developers in Southern Africa.* Cape Town: Energy and Development Research Centre, University of Cape Town.

Epilogue
CDM Conference Report

INTRODUCTION

To present the results of this study, the Chinese Government—in cooperation with the World Bank, the GTZ, and supported by the Governments of Germany and Switzerland—hosted an international conference in Beijing on July 1 and 2, 2004 (see Annexes IX and X in the CD-ROM attachment). The meeting marked the conclusion of the study and provided an opportunity for Chinese and international experts to discuss:

- The main results and recommendations of the China CDM Study
- The current development of carbon markets and the Clean Development Mechanism
- China's new policies and institutional arrangements for CDM application
- Proactive strategies to remove CDM implementation barriers
- Future plans for both formal and information cooperation.

July 1st proved to be a significant day for the CDM in China. In addition to the China CDM conference, which was attended by about 250 Chinese and international experts, the Chinese National Climate Change Coordination Committee (NCCCC) held its annual meeting, and new "Interim Measures for the Management of CDM Project Activities" in China went into effect (see Annex 4). The interim measures provided for the official designation of the National Development and Reform Commission (NDRC) as the Chinese National Authority for the CDM, thus paving the way for host country approval of Chinese CDM projects. Conference participants were able to interact with the newly appointed Chinese DNA contact person, Mr. Gao Guangsheng (Director General, NCCCC, NDRC), as well as other NCCCC members.

CONTEXT FOR CDM IN CHINA

Anthropogenic climate change is intimately linked to sustainable development, and participants at the conference—ranging from government authorities to development banks, academic researchers, and private sector representatives from a range of sectors—expressed the view that climate change is an issue that will be with us for a long time to come.

"The lifetime of the CDM will be longer than that of the Kyoto Protocol, which is only a first step (until to 2012); climate change mitigation is a long-term task."

Gao Guangsheng, NCCCC, NDRC

Whether or not the Kyoto Protocol will be the international framework of choice in the period after the first commitment period ends in 2012 is less certain, but Chinese authorities and other participants nonetheless expressed their firm belief that the Clean Development Mechanism would play an important role in future global efforts to mitigate climate change. China and other developing countries thus intend to seek to integrate the CDM into future agreements beyond 2012 and to promote and expand carbon markets.

Policy remarks by the chairman and members of the China NCCCC, as well as a panel dedicated to a discussion of "Challenges and Opportunities for China CDM," demonstrated that China regards the CDM as an important instrument to enable developing countries to fulfill their "common, but differentiated responsibility" under the UNFCCC to reduce their greenhouse gas emissions, while at the same time addressing local sustainable development challenges.

"The CDM will be an essential tool for equitable climate change mitigation . . . China has taken a major decision to enter into CDM by issuing rules of the game."

Maria Teresa Serra, The World Bank

To realize the promise of the CDM, however, carbon markets must expand significantly, which is only possible if the United States, Australia, and others eventually participate. Chinese authorities expressed their gratitude to the member states of the European Union for their leadership in the global effort to mitigate global climate change. Without ratification of the Kyoto Protocol by either the United States or the Russian Federation, the value of Certified Emission Reductions (CERs) is largely dependent on demand from the EU Emission Trading Scheme (EU-ETS), which is therefore crucial to carbon market development.

The conviction that the CDM is a "win-win" proposition and that carbon markets will expand in the future, coupled with the EU plan to implement a Community-wide emission trading system on January 1, 2005, provided sufficient foundation for the Government of China to adopt a proactive policy toward the CDM that is consistent with recommendations in the China CDM Study.

"We are at a critical juncture in China with respect to both reform efforts and sustainable development challenges. The CDM can help overcome some of the severe bottle-necks, such as electricity shortages, that may otherwise prevent us from attaining our goal of an all around well off society by 2020. Thus China can take advantage of the CDM to facilitate the necessary scientific approach to development."

Gao Feng, Department of Foreign Affairs

In general, participants expressed confidence and optimism about future CDM development, noting the greater than anticipated conference participation, the active interest shown by both Chinese and foreign experts, the broad representation of stakeholder groups, the tremendous learning that had gone on in a very short time, the fact that the Chinese Government had put in place the necessary institutional prerequisites for CDM implementation, and the significant opportunities that the CDM offers to make progress on climate change. The China CDM Study was regarded by Chinese authorities to be of great significance to China, and the conference marked a turning point from study to implementation.

INTERIM MEASURES AND IMPLICATIONS FOR CDM IN CHINA

Statements made by officials confirmed that the Chinese Government has fully embraced a "proactive and sustainable" approach to the CDM and is providing significant support. The referred interim management measures represent a crucial first step. According to the Chinese authorities, the rationale for adopting interim rules, as opposed to more permanent arrangements, is to retain flexibility to fine-tune rules, based on experience gained through the implementation of CDM projects, before they are finalized in a planned CDM Management Decree to be approved by the State Council. This approach balances the desire to act rapidly to implement CDM projects with prudence and a "learning-by-doing" approach to ensure sustainable development benefits.

"CDM development in China has moved from theory to project level implementation."

Wang Zhongjing, International Department, Ministry of Finance

Sun Cuihua (Division Director, NCCCC, NDRC), provided an overview of the Interim Measures for the Management of CDM Project Activities in China, including general rules, admission requirements, institutional arrangements, project approval procedures, and several other miscellaneous items (see annex 4). These provisions are largely consistent with the preliminary information published in the China CDM Study, with two notable additions, which raised particular concerns among foreign participants and potential investors and intermediaries, namely:

- The requirement that the project developer* shall be a wholly China-owned or China-controlled enterprise
- The plan to regulate the sharing of benefits between the project developer* and the Chinese Government (with the benefits to be owned solely by the project developer prior to the determination).

The Chinese authorities believe that greater consideration of these important issues is needed and that final decisions should be based on practical experience.

