CHINA HUMAN DEVELOPMENT REPORT 2009/10

China and a Sustainable Future: Towards a Low Carbon Economy and Society

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FOREWORD

In the last three decades China has undergone a remarkable transformation. The highly planned and centralised country of the 1970s has given way to a dynamic market economy that has caught the attention of the world. Since 1979, with the introduction of reforms, China's GDP has grown at an average of 9.8 percent per annum, per capita income has increased fifty-fold and some 500 million people have been lifted out of poverty. This high level of GDP growth is already on track to continue despite the international financial and economic crises experienced in 2008/9. In China, many of the Millennium Development Goals have already been achieved. Chinese people are now wealthier, better educated and healthier than ever before.

Yet out of this unprecedented economic and social progress significant new challenges have emerged, not least the challenge of balancing further economic development with environmental sustainability, and with the need to respond to the threat of climate change.

Fortunately, China's leadership attaches great importance to achieving this balance. Moreover, it is increasingly being recognized that the move to a low carbon economy and society need not be a hindrance, and that instead a low carbon approach can be a catalyst for further growth and development, and for sustainable improvements in the lives of ordinary Chinese people.

By further investing in a green economy and green growth underpinned by emerging green technologies, China could now leapfrog over decades of traditional development based on high polluting fuels. There is also an invaluable window of opportunity to build new low carbon communities from scratch: in the next 20 years, 350 million people are expected to move into Chinese cities, using housing and transport infrastructure that is yet to be built.

China's political commitment to developing a low carbon economy and society was made clear at the UN Climate Change Summit in September 2009, when President Hu Jintao committed China "to step up efforts to develop a green economy, low-carbon and circular economy, and enhance research, development and dissemination of climate friendly technologies". In December 2009, China made its commitment to reduce carbon dioxide emissions per unit of GDP in 2020 by 40 percent to 45 percent compared with 2005 levels. Meanwhile, Chinese companies are already seizing some of the opportunities of the low carbon development model, with a renewable energy sector already worth $17 billion and employing close to one million workers.

For the United Nations, tackling climate change and supporting the move to a low carbon economy and society are also of the utmost importance. The UN Secretary-General has called climate change the "defining issue of our generation". And, in Beijing in July 2009, he noted that "China has long been the world's fastest-growing major economy. It is also a leading emitter of greenhouse gases, and it is one of the countries most vulnerable to the impact of climate change. Thus China's progress on achieving sustainable economic and energy policies simultaneously is crucial not just for the citizens of China, but also for the citizens of the whole world."

Given the importance of these issues to China and to the world, the United Nations in China has a strong and growing portfolio of work on climate change mitigation and adaptation, and on the broader move to a low carbon economy. Indeed, one of the three overall Outcomes of the UN's Framework for supporting China over the next five years is that 'Government and other stakeholders ensure environmental sustainability, address climate change, and promote a green, low carbon economy'.

In this context, UNDP China took the initiative to focus this National Human Development Report on the topic of "Sustainable Future: Towards a Low Carbon Economy and Sustainable Society". By analyzing both the risks and potential benefits to China of a shift to a low carbon economy and society, it is hoped that this report will provide a considered contribution to China's rapidly evolving policies in this area. The report highlights that, if China can fully grasp the opportunities at hand, it will be possible to move to a society which is not only environmentally sustainable, but which creates the conditions for greater job creation, greater resource efficiency and energy security, enhanced food security, and better health outcomes for its people; a society which, in line with China's own Xiaokang vision, is well balanced and moderately prosperous.

Continuing the practice that was established with the 2005 China Human Development Report, this report was produced by an outstanding group of national experts under the coordination of Renmin University of China. I extend my warmest thanks and congratulations to all the authors and Professor Zou Ji's team for this successful outcome. I would also like to take this opportunity to express our gratitude to Stora Enso, Royal Norwegian Embassy, Peace and Development Foundation for their generous support for this report, and to the many colleagues in the United Nations System who provided valuable inputs and support.

Khalid Malik

UN Resident Coordinator and

UNDP Resident Representative

PREFACE

After more than thirty years of reform and upon opening its doors, China has achieved immense success on issues involving human development. Yet, the country continually faces evolving circumstances at home and abroad. Compelling challenges include establishing a well-off society in China, improving the livelihoods of the country's people, and maintaining equitable human development while balancing increasingly limited natural resources and the threat of climate change. Standing at the epicenter of a booming economy, how will China's policy-makers make insightful, intelligent and practical decisions to ensure that an increasing number of its citizens will share in the country's economic success while maintaining effective and sustainable development? How will government officials seize the opportunity to make sound judgments based on an analytical and systematic approach? These outcomes and conclusions will have significant influence in shaping the country's roadmap as it faces a critical juncture in administering its 12th Five-Year Plan (2011-15).

A widely recognized conclusion is that China needs to take advantage of the international low carbon development boom in order to speed up its shift to a more efficient pattern of economic growth. China should transition from its heavy dependence on energy and resource consumption to improving energy efficiency while also enhancing the country's high-value-added and high-tech industries. Such a transformation is necessary not only for China's economic growth, but for sustainable development. The fundamental shift will determine the quality of the country's social development and economic growth, its future competitiveness, as well as the welfare of its 1.3 billion people, let alone the rest of the world.

To achieve such a fundamental transformation, the country must also revolutionize its mindset. China's leadership as well as its academic and think tank community must continually question and challenge themselves. Specifically, they must examine how their efforts are meeting the needs of the Chinese people for food, clothing, social security, and dignity, to a maximum degree. The Chinese approach of a "Scientific Outlook on Development" has presented strategic guidelines. It is our duty to elaborate on and transform the theories proposed by this report into a reality by detailing development strategies, long-term plans, implementation mechanisms, policy-making strategies, R&D guidelines, and project investments. We must also place income levels, development capacity, and freedom of choice at the forefront when considering strategies and policies on mitigating climate change and on developing a low carbon economy and society. A close connection should be fostered between mitigation of and adaptation to climate change on the one hand, and ensuring human development on the other.

The industrialization and modernization of the developed countries largely depended on the consumption of fossil fuels. In addressing the global challenge of climate change, worldwide efforts to delink the use of fossil fuels to economic growth must be accomplished. The fundamental solution is embedded in revolutions of mindsets, mechanisms, industries, science, and technology. It requires China to explore a new growth pattern, different from those taken by developed countries in the past. The new road to industrialization must improve Chinese people's standard of living while strengthening the country's competitiveness and reducing its heavy dependence on fossil fuel-based energy. Overcoming this obstacle is not just a challenge, it is also a strategic task towards a new era.

Climate change must be addressed with innovative solutions in terms of policy-making. Experience has proved that practice and innovation always lead to theoretical breakthroughs and progress. Renmin University of China is a leading Chinese research institutes in analyzing the economics of populations, resources and the environment. As UNDP China commissioned the Programme of Energy & Climate Economics (PECE), led by Professor Zou Ji, to conduct research for this report, it shows Renmin University of China's dedicated commitment to this field of study. It is my sincere hope that this report will not only provide constructive support in policy-making on the issue of building a low carbon economy in China, but that it will make significant contributions to the academic field as well.

I would like to take this opportunity to express my gratitude to UNDP China, our esteemed researchers, respected governmental officials and the PECE research team, who all have made valuable contributions to the report.

Ji Baocheng

President

Renmin University of China

April 2010

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The China Human Development Report 2009/10 is now complete as a result of collaborative research efforts and production to which many partners have contributed.

Low carbon economy and society has become a policy priority for China as stated in the Resolution from the National People's Congress of China in 2009 and in speeches from President Hu Jintao and Premier Wen Jiabao. Numerous research reports on low carbon economy in China have been conducted and published recently, all of which provided important background for this report. Based on existing studies, the NHDR takes into account the human development aspect in the transition to a low carbon economy and society. Moreover, as different countries define the low carbon content based on their own national conditions and circumstances, the NHDR also explores the pathway for China to achieve low carbon economy and human development simultaneously.

The inception workshop was held in April 2009. At the workshop and in the process that followed, a number of experts and scholars have actively participated in the discussions of the report both for the framework and contents and provided many constructive suggestions. Chen Shaofeng, Chen Ying, Cheng Siwei, Ajay Chhibber, Du Sen, Gao Guangsheng, Huang Wenhang, Hou Xin'an, Hu Xiulian, Sherasyi Jha, Jiang Kejun, Li Yingtao, Lin Erda, Liu Shijun, Lu Xuedu, Lu Yibin, Lu Yuebing, Katherine Morton, Pan Jiahua, Pei Xiaofei, Jeffrey Sachs, Tim Scott, Sun Cuihua, Sun Xuebing, Wei Yiming, Xue Huanbai, Yuan Wei, Annie Wu, Yang Fang, Zhang Kunmin, Zhao Baige, Zhu Liucai, and colleagues at the Human development Report Office, all have made valuable contributions. During the initial stage of this study, UNDP China Country Office and Renmin University of China jointly held a number of workshops, including a high level roundtable in July 2009 to solicit advice, which have been incorporated in the final version.

Renmin University of China commissioned background papers from Chinese experts. These include Jiang Kejun (on energy and emission scenario studies), Lin Erda (on climate impacts and adaptation issues), Pan Jiahua (on carbon budget), Tan Xiaomei (on international comparative studies and social development). All the above background and baseline research reports have been important as sources of ideas and data for preparing this report.

The first draft of the China Human Development Report 2009/10 was completed in September 2009 and was followed by several consultations meetings with representatives from Chinese ministries, experts as well as the UN system in China.

In December 2009, during UNFCCC climate summit in Copenhagen, UNDP China held a side event in Copenhagen to publicize the Key Findings of the NHDR where the Administrator of UNDP, Helen Clark was present. In addition we appreciate the distinguished panelists that participated in the event including: Jet Li, Johan Rockstrom, Pan Jiahua, Hans Joachim Schellnhuber, Erik Solheim and Zhao Baige We would also like to express our gratitude to the staff at the UNDP Nordic office and the UNDP China office for their tremendously efficient operational support for this event: Kristian Andersen, Mikkel Bonne, Ge Yunyan, Stine Junge, Henrik Kastoft, Nadja Mangulad, Pasi Rajala, Jakob Simonsen, Michael Toft and Zhang Zhiming.

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All UNDP China NHDRs have benefited from support from the UN system, and this year's report also followed such practice. In particular we would like to thank the UN Country Team in China for their precious comments and insights: Vincent Jugault, Marja Paavilainen, and Peter Poschen from ILO; Jiang Nanqing and Zhang Shigang from UNEP, Emma de Campo, Shirley Matheson and Catherine Wong from UNIDO; Fu Rong from FAO; Ramasamy Jayakumar and Liu Ke from UNESCO; Ai Yuxin from UNAPCAEM; Julie Broussard from UNIFEM; Veerle Vandeweerd, Koos Neefjes, and Lu Yibin from UNDP.

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Our special appreciation also goes to the project team at UNDP China: Goerild Heggelund, Andrea De Angelis and Wang Dong, their huge input both content-wise, technically and operationally throughout the production process assured the quality of the NHDR. In addition I would like to thank Inga Fritzen Buan for her valuable support in addition to Lei Yu and Shi Minzhi for their support in the finalization process for the report.

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To wind up our acknowledgements as chief editor of the report, we would like to take this opportunity to thank Josie Jin Zhou and Hu Tao who also provided contribution to the report We would also like to thank copy editor Gretchen Luchsinger in particular, as well as the task force for their hard work in the past year, including Chen Minpeng, Cui Xueqin, Fu Sha, Liu Qing, Luis Gomez-Echeverri, Wang Ke, Wang Shiyue,Weng Weili, Xing Lu, and Zhang Hongli, Zhou Yuanchun.

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ABBREVIATIONS FOR NHDR

ADB	Asian Development Bank
BAU	Business As Uaual
BOD	Biochemical Oxygen Demand
BP	British Petroleum
CAAS	Chinese Academy of Agriculture Science
CAIT	Climate Analysis Indicators Tool
CAS	Chinese Academy of Science
CASS	Chinese Academy of Social Science
CBM	Coal-Bed Methane
CBRC	China Banking Regulatory Commission
CCICED	China Council for International Cooperation on Environment and Development
CCHP	Combined cooling, heating, and power
CCPP	Combined Cycle Power Plant
CCS	Carbon Capture and Storage
CDC	Common but Differentiated Convengence
CDM	Clean Development Mechanism
CDQ	Coke Dry Quenching
CE	Coal and Electricity
CER	Certified Emissions Reduction
CHP	Combined Heat and Power Cogeneration
CMC	Coal Moisture Control
COG	Coke Oven Gas
CO2	Carbon dioxide
CO2e	Carbon dioxide equivalent
CPC	Central Committee of Communist Party of China
CPPCC	Chinese People's Political Consultative Conference
CSP	Concentrating solar power
EA	Emission Abatement Scenario
EAF	Electric Arc Furnance

EC	Emission Control Scenario
EFLH	Equivalent full load hours
EIA	Energy Information Administration
EPO	European Patent Organization
ERI	Energy Research Institute
EU	European Union
GAINs	Gas-Air Pollution Interactions and Synergies
GDP	Gross Domestic Product
GHG	Greenhouse gas
GW	Gigawatt
GT	Gigatonne (one billion tonnes)
GWEC	Global Wind Energy Council
GWP	Global Warming Potential
HDI	Human Development Index
IIASA	Institute for Applied Systems Analysis
ICE	Internal Combustion Engine
IEA	International Energy Agency
IGCC	Integrated gasification combined cycles
IPCC	Intergovernmental Panel on Climate Change
kWh	Kilowatt hours
LCE	Low-Carbon Economy
LED	Light Emitting Diode
MDG	Millennium Development Goals
MIIT	Ministry of Industry and Information Technology
MOA	Ministry of Agriculture
MOHURD	Ministry of Housing and Urban-Rural Development
MOEP	Ministry of Environmental Protection
MOFA	Ministry of Foreign Affairs
MOF	Ministry of Finance
MOR	Ministry of Railway
MOST	Ministry of Science and Technology
MOT	Ministry of Transport

MT	Million Tonnes
MW	Megawatt
NDRC	National Development and Reform Commission
NHDR	National Human Development Report
NOx	Nitrous Oxide
OECD	Organization for Economic Co-operation and Development
PECE	Programme of Energy and Climate Economics
PM	Particulate Matter
PPP	Purchasing Power Parity
PV	Photovoltaics
PWR	Pressurized Water Reactor
R&D	Research and Development
SAT	State Administration of Taxation
SERC	State Electricity Regulatory Commission
SFA	State Forestry Administration
SO2	Sulfur Dioxide
TCE	Tonnes of Coal Equivalent
TOE	Tonnes of Oil Equivalent
TPES	Total Primary Energy Supply
TWh	Terrawatt hours
UHV	Ultra High Voltage
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
USC	Ultra Super Critical
VAT	Value-Added Tax
VER	Vertified Emissions Reduction
WEO	World Energy Outlook
WIPO	World Intellectual Property Organization
WRI	World Resources Institute

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INTRODUCTION

Human development should be the ultimate objective for all economies and societies. As defined in this report, human development is not the same as economic growth. It is a larger process of enlarging choices for an entire society so people acquire capabilities to live long and healthy lives, have access to knowledge, enjoy a decent standard of living, and participate in the life of their community and the decisions that affect them.[1]

These objectives are consistent with the strategic guidelines for Chinese socioeconomic development, which are oriented around attaining the Millennium Development Goals (MDGs)[2] and achieving a "Xiaokang" or reasonably well-off society by 2020. The concept of human development also accords with China's scientific outlook on development, a comprehensive approach emphasizing development's human dimensions. Although economic growth is an important means of achieving human development, it is not, in itself, sufficient. The quality of the growth—defined by the ways in which growth is pursued and achieved—is equally important.

In the last three decades, China has undergone a remarkable transformation. The highly planned and centralized country of the 1970s has given way to a dynamic market economy that has caught the attention of the world. Since 1979, with the introduction of economic reforms, China's GDP has grown an average of 9.8 percent per annum, nominal per capita income has increased 50-fold, and some 500 million people have risen out of poverty.[3] A World Bank report on poverty in China states that between 1981 and 2004, the absolute number of poor people fell from 652 million to 135 million,[4] that is, from 65.2 to 10.4 percent of the population,[5] using $1 per day as the threshold for absolute poverty. Chinese people are now wealthier, better educated and healthier than ever before.[6] And despite the recent international financial and economic crises, China's high GDP growth rate is on track to continue.

UNDP's China Human Development Report China 2007/08 analyses the factors behind China's human development progress over the past three decades and estimates that economic growth during this period was the most important driving force behind China's 52.2 percent rise on the Human Development Index (see Box 1).[7] Growth opened the door to sustained and rapid increases in personal income and government fiscal resources, both vital preconditions for human development. As living standards have risen, China has moved into its current stage of rapid industrialization and urbanization. Yet amid unprecedented economic and social progress, there are concerns about whether or not these achievements will prove to be sustainable or equitable.

Box 1. The Human Development Index

The Human Development Index is calculated as the simple arithmetic mean of three sub-indices that measure basic dimensions of human life:

- **Life expectancy at birth, to represent the dimension of a long and healthy life;**
- **Knowledge, represented by the adult literacy rate (two-thirds weight), and combined school enrolment ratios at primary, secondary and tertiary levels (one-third weight); and**
- **Real GDP per capita (PPP$) to serve as a proxy for the resources needed for a decent standard of living.**

Two Challenges: Sustainability and Equity

The benefits of rapid growth have not come without some serious costs, including damages to China's environment and natural resources that could undercut sustainable future growth and development. In some areas of the country today, air, water, solid waste and other types of environmental pollution threaten people's lives, health and productivity. Environmental degradation adds pressure to China's existing resource and environmental constraints. China's large population makes its per capita endowment of many essential resources, particularly land and water, lower than the world average. In China, an unsustainable use of resources due to a low technological level has combined with rapid depletion of resources due to increased demand from a large population to make the economic growth unsustainable.

The unsustainable use of resources has occurred through economic growth that is heavily reliant on high-polluting coal and other fossil fuels. Industrialization and urbanization have driven greatly increased energy consumption—China's cities will add 350 million people in the next 20 years.[8] Lifestyle changes are leading to increased energy demand as people seek out a "higher-quality life," with easier access to goods and services, modern household appliances and houses. Despite some improvements, high dependence on coal and low energy efficiency will continue into the foreseeable future.

Another challenge relates to the uneven development that has left China facing growing human development disparities among urban and rural areas, different regions and diverse social groups. Rural-urban income and gender disparities have grown sharply, and considerable policy efforts have not narrowed the gap between the eastern and western provinces. Poor communities left untouched by economic growth are now widely dispersed across China, particularly in the Western region of the country.

While China may be the third largest economy in the world, it is also the largest developing country. There are still 100 countries ahead of China in terms of per capita income. Premier Wen Jiabao in his address to the 2009 international negotiations on climate change in Copenhagen[9] stated that China has 150 million people living below the poverty line.[10] A World Bank report estimates that as of 2005, China still had 254 million people consuming less than $1.25 per day in 2005 PPP dollars, the second largest concentration of poor people in the world after India.[11] In 2007, 251 million people were without access to an adequate supply of safe drinking water and other basic public infrastructure.[12]

Poverty is most severe in mountainous areas where natural conditions are harsh, and socioeconomic development lags behind the more prosperous coastal areas. It is also common in fragile eco-systems that face pressure from changes in the climate, as well as from urbanization and industrialization. Inequality within urban areas has risen, especially among members of the large migrant population of about 150 million to 200 million people. They have been key contributors to economic growth and urbanization, but are vulnerable in part because they do not receive the same social services and social security benefits as official urban residents.