"The intent [of the Interim Measures] is to reflect the spirit of the CDM, not to create barriers to CDM investment . . . The door is not closed for CDM hosting by 100% foreign owned enterprises, but the issue requires further consideration, and we welcome your views on these difficult issues."

Lu Xuedu, Division of Resources and Environment, Ministry of Science and Technology

The idea behind the concept of benefits sharing between enterprises and the state, for example, is that priority projects with high sustainable development benefits, such as renewable energy projects, will not be "taxed" at all, whereas projects with relatively low sustainable development benefits and low costs (such as HFC-23 decomposition at under $1 per ton of CO2e) would have to deliver some revenues to the state. Many participants viewed this provision as an economic instrument to allow China to channel CDM investment to priority CDM projects, thereby retaining responsibility for ensuring the sustainable development benefits of CDM projects that apply baseline methodologies that have already been approved by the CDM Executive Board. Participants noted that the key to the success of such an approach is transparency, consistency, and predictability, as well as the actions of other host countries.

OVERCOMING BARRIERS TO CDM IMPLEMENTATION IN CHINA

Participants benefited from a lively panel discussion dedicated to "Industrial Sector Views on Barriers to and Incentives for CDM," as well as the active participation of many representatives of private enterprises throughout the conference. The key barriers to CDM implementation are divided between those specific to the Chinese context and more universal barriers.

Among the serious universal barriers to active engagement of the private sector in the CDM, participants highlighted a lack of market demand—linked to continuing international and Annex I domestic regulatory uncertainty and a lack of political will for some major players to participate—as well as complex/uncertain rules, high transaction costs (in particular, with respect to small-scale projects), and a lack of up-front funds for project development.

"The potential for CER financing of projects that would otherwise have been left aside (e.g. renewables) needs to be seen against perceived market and regulatory risk."

Kai-Uwe B. Schmidt, Cooperative Mechanisms, UNFCCC Secretariat

Many Chinese players (and the China CDM Study) pointed out that current "market prices" (< \$5/t CO2) are simply too low to cover the full incremental costs of implementing many types of CDM projects, and that the CDM therefore can only facilitate additional climate mitigation in combination with other incentives. Despite the significant mitigation cost savings that the CDM can represent for some investors, it is unlikely that the demand side will be willing to share these savings with host countries, given the availability of EU emission allowances at 7–8/ton CO2e.

As a result, Chinese authorities have been reluctant to encourage industry to enter into the CDM. Awareness of climate change and the CDM are concentrated in a small pool of experts, centered geographically on Beijing, and CDM has yet to be demonstrated in practice in China. Recent efforts to overcome information barriers included the launch of a China CDM web site (www.cdm.ccchina.gov.cn), the establishment of CDM centers at the provincial level (such as the Ningxia CDM Service Center), and the development of new CDM training programs in cooperation with international partners.

Enterprises in China also mentioned the "paradox of additionality" (i.e., the fact that at low CER prices, projects that are clearly additional are not viable, as the CDM does little to raise IRR to levels required for host government and financial institution approval) and the need to clarify how CDM approval procedures can be integrated into existing domestic approval processes. More needs to be done by governmental authorities to clarify the role that CDM can play in implementing priority sustainable development projects; for example, the role of small-scale CDM in alleviating poverty in rural China, the CDM contribution to renewable energy projects, the use of advanced coal-fired power plant technologies, or energy efficiency/ energy auditing efforts.

Although the China CDM study only investigated case studies in the power sector (see below), private sector participants expressed interest in exploring CDM potential in other sectors, such as industry (e.g., chemicals, cement), commercial and residential buildings, and sinks.

THE POWER SECTOR

Despite the critical importance of the power sector for China's future development and its dominant impact on Chinese greenhouse gas emissions (approximately 40 percent), the sector was prominent in its absence. This reflects reservations about the CDM due to a range of factors:

- Lack of awareness of the CDM at the strategic level. Although some individual power plant operators have shown an interest in exploring CDM opportunities, strategic decisions at the corporate level are needed.
- Uncertainty and skepticism about the financial benefits of CDM, coupled with up-front CDM project development costs.
- Recognition that the CDM—under current market conditions—can only add a small percentage to a major power project's IRR.
- Lack of government guidance on the CDM project approval process in relation to existing requirements for Chinese power plant approval (which may run counter to additionality, as projects must be financially viable and employ proven technology to receive NDRC approval).

"Recent and projected electricity shortfalls are being met by mass production of coal-fired power stations manufactured in China, and no one is looking at CDM opportunities . . . There is an urgent need for strategic awareness raising and institutional capacity building."

Paul Suding, GTZ (German Technical Cooperation), Beijing

Due to pressures resulting from increasing power shortages, which threaten China's economic development, and the frantic pace of power plant construction, the CDM has not been considered a priority, but participants pointed to the strategic significance of this sector and the need to give immediate consideration to means of leveraging the CDM to contribute to a more sustainable energy supply. Engaging the power sector is also a prerequisite for developing standardized, regional baselines, which would help lower transaction costs. Both aspects require government leadership.

FUTURE ACTIVITIES IN COOPERATION WITH FOREIGN PARTNERS

Another panel—"Efforts to Promote CDM by Donor Organizations and Buyers"—demonstrated that there was readiness on all sides to continue cooperation. Donors (e.g., UNDP CDM Capacity Building Program, ADB CDM Facility, METI Japan, GTZ), buyers (e.g., German KfW Carbon Fund, Italian Carbon Fund, World Bank Carbon Finance funds), and intermediaries expressed interest/willingness to purchase CERs in China, now that rules of the game have been published.

"The objective of China's future CDM actions is to build gradually an excellent cooperation environment, including clear policies, transparent and efficient management service and capable technological consultancy for CDM project cooperation and implementation with foreign partners."