Climate Change Threatens Human Development

Climate change adds new complexities to China's quest for sustainable and equitable development. The analysis carried out for UNDP's global Human Development Report 2007/08 emphasizes that "there is overwhelming scientific evidence linking the rise in temperature to increases in the concentration of greenhouse gases in the Earth's atmosphere."[13] The report highlights climate change as a significant, long-term threat to human development worldwide. Climate-driven risks will affect vulnerable countries especially in terms of income poverty, nutrition levels, child mortality rates and general health indicators.

In China and elsewhere, other impacts are already visible. Extreme weather events have become more common. China's National Assessment Report concludes that the trend towards a warmer climate is consistent with the global warming trend of the past century, and that the warming trend after the mid-1980s is significant.14 By 2020, average temperatures in China are projected to be between 1.1ºC and 2ºC above the average levels registered between 1961 and 1990.[15]

As examples of extreme weather events, China's National Assessment Report chronicles droughts in north-eastern China, flooding in the middle and lower reaches of the Yangtze River, and coastal flooding in major urban centers, such as Shanghai. Yields of the three major grains—wheat, rice and maize—are projected to decline with rising temperatures and changed rainfall patterns. Glaciers in western China are expected to thin, and large reductions in water availability may occur across several river systems.

Many areas in China's vast territory have fragile eco-environments prone to unfavourable climate shifts. Continued eco-environmental degradation appears through soil erosion, desertification, the loss of pastures and forests, and reduction in biodiversity reduction. Damages to agriculture, animal husbandry, forestry, water resources and coastal areas can already be seen. For example, the river system in northern China—the Hai, Huai and Huang (Yellow) rivers, known as the 3-H river basins—is already suffering water shortages due to growing demand from industry, urbanization and agriculture. Increased ecological pressures may further reduce water flow, and turn into an ecological crisis with serious economic and social repercussions.[16]

In light of current and future threats from climate change and its growing greenhouse gas emissions from fossil fuels, China must work on two fronts. It must deal with the existing and inevitable effects of climate change, and lower the growth of greenhouse gas emissions to prevent even greater threats. These tasks are linked and equally urgent. Addressing both simultaneously will benefit the economy and society as a whole. On the flip side, neglecting climate risks may seriously undermine human development. Prolonged inaction in lowering greenhouse gas emissions today could significantly increase mitigation costs in the future.

Globally, there is growing recognition that climate change poses one of the greatest challenges of the 21st century. With each passing year, opportunities to take effective action against it are reduced or become more costly.

A Holistic Path for Development

If climate change impacts are not adequately addressed in China, there is a danger that three decades of achievements may be reversed. China's most strategic choice is therefore to embark on a low carbon development path that will preserve and increase its human development achievements in the years to come. The political leadership recognizes this necessity and is determined to move forward, as expressed in resolutions, speeches and China's pledge to the Copenhagen Accord.[17] The challenge is to do this in a systematic way that builds on past achievements and simultaneously achieves human development objectives.

China's National Human Development Report for 2009/10 examines some of the key issues related to China's transition to a low carbon economy. The report considers the main obstacles in the short and medium term, the needs of development and transfer of technologies, and the costs, including the opportunity costs which lead to needs for financial resources. It questions whether or not China can pursue a new economic, technological and social system of production and consumption that conserves energy and reduces greenhouse gas emissions while maintaining momentum on economic and social development.[18] One essential element in a successful strategy for transitioning to a low carbon economy is to investigate and recognize both the potential economic, social and political benefits and costs and assess them in an integrative manner.

This report breaks new ground in attempting to link economic growth, carbon emissions and human development in China. It highlights a holistic approach that goes beyond carbon productivity and mitigation, and demonstrates why a low carbon economy and society are feasible. More sustainable climate and energy policies can bring development benefits and opportunities by:

- Enhancing energy efficiency to foster economic development, while reducing climate risks;
- Lowering dependency on imported oil to increase stability and energy security;
- Developing climate-friendly sectors to provide long-lasting green job opportunities;
- Addressing adaptation needs to improve human and social resilience and capture environmental and social benefits;
- Boosting social equity in the energy sector to enhance carbon and energy productivity, and alleviate the burdens of socially vulnerable groups, particularly the poor;
- Encouraging innovation for diverse economic and social benefits;
- Investing in green energy technologies and projects to spur economic growth as climate-friendly technologies become more widely deployed;
- Developing more renewable energy resources to help to meet the needs of poor people and vulnerable groups who usually have no, or limited, access to energy resources; and
- Improving resource and energy efficiency, carrying out economic restructuring and enhancing the capacity of carbon sinks to protect and sustain the environment.

Carbon productivity, measured as GDP per unit of carbon emissions, is an important indicator of the climate-related performance of an economy and society. During the past decade or so, China has introduced rigorous energy conservation and emission reduction policies that have significantly improved its carbon productivity. At present, it is exploring major reforms to adjust its economic structure, enhance its capacities for technological innovation, and improve its implementation of laws and regulations.

The Eleventh Five-Year Plan (2006–2010) sets specific goals for improving the efficiency of energy and resource utilization. It establishes the following targets: cutting energy consumption per unit of GDP by around 20 percent; reducing water consumed per unit of industry value added by 30 percent; raising the effective utilization coefficient of field irrigation water to 0.5; and increasing the recycling rate for industrial solid wastes to 60 percent.

The National Climate Change Program outlines a strategy and actions to address climate change, and China has pledged autonomous and voluntary domestic actions related to the UN Framework Convention on Climate Change. It has agreed to endeavour to lower its carbon dioxide emissions per unit of GDP by 40 to 45 percent by 2020 compared to the 2005 level; increase the share of non-fossil fuels in primary energy consumption to around 15 percent by 2020; and expand forest coverage by 40 million hectares and forest stock volume by 1.3 billion cubic meters by 2020 from 2005 levels.[19]

The Government's efforts to reduce carbon intensity reflect a recognition that by investing in a green economy and green growth underpinned by emerging green technologies, China has an opportunity to leapfrog over decades of traditional development based on high-polluting fuels. The transition, however, cannot take place overnight. Given its current technological capacity and its high dependence on coal for the foreseeable future, economic growth will mean increased carbon emissions. And with China still facing a combination of major socioeconomic development pressures, it will need to embark on multiple, simultaneous strategies for its development objectives.

Defining a Low Carbon Economy in China

Ideally, a low carbon economy is one that maximizes carbon productivity, improves capacities for adaptation to climate change, minimizes the negative impacts of climate change, improves human development, and accommodates both inter- and intra-generational needs, thereby laying a foundation for sustainable socioeconomic development. The ultimate objective of a low carbon economy must be to advance human and sustainable development.

While "low carbon" is a globally accepted term, different countries must define the content of their low carbon policies based on their own national conditions and circumstances. From a long-term perspective, the objectives of human development are fully consistent with those of a low carbon economy. In the short-term, however, given current national needs, quick and massive carbon emission reductions would pose major challenges to a developing country such as China, which are as follows:

- A very large population with concomitant employment pressures, requiring China to continue to maintain relatively high rates of economic growth, investment and consumption;
- A very high rate of urbanization and industrialization characterized by carbon-intensive and chemical industries;
- High dependence on coal for energy needs;
- Weak technological and innovation capacities;
- Potential employment and social problems if a massive phase-out of outdated technologies is carried out too quickly and in a disorganized manner;
- Difficulties that could arise from the reorientation of massive amounts of funds and technologies now used in other social development endeavors; and
- The inadequacy or lack of basic capacities and systems, public awareness and social mechanisms.

In analysing the potential scope of a low carbon future for China, this report starts from the notion that China must blaze a unique trail in accordance with its own national conditions. It must examine opportunities and risks in a comprehensive and prudent way, and work out optimal climate change strategies harmonized with economic development, energy production and consumption, environmental protection and human development objectives.

1 UNDP Human Development Report 1990, "Defining Human Development." Available at http://hdr.undp.org/en/reports/global/hdr1990/chapters/ (last accessed on 31 March 2010).

2 The eight MDGs, which range from halving extreme poverty to providing universal primary education, all by the target date of 2015, form a blueprint agreed to by all the world's countries and leading development institutions.

3 Xinhua Net, 18 December, 2008, "China celebrates 30th anniversary of landmark reform, opening-up." Available at http://news.xinhuanet.com/english/2008-12/18/content_10522874.htm (last accessed 19 March 2010).

4 World Bank, 2009, From poor areas to poor people: China's evolving poverty reduction agenda—An assessment of poverty and inequality in China, Poverty Reduction and Economic Management Department, East Asia and Pacific Region, World Bank. Available at http://siteresources.worldbank.org/CHINAEXTN/Resources/318949-1239096143906/China_PA_Report_March_2009_eng.pdf (last accessed 29 March 2010).

5 National Bureau of Statistics Database of China, yearly data available at http://www.stats.gov.cn/english/statisticaldata/yearlydata/

6 UNDP and China Institute for Reform and Development, 2008, Human Development Report, China 2007/08, "Access for all: Basic public services for 1.3 billion people."

Available at http://hdr.undp.org/en/reports/nationalreports/asiathepacific/china/China_2008_en.pdf (last accessed on 31 March 2010).

7 UNDP and China Institute for Reform and Development, 2008.

8 McKinsey Global Institute, 2009, "Preparing for China's Urban Billion." Available at www.mckinsey.com/mgi/reports/pdfs/china_urban_billion/China_urban_billion_full_report.pdf (last accessed 19 March 2010).

9 The talks were held under the United Nations Framework Convention on Climate Change.

10 Gov.cn, the Chinese Government's Official Web Portal. The full text of the Chinese Premier's address at the Copenhagen summit on 19 December 2009 is available at http://english.gov.cn/2009-12/19/content_1491267.htm (last accessed on 19 March 2010).

11 World Bank, 2009, From poor areas to poor people: China's evolving poverty reduction agenda—An assessment of poverty and inequality in China, Poverty Reduction and Economic Management Department, East Asia and Pacific Region, World Bank. Available at http://siteresources.worldbank.org/CHINAEXTN/Resources/318949-1239096143906/China_PA_Report_March_2009_eng.pdf (last accessed 29 March 2010).

12 China's Ministry of Foreign Affairs and the United Nations system in China, 2008, "China's Progress Towards the Millennium Development Goals 2008 Report." Available at www.un.org.cn/public/resource/b0bb7b863d301be218a33ac8094b772a.pdf (last accessed on 9 March 2010).

13 UNDP and China Institute for Reform and Development, 2008.

14 National Climate Change Coordination Committee, 2006, China's National Assessment Report on Climate Change, Beijing, Science Press.

15 UNDP and China Institute for Reform and Development, 2008.

16 UNDP and China Institute for Reform and Development, 2008.

17 Resolution of the Standing Committee of the National People's Congress of China on Actively Responding to Climate Change, adopted at the Tenth Meeting of the Standing Committee of the Eleventh National People's Congress, 27 August 2009. UN DPI, "Join Hands to Address Climate Change," statement by H. E. Hu Jintao, President of the People's Republic of China, at the Opening Plenary Session of the UN Summit on Climate Change, New York, 22 September 2009. Available at http://www.un.org/wcm/webdav/site/climatechange/shared/Documents/China.pdf (last accessed 17 March, 2010). National Development and Reform Commission, 28 January 2010, "Letter including autonomous domestic mitigation actions." Submission letter to the United Nations Framework Convention on Climate Change. Available at http://unfccc.int/files/meetings/application/pdf/chinacphaccord_app2.pdf (last accessed 17 March 2010).

18 Definition of a low carbon economy in the China Council for International Cooperation on Environment and Development's Task Force Report on China's pathway toward a low carbon economy, November 2009: CCICED Task Force on China's Pathway Towards Low Carbon Economy, 2009, "Task force report on China's pathway towards a low carbon economy." Available at http://www.cciced.net/encciced/policyr/Taskforces/phase4/tflce/200911/P020091124512243707328.pdf (last accessed 24 March 2010).

19 National Development and Reform Commission, 28 January 2010.

CHAPTER 1
HUMAN DEVELOPMENT IN A LOW CARBON SOCIETY

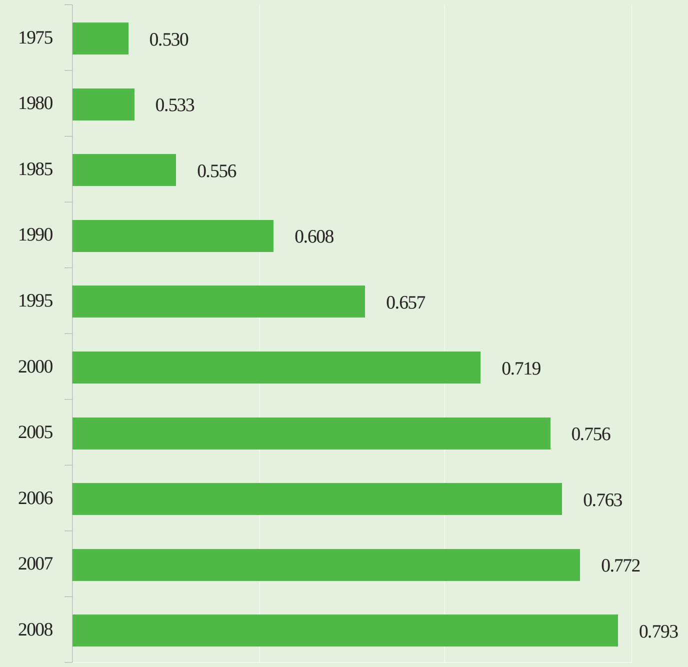
The series of global and national human development reports put out by the United Nations Development Programme (UNDP) have been instrumental in helping to shift the definition of development from an emphasis on economic growth to a new understanding that people belong at the centre of progress. The ultimate goal of development is to create an environment where individuals can lead long, healthy and productive lives, whereas per capita income is one, albeit important, means to this end. From this perspective, analysing China's future economic prospects needs to include factors that pose both human development challenges and opportunities. One of the most important of these is climate change.

Sustained economic growth has been instrumental in China's rapid human development gains, and will need to continue to meet needs for employment, social services and social infrastructure. An economic growth model based on the intensive use of energy and other resources and high dependence on fossil fuels, however, has come at a high price in terms of resource degradation and pollution. In the long term, it is unsustainable. This places China at a strategic crossroads. A development path that meets the dual objectives of human development and sustainability will be the key to its future.

A Well-laid Foundation

Since China adopted its economic opening up and reforms in the late 1970s, including the programme of economic reforms called "socialism with Chinese characteristics," hundreds of millions of people have risen from poverty to pursue better lives.[1] China has made impressive progress on the Human Development Index (see Figure 1.1 and Table 1.1), and has met many of the Millennium Development Goals (MDGs), while being well on the way to achieving others (see Box 1.1).[2]

Figure 1.1 **China's rise on the human development index (1975-2008)**



Source: Data of 1975 is from UNDP, 2008, Human Development Report 2007/2008—Fighting climate change: human solidarity in a divided world;
Data of 1980 to 2007 is from UNDP, 2009, Human Development Report 2009—Overcoming barriers: Human mobility and development;
Data of 2008 is adapted by Taskforce on NHDR 2009-2010 based on China Statistical Yearbook 2009.

Table 1.1: Human Development Indicators in China

Literacy, age 15 and over, can read and write (2000 census)	Total population: 90.9% Male: 95.1% Female: 86.5%
Education, school life expectancy (2006 census)	Total: 11 years Male: 11 years Female: 11 years
Life expectancy at birth (2009 est.)	Total population: 73.47 years Male: 71.61 years Female: 75.52 years
Infant mortality rate (2009 est.)	Total: 20.25 deaths/1,000 live births Male: 18.87 deaths/1,000 live births Female: 21.77 deaths/1,000 live births
Percentage of population with electricity access (2008 est.)	National: 99.4% Rural: 99% Urban: 100%

Sources: Central Intelligence Agency, 2010, CIA World Factbook China pages. Available at www.cia.gov/library/publications/the-world-factbook/geos/ch.html (last accessed 17 March 2010). IEA/OECD, 2009, "World Energy Outlook 2009," Paris, OECD/IEA.

Box 1.1: Making Progress Towards the MDGs

At the UN Millennium Summit in September 2000, 189 UN Member States adopted the Millennium Declaration, a framework for the specific human development objectives known as the Millennium Development Goals (MDGs). The eight goals, to be achieved by 2015, are to: eradicate extreme poverty and hunger; achieve universal primary education; promote gender equality and empower women; reduce child mortality; improve maternal health; combat HIV/AIDS, malaria, and other diseases; ensure environmental sustainability; and develop a global partnership for development. The MDGs constitute the most comprehensive set of development goals ever agreed by the international community.

The Chinese Ministry of Foreign Affairs and the UN System in China jointly drafted "China's Progress towards the Millennium Development Goals, 2008 Report." It summarizes the economic and social development of China over the past three decades of reform and opening-up, outlines the progress and achievements China has made in achieving the MDGs, identifies problems and challenges of implementation ahead, and offers recommendations for future development.

According to the 2008 report, while China is likely to achieve all the MDGs by 2015, the country should focus more attention on the following goals: promoting gender equality and empowering women; containing and reversing the spread of HIV/AIDS by 2015; and reversing environmental and resource degradation by 2015.

The table below summarizes the report's findings.

GOALS / indicators	**Will the goal or target be met?**	**State of national support**
MDG1: Eradicate extreme poverty and hunger		
1a) Halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day	Already met	Strong
1b) Achieve full and productive employment and decent work for all, including women and young people	Potentially	Strong
1c) Halve, between 1990 and 2015, the proportion of people who suffer from hunger	Already met	Strong
MDG2: Achieve universal primary education		
2a) Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling	Already met	Strong
MDG3: Promote gender equality and empower women		
3a) Eliminate gender disparity in primary and secondary education, preferably by 2005, and in all levels of education no later than 2015	Likely	Strong
MDG4: Reduce child mortality		
4a) Reduce by two-thirds, between 1990 and 2015, the under five mortality rate	Already met	Strong
MDG5: Improve maternal health		
5a) Reduce by three quarters, between 1990 and 2015, the maternal mortality ratio	Likely	Strong
5b) Achieve, by 2015, universal access to reproductive health	Potentially	Good
MDG6: Combat HIV/AIDS, malaria and other diseases		
Target 6.A: Have halted by 2015 and begun to reverse the spread of HIV/AIDS	Likely	Strong

Target 6.B: Achieve, by 2010, universal access to treatment for HIV/AIDS for all those who need it	Potentially	Good
Target 6.C: Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases	Likely	Good
MDG7: Ensure environmental sustainability		
Target 7.A: Integrate the principles of sustainable development into country policies and programmes	Likely	Strong
Target 7.B: Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss	Potentially	Good
Target 7.C: Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation	Likely	Strong
MDG8: Develop a global partnership for development	-	-

Source: Chinese Ministry of Foreign Affairs and the UN System in China, 2008, "China's Progress Toward the Millennium Development Goals: 2008 Report."