Lu Xuedu, Division of Resources and Environment, Ministry of Science and Technology

ANNEX

A1

Decisions by the COP and the CDM EB after COP 7 up to the 12th CDM EB Meeting Relevant to Methodological Issues

Meeting	Issues	Decisions
EB 3rd	**Further clarification on definitions of eligible small-scale CDM project activities (Annex 2)**	1. Renewable energy (15MW): an indicative list of energy sources/eligible project activities; output defined as installed/rated capacity as indicated by the manufacturer; MW as MW(e) (not MW(p) or MW(th)); 2. Energy efficiency improvement project activities: an indicative list of eligible project activities/sectors; 3. 15 GWh=54TJ 4. Other types: shall not exceed total direct emissions of 15kt of CO_2 equivalent annually and must reduce GHG emissions. 5. Three types of project activities are mutually exclusive; for a project activity with more than one component to benefit from SMP, each component shall meet the threshold criterion of each applicable type;

Background:

(i) Renewable energy project activities with a maximum output capacity equivalent of up to 15 megawatts (or an appropriate equivalent);
(ii) Energy efficiency improvement project activities that reduce energy consumption, on the supply and/or demand side, by up to the equivalent of 15 gigawatt/hours per year;
(iii) Other project activities that both reduce anthropogenic emissions by sources and directly emit less than 15 kilotons of carbon dioxide equivalent annually;

Meeting	Issues	Decisions
EB 5th	**Baseline and additionality (Annex 3)**	1. Paragraph 43 of the CDM modalities and procedures stipulate that a CDM project activity is additional if its emissions are below those of its baseline. The definition of a baseline is contained in paragraph 44 of the CDM modalities and procedures. The Executive Board agreed that no further work is required regarding this issue.

Background:

43. A CDM project activity is additional if anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the registered CDM project activity.

(*continued*)

Meeting	Issues	Decisions

Background:

44. The baseline for a CDM project activity is the scenario that reasonably represents the anthropogenic emissions by sources of greenhouse gases that would occur in the absence of the proposed project activity. A baseline shall cover emissions from all gases, sectors, and source categories listed in Annex A within the project boundary. A baseline shall be deemed to reasonably represent the anthropogenic emissions by sources that would occur in the absence of the proposed project activity if it is derived using a baseline methodology referred to in paragraphs 37 and 38 above.

Meeting	Issues	Decisions
EB 5th	**Baseline approaches / Methodology**	A **methodology is an application** of the approaches, defined in paragraph 48 of the CDM modalities and procedures, **to an individual project** (reflecting aspects such as sector and region). It further agreed that no methodology should be excluded a priori so that project participants have the opportunity to propose any methodology. In considering paragraph 48, the Executive Board agreed that, in the cases below, the following applies: (a) Case of a new methodology: In developing a baseline methodology, the first step is to identify the most appropriate approach for the project activity and then an applicable methodology. (b) Case of an approved methodology: In opting for an approved methodology, project participants implicitly choose an approach. The board agreed that the three approaches identified in paragraph 48 (a) to (c) are the only ones applicable to CDM project activities. Establishing a baseline in a "transparent and conservative manner" means that assumptions are explicitly explained and choices are substantiated. In case of uncertainty regarding values of variables and parameters, values that generate a lower baseline projection shall be used. The board agreed that no further work is required.
	Simplified Modalities & Procedures	If the maximum reference value of a small-scale CDM project activity is exceeded on an annual average basis during any verified period, CERs should be issued only up to the maximum value.
COP8	**Simplified Modalities & Procedures**	Modalities and procedures are simplified as follows: (a) Project activities may be bundled or portfolio bundled at the following stages in the project cycle: the project design document, validation, registration, monitoring, verification, and certification. The size of the total bundle should not exceed the limits stipulated in paragraph 6 (c) of decision 17/CP.7. (b) The requirements for the project design document are reduced. (c) Baselines methodologies by project category are simplified to reduce the cost of developing a project baseline. (d) Monitoring plans are simplified, including simplified monitoring requirements, to reduce monitoring costs. (e) The same operational entity may undertake validation, and verification and certification.

(*continued*)

Meeting	Issues	Decisions
A simplified baseline and monitoring methodology listed in Appendix B (of the simplified M&P) may be used for a small-scale CDM project activity if the project participants are able to demonstrate to a designated operational entity that the project activity would otherwise not be implemented due to the existence of one or more of the barriers listed in attachment A of Appendix B. *((a) Investment barrier: a financially more viable alternative to the project activity would have led to higher emissions; (b) Technological barrier: a less technologically advanced alternative to the project activity involves lower risks due to the performance uncertainty or low market share of the new technology adopted for the project activity and so would have led to higher emissions; (c) Barrier due to prevailing practice: prevailing practice or existing regulatory or policy requirements would have led to implementation of a technology with higher emissions; (d) Other barriers: without the project activity, for another specific reason identified by the project participant, such as institutional barriers or limited information, managerial resources, organizational capacity, financial resources, or capacity to absorb new technologies, emissions would have been higher.)* Where specified in Appendix B for a project category, quantitative evidence that the project activity would otherwise not be implemented may be provided instead of a demonstration based on the barriers listed in attachment A to appendix B.		
COP8 (continued)	**Simplified Modalities & Procedures (continued)**	I. TYPE I - RENEWABLE ENERGY PROJECTS I. A. Electricity generation by the user I. B. Mechanical energy for the user I. C. Thermal energy for the user I. D. Renewable electricity generation for a grid II. TYPE II - ENERGY EFFICIENCY IMPROVEMENT PROJECTS II. A. Supply side energy efficiency improvements – transmission and distribution II. B. Supply side energy efficiency improvements – generation II. C. Demand-side energy efficiency programs for specific technologies II. D. Energy efficiency and fuel switching measures for industrial facilities II. E. Energy efficiency and fuel switching measures for buildings III. TYPE III - OTHER PROJECT ACTIVITIES III. A. Agriculture III. B. Switching fossil fuels III. C. Emission reductions by low-greenhouse gas emitting vehicles III. D. Methane recovery and avoidance
EB 8th	**Information relevant to baseline methodology to be included in the PDD**	When proposing a new baseline methodology, the following information elements shall be covered and reported through annex 3 of the CDM-PDD: (a) Basis for determining the baseline scenario: • Explanation of how the baseline is chosen, taking into account paragraph 45 (e) • Underlying rationale for algorithm/formulae (e.g. marginal vs. average, etc.) • Explanation of how, through the methodology, it is demonstrated that a project activity is additional and therefore not the baseline scenario (section B4 of the CDM-PDD) (b) Formulae/algorithms shall specify: • Type of variables used (e.g. fuel(s) used, fuel consumption rates, etc.) • Spatial level of data (local, regional, national, etc.)