According to World Bank statistics, China's 2008 GDP was US $2.60 trillion (in 2000 US dollars), making it the third largest economy in the world, up from the tenth largest in 1978.[3] China's GDP share of the world economy has increased sharply, from 1.8 percent in 1978 to 6.42 percent in 2008.[4] National fiscal revenues rose from 113.2 billion yuan in 1978 to 6.13 trillion yuan in 2008, resulting in a significant rise in public spending.[5] During the 1978-2008 period, the per capita disposable income of urban families rose from 343 yuan to 15,781 yuan, and both urban and rural incomes rose more than six-fold.[6] By World Bank definitions, China has moved from the low-income to the lower-middle-income category.[7] Lifestyle patterns, in which people formerly emphasized basic food and clothing, now include multi-level consumption enhancing the average well-being of the population (see Table 1.2 and Box 1.2).

Box 1.2: From "Three Old Things" to "Three New Things"

During the decades of reform and opening-up, the daily life of the Chinese people has undergone significant change. The types of commodities that symbolize status and wealth have also changed.

In the 1970s the bicycle, sewing machine and wristwatch were symbols of a Chinese family's status and wealth. When a couple got married, their families presented "three turning things and one ringing thing" as betrothal gifts or dowry, that is a bicycle, a sewing machine, a wristwatch, and a radio. As time went on, these were gradually replaced by the "three new things:" in the 1980s, a black and white TV set, a refrigerator and a motorcycle, and in the 1990s, a colour TV set, air-conditioner and mobile phone. In the 21st century, new consumer goods were continually introduced. The MP3, DVD, notebook computer, camcorder, digital camera, car and multi-story building all became —almost imperceptibly— part of the urban way of life and have spread rapidly to rural areas.

Statistical data indicate that the consumption structure of the Chinese people has rapidly improved with the Engel's coefficient falling year after year. This means that the emphasis on personal consumption is shifting from food and clothing to housing and transportation. With personal consumption moving fast from the 1,000 yuan and 10,000 yuan levels to the 100,000 yuan and 1 million yuan levels, a new era of "three big things" based on having an education, a house and a car is replacing the old list.

Sources: Xinhua, 2005, "New 'Three Big Things' entering ordinary Chinese families," 25 September. Gansu Daily, 2007, "From 'Three Old Things' to 'Three New Things'," 29 October. Tianjin Daily, 2008, "Changes in betrothal gifts over 30 years," 27 November. China National Bureau of Statistics, 2009, China Statistical Yearbook 2009.

Table 1.2: Rising Living Standards (1978–2007)

	Rural		Urban	
Income level	**1978**	**2007**	**1978**	**2007**
Per capita rural net income (yuan)	133.6	4,140.4		
Per capita urban disposable income (yuan)			343.4	13,785.8
Family Engel's coefficient (%)	58.8	43.1	54.2	36.3
Clothing				
Per capita purchased clothes (per piece of clothing)	0.7	2.4	3.13	7.82
Food				
Per capita grain consumption (kg)	248	199	205.3	77.6
Per capita pork consumption (kg)	5.2	13.4	13.7	18.2
Per capita poultry and egg consumption (kg)	0.8	4.7	1.97	10.3
Housing				
Per capita housing space (square metres)	8.1	31.6	4.2	22.6
Transportation	**2000**	**2007**	**2000**	**2007**
Car ownership per 100 families (no.)			0.5	6.06
Motorcycle ownership per 100 families (no.)	21.94	48.52		
Consumer durables	**1985**	**2007**	**1985**	**2007**
Colour TV ownership per 100 families (set)	0.8	94.4	17.2	137.8
Refrigerator ownership per 100 families (no.)	0.1	26.1	6.6	95.0
Washing machine ownership per 100 families (no.)	1.9	45.9	48.3	96.8

Source: China National Bureau of Statistics, 2008, China Statistical Yearbook 2008.

By 2008, the nine-year compulsory education system covered 99 percent of the Chinese population, with a total enrolment of 159 million pupils. Since 2000, the primary school enrolment rate has been consistently above 99 percent, while the middle-school gross enrolment rate rose from 88.6 percent in 2000 to 98.5 percent in 2008.[8] Primary and junior high school dropout rates have reached a record low. In 2007 and 2008, China waived tuition and miscellaneous fees for compulsory education in rural and urban areas, enabling equal educational opportunities for all.

In health, China has made impressive achievements in the last three decades, as is evident from longer life expectancies. According to data published by the Ministry of Health, the average life expectancy in China before 1949 was 35 years, rising to 73 years in 2007,[9] and exceeding the world average level of 67 years.[10] The maternal mortality rate dropped from 53 per 100,000 in 2000 to 31.9 per 100,000 in 2009,[11] which was less than one-tenth of the 2004 average mortality rate for developing countries.[12] The mortality rate of children under five dropped from 3.97 percent in 2000 to 1.72 percent in 2009[14], lower than the 2007 average levels of 7.4 percent for developing countries and 2.7 percent for the East Asian and Pacific region.[15] Some health achievements are now under threat, however, from air pollution, primarily from burning fossil fuels to feed economic growth.[16]

But Growth has not Benefited All

In China, improvements in overall human development coexist with worsening disparities. Despite impressive rates of growth in GDP, the profits of state-owned enterprises and government tax revenues,[17] China's income distribution gap has widened between the rich and the poor, as well as between regions, urban and rural areas, and males and females. The social security system is in urgent need of reform. Finding jobs, accessing medical services, and attending schools have become the "three big mountains" for the Chinese people. Converting income growth into sustainable progress in human development for all Chinese citizens is one of the country's major challenges in the decades ahead, complicated by growing costs from high environmental pollution and resource degradation.[18] The negative impacts of climate change could make this task even more formidable, a prospect that underlines the need for urgent action.

As evidence of persistent disparities, the 2008 Human Development Index varied widely across different regions of China. The highest ranking, for Shanghai, was 44 percent higher than the lowest ranking, in Tibet. The index for the eastern region was visibly higher than for the western region (see Figure 1.2). The level of human development in Beijing, Shanghai and other regions was on par with the Czech Republic, Portugal and other countries with a high HDI, while the low level of Guizhou and the western region was similar to that of the Democratic Republic of Congo and Namibia.[19]

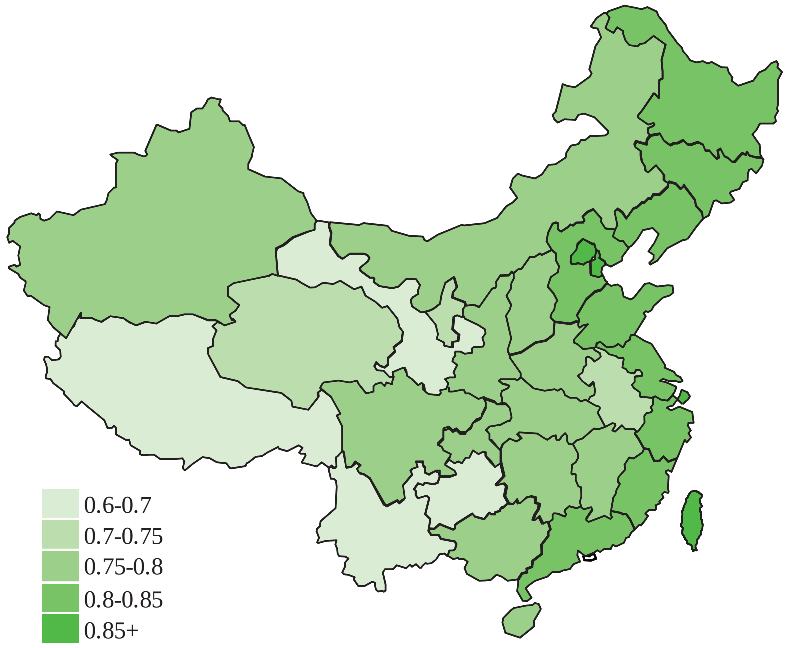
Disparities like these extend across all aspects of human development in China. Data from the Asian Development Bank (ADB) shows that China now has one of the most uneven income distributions of all Asian countries, with a Gini coefficient[20] that rose from 40.7 in 1973 to 47.3 in 2004.[21] According to World Bank estimates, the income gap in China is now the second highest in Asia and threatens future development.[22] Income differences between urban and rural areas, and between the eastern and western regions are particularly stark. In 2008, the per capita GDP of Shanghai reached 73,124 yuan, while that of Guizhou was nearly ten times lower at 8,824 yuan.[23]

With a growing urban population, the Chinese Government has been obliged to make large investments in urban infrastructure. Consequently, public expenditures on rural medical, educational, and other sectors have lagged behind, reflected in poorer education, health, and other key human development indicators. The 2007 life expectancy in Beijing, Shanghai, and other locations in the eastern developed region exceeded 80 years,[24] while that of Guizhou was below 70 years.[25] The infant mortality rate in Qinghai was 2.98 percent in 2007,[26] nearly ten times that of Shanghai at 0.3 percent.[27] Beijing, Shanghai and Tianjin are the regions with the highest level of education, with literacy rates among people over age 15 exceeding 96 percent in 2008, while for Gansu, Qinghai, Guizhou and other places in the western region, the rate is about 86 percent.[28]

Human development disparities in China also cut along the lines of gender, despite a variety of measures taken by the Government to promote gender equality. Women continue to face discrimination in wages, labour market participation and education, and more so if they live in rural areas. A sample survey, for example, found that the literacy rate for rural adult females over 15 was 78 percent, while for males over 15, it was 92 percent.[29]

By promoting an "egalitarian approach" in its Five-Year Plans, the Chinese Government has tried to address development disparities. But uneven implementation of policies for compulsory education, basic health care, employment opportunities and social security have fostered unequal access to development opportunities, even on top of disparities linked to varying rates of economic growth.

Figure 1.2 **Regional HDI disparities in China (2008)**



Source: Data from China National Bureau of Statistics, 2009, "China Statistical Yearbook 2009", Beijing, China Statistics Press, adapted by Taskforce on NHDR 2009-2010, Renmin University of China.

Disparities Might Worsen Through Climate Change

For all nations around the world, global climate change poses one of the greatest development challenges of the 21st century. In China, it may both aggravate existing human development shortfalls, including socioeconomic disparities, and hinder long-term human development prospects for the country at large. If human development disparities widen, they will pose ever more serious threats to social equity and harmony.

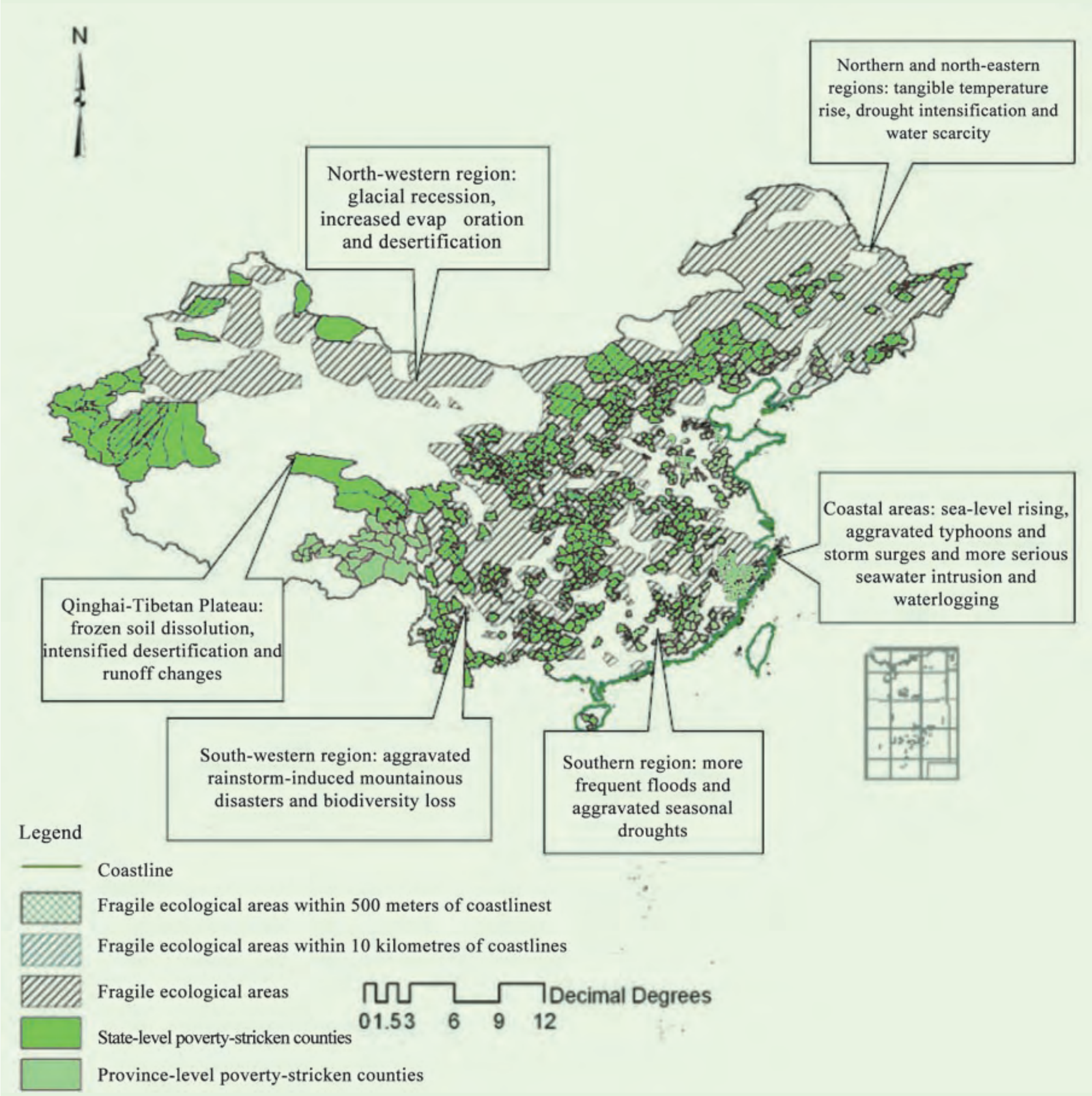
Thirty years of sustained economic growth in China have taken a heavy toll on its environment and natural resources. Air, water and other forms of pollution are endangering people's lives and health, and compromising productive capacities. Ecosystem degradation, such as through soil erosion, desertification, the loss of forests and the reduction of biodiversity, puts sustainable development at risk. Agriculture is an area of particular concern. Although China has made great progress in providing its population with basic food and clothing, ensuring food security remains a daunting task, given the potential for crop failures due to climate-related droughts, floods and other natural disasters.

In general, poor people, people living in ecologically fragile areas (see Figure 1.3), and some groups of women and children will be most affected by climate change and are most vulnerable to climate risks.[30] The quality of infrastructure, education, health and basic social services is generally low for China's poorest populations, rendering many with weak capacities to cope with climate change. The poor are also most at risk from food insecurity, and are more dependent for livelihoods on primary agriculture and fisheries—industries that are highly affected by changes in temperature, rainfall and other natural conditions. Crop failure due to climate change could lead to hunger and malnutrition.

Already overburdened health systems, especially in rural areas, will likely not be able to keep up with a range of impacts on health. Higher temperatures will reduce human immunity and resistance, and increase disease incidence and death rates, especially among the aged and people suffering cardiovascular and respiratory diseases. Extreme weather events may cause outbreaks of cholera, malaria, and other infectious diseases. Changes in temperature and rain patterns could extend the geographical distribution of malaria, dengue fever, viral brain fever, and other infectious diseases, as well as vector-borne diseases.

The fragile ecosystems in the western region will likely be more vulnerable to climate change, including through the degradation of forests and pastureland, and desertification. This may increase the incidence and intensity of geological disasters

Figure 1.3 **Links between fragile ecosystems and poverty-stricken counties**



Source: Greenpeace and Oxfam, 2009, "Climate Change and Poverty, China Case Study." Available at www.greenpeace.org/usa/assets/binaries/poverty-and-climate-change (last accessed 17 March 2010).
Li Zhou, Sun Ruomei, Gao Ling, et al., 1997, "Study of Relations between China's Mode of Development of Poverty-Stricken Mountainous Areas and Ecological Changes," Taiyuan, Shanxi Economic Publishing House.

that cause serious human and financial losses. These vulnerable ecosystems are already linked to poverty. The 2005 statistics of the Ministry of Environmental Protection indicate that 95 percent of people in absolute poverty live in ethnic minority areas, in remote and border regions and in ecologically fragile regions.[31] In Shanghai, Beijing and other developed areas of China, climate change, assuming that temperature shifts are relatively moderate, may simply mean that people will have to use their air conditioners for more days of the year, endure more frequent typhoons and rainstorms, and adapt to seasonal changes, all of which they will easily be able to cope with. In Guizhou, Gansu and other western provinces, climate change may mean crop failure, hunger, displacement or even death.

Poor women in China, particularly those in western rural areas, will confront greater burdens from climate change because of their marginalized status and excessive dependency on local rural natural

Box 1.3: Case Study of Climate Change Impacts on Women[32]

Thus far, no extensive research exists on the impact of climate change on women in China, but studies from many parts of the world show that women, in particular poor women, are disproportionately vulnerable to the adverse effects of climate change, including extreme weather events, natural disasters and the spread of disease.[33]

In a report from 2009, the UNDP explains the different and interlinked ways in which this happens and the equally complex reasons for this. [34] Among the many reasons why women are more exposed is their role in agriculture, a sector highly exposed to climate changes. According to the Food and Agriculture Organization rural women in China have an active role and extensive involvement in livestock production, and forests and water resource use, but this work is getting harder and more time-consuming due to ecological degradation in combination with other factors.[35] In large parts of the world, women and girls who are responsible for collecting water. Limited availability of drinking water, such as in a water-scarce country like China, increases the work of collecting, storing, protecting and distributing it, however.

Recent natural disasters have resulted in more female than male victims in both developed and developing countries, such as during the 2003 European heat wave,[36] and in the aftermath of the 2004 tsunami which affected large parts of the Asia-Pacific region.[37] In cases of extreme weather events brought on by climate change, in some regions of the world, restrictions on the independence and empowerment of women hamper their access to shelter or medical care during cyclones, earthquakes and floods. In terms of other adverse effects of climate change, women may be more exposed than men to diseases brought on by warmer climates and vector-borne diseases, since they traditionally are responsible for caring for the sick.[38]

The 2009 UNDP report also emphasizes, however, the positive roles played by women in supporting households and communities in both mitigation of and adaptation to climate change.

resources (see also Box 1.3). Climate change may translate into women having to contribute more labour in order to get water, fuel, animal feed and other daily necessities. Resource shortages and labour market instability may force women and men to migrate for work. In some communities, women will stay behind to carry out heavy agricultural production and household chores.

The long-term negative impacts of climate change on human development are potentially greater than those from short-term economic losses associated with curbing greenhouse gas emissions. Losses caused by poor health, fewer educational and livelihood options, damage to ecosystems and malnutrition are serious and potentially irreversible threats. Human beings have a threshold in their ability to recover from the negative impacts of climate change. Before this threshold is crossed, people can recover through reconstruction and reproduction. But once the threshold is exceeded, there is a danger of plunging into a downward spiral of low human development.[39] Poverty leads to weaker responses to climate change; people experience more harm; they become even more fragile.

The Human Development Case for a Low carbon Economy

One essential strategy to confront climate change will be the shift towards a low carbon economy. As illustrated in the introduction this report is based on the following definition: low carbon development maximizes carbon productivity, improves capacities for adaptation to climate change, minimizes the negative impacts of climate change, improves human development, and accommodates both inter- and intra-generational needs, thereby laying a foundation for sustainable socioeconomic development. The ultimate objective of a low carbon economy and society must be to advance human and sustainable development'. The China Council for International Cooperation on Environment and Development (CCICED) Task Force on China's Pathway

Towards a Low Carbon Economy has issued a report, listing three principles that underpin the definition:[40]

a) A low carbon economy would eventually decouple economic growth from greenhouse gas and other polluting emissions, through technological and other innovations, and through changes in infrastructure and behaviours.

b) For the current state of development of China, which is still undergoing industrialization and urbanization, "low carbon" is a relative, rather than an absolute concept. Emissions per unit of economic output are reduced more rapidly in a low carbon economy than if the status quo continues.