(*continued*)

Meeting	Issues	Decisions
EB 8th (continued)	**Information relevant to baseline methodology to be included in the PDD (continued)**	• Project boundary (gases and sources included, physical delineation) • Vintage of data (relative to project crediting period) (c) Data sources and assumptions: • Where the data are obtained (official statistics, expert judgment, proprietary data, IPCC, commercial and scientific literature, etc.) • Assumptions used
	Additional guidance on the "average emissions" approach	1. Project participants wishing to select the "average emissions" approach shall elaborate in their submission of a proposed new baseline methodology, inter alia, on: (a) How they determine "similar social, economic, environmental and technological circumstances." (b) How they assess the "performance among the top 20 per cent of their category" defined as greenhouse gas emissions performance (in terms of CO_2equ emissions per unit of output). 5. Project participants wishing to use this approach and a related approved methodology shall assess the applicability and use the most conservative of the following options: (a) The output-weighted average emissions of the top 20 per cent of similar project activities undertaken in the previous five years in similar circumstances. (b) The output-weighted average emissions of similar project activities undertaken in the previous five years under similar circumstances that are also in the top 20 per cent of all current operating projects in their category (i.e. in similar circumstances as defined above).
	Proposed project activities applying more than one methodology	If a proposed CDM project activity comprises different "sub-activities" requiring different methodologies, project participants may forward the proposal using one CDM-PDD but shall complete the methodologies sections (sections A.4.2, A.4.3, A.4.4. and B to E of the CDM-PDD) for each "sub-activity."
	Circumstances and modalities for operationalizing paragraph 47 of the CDM modalities and procedures	7. Paragraph 47 stipulates that "the baseline shall be defined in a way that CERs cannot be earned for decreases in activity levels outside the project activity or due to force majeure." 8. An output- or product-linked definition of baseline values (i.e. CO_2equ. per unit of output) shall be applied, unless the project participants can demonstrate why this is not applicable and provide an appropriate alternative.
	Guidance regarding the treatment of "existing" and "newly built" facilities	If a proposed CDM project activity seeks to retrofit or otherwise modify an existing facility, the baseline may refer to the characteristics (i.e. emissions) of the existing facility only to the extent that the project activity does not increase the output or lifetime of the existing facility. For any increase of output or lifetime of the facility which is due to the project activity, a different baseline shall apply.
EB 9th	**Further clarification for project participants for drafting a proposal for a new methodology**	1. Decision tree: When drafting a proposed new baseline methodology, project participants shall follow the following steps: (a) Choose and justify why one of the approaches listed in paragraph 48 of CDM M&P is considered to be the most appropriate.

(*continued*)

Meeting	Issues	Decisions
EB 9th (continued)	**Further clarification for project participants for drafting a proposal for a new methodology (continued)**	(b) Elaborate a proposal for a new methodology, i.e. an application of the selected approach to a project activity, reflecting aspects such as sector, technology and region. The Board agreed that no methodology is to be excluded a priori so that project participants have the opportunity to propose any methodology which they consider appropriate. (c) Describe the proposed new methodology in Annexes 3 and 4 of the CDM-PDD taking into account guidance given by the Board at its fifth and eighth meeting as well as the information provided in the CDM PDD Glossary of Terms. (d) Demonstrate the applicability of the proposed methodology, and, implicitly, that of the approach, to a project activity by providing relevant information in a draft CDM-PDD. 2. In accordance with the Board's guidance at its eighth meeting, a proposed new methodology shall explain how a project activity using the methodology can demonstrate that it is additional. Project participants shall therefore describe how to develop the baseline scenario and "how the baseline methodology addresses...the determination of project additionality." In addition, the methodology shall provide elements to calculate the emissions of the baseline. The project participants shall ensure consistency between the elaboration of the baseline scenario and the procedure and formulae to calculate the emissions of the baseline. 3. Drafting quality: Proposals should be written in a concise and clear manner. Important procedures and concepts should be supported by equations and diagrams. Non-essential information should be avoided. The Annexes 3 and 4 to the CDM-PDD shall not contain information which is related to the application of the proposed new methodology to the project activity for illustrative purposes. Project participants shall refrain from providing glossaries or using key terminology not used in the COP documents and the CDM glossary (environmental/ investment additionality), and from rewriting the CDM-PDD instructions. 4. Provide complete Annexes 3 and 4: All algorithms, formulae, and step-by-step procedures for applying the methodology shall be included here. These Annexes shall provide stand-alone replicable methodologies, and avoid reference to any secondary documents if they wish to convey essential information, except where considered absolutely necessary (e.g. model documentation). 5. Avoid repetitions: Do not unnecessarily repeat in the main CDM-PDD Sections A-E, submitted as a demonstration of the application of the proposed new methodology, text and methodological explanations already provided in the Annexes. The CDM-PDD Sections A-E are meant to provide information on the application of the methodology(ies) to the project activity.