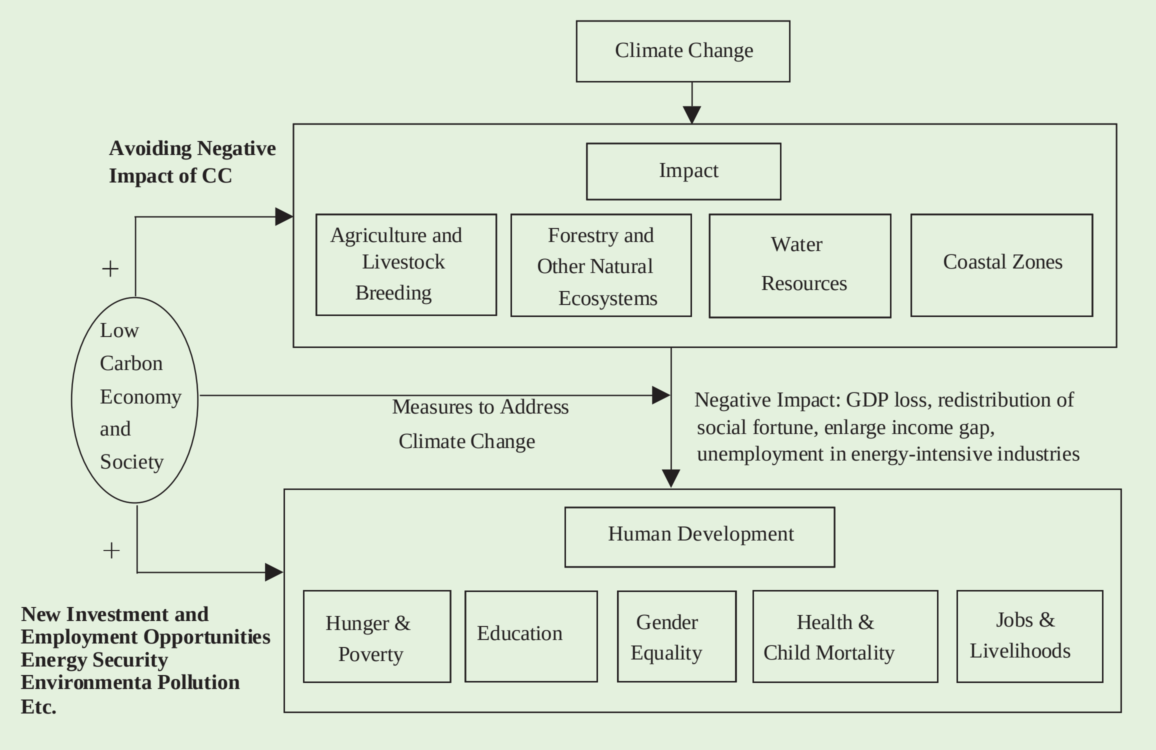
c) A low carbon economy achieves many key development objectives, including long-term and more equitable economic growth, creation of jobs and economic opportunities, reduction of resource consumption and enhancement of technological innovation.

According to the CCICED report, central to the vision of a low carbon economy is the recognition of its potential economic, social and political benefits, rather than just the associated costs.[41] The National Human Development Report attempts to gauge these benefits for China, while realistically taking into account the costs. A basic premise is that the move to a low carbon economy is no longer a choice but a necessity, given the scientific evidence and broad acceptance of the threats from climate change.

Policy measures to mitigate climate change through reduced greenhouse gas emissions can produce a variety of positive effects, including reductions in pollution and socioeconomic benefits (see Figure 1.4). A low carbon economy also provides major opportunities to promote technological innovation in the energy sector, transform social production and consumption patterns, and sustain national economic development. Already, recent investments made in low carbon technologies by stimulus packages designed to respond to the global financial crisis are fueling new economic growth and job opportunities.

Mitigation of climate change is highly consistent with

Figure 1.4 **The low-carbon economy and human development**



Source: Taskforce on NHDR 2009-2010, Renmin University of China.

China's other goals of energy security, environmental protection and sustainable development. Energy efficiency and renewable energy technologies will reduce China's energy demand and ease its extremely strained energy supply. Reduced use of coal and other fossil fuels will cut sulfur dioxide (SO_2) and nitrous oxide (NO_x) emissions to alleviate air pollution and acid rain. By increasing investments in low carbon technologies, China can enhance its own technological strength, achieve economic transformation and improve its standing in the world.

Current Challenges Imply a Careful Transformation

Although a low carbon economy can improve human development in the long run, care must be taken to alleviate short-term risks. Transformation cannot take place overnight without regard for possibly negative economic repercussions. A period of transition is required for China to introduce new mechanisms and develop capacities to manage the low carbon shift. Recent research in China demonstrates the adverse impacts of transformation to a low carbon economy carried out too hastily, and without measures to counteract negative effects or enhance potential benefits.[42]

China faces diverse and difficult challenges that must be managed in the move towards a low carbon economy.

- A large population, population growth, and the need to make ongoing improvements in human development will exert great pressures on efforts to control much less reduce greenhouse gas emissions. China's future population growth is expected to peak in around 2030.[43] Even if per capita emissions were to remain unchanged, population growth will drive up emissions (see Chapter 3 for more details). The demand for improved living standards will continue to grow, with a concomitant desire for consumer goods, more transportation services, more per capita housing space and more food consumption. All these trends mean more energy consumption and higher per capita emissions. Shifting to a low carbon economy will depend on gradually changing the pattern of investments in each of these areas so that energy consumption is decoupled from growth, and policies are implemented to encourage consumption and production patterns that are sustainable and less resource-intensive.
- China is in a process of industrialization, with rapid development in heavy and chemical industries such as machine building, steel, building materials and chemicals. The proportion of energy-intensive industries in the economy continues to rise. Urban growth is simultaneously accelerating, with massive infrastructure construction underway, both factors that will spur sustained growth in energy consumption. As the Chinese Government moves towards adjusting economic structures and models of growth, there are opportunities at each stage for exploring the switch to lower energy consumption technologies and practices.
- With abundant coal, less natural gas and scarce oil, China's resource endowments will make coal dominant in energy production and consumption for the foreseeable future. In 2008, coal accounted for 68.67 percent of China's energy consumption, with oil and natural gas accounting for 18.78 percent and 3.77 percent, respectively.[44] China's dependency on coal will be much greater than that of most other countries, even though the carbon intensity of coal is far higher than that of other fossil fuels (see Annex 1.1 on carbon productivity and carbon intensity). To produce the same amount of heat, the ratio of carbon dioxide emissions between coal, oil, and natural gas is roughly 5:4:3. This high emission intensity will make it more difficult for China to develop a low carbon economy. Accelerated development, diffusion, and dissemination of technologies such as carbon capture and storage (CCS) would go a long way towards resolving excessive emissions until low carbon technologies can be implemented.

- China still has a relatively low level of science and technology know-how in several key areas critical to a low carbon economy, along with limited capacities for technology development. As the replacement costs for existing facilities and infrastructure would be immense, China will find it difficult to switch quickly to a low carbon economy and rely entirely on its own technology development. In the short term, it must turn to external technological expertise to introduce new technologies and replace inefficient facilities and infrastructure. The international community is exploring several ongoing initiatives, particularly under the umbrella of global climate change negotiations, to make some of these technologies more readily available. In the meantime, China has been introducing legislation and incentives to produce renewable solar and wind energy, making it a leader in renewable energy use. Much more needs to be done, however, to build institutions, develop capacities and encourage innovation in general.
- The shift to a low carbon economy requires major investments that have opportunity costs and should not be made to the detriment of infrastructure and social services. Investments should be guided by the criteria that they are both crucial for human development and pay off in positive low carbon outcomes. Especially in building and energy infrastructure, public transportation, and urbanization schemes, there are opportunities for low carbon outcomes that can benefit the economy and society. When phasing-out and replacing outdated production capacities, there needs to be focus on counteracting job losses and other social sacrifices.
- Finally, China still suffers from a low level of capacities, skills and institutions overall. It lacks strong macro-management capacities, and its laws, regulations and policies are weak in many key areas.[45] Official greenhouse gas emissions data are only available for 1994[46] and 2004[47], for example, and both the accounting and enforcement capacities for monitoring and regulation are minimal. Climate awareness among enterprises and public officials is universally low, and the relevant expertise is scarce.

Reaping Economic Returns from Low Carbon Investments

Despite the challenges it faces, China is making efforts to build a low carbon economy that will boost economic growth and job creation, increase capacities for independent innovation, and achieve energy and environmental goals. As a latecomer to development, China may be able to leapfrog over outdated technologies to embrace cleaner, greener options from the outset. This will increase its future international competitiveness, and improve its disadvantageous position at the lower end of international industrial chains. For a long time, China has acted as the "workshop of the world," but it now faces competition from neighbouring countries, along with growing natural resource scarcity, ecological degradation, and the need for technology upgrading and industrial restructuring.

- Actions to address climate change can create considerable business opportunities. Low carbon energy technologies and other low carbon commodities and services will shape new markets, where job opportunities will grow. Chinese enterprises will find opportunities to increase their standing in the world, boost their innovation and competition capacities, and explore new business pursuits. According to Roland-Berger Strategy Consultants, by 2020, the global markets for environmental products and services are expected to double to US $2.74 trillion from their current annual value of US $1.37 trillion.[48] Energy markets will account for half of this. In Germany, the environmental technology market's share of industrial output value will top 16 percent by 2030; the jobs offered by environmental industries will exceed the current total of the machine-building, auto and other main industrial sectors. In Europe and America alone, increased investment in energy conservation in buildings will yield 2 million to 3.5 million new green jobs.[49] Developing countries, due to current low energy efficiency in buildings, will have even greater potential in this arena.

- A proactive approach to a low carbon economy could help enhance China's overall scientific research and technology innovation capacities. Advanced low carbon technologies will not only promote the domestic low carbon economy, but can also be exported, especially if China can lead breakthroughs in important low carbon technologies such as integrated gasification combined cycles (IGCC) and CCS.
- Since global competitiveness may eventually be defined in part by carbon consumption rates, including through the potential merger of international trade rules and carbon emissions regulations, low carbon economies will gain an edge over those that remain heavy emitters. Globally, carbon emission allowances will gradually decrease under the pressure of international commitments. China may be obliged to increase carbon productivity in order to control its emissions.

Weighing Human Development Costs and Benefits

Mitigating negative fallout from emissions and moving towards a low carbon path also stands to lower the human development costs of climate change.[50] Some of these costs will be hard to measure, but they should be considered in weighing abatement options. The Chinese Government has already begun giving priority to climate adaptation programmes, recognizing that strengthening the resilience of communities and societies is cost effective and makes people better equipped to cope with climate change.

Slowing the pace of climate change and environmental damage will ease constraints on human development especially for poor or otherwise excluded groups most vulnerable to climate change. Expected large investments in low carbon technology, including in energy-efficiency projects and renewable energies, can make direct contributions to speeding up human development, such as in the less developed central and western regions of China. For example, renewable energy sources can help provide modern energy sources to poor, rural and otherwise vulnerable groups who currently have limited or no access to these.

New low carbon technologies that reduce pollution will improve human health, protecting people from the spread of disease and limiting new demands for services from health care providers that are already overburdened.[51] For over a decade, the government has been introducing measures to restructure industry and the economy that have made some headway in reducing air pollution. Emissions of sulphur dioxide (SO_2) dropped by some 10 percent between 1995 and 1999. Other studies suggest that annual total suspended particulates in some 140 cities in China fell from a mean of 500 micrograms per cubic metre in 1986 to 300 micrograms per cubic metre in 1997. Some of these improvements have levelled off or even reversed, but there is recognition that this major challenge must be addressed. Aside from harming human health, air pollution may also be a drag on the economy. While more research is needed, some estimates suggest levels cost ranging from 3 percent to 7.7 percent of gross domestic product.

Two basic inputs that people need at all levels of development are food and water; climate change is expected to dramatically affect both of these. According to research, climate change will foster greater fluctuations in agricultural output, and undercut the stability and sustainability of grain production.[52] Mitigation and adaptation thus become part of maintaining agricultural productivity. In the absence of mitigation actions, the productivity of Chinese agriculture may drop by from 5 percent to 10 percent by 2030. Wheat, rice, and maize are the three major crops that will be most affected because of their sensitivity to temperature change.

Among other impacts, higher winter temperatures mean the survival of greater numbers of insects and pathogens, while overall temperature rise has increased the number of insect generations per year.

Losses arising from insect pests in China already account for 20 to 25 percent of total agricultural output value. The Government of China has been increasing research to improve knowledge on links between agriculture and climate change. One area of research that requires more attention involves tradeoffs between land and water for agriculture and other uses stemming from an accelerated rate of urbanization.

Scenario analysis and research indicate that climate change will aggravate the uneven temporal and spatial distribution of China's water resources.[53] Both the quantity and quality of water are suffering from climate variability and resource degradation caused by current production and consumption practices. Based on the RCM-PRECIS model developed by the UK's Hadley Centre, China's multi-year average rainfall in the next 100 years will increase, with growth highest in Fujian Province. But in the northern region of China, temperature rise is expected to aggravate water resource scarcity, worsening drought and semi-drought conditions, and encouraging further desertification. Spring drought affected well over half of the wheat crop in many of China's Northern provinces in 2009. In the central and western areas of Jilin Province, rainfall in the 1990s was 21 percent less than in the 1950s, making the decade the driest for 50 years.[54] Drought has led to soil salinity and serious desertification in some areas, threatening vegetation and human livelihoods.[55]

Water is not only essential to living conditions and physical health, but is also critical for economic development. Insufficient water supply causes an annual economic loss to urban industries of over 200 billion yuan and affects 40 million urban residents. Each year, drought afflicts 200 million to 600 million *mu* [56] of farmland in China.[57] As the Chinese population and economy grow, water resource scarcity will become even more serious. In 2005 per capita water availability was at 2,140 cubic metres, is already less than one-third the world average.[58]

At the opposite extreme, too much water will take a toll along the Yangtze River, where heavy rains and floods are expected to become more frequent and severe. In 2008, the total rainfall in parts of Guangdong and Guangxi provinces was the highest for a century. Severe floods occurred in the Pearl River Basin and upstream of the Xiangjiang River, and caused serious economic losses and human casualties. Sea level rise is another concern, threatening socioeconomic activities along coastlines through flooding and disruptions of marine ecology. By 2050, the 100-year high tides affecting the western coastline of the Bohai Sea and the Pearl River Delta may occur once every 20 and 5 years, respectively. The 100-year high tidal level in the Yangtze River Delta will occur once a decade.[59]

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CHAPTER 2
CHINA'S CARBON FOOTPRINT

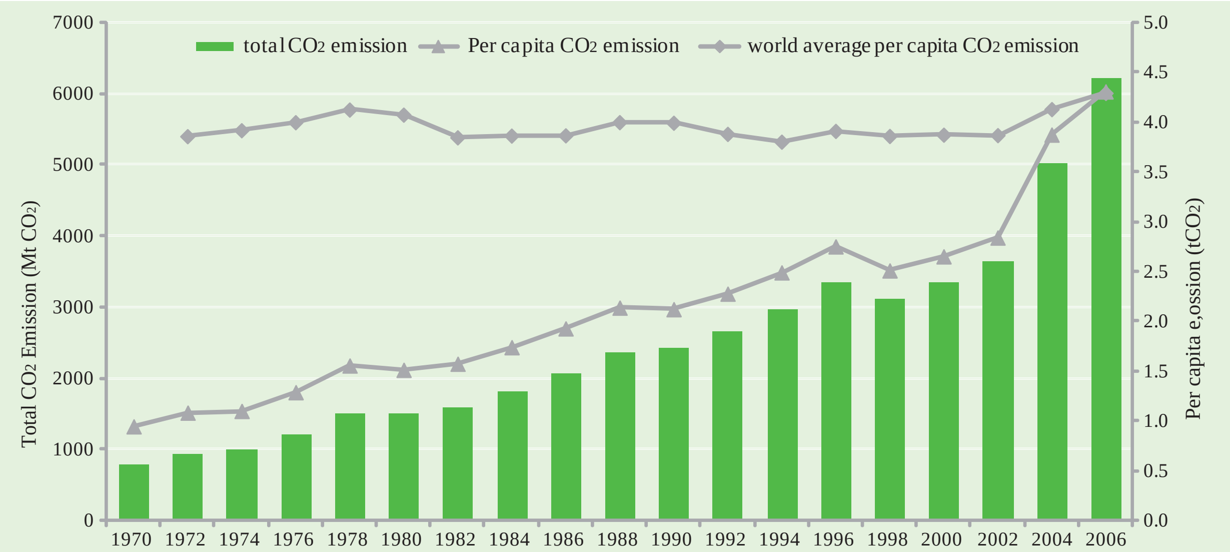
The term "carbon footprint" vividly describes the trace made by direct and indirect emissions of carbon dioxide. It can be applied to a product, service, individual, family, enterprise, organization, country or region. A country's CO2 emissions are estimated by doing an inventory of emissions within the country, but without taking into account that a country's consumption also instigates production and hence pollution outside of the country when goods are imported.[1] In this report, per capita carbon footprint is the amount of CO2 emissions per person; and the product/service carbon footprint indicates CO2 emissions resulting from a product or service as it moves through production, to consumption, to final disposal. Emissions density refers to the total CO2 emissions in a territorial unit, while emissions intensity refers to emissions per unit of GDP. Per capita historical emissions describe emissions over a specific period, and indicate a sense of historic responsibility.[2]

China's total greenhouse gas emissions have grown rapidly in the course of industrialization and urbanization over the past few decades. From 1970 to 2007, the total amount rose over seven times (see Figure 2.1). In 2007, China's overall CO2 emissions surpassed those of the United States and are now the highest in the world.[3] Its per capita emissions level, however, is still far below that of developed countries.

Where China's Emissions Come From

China's industrial sector accounts for a high proportion of GDP and produces over 84 percent of total emissions. Its emissions intensity is higher than that of the agricultural and service sectors. Based on the sectoral classification adopted by the International Energy Agency (IEA), the electricity and heating industries have the highest share of total CO_2 emissions at nearly half of the total, followed by the manufacturing and construction industries with a 31.2 percent share. Transportation and daily life each have fairly low shares (see Figure 2.2).

Figure 2.1 Trends in China's total and per capita emissions (1970-2006)



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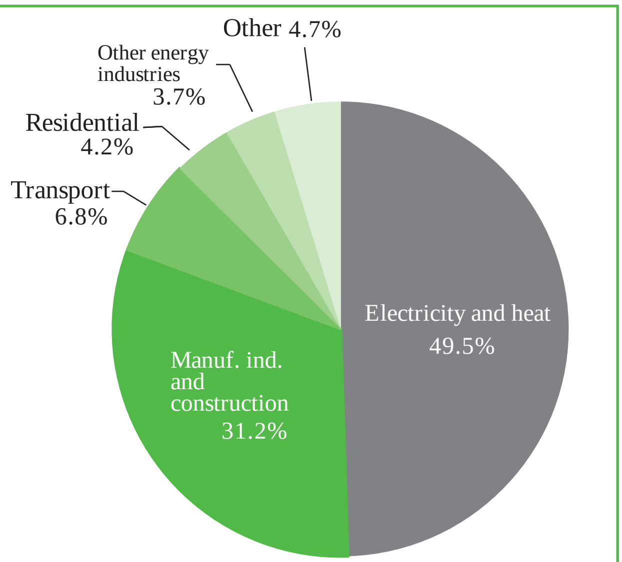
Note: Data on world per capita emissions are available from 1972.

Figure 2.2 How emissions from different sectors compare



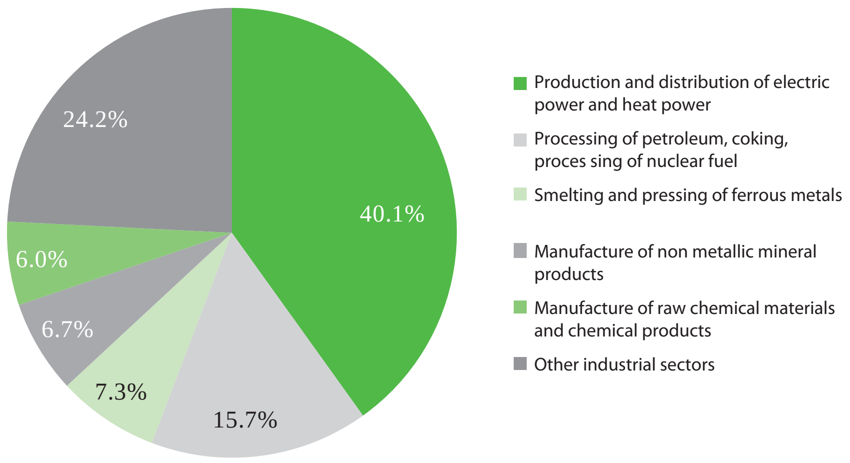
Source: IEA, 2009, "CO2 Emissions from Fuel Combustion Highlights, 2009 Edition." Available at www.iea.org/co2highlights/CO2highlights.pdf (last accessed 19 March 2010).

Under China's own sectoral classification, the top five emitters of greenhouse gases within the industrial sector are electricity and heat production and supply; petroleum processing, coking and nuclear fuel processing; smelting and pressing of ferrous metals; the manufacture of non-metallic minerals; and the manufacture of chemical materials and products (see Figure 2.3). These five industries, which account for 75 percent of the CO_2 emitted by the industrial sector, will thus be a priority in formulating abatement policies.

There are large gaps in emissions within single industries, often due to different degrees of modernization. The growing market economy has put some enterprises on a par with international competitors in governance structure, financial resources and technological competence. Modernized enterprises, particularly those that are state-owned, often boast advanced technologies and low energy consumption per unit of output. By contrast, a great number of medium and small enterprises still use outmoded equipment and technologies that waste energy and produce high levels of emissions. Most of the current manufacturing capacity in China is based on outmoded and energy-intensive technologies.

One example can be found in the thermal power industry. The Zhejiang-based Huaneng Yuhuan Power Plant, which was commissioned in 2006, has four 1,000 megawatt ultra-supercritical generating units. It is the world's largest and most efficient power plant, with a coal consumption rate of only

Figure 2.3 **Major CO_2 emitters in the industrial sector**



Source: National Bureau of Statistics of P.R. China, 2008, "China Energy Statistical Yearbook 2008," Beijing, Statistics Press.

282.6 grams per kilowatt-hours[4] (see Table 2.1). At the same time, a large number of outmoded generators operating below 200,000 kilowatts still comprise a total capacity of 80 million kilowatts.[5] For each kilowatt-hour of electricity they generate, these small and inefficient machines emit 250-350 grams more CO2 into the atmosphere than the most advanced generators. Similarly large emissions gaps exist in the cement and many other industries.[6]

Table 2.1 Average Coal Consumption of Thermal Power Generators

Generator capacity (10,000 kilowatts)	Combined capacity (10,000 kilowatts)	As a percentage of the thermal power generators (6,000 kilowatts and above)	Average coal consumption (grams of standard coal per kilowatt-hour)
60 and above	13,128	25.6%	324
30–60	18,451	35.9%	334
20–30	5,175	10.1%	362
10–20	6,957	13.5%	377
Less than 10	7,646	14.9%	415

Data Source: China Electricity Council, 2007, "China Electricity Statistics and Analysis 2007", Beijing: China Electricity Council Publishing House.

Agriculture does not represent a high proportion of total carbon emissions, despite its prominent role in the economy. It could contribute to capturing and sequestering carbon, thus aiding the mitigation of emissions. Land improvement measures forfarmlands,grasslands and wetlands, for example, could reduce CO2 emissions to the atmosphere by 0.4–0.9 petagrams of coal per year,[7] while newly planted forests nationwide are expected to absorb an estimated 100 million tonnes of carbon by 2020, four times the current level.[8] The carbon sequestration potential of China's 3.9 million square kilometers of grassland—40 percent of national territory—is 23.9 million tonnes per year, or 29 percent of the national total. The serious degradation and desertification of grasslands in the north, however, will constrain this.[9]

China's sectoral emission structure is closely linked to its current stage of economic development. At present, with secondary industry dominating the industrial sector, emissions from industry are much higher than the world average. Emissions from consumption and transportation are still very low.

As China's industrialization process advances, the share of industrial emissions is expected to gradually decline, while the shares of transportation, everyday activities and other sources will rise, propelled by growing demand from China's increasingly affluent population.

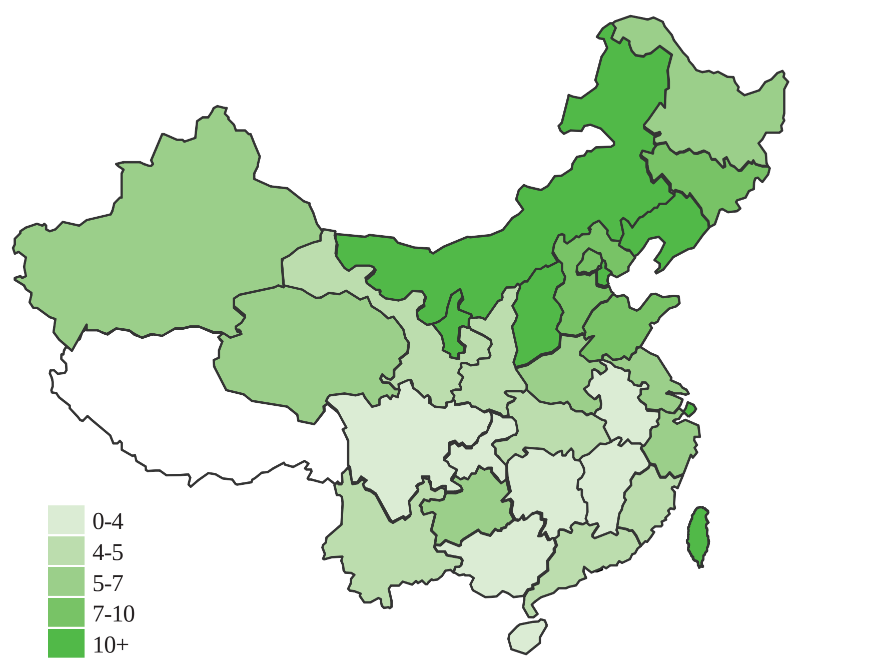
VARIATIONS BY REGION

China's provinces and regions vary widely in their carbon footprints (see Figure 2.4). In 2007, China's top five per capita CO2 emitters were Inner Mongolia, Shanghai, Ningxia, Tianjin and Shanxi. While Inner Mongolia was the highest emitter with a per capita emissions rate of 17.14 tonnes per person, Hainan Province was the lowest, with only 2.65 tonnes per person. The highest was over 6 times the lowest. Overall, per capita emissions in the coastal developed regions are higher than in the inland, less-developed regions, except for Inner Mongolia, Ningxia, and a few other provinces and regions.

In terms of CO_2 emissions density, or emissions per unit of territorial area, the high-density areas are mainly in the most developed regions, that is, the Bohai Rim, the Yangtze River Delta and the Pearl River Delta, where CO_2 emissions density is higher than 2,000 tonnes per square kilometer. Shanghai's density of 33450 tonnes per square kilometer is far higher than in all other provinces and regions, and is 3.24 times that of Tianjin, which is the second-highest. Emissions density in the western region as a whole is below 500 tonnes. In Xinjiang and Qinghai, emissions density is only 88 and 41 tonnes per square kilometer respectively, which is less than 1/350 that of Shanghai.[10]

While the eastern region has higher regional per capita emissions and emissions density than the central and western regions, its emissions intensity is visibly lower (see Figure 2.5). Ningxia, Guizhou, Inner Mongolia and other provinces in the central and western regions are among the provinces with the highest emissions intensity. The distribution of emissions intensity in general is higher in the north-western and south-western regions, and lower in the eastern and central regions. The emissions intensity in the coastal south-eastern and southern regions is notably lower than in other parts of the country.

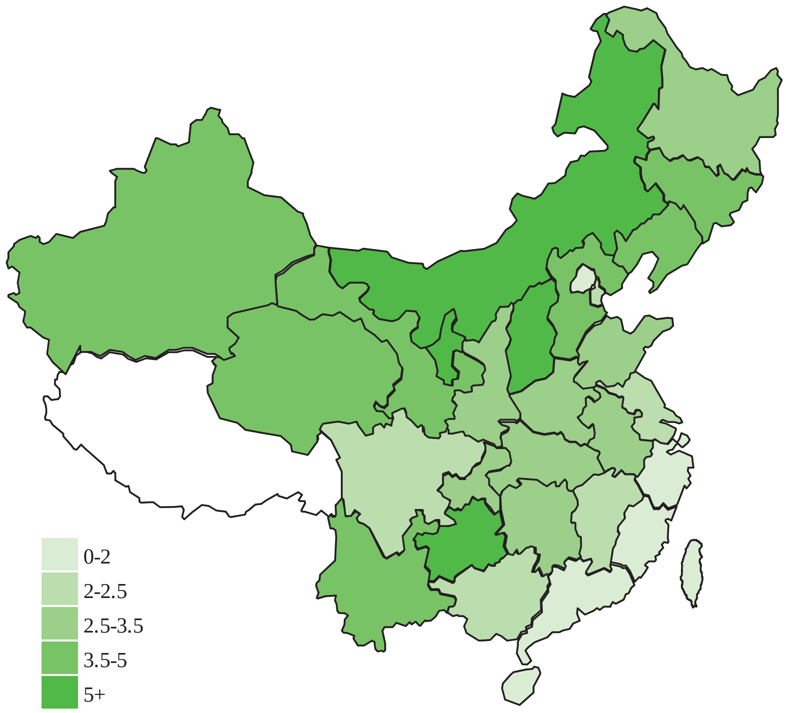
Figure 2.4 **Provincial per capita CO_2 emissions in tonnes (2007)**



Source: Data from China National Bureau of Statistics, 2008, "China Statistical Yearbook 2008", "China Energy Statistical Yearbook 2008," Beijing, China Statistics Press, adapted by Taskforce on NHDR 2009-2010, Renmin University of China.
Note: Data for Tibet were unavailable.

Disparities in carbon emissions among provinces correspond to economic development, the structure of the economy, the level of technology and the regional economic strategy. As the eastern region has levels of economic development and per capita income that are higher than those of the central and western regions, it has greater personal consumption and, consequently, higher per capita emissions. A comparison of per

Figure 2.5 **Carbon intensity in different provinces (2007)CO_2 tonnes per 10,000 yuan**



Source: Data from China National Bureau of Statistics, 2008, "China Statistical Yearbook 2008", "China Energy Statistical Yearbook 2008," Beijing, China Statistics Press, adapted by Taskforce on NHDR 2009-2010, Renmin University of China.
Note: Data for Tibet were unavailable.

capita personal consumer spending in different regions indicates a basic pattern of consumption rates in the eastern region exceeding those in the central region, and both surpassing those in the western region. This applies to both urban and rural residents (see Figure 2.6).

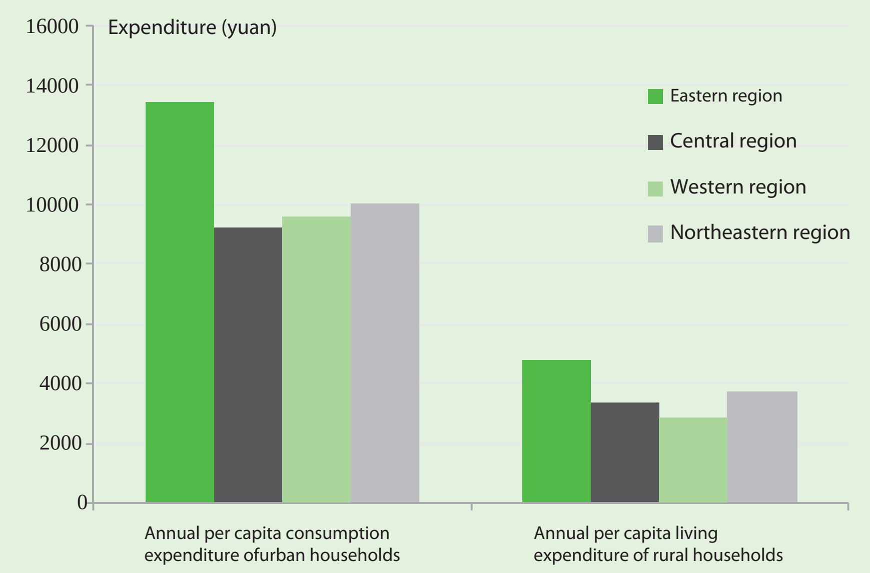
Energy-intensive industries, having higher carbon emissions, account for a relatively high proportion of the western region's industrial structure, while the eastern region has a relatively high ratio of technology-intensive industries featuring high added value, low energy consumption and low emissions. As a result, the eastern region's carbon intensity is lower.

In 2008, China's top five provinces in tertiary industry rankings were mainly in the eastern region. These were Beijing, Shanghai, Guangdong and Zhejiang, all of whose carbon intensity was below 2 t/10,000 yuan, far below the national average, and Guizhou, which has relatively high carbon intensity. The bottom ten provinces in tertiary industry rankings were mostly in the central and western regions; the carbon intensity indicator of each was higher than the national average (see Figure 2.7).

Enterprises in the central and western regions are also noted for their relatively outdated production processes and technologies, and for their low energy efficiencies; they have higher emissions intensity than counterparts in the eastern region (see Figure 2.8). In 2008, all of China's top 10 provinces in terms of energy consumption per unit of industrial added value were in the central and western regions, while the bottom five provinces or municipalities were mainly in the eastern region—an indication of the universally lower level of technology in the western region.

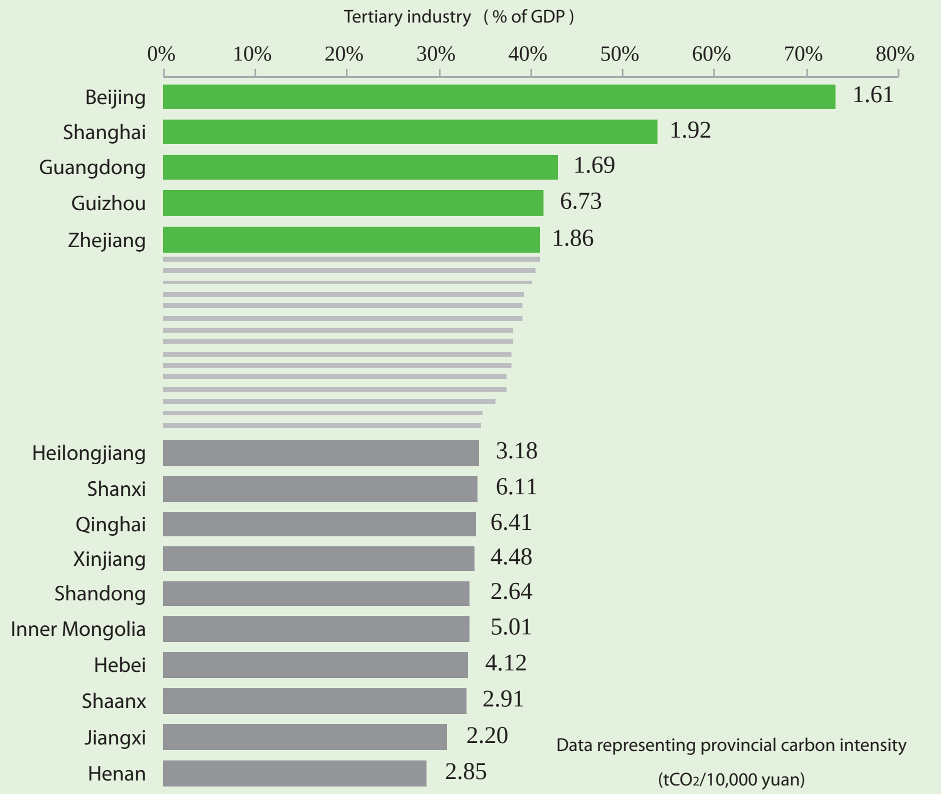
Higher carbon intensity in the central and western provinces can be attributed in part to the national strategic plan for macroeconomic development. Under the existing plan, the eastern region is mainly a net energy importer of energy, while the western region is mainly a net energy exporter. This has led to a spatial decoupling of energy production from energy consumption. Nationally, the eastern region in 2007 produced 11 percent of coal, 37 percent of crude oil, 13 percent of natural gas and 43 percent of electricity. But it consumed between a third and a half of each of these energy sources.[11] At present, provinces with high carbon intensity, such as Inner Mongolia, Shanxi and Guizhou, are the leading exporters of energy and electricity.

Figure 2.6 **Per capita consumer spending by region (2008)**



Source: National Bureau of Statistics of P.R. China, 2009, "China Statistical Yearbook 2009," Beijing, China Statistics Press.