(*continued*)

Meeting	Issues	Decisions
EB9th (continued)	**Further clarification for project participants for drafting a proposal for a new methodology (continued)**	6. Data requirements and sources: Clearly specify data requirements and sources, as well as procedures to be followed if expected data are unavailable. For instance, the methodology could point to a preferred data source (e.g. national statistics for the past 5 years), and indicate a priority order for use of additional data (e.g. using longer time series) and/or fall back data sources to preferred sources (e.g. private, international statistics, etc.). Use International System Units (SI units). 7. Titles: Provide an unambiguous title for a proposed methodology. Avoid project-specific titles. The title, once approved, should allow project participants to get an indication of the applicability of an approved methodology.
	Clarification on baseline methodologies for electricity generation CDM projects	9. Electricity generation: Justification of exclusion of hydropower from operating margin in the **case of hydro-dominated grids:** If an electricity generation CDM project activity which uses an operating margin methodology is connected to a primarily hydropowered grid, project participants who want to exclude hydropower from the operating margin must justify this explicitly.
EB 10th	**Clarification on additionality**	1. As part of the basis for determining the baseline scenario, an explanation shall be made of how, through the use of the methodology, it can be demonstrated that a project activity is additional and therefore not the baseline scenario. 2. Examples of tools that may be used to demonstrate that a project activity is additional and therefore not the baseline scenario include, among others: (a) A flow-chart or series of questions that lead to a narrowing of potential baseline options; and/or (b) A qualitative or quantitative assessment of different potential options and an indication of why the non-project option is more likely; and/or (c) A qualitative or quantitative assessment of one or more barriers facing the proposed project activity (such as those laid out for small-scale CDM projects); and/or (d) An indication that the project type is not common practice (e.g. occurs in less than [<x%] of similar cases) in the proposed area of implementation, and not required by a Party's legislation/regulations.
	Clarifications for describing a proposed new methodology and justifying the selection of the most appropriate approach	3. Developers of a new baseline methodology shall select the approach from paragraph 48 of the CDM modalities and procedures that is most consistent with the context of applicable project types, and most consistent with the underlying algorithms and data sources used in the proposed baseline methodology, and justify the choice on this basis. 4. Proponents of methodologies have indicated some apparent overlap between approaches (a), (b), and (c) of paragraph 48 of the CDM modalities and procedures. Since paragraph 48 stipulates that only one approach should be chosen, developers are advised to select the one that most closely reflects the process

(*continued*)

Meeting	Issues	Decisions
EB 10th (continued)	**Clarifications for describing a proposed new methodology and justifying the selection of the most appropriate approach (continued)**	used for calculating baseline emissions or baseline emission rates. The tool used in order to demonstrate additionality (see paragraph 2 above) does not need to be linked to one of the three approaches of paragraph 48 of the CDM modalities and procedures.
	Clarifications on ex post calculation of baselines	6. "The ex post calculation of baseline emission rates may only be used if proper justification is provided. Notwithstanding, the baseline emission rates shall also be calculated ex-ante and reported in the draft CDM-PDD in order to satisfy the requirements for identification of the elements of a baseline methodology agreed by the Executive Board at its eighth meeting."
	Link between baseline and monitoring methodologies	7. A strong link between baseline and monitoring methodologies are to be provided. New baseline and monitoring methodologies shall be proposed and approved together. If project participants would like to use different combinations of approved baseline and monitoring methodologies, they shall submit a proposal for consideration of the Meth Panel and approval by the Board.
	Approval of baseline and monitoring methodologies	Baseline and monitoring methodologies contained in following projects have been approved: 1. Salvador da Bahia landfill gas project" HFC decomposition project in Ulsan
EB 11th	**Amendments to procedures for submission and consideration of a proposed new methodology**	(a) Within ***ten*** working days after the receipt of the preliminary recommendation of the Meth Panel by the designated operational entity (DOE), the project participants may submit, via the DOE, clarifications to the Meth Panel, through the secretariat, on technical issues concerning the proposed new methodology raised in the preliminary recommendation by the Meth Panel. ***Technical clarifications provided by the project participants shall include revisions in annexes 3 and 4 of the CDM-PDD in highlighted form.*** Clarifications provided by the project participants shall be made available to the Executive Board and to the public soon after they have been received by the secretariat; (b) If project participants do not provide any clarification related to the preliminary recommendation by the Meth Panel within the ***ten***-day period***,*** or if the preliminary recommendation by the Meth Panel is in favor of approving the proposed new methodology, it shall be considered as a final recommendation, forwarded to the Executive Board and made publicly available.
	Amendment to procedures for registration of a proposed CDM activity	A "request for registration" (as defined in paragraph 40 (f) of the CDM modalities and procedures) shall be made publicly available through the UNFCCC CDM web site for a period of eight (8) weeks. The secretariat shall announce a request for registration of a proposed CDM project activity on the UNFCCC CDM web site and in the CDM news facility. The announcement shall specify where the request for registration can be found, the name of the proposed CDM project activity and the first and last day of the eight-week period. The secretariat shall notify the DOE requesting a registration when the request for registration has been posted.

(*continued*)