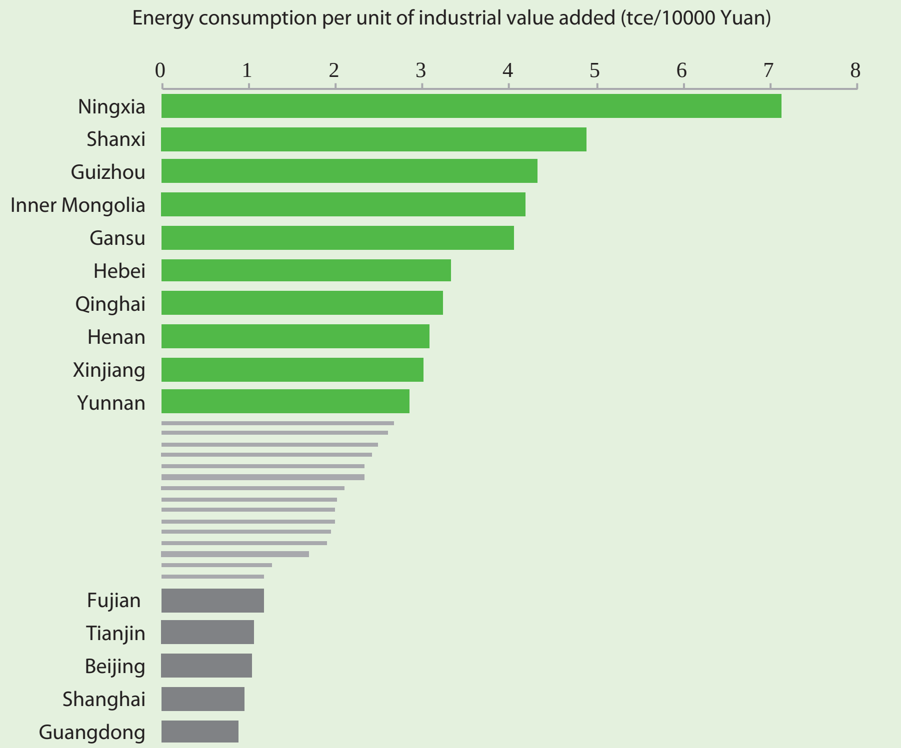
Figure 2.7 **Proportions of tertiary industry by province (2008)**



Source: National Bureau of Statistics of P.R. China, 2009, "China Statistical Yearbook 2009," Beijing, Statistics Press.
Note: Data for Tibet were unavailable.

by rapid economic development, fast-moving industrialization and urbanization. Even though China now has the highest total national emissions in the world, however, per capita emissions stood at 4.58 tonnes in 2007, compared to 19.1 tonnes and 18.75 tonnes for the United States and Australia, respectively. Even in Germany and the United Kingdom, where emissions reductions have intensified, per capita emissions were 9.71 tonnes and 8.60 tonnes, respectively (see Figures 2.9 and 2.10).[12]

Figure 2.8 **Provincial energy efficiency (2008)**



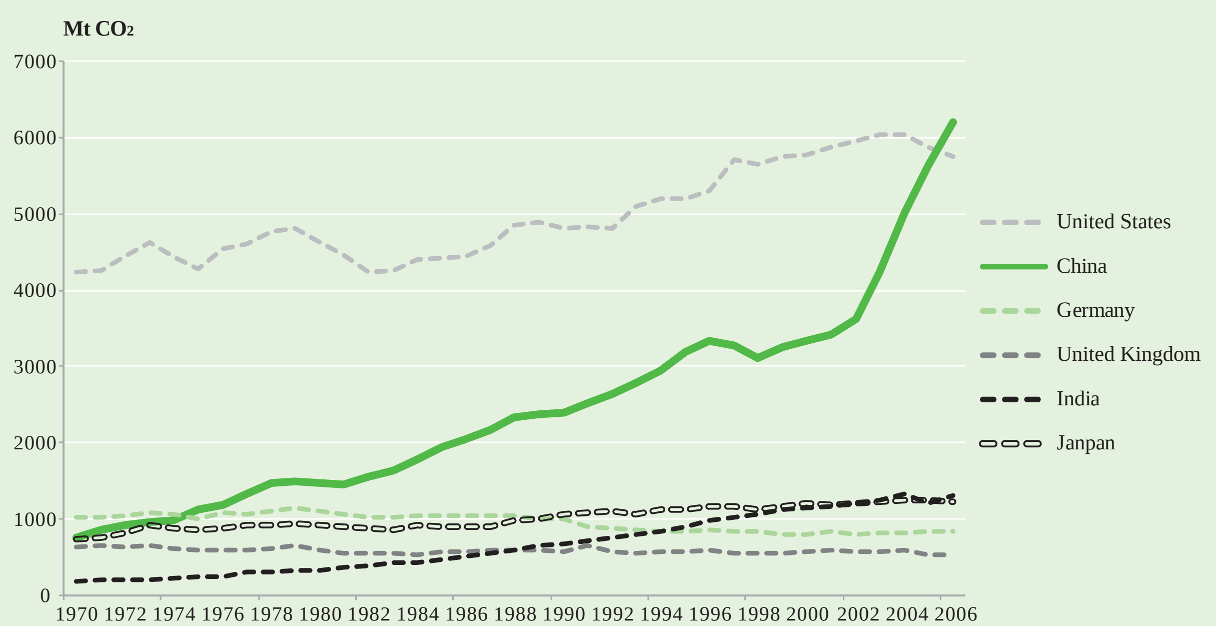
Source: National Bureau of Statistics of P.R. China, 2009, "China Statistical Yearbook 2009," Beijing, Statistics Press.
Note: Data for Tibet were unavailable.

INTERNATIONAL COMPARISONS

Since the beginning of the reform era in China, rising greenhouse gas emissions have been spurred

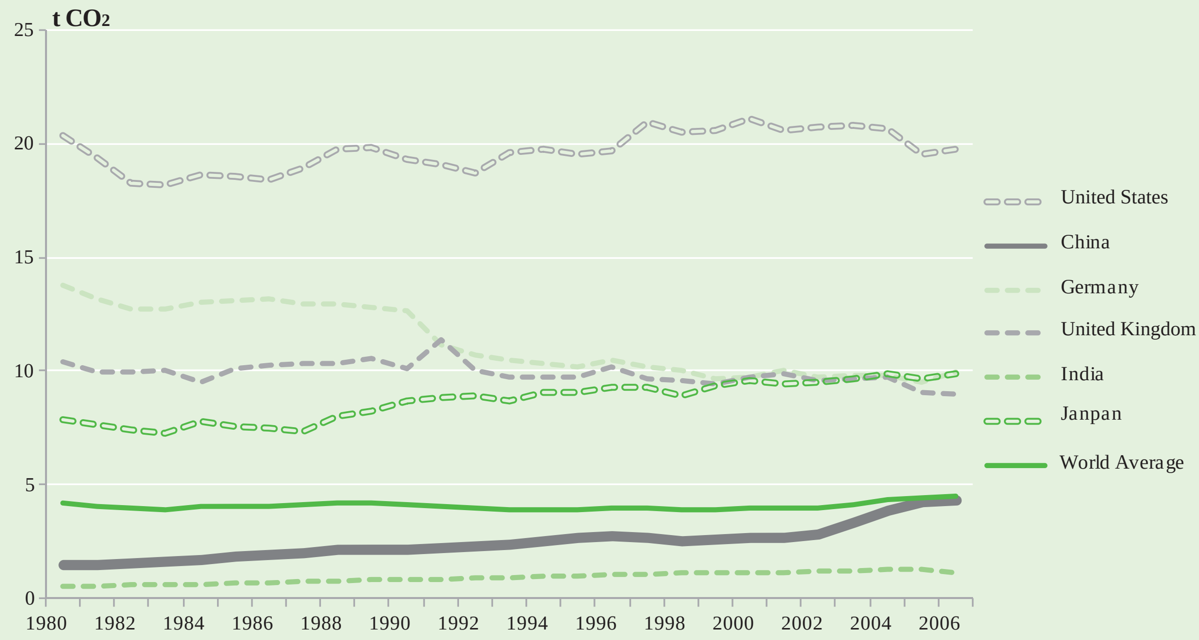
For two centuries, starting with the Industrial Revolution, human-induced greenhouse gases have been released and accumulated at a rate that is much higher than can be cleared naturally from

Figure 2.9 **Cross-country comparisons of total emissions (1970-2006)**



Source: World Resources Institute, Climate Analysis Indicators Tool. Available at http://cait.wri.org/, (last accessed 18 March 2010).

Figure 2.10 **Cross-country comparisons of per capita emissions (1970-2006)**



Source: World Resources Institute, Climate Analysis Indicators Tool. Available athttp://cait.wri.org/ (last accessed 18 March 2010).

the atmosphere. This has led to a gradual build-up of atmospheric greenhouse gases. The impacts of this historical accumulation, mainly in the form of global warming, are expected to be felt well into the future. To clearly identify each country's responsibility for greenhouse gas emissions, there is a need not only to measure the amount of emissions countries are currently releasing into the atmosphere, but also to trace each country's cumulative emissions back to the beginning of the industrialized era.

The majority of the current emissions in the atmosphere have come from developed countries (see Table 2.2). From 1850 to 2006, 1,150.8 billion tonnes of carbon dioxide were emitted worldwide. Industrialized countries and those currently classified as economies in transition emitted 74 percent of the total.

Table 2.2: Historical Emissions by Country, 1850–2006

Country	Historical cumulative emissions (Mt C02)	Per capita historical cumulative emissions (t C02)
United Kingdom	68236	1133.0
United States	333748	1125.6
Germany	80377	974.6
Russia	93082	650.2
Australia	12716	623.3
France	32279	530.3
Japan	44535	348.5
South Africa	12793	272.8
Mexico	11768	114.2
China	99204	76.0
Brazil	9458	50.6
India	27434	25.1
World	1150800	178.0

Source: World Resources Institute, Climate Analysis Indicators Tool. Available athttp://cait.wri.org/ (last accessed 18 March 2010).

In looking at sources of emissions, some complexity has come with the current accelerated rate of globalization, where many products are produced in one country and consumed in another. In recent years increased attention has been paid to the discussion of with whom the responsibility of emissions should be placed: the manufacturer, the consumer, or both.[13] Some claim consumption-based emissions, that is, emissions which occur within the manufacturing country minus the emissions embodied in net exports, is a more accurate reflection of this responsibility than the total gross emissions.

Attracted by low-cost labour and other resources, an increasing number of multinational companies, particularly those in energy- and emissions-intensive industries, are moving their manufacturing operations to China. It is likely that a very large proportion of the ever-growing carbon emissions in China result from production for export to developed countries.[15] It is also important to keep in mind that production for exports has been and is fueling China's economic growth and poverty reduction, thus the production of these goods and therefore these emissions, can not be reduced in the near future. Emissions related to local consumption still rank low internationally.

Table 2.3: Consumption-Based Emissions by Country (1850–2005)

Country	Cumulative consumption-based emissions (Million tones CO2)	Per capita cumulative consumption-based emissions (tonnes CO2)
United Kingdom	71,444	1,186
United States	290,074	966
Germany	69,330	848
France	44,769	735
Australia	10,685	526
Japan	55,631	435
Russia	37,552	262
Mexico	16,680	162
South Africa	6,393	136
Brazil	23,283	125
China	59,331	45
India	38,706	35
World	1,054,922	164

Source: Fang Gang (ed), 2010, "Toward a Low carbon Development: China and the World", Beijing: China Economic Publishing House

Fan Gang et al. have estimated the cumulative and per capita cumulative consumption-based emissions of the world's leading countries between 1850 and 2005 (see Table 2.3).[14] When the measurement of emissions is based on consumption, China has a per capita cumulative emission rate of only 45 tonnes—only one-quarter of the world's average, and much smaller than the production-based emissions of 76 tonnes between 1850 and 2006.

China's goal to reduce energy consumption per unit of GDP by 20 percent during its 11th Five-Year Plan implies conservation of 1,750 metric tonnes carbon equivalent of energy during this period, or twice Japan's annual energy consumption. In 2010, China's absolute value of energy conservation (based on the 2005 energy consumption base per unit of GDP) will be 2.5 times that of the United States, 3.4 times that of the countries of the Organisation for Economic Co-operation and Development (OECD) and nine times that of Japan.[16]

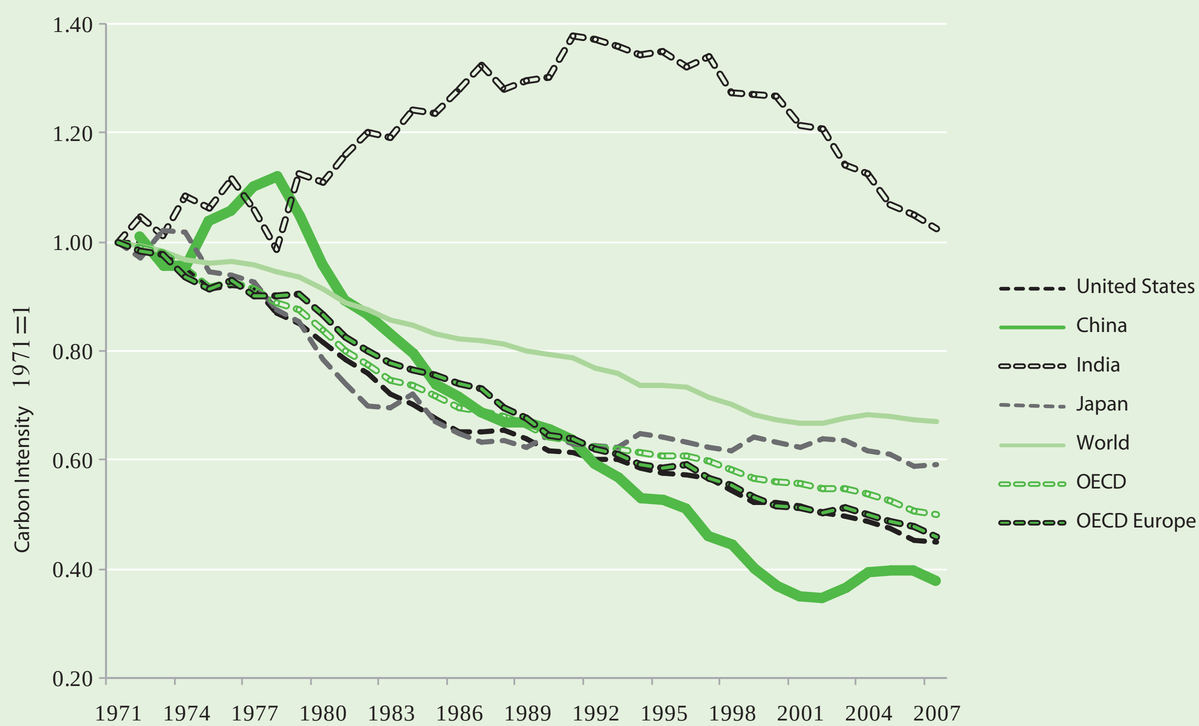
Since 1980, China's carbon intensity has been gradually decreasing, dropping 60 percent, from 6.09 kg of CO_2 per dollar (year 2000 price) in 1971 to 2.31 kg of CO_2 per dollar in 2007. This is one of the best achievements in reduced carbon intensity worldwide (see Figure 2.11). Since 2005, while China maintained a double-digit growth rate, and despite rapid industrialization, the rate of GDP growth has been greater than that of energy consumption.

Shifts Through Human Development

Historical data indicate that the level of human development correlates with carbon footprint. Countries with high human development have larger carbon footprints. Income and consumption rates define the Human Development Index, and income growth and higher levels of consumption can bring major changes to carbon emissions. Direct emissions from everyday energy consumption, such as for private cars, will increase. Indirect emissions from greater consumption of products and services will also rise rapidly and become the main source of carbon footprints if emissions from product manufacturing and services are not significantly reduced (see Figure 2.12).

Increased human development does not automatically mean a spike in emissions. From 1980 to 2006, both Brazil and Mexico rose on the Human Development Index,[17] while the growth in per capita CO_2 emissions was relatively small. Per capita emissions in Mexico went from 3.4 to 4.2 tonnes, and in Brazil increased slightly from 1.6 to 1.9 tonnes.[18] These experiences confirm that sustainable human development models are possible, and provide good reference points for the development of a low carbon economy in China.

Figure 2.11 **Changes in carbon intensity by country (1971–2007)**



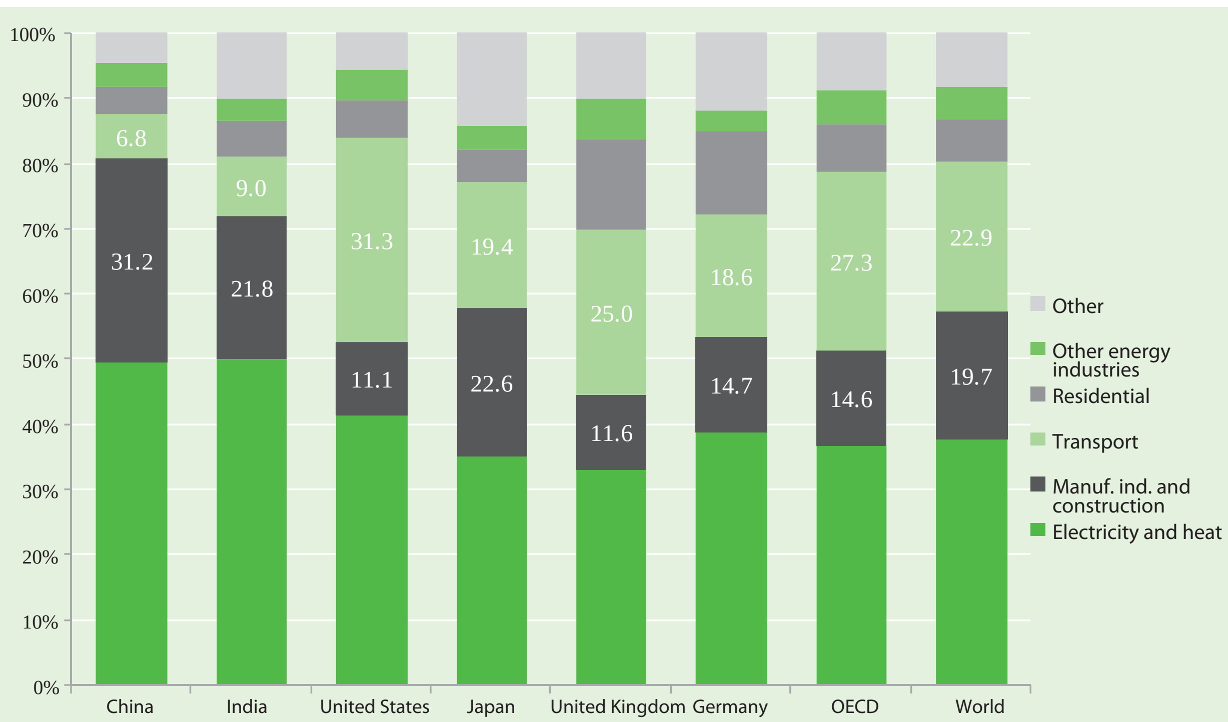
Sources: IEA, 2009, "CO2 Emissions from Fuel Combustion Highlights, 2009 Edition." Available at www.iea.org/co2highlights/CO2highlights.pdf (last accessed 19 March 2010).

One phenomenon that can be observed through international comparisons is that countries with high levels of human development have two different patterns of per capita emissions (see Figure 2.13). One pattern is represented by European countries and Japan, where per capita emissions are relatively low, and the other pattern is represented by Australia, Canada and the United States, where per capita emissions remain high. Whether China's future development path will exemplify "high human development and high emissions" or "high human development and relatively low emissions," or whether China will blaze a new trail of its own, will be vitally important for socioeconomic sustainability in China and action on climate change globally.

Among provinces in China, economic and human development have already begun decoupling from carbon emissions. As illustrated in Figure 2.14, there is a positive correlation between carbon productivity (economic output from per tonne of CO_2 emissions) and the Human Development Index. Guizhou, Qinghai and other provinces in the western region are located in the left-hand lower corner of Figure 2.14, which represents an undeveloped economy, low levels of human development and low carbon productivity. In contrast, the developed provinces in the eastern region are noted for relatively high levels of economic and human development, and their carbon productivity is also visibly higher.

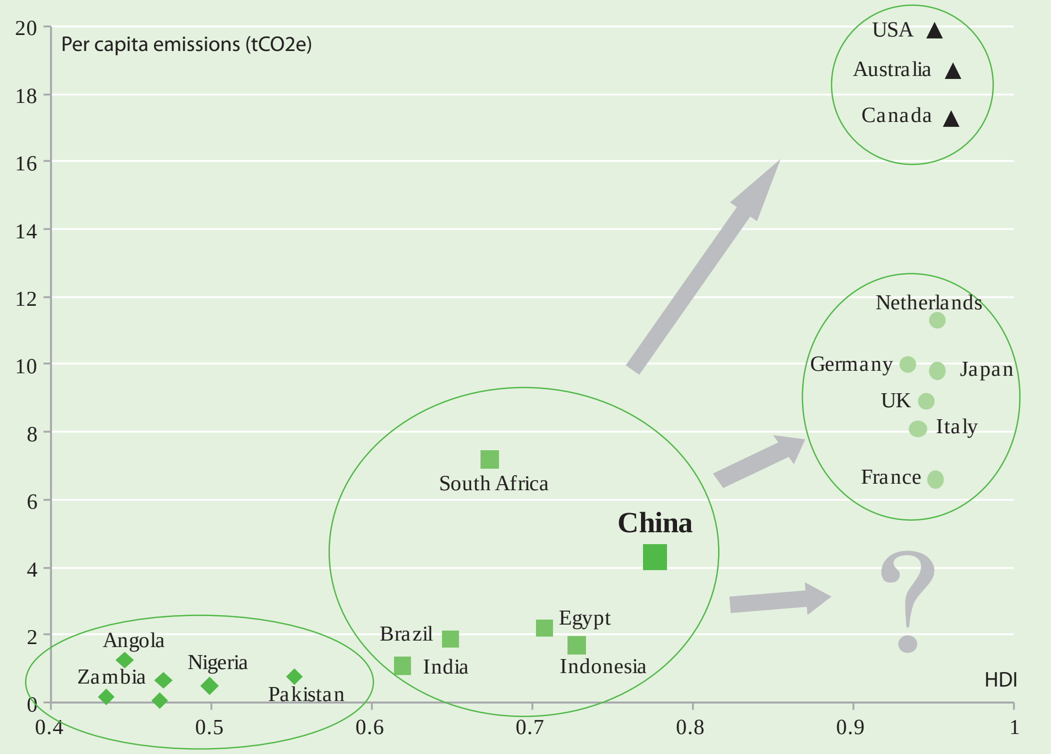
There are three major reasons behind the disparity of carbon productivity between the provinces and municipalities directly under central authority (Beijing. Chongqing, Shanghai, and Tianjin). These are economic structure, technological level and energy — especially electricity import and export. Secondary industry has higher energy intensity than primary and tertiary industry, so provinces with relatively high proportions of secondary industry are likely to have lower carbon productivity. For example, the proportion of secondary industry in Beijing, which is 25.7%, is smaller than that of Shanghai, thus Beijing's carbon productivity is higher than that of Shanghai. Most of the provinces with lower carbon productivities, like Guizhou, Ningxia, and Inner Mongolia (see Figure 2.14) have high proportions of secondary industry, relatively low levels of technology, and export energy and electricity to other regions. Achieving a sustainable low carbon

Figure 2.12 **CO_2 emissions by sector in different countries (2007)**



Source: IEA, 2009, "CO2 Emissions from Fuel Combustion Highlights, 2009 Edition." Available at www.iea.org/co2highlights/CO2highlights.pdf (last accessed 19 March 2010).

Figure 2.13 **Human development and per capita emissions by country (2005)**



Source: World Resource Institute, Climate Analysis Indicators Tool. Available at http://cait.wri.org/ (last accessed 18 March 2010). UNDP, 2008, Human Development Report 2007/2008: Fighting climate change: Human solidarity in a divided world. Available at http://hdr.undp.org/en/media/HDR_20072008_EN_Complete.pdf (last accessed 19 March 2010).

development pathway while maintaining human development progress requires an understanding of the reasons for the large differences between provincial Human Development Index rankings and carbon productivity. There is a clear imperative for diverse policy objectives and priorities throughout the country. Some work on this has already been initiated, and by the end of July 2009, 31 provinces, autonomous regions and municipalities had completed provincial programmes to address climate change.[19] In the process, local governments have gained a more comprehensive understanding of issues such as the potential technical measures and institutional mechanisms to reduce carbon emissions and address climate change. Much work remains to strengthen capacity building, policy formulation and implementation, but the foundation is being laid to avoid the past trajectory of economic and social development bringing damaging environmental and other costs.

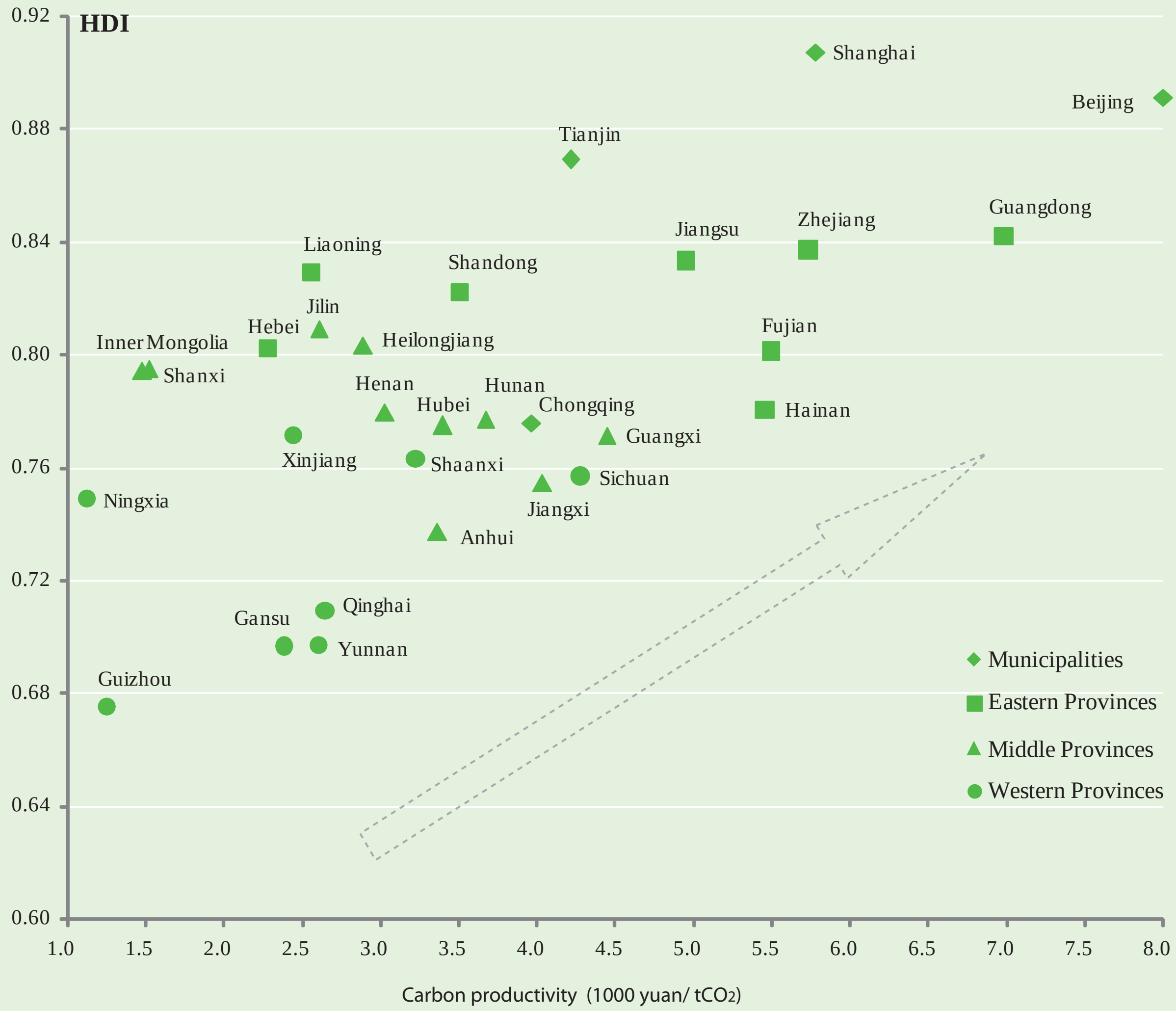
Key Factors in China's Carbon Outputs

The Intergovernmental Panel on Climate Change's Fourth Assessment Report in 2007 emphasized that the use of fossil fuels, land use changes and other human socioeconomic activities are the main drivers of the emissions that cause global warming. Since the 1980s, Chinese and foreign researchers have developed many models for quantitative analysis of emissions to establish links between resources, the economy, technology, population and carbon footprints, and to help develop relevant climate and energy policies. These factors are analysed here in the context of China.

POPULATION AND URBANIZATION

Every industrializing economy and society will experience increasing urbanization. China's urbanization ratio rose from less than 30 percent in 1991 to over 45 percent in 2007, and will continue to

Figure 2.14 Carbon productivity and China's provincial human development index rankings (2007)



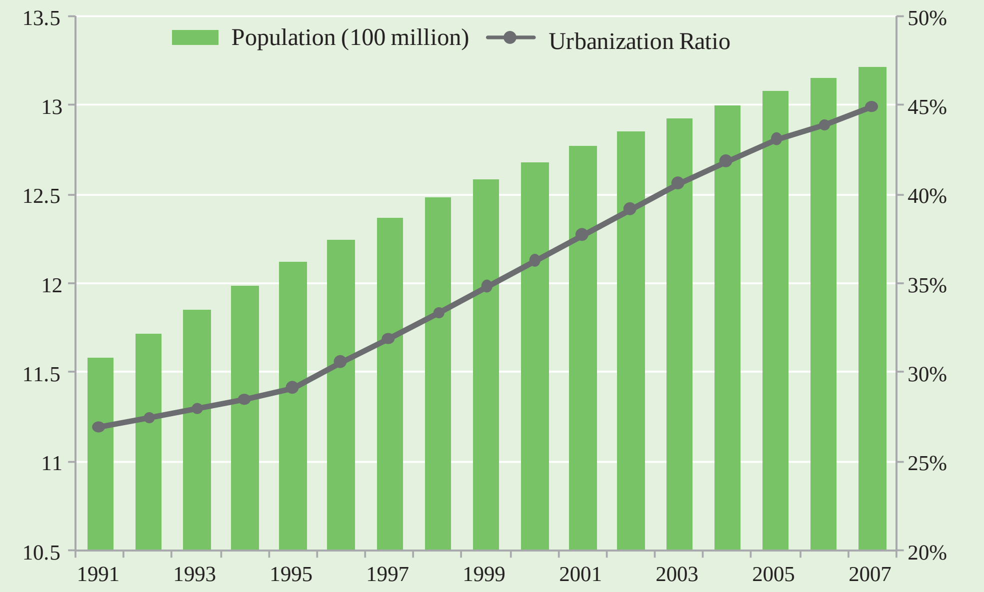
Source: National Bureau of Statistics of P.R. China, 2008, "China Statistical Yearbook 2008," Beijing, China Statistics Press. Provincial Human Development Index data are being developed by the research group.
Note: Data on Tibet were unavailable.

rise (see Figure 2.15). Still, urbanization in China is low compared to that of other countries, especially developed countries. In 2007, the ratio of the urban population was 50 percent worldwide, and over 70 percent in Germany, Japan, the United Kingdom, the United States and other developed countries. Many research studies have forecast that China's urbanization ratio is likely to reach 65 percent by 2030, when its urban population will exceed 1 billion.[20]

In the next two decades, nearly 350 million Chinese people are expected to migrate to urban areas, a number exceeding the current total population of the United States. Since urbanization generally increases emissions (see Figure 2.16), China will face enormous pressures to reduce emissions while economic development and urbanization move forward.

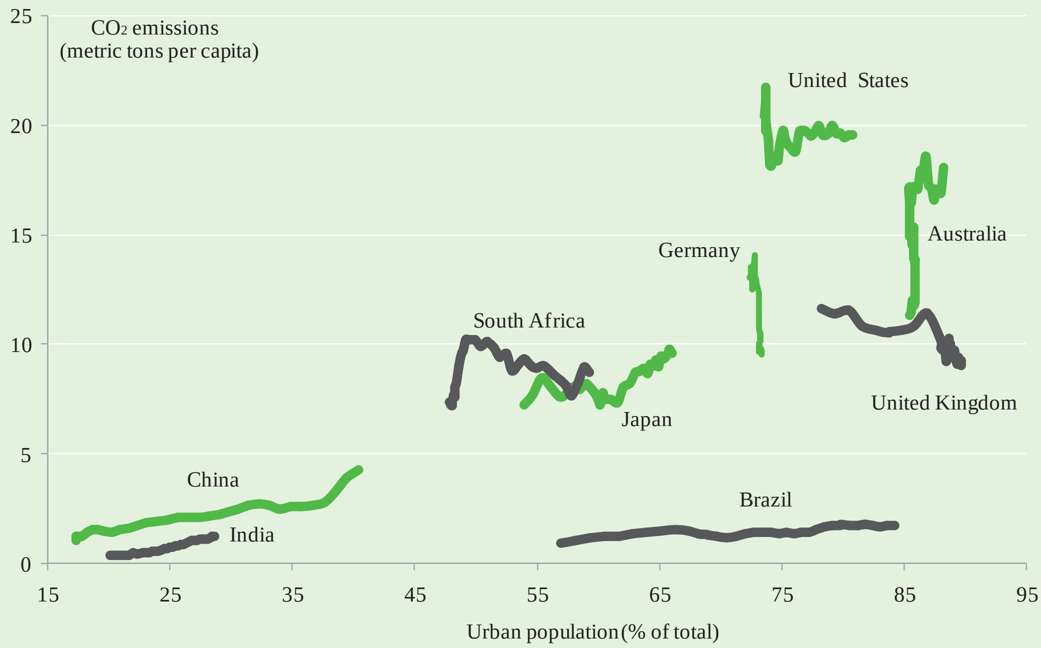
Urban energy consumption typically rises through greater everyday energy consumption and the use of urban infrastructure. As rural populations migrate to urban areas, their income and purchasing power become higher, while the commodity supply in urban areas is richer. Urban families have more home appliances than rural families, for example, and make greater use of them (see Figure 2.17). In 2007, everyday per capita energy use in urban areas in China was 2.1 times that of rural areas.

Figure 2.15 Population and urbanization ratio (1990–2007)



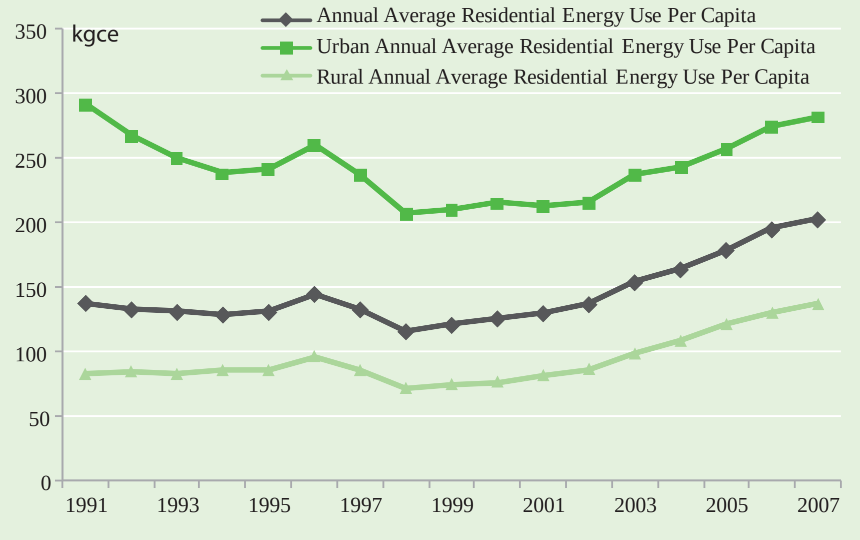
Source: National Bureau of Statistics of P.R. China, 2008, "China Statistical Yearbook 2008," Beijing, China Statistics Press.

Figure 2.16 Urban population ratios and emissions by country (1971-2005)



Source: World Bank, World Development Indicators Database. Available at http://ddp-ext.worldbank.org/ext/DDPQQ/member.do?method=getMembers&userid=1&queryId=6 (last accessed 25 March 2010).

Figure 2.17 **Changes in China's everyday energy use (1991-2007)**



Source: National Bureau of Statistics of P.R. China, 2008, "China Energy Statistical Yearbook 2008," Beijing, China Statistics Press.

To cope with urbanization, China will need to construct an estimated 50,000 new high-rise buildings and 170 new mass transportation systems (compared with 70 such systems currently in Europe).[21] To meet demands for rapid freight growth required for urban construction and city operation and to support consumption in the future, China must increase the building of highways, railways and ports. According to national plans, nationwide railway mileage will exceed 90,000 kilometres and highways will total 2.3 million kilometres in 2010.[22] Expressways will total 65,000 kilometres, an almost 60 percent increase over 2005.[23]

Increased urbanization also triggers large-scale construction of infrastructure and residential buildings, with a corresponding need for huge amounts of cement and steel. There are greater demands for transportation, medical care, drainage facilities, landscaping, and other services. The construction, operation and maintenance of new facilities means more energy consumption. Urban transportation systems force residents to rely on cars or taxis, subways, buses, and other means of public transportation for travelling, all of which consume more energy than traditional rural means of transportation (see Figures 2.18 and 2.19). To control and reduce urban emissions, China needs to vigorously develop public mass transportation, and introduce and enforce strict standards of energy efficiency for buildings and electronic appliances.

URBAN INFRASTRUCTURE

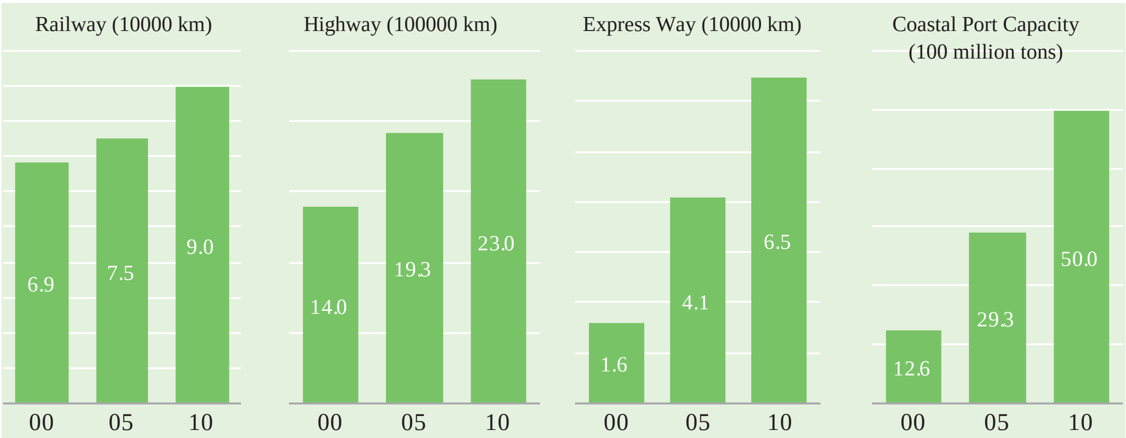
Accelerated urbanization feeds on energy-intensive raw materials such as steel products, cement and chemical materials. Data from China's 2006 Energy Report on projects worth 5 million yuan or more show investments concentrated in high energy-consuming industries. Growth in steel was 96.6 percent, in electrolytic aluminium 92.9 percent, in cement 121.9 percent, in automobiles 87.2 percent, and in coal 52.3 percent.

RESIDENTIAL AND TRANSPORTATION ENERGY CONSUMPTION

With higher living standards and accelerated urbanization, housing demand has continued to rise. Residential buildings now total over 40 billion square metres and will increase by 30 billion square metres by 2020. Nearly 95 percent of existing buildings consume high amounts of energy. Energy consumption for heating, for example, is two to three times what it is in developed countries in the same climatic zones. Energy consumption by buildings accounts for 27.5 percent of total end-use energy consumption. If there are no improvements in the future, the annual energy consumption of buildings will total 1.2 trillion kWh and 410 million tonnes of coal equivalent, nearly three times the country's total current consumption for buildings.