Meeting	Issues	Decisions
EB 11th (continued)	**Amendment to procedures on public availability of the CDM project design document and for receiving comments as referred to in paragraphs 40 (b) and (c) of the CDM modalities and procedures**	Comments from the public will be kept publicly available until the designated operational entity (DOE) issues a request for registration or communicates to the secretariat that it does not intend to validate the project activity.
	Additional clarifications to the validation requirements to be checked by a designated operational entity	In issuing a validation opinion in the validation report regarding paragraph 37 (d) of the CDM modalities and procedures, the DOE shall include a statement of the likelihood of the project activity to achieve the anticipated emission reductions stated in the CDM-PDD. This statement will constitute the basis for the calculation of the registration fee.
	Approval of baseline and monitoring methodologies	Baseline and monitoring methodologies contained in following projects have been approved: 1. NovaGerar landfill Gas to Energy Project 2. Durban Landfill-gas-to-electricity project 3. Graneros Plant Fuel Switching Project 4. A.T. Biopower rice husk power project
COP9	**Modalities and procedures for afforestation and reforestation project activities under the Clean Development Mechanism in the first commitment period of the Kyoto Protocol**	As contained in FCCC/SBSTA/2003/L.27.
EB 12th	**Amendment to Appendix B of the simplified modalities and procedures for small-scale CDM project activities**	1. The reference to "solar water pumps" in paragraph 1 of section I.A is deleted and kept only under paragraph 9 of section I.B. 2. The following provision is added in paragraph 6 of section I.A: "A small-scale project proponent may, with adequate justification use a higher emissions factor from Table I.D.1." 3. The following provision shall replace paragraph 29 (a) (ii) in section I.D: "The "build margin" is the weighted average emissions (in kg CO2equ/kWh) of recent capacity additions to the system, which capacity additions are defined as the greater (in MWh) of most recent1 20per cent2 of existing plants or the 5 most recent plants." 4. The reference to the metering of energy use under monitoring in paragraph 69 in section II.E is deleted. 5. The title of section III.D is changed to "Methane Recovery." 6. The following new section is added after section III.D: "Methane Avoidance." The Board requested the Meth Panel to further develop recommendations on simplified methodologies for this new section.
	Approval of baseline and monitoring methodologies	Baseline and monitoring methodologies contained in the following projects have been approved: 1. Methodologies proposed for Vale do Rosario Bagasse Cogeneration; 2. CERUPT Methodology for Landfill Gas Recovery; 3. Methodologies proposed for El Gallo Hydro-electric Project

Detailed Description of the CDM Institutions

PROJECT PROPONENTS

The project proponents—any private or public entities in the investing and host countries or even third parties such as international organizations who are entitled to engage in a CDM project—play the most important role in the CDM process. For example, proponents:

- Design, invest in, and may operate the CDM project and receive the CERs as investors.
- May develop or might entrust other institutions to formulate the Project Design Document, including a baseline study, monitoring procedures, and an environmental impact assessment.
- May cooperate with nongovernmental organizations (in the investing and/or the host country) and receive comments by other stakeholders.
- Have to implement the monitoring plan.

COP/MOP

The Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (COP/MOP) provides guidance to the CDM. More specifically, it provides guidance to the Executive Board by taking decisions on (a) rules of procedure of the Board; (b) designation of operational entities accredited by the Board; and (c) other recommendations made by the Board.

The COP/MOP also has other responsibilities, such as reviewing annual reports of the Board; reviewing the regional and subregional distribution of designated operational entities and promoting accreditation of such entities from developing country Parties; reviewing the regional and subregional distribution of CDM project activities and take appropriate decisions; and assisting in arranging funding of CDM project activities.

At COP8 and COP9, the COP adopted guidance to the Executive Board on several major issues, as contained in relevant decisions (UNFCCC, 2002(a); UNFCCC, 2003).

CDM EXECUTIVE BOARD

Article 12 of the Kyoto Protocol provides for the establishment of a CDM Executive Board: "The Clean Development Mechanism shall be subject to the authority and guidance of the Conference of the Parties serving as the meeting of the Parties to this Protocol and be supervised by an executive board of the Clean Development Mechanism."

In Bonn, it was agreed (UNFCCC, 2001(a)) that the Board shall comprise ten members from Parties to the Kyoto 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. In Marrakech, it was decided further that an alternate for each member of the executive board should be elected.

In order to facilitate a prompt start of the CDM, members of the Board as well as their alternates were elected, from Parties to the Convention, by the seventh session of the Conference of the Parties. To prevent members whose countries have not ratified or acceded to the Kyoto Protocol from serving on the executive board, it was decided that upon the entry into force of the Kyoto Protocol, any such member shall be replaced.

In COP7, delegates from South Africa, Iran, the Russian Federation, Brazil, France, Antigua and Barbuda, Costa Rica, Morocco, Japan, and Denmark were elected members of the CDM Executive Board. Delegates from Senegal, Malaysia, Georgia, Chile, Switzerland, Samoa, Saudi Arabia, China, Canada, and Norway were elected alternates of members of the CDM executive board. Five members as well as five alternates will server a term of 3 years; the others will serve a term of 2 years.

According to the Marrakech Accords, the Executive Board will supervise the CDM, under the authority and guidance of the COP/MOP. In this context, the board assumes a series of important responsibilities, such as making recommendations to the COP/MOP on further modalities and procedures for the CDM; approving new methodologies related to baselines, monitoring plans and project boundaries; reviewing provisions with regard to simplified modalities, procedures, and the definitions of small-scale project activities; reviewing the accreditation standards of operational entities and being responsible for the accreditation of operational entities; and developing, maintaining, and making publicly available a repository of approved rules, procedures, methodologies and standards.

According to the rules of procedures of the executive broad, a quorum of the board requires at least two thirds of the members, representing a majority of members from Annex I Parties and a majority of members from non-Annex I Parties. Decisions by the board shall be taken by consensus whenever possible, and as a last resort by a three-fourths majority of the members present and voting at the meeting.

By the end of July 2003, the Board had convened 10 meetings, and numerous methodology-relevant decisions had been adopted. At its third meeting, the Board established the Small-scale CDM Project Activities Panel (SSC Panel) to assist it in developing simplified modalities and procedures for small-scale CDM project activities, as well as the Meth Panel to assist it in relevant methodological work. At its fourth meeting, the Executive Board established the CDM Accreditation Panel to assist it in the development of procedures of accrediting operational entities.

A summary of decisions by the Board that are relevant to methodological issues up to its tenth meeting is provided in Annex 1. The Executive Board decisions are regularly updated on www.unfccc.int/cdm.

Operational Entity

An operational entity is a legal entity that shall be accredited by the executive board, designated by the COP/MOP and selected by CDM project participants to perform such functions as validation, verification, and/or certification. Functions of the operational entity are closely related to the quality of CDM project activities, the amount of credits issued to the project participants, and thus the environmental integrity of the Kyoto Protocol. Therefore, a legal entity has to meet a series of requirements before it can be accredited by the Executive Board and designated by the COP/MOP to perform the functions of an operational entity.

In accordance with the agreed accreditation standards for operational entities, some of the most important requirements for an operational entity are (a) necessary technical, environmental, and methodological expertise and competence to perform validation, verification, and certification functions; (b) financial stability, insurance coverage, and resources required for its activities; (c) sufficient arrangements to cover legal and financial liabilities arising from its activities; (d) documented internal procedures; (e) a management structure to ensure the implementation of the entity's functions; (f) work in a credible, independent, nondiscriminatory, and transparent manner; and (g) adequate arrangements to safeguard confidentiality of the information obtained from CDM project participants.

In performing its functions, an operational entity also faces some risks. If significant deficiencies are identified in the validation, verification, or certification report completed by one operational entity and a review reveals that excess CERs were issued, the operational entity shall acquire and transfer an amount of reduced tons of carbon dioxide equivalent equal to the excess CERs issued to a cancellation account. Furthermore, any cost related to the review shall be borne by the operational entity.

The executive board will confirm whether to reaccredit each operational entity every three years, on the basis of the results of review and spot-checking, and may recommend to the COP/MOP to suspend or withdraw the designation of a designated operational entity if it has found that the entity no longer meets the accreditation standards or other related provisions.

Parties

Parties involved in CDM projects also play important roles. An involved Annex I Party needs to issue a written certificate of voluntary participation in the project activity; an involved host Party needs to issue a written certificate of voluntary participation in the project activity, and also confirm that the project activity could promote sustainable development of the host country.

To utilize Kyoto mechanisms, a Party must meet some requirements. For non-Annex I Parties, the requirements are simple: it shall designate a national authority for the CDM, and it shall be a Party to the Kyoto Protocol. For Annex I Parties, the requirements are comparatively complex. Besides the two requirements for non-Annex I Parties, an Annex I Party has to comply with the following requirements if it is to use CERs to contribute to compliance with part of its commitments:

- Its assigned amount has been calculated and recorded
- It has in place a national system for the estimation of anthropogenic emissions by sources and anthropogenic removals by sinks of all greenhouse gases not controlled by the Montreal Protocol
- It has in place a national registry
- It has submitted annually the most recent required inventory
- It has submitted supplementary information on assigned amounts.

Whether or not an Annex I Party is eligible to participate in CDM is to be decided by the enforcement branch of the compliance committee, in accordance with certain procedures and mechanisms approved by the COP/MOP.

Supporting Institutions

To effectively perform its functions, the Board needs assistance from supporting institutions. The secretariat of the Convention provides administrative and daily assistance to the Board, such as arranging meetings; receiving relevant applications on behalf of the Board; providing relevant technical assistance; and presiding over the Board meeting where necessary.

Other Stakeholders

The Marrakech Accords provide for the possibility that other stakeholders could actively participate in the process of CDM project development and implementation. They could provide comments on the proposed project activity. The project proponents are also required to invite com- ments by local stakeholders, provide a summary of the comments received, and provide a report to the designated operational entity on how they accounted for any comments received.

Detailed Description of the CDM Project Cycle

Preparation of a Project Design Document

The results and methodologies used in the quantification of greenhouse gas benefits will need to be presented in a Project Design Document. The main contents of the PDD are:

1. Description of the CDM project
2. Approved or new methodologies on determining the baseline
3. Crediting period
4. Additionality
5. Environmental assessment
6. Stakeholder comments
7. Monitoring plan

Annex 1 notes six reports of the projects chosen as case studies. They are structured according to the requirements of the project design documents. The scope of the reports, however, are more detailed and so far go beyond the PDD requirements.

Validation

To be a CDM project, the first evaluation process a proposed project activity has to go through is validation. This is a process of independent evaluation of a project activity by a designated operational entity, contracted by the project participants, against the requirements of the CDM, on the basis of the project design document.

During the process of validation, the designated operational entity will review the project design document and any supporting documentation to decide whether certain requirements have been met, including participation requirements for the involved Parties have been met; comments by local stakeholders have been invited, summarized, and properly taken into account; documentation on the analysis of the environmental impacts of the project activity has been submitted; the project activity will result in an additional reduction in anthropogenic emissions of greenhouse gases; and documentation that proper baseline and monitoring methodologies have been used.

Based on the results of the review and comments received from other sources, the designated operational entity shall make a decision on whether the project activity should be validated and notify the project participants of its determination. And if it determines the proposed project activity it valid, it shall submit to the Executive Board a request for registration.

Registration

Registration is the formal acceptance by the Executive Board of a validated project as a CDM project activity and is the prerequisite for the verification, certification, and issuance of CERs.

The proposed CDM project activity will be considered as being registered eight weeks after the date of receipt by the Executive Board of the request for registration, unless a Party involved in the project activity or at least three members of the Executive Board request a review. The review by the Executive Board will be restricted to issues associated with the validation requirements and be finalized no later than the second meeting following the request for review.

Even if a proposed project activity is not accepted, it can be reconsidered for validation and subsequent registration thereafter if appropriate revisions have been made.

Monitoring

After being registered, a CDM project is now eligible to generate emission reductions. To determine the emission reductions, it is necessary to monitor the operating process of the project, i.e. collect and archive all the necessary data and information to determine the emission reductions. Data quality of the monitoring process is crucial to ensure the accurate calculation of emission reductions of a registered CDM project. Therefore, the project participants shall include in the project design document the monitoring plan, which needs the validation of the designated operational entity before it can be implemented in the project.

Data and information to be collected and archived in the monitoring process include data necessary for estimating anthropogenic emissions occurring within the project boundary; data necessary for determining the baseline; and data on leakage.

The project participants shall implement the approved monitoring plan. Any revision to the previously approved monitoring plan shall be justified by the project participants and sent to the designated operational entity for validation.

Verification and Certification

Based on the monitoring data, which need to be further verified, the emission reductions of a CDM project activity can be calculated.

Verification is the periodic independent review and ex post determination by the designated operational entity of the emission reductions of a registered CDM project activity during the verification period.

To perform the function of verification, the designated operational entity may review performance records, interview with project participants and local stakeholders, test the accuracy of monitoring equipment, and review monitoring results. If it concludes that the monitoring methodologies have been applied correctly and their documentation is complete and transparent, it will provide a verification report to the project participants, the Parties involved, and the Executive Board.

Certification is the written assurance by the designated operational entity that, during a specified time period, a project activity achieved the emission reductions as verified. Based on its verification report, the designated operational entity shall complete a written certification report and inform relevant stakeholders of its decision.

Issuance of CERs

The subsequent step to the certification is the issuance of Certified Emission Reductions (CERs). Actually, the certification report delivered to the Executive Board constitutes a request for issuance of CERs equal to the verified amount of emission reductions.

If a Party involved in the project activity or at least three members of the Executive Board request a review of the proposed issuance of CERs, within 15 days from the date the Board receives the request a review will be conducted by the Board. Otherwise, the request shall be considered as approved.

In the case of request for a review, the Board shall decide at the next meeting of the receipt of request whether to perform a review. If a review is to be conducted, the contents shall be limited to issues of fraud, malfeasance, or incompetence of the designated operational entities and shall be completed within 30 days from the date of decision to perform a review.

When the issuance is decided by the Board, certain quantity of CERs corresponding to the share of proceeds will be forwarded to the appropriate accounts in the CDM registry and the remaining CERs will be forwarded to the registry accounts of Parties and project participants involved, in accordance with their request.

A4

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

I. GENERAL PROVISIONS

Article 1 These interim measures are formulated in accordance with the provisions of the United Nations Framework Convention on Climate Change (hereinafter referred to as "the Convention") and its Kyoto Protocol (hereinafter referred to as "the Protocol") ratified and approved by China respectively, 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 projects.

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 A 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 the 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. To report to the Committee on the overall progress of CDM project activities, issues emerged, and further recommendations; and
3. To make recommendations on the amendments to this CDM interim 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 a written approval letter 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 A Project owner, which refers 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 under the supervision of NDRC; develop and implement a project monitoring plan to ensure that the emission reductions are real, measurable, long-term, and additional;
4. Contract designated operational entities to validate the proposed project activity and to verify emission reductions of the project activity under the guidance of NDRC; provide necessary information and monitoring records, and submit the information to NDRC for record purposes; and protect state and business confidential information in accordance with relevant laws and regulations;
5. Report to NDRC on CERs issued;
6. Assist 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. The 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 letter accordingly;
5. 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 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 Existing other 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. Project owner is responsible for presenting NDRC and designated operational entity project implementation and monitoring reports;
2. NDRC supervises the implementation of the project to ensure the quality of the activity;
3. 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 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 Revenue from the transfer of CERs shall be owned jointly by the Government of China and the project owner, with allocation ratio of the revenue to be decided by the Government of China. Before the decision, the revenue belongs to the project owner.

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

Article 26 These interim measures take effect as of June 30, 2004.

Source: Office of National Coordination Committee on Climate Change

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User Guide to the CD-ROM

The attached CD-ROM contains all materials from the China CDM Study. It includes a PDF version of the full report, material integral to the report that was not included in the printed version, as well as selected reference materials. This page provides an overview of its contents.

CLEAN DEVELOPMENT MECHANISM IN CHINA – TAKING A PROACTIVE AND SUSTAINABLE APPROACH

This is a PDF version of the full printed report (2nd edition).

ANNEXES TO THE REPORT

The CD-ROM contains the following Annexes, which are in addition to those four annexes (1–4) included in the main report:

Annex I: **Six CDM Case Studies**
Annex II: **Project Development Documents (PDDs) for each Case Study**
Annex III: **Methodological Annexes to Chapter 5 and 6**
Annex IV: **Matrix of Major International-Funded CDM Studies in China**
Annex V: **Relevant Materials from Other CDM Projects in China**
Annex VI: **Key Literature on CDM in China**
Annex VII: **Participants and Minutes from CDM Stakeholder Meetings**
Annex VIII: **Project Participants (Persons and Institutions)**
Annex IX: **Written China CDM Conference Materials**
Annex X: **Video Presentations of the CDM Conference**

Annexes I-III are an integral part of the report. Due to the nature of this study, the materials produced were too extensive to publish in printed form, but the materials in Annexes I and II present the detailed case study analyses and completed PDDs for the six case studies investigated. Annex III provides an in-depth explanation of the technology, economic, and market models used in the study and the assumptions made in modeling work.

Annexes IV, VII, IX and X provide more depth on some of the material presented in the main body of the report. Annex IV is a more detailed version of Table I.2, which provides an overview of CDM activities in China. Annex VIII contains documentation from two stakeholder consultation meetings to discuss the study's preliminary findings, one with government officials (Annex VII-1, Minutes Policy Dialogue Meeting; Annexes VII-2 to VII-6, presentation materials, mainly in Chinese) and the other with industrial stakeholders (Annex VII-10, Workshop Minutes Stakeholder Meeting; Annexes VII-7 to VII-9, presentation materials, mainly in Chinese). Annex IX includes the agenda and all PowerPoint presentations made at the international Conference "*Clean Development Mechanism in China—Taking a Proactive and Sustainable Approach*," held on July 1 and 2, 2004 in Beijing. Annex X provides video presentations of some of the important presentations and discussions at the international conference.

The remaining annexes are reference material. Annex V provides some further information about three other major CDM study initiatives in China, while Annex VI provides references to key literature on CDM application in China. Annex VIII lists the people and institutions involved in the study.

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