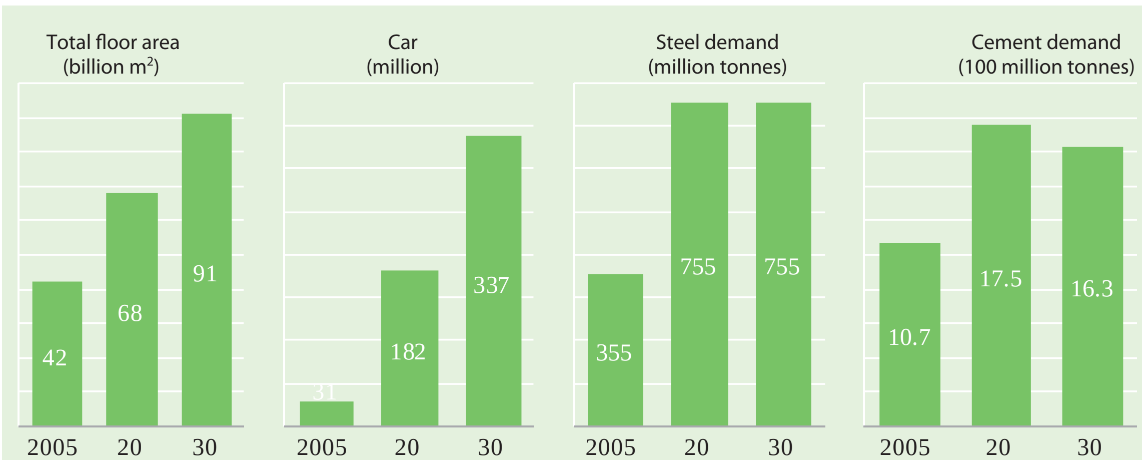
Urban families have started owning automobiles at an increasing pace in recent years. Urban car ownership per 100 families in China was only 0.34 percent in 1999, but has grown at an annual rate of over 30 percent, almost at the same speed as some

Figure 2.18 **Constructing transportation infrastructure (2000–2010)**



Source: National Bureau of Statistics of P.R. China, 2001-2009, "China Statistical Yearbook, 2001-2009" (multiple publications), Beijing, China Statistics Press; Ministry of Railways, Eleventh Five-Year Plan for Railways; Ministry of Transport, Eleventh Five-Year Development Plan for Highway and Waterway Communication.

Figure 2.19 **Variations in demand for building areas, cars and basic raw materials**



Sources: China Statistics Press, 2006, "China Industrial Economic Statistical Yearbook," Beijing, China Statistics Press. McKinsey Global Institute, 2009, "China's Green Revolution: Prioritizing technologies to achieve energy and environmental sustainability." Available at www.mckinsey.com/locations/greaterchina/mckonchina/reports/china_green_revolution_report.pdf (last accessed on 19 March 2010).

home appliances. In 2003, China's automobile oil consumption was about 76 million tonnes, or 28 percent of total oil consumption. Experts forecast that China's automobile oil consumption will reach 130 million tonnes in 2010 and account for 30.8 percent of total oil consumption. The ratio of automobile energy consumption to total end-use consumption is currently 27 percent for OECD countries. China's ratio is now 6.2 percent, and expected to rise.

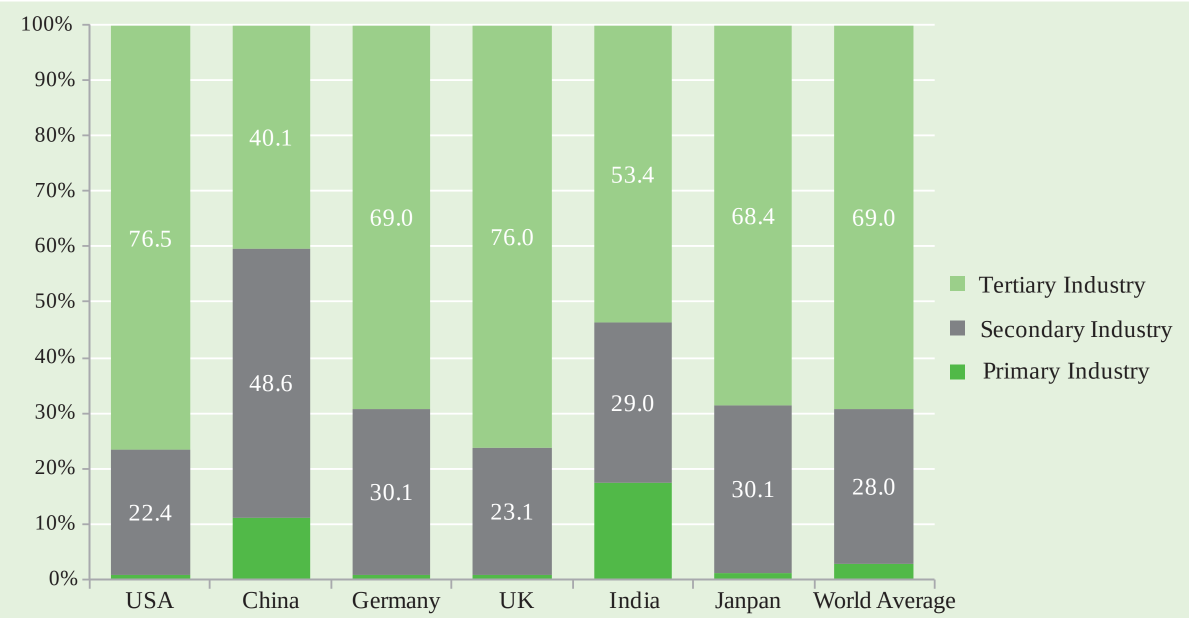
ECONOMIC DEVELOPMENT STAGE AND STRUCTURE

Generally speaking, as a country industrializes, tertiary industry becomes the main driver of the national economy. Compared with developed countries that have already completed the process of industrialization, China is in the middle phase. The proportion of its secondary industry is much higher than that of developed countries, and will likely continue to be so for some time to come (see Figure 2.20).

The industrial structure of China has been increasingly oriented towards heavy industry in the past few years, and the proportion of heavy industry in the economy has grown. Energy consumption per unit of output in heavy industry is much higher than in light industry. Figure 2.21 shows that while the energy intensity of light industry and heavy industry have remained stable, the increase in the proportion of heavy industry promoted the overall growth of energy intensity in China between 2002 and 2005.

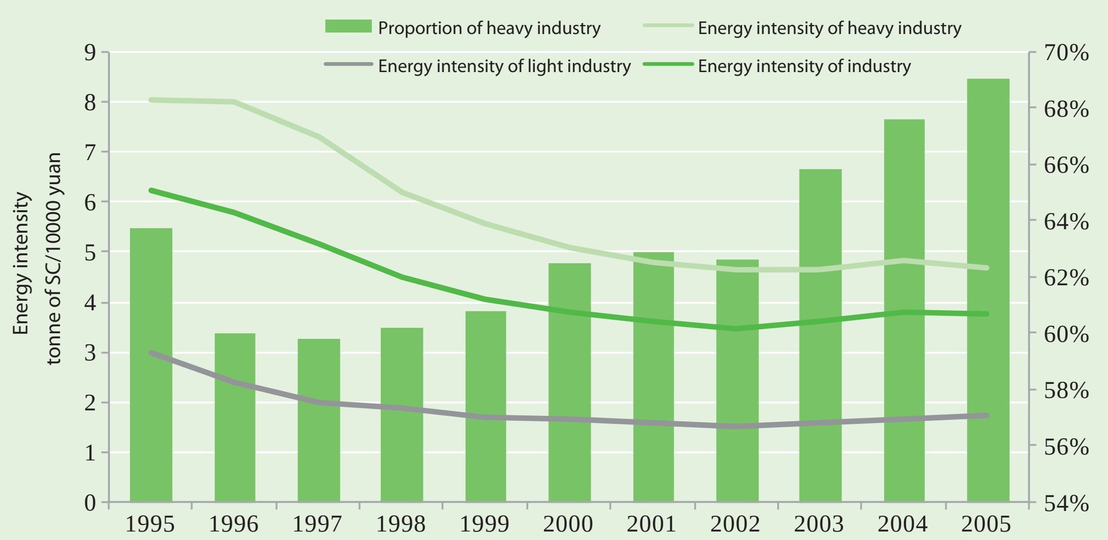
In 2007, the value added of a handful of industries—chemical materials, building materials and cement, power, mining, petroleum processing, and non-ferrous metallurgy—accounted for 37 percent of the total industrial value added and 15.6 percent of GDP,[24] while their energy consumption accounted for 64.4 percent of industrial energy consumption and 45.6 percent of total energy consumption.[25] Between 1990 and 2007, China's production of energy-intensive products increased rapidly (see Figure 2.22).

Figure 2.20 Comparing economic structures of major countries (2007)



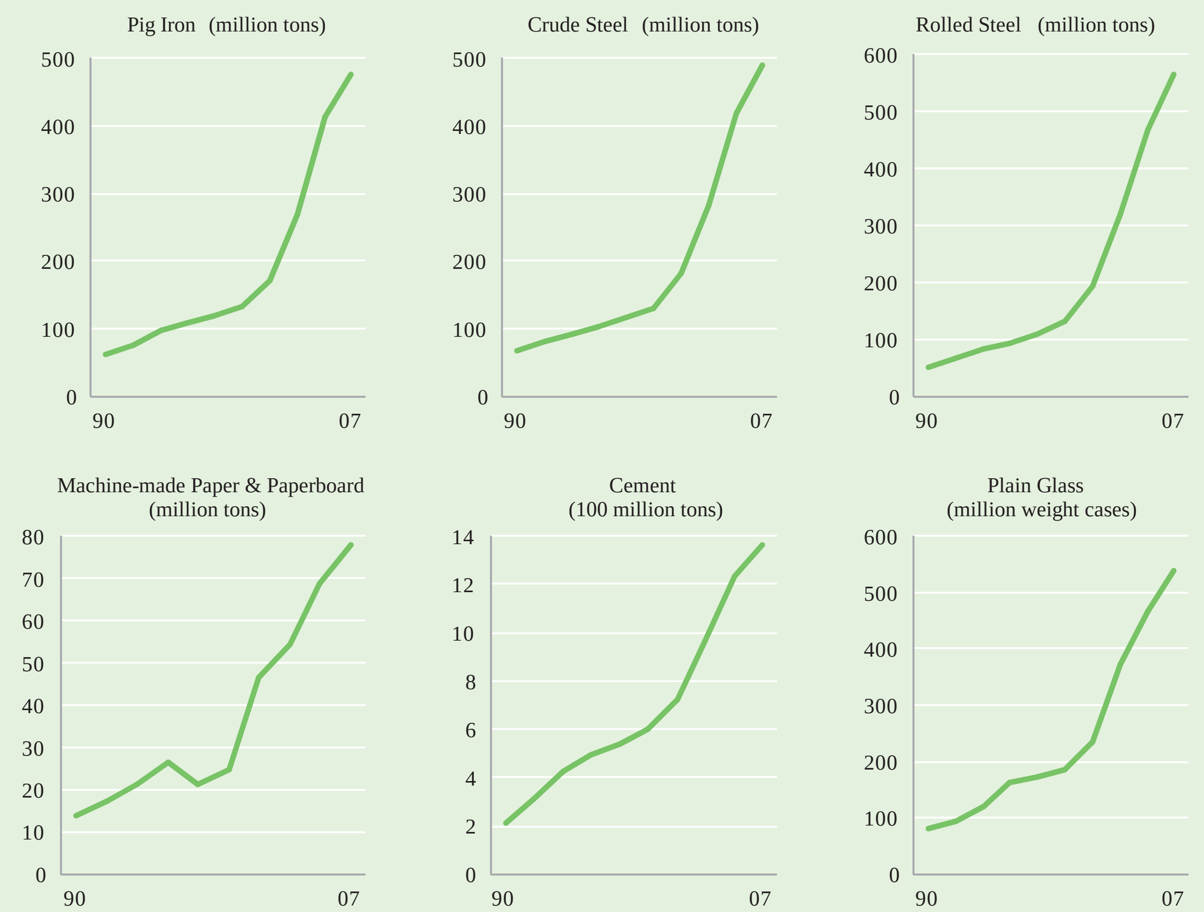
Source: National Bureau of Statistics of P.R. China, 2009, "International Statistical Yearbook 2009," Beijing, China Statistics Press.

Figure 2.21 China's industrial energy intensity and proportion of heavy industry (1995-2005)



Source: Qi Zhixin, Chen Wenying and Wu Zongxin, 2007, "Effect of Light-heavy Industry Structure Changes on Energy Consumption", China Industrial Economy, 2007 (2).

Figure 2.22 **Growth trends in some energy-intensive products (1990-2007)**



Source of data: National Bureau of Statistics of P.R. China, 1991-2008, "China Statistical Yearbook 1991–2008" (multiple publications), Beijing, China Statistics Press.

The Government is cutting back on the excessively rapid growth of sectors that consume high amounts of energy under its goal of reducing energy consumption per unit of GDP by 20 percent. Elimination of outdated production capacity and technological equipment in energy-intensive sectors has become the most important means of modernizing industries and energy use. Statistics show that the copper, lead and zinc metallurgy sectors, respectively, eliminated 1 million, 350,000 and 560,000 tonnes of outdated production capacity through technological transformation in 2006. The outdated self-roasting tank production process, equipment and technology of the aluminium electrolysis sector have been eliminated, and most of the high-energy-consuming wet method kiln processes of the cement sector have been dismantled or shut down. In 2007, government plans were made to shut down small thermal power-generating units with a capacity of 10 GW, reduce outdated iron-works capacity by 30 million tonnes and outdated steel-making capacity by 35 million tonnes, replace the 50 million tonnes mechanical shaft kiln cement and building material production capacity with an equivalent capacity, and further strengthen efforts to eliminate outdated production capacities for aluminium electrolysis, ferroalloys, coke and calcium carbide.

ENERGY RESOURCE ENDOWMENTS

China is one of the few countries in the world whose main energy source is coal. Although the energy structure of China began to show a trend of constant optimization in the early 1970s, coal still occupies a dominant position and a much larger share than in other countries. CO2 emissions for the same thermal output are much higher for coal than for oil or natural gas.

In developed countries such as Japan, the United Kingdom and the United States, energy consumption structures are relatively balanced, with oil usually playing the main role, and natural gas, hydropower, nuclear power, etc. also part of the energy mix (see Figure 2.23). According to the British Petroleum Statistical Review of World Energy 2009, coal accounted for only 29.24 percent of global primary energy consumption in 2008.[26] China's proportion was as high as 70.23 percent. Its energy consumption accounted for 17.7 percent of the world total, while its carbon dioxide emissions related to energy accounted for 21.8 percent of the world total.[27] China's endowment of energy resources will make it more difficult to control its greenhouse gas emissions than will be the case in other high-emitting countries.

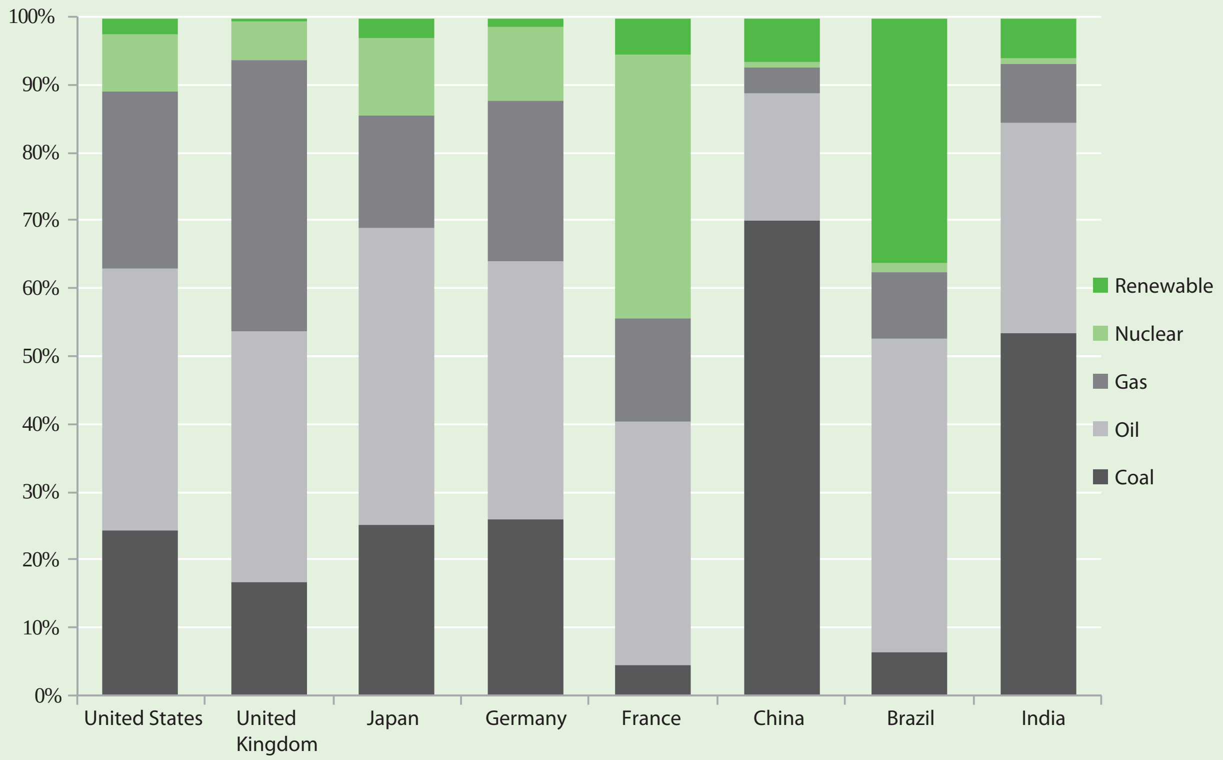
Other developing countries such as India also have a high dependence on coal, but still less so than China, and their proportion of renewable energy, such as from wind power, has increased rapidly in recent years. Brazil benefits from its abundant hydroelectric power resources and biofuels; the proportion of coal in its energy consumption structure is very low.

Although a coal-dominant energy endowment and consumption structure cannot be changed in the short term, China still could make progress in reducing emissions through clean technologies. Hydropower, wind power, solar energy and other renewable energy sources could be developed at a much faster speed to help reduce the reliance on coal.

TECHNOLOGICAL LEVEL

Although China was a late developer of climate-friendly technologies, it has made impressive progress in recent years. The energy consumption of the most energy-intensive industrial products decreased in 2007 over 2000.

Figure 2.23 **Comparison of energy consumption structures of the world's major countries (2007)**



Source of data: BP, 2009, "BP Statistical Review of World Energy 2009". Available at http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2008 /STAGING/local_assets/2009_downloads/statistical_review_of_world_energy_full_report_2009.pdf (last accessed 18 March 2010)

Table 2.4 shows that although China has made remarkable progress on energy efficiency of major energy-intensive industrial products since 2000, it still lags behind the international advanced level. As illustrated in the table, the coal consumption of thermal generators fell from 363 to 333 grams of standard coal; the comparable energy consumption per tonne of steel in key enterprises decreased from 784 to 668 grams of standard coal; and the overall energy consumption of copper metallurgy decreased by more than 50 percent from 1,277 kg to 610 kg of coal equivalent per ton. The energy consumption of China's aluminium electrolysis sector has reached an advanced world level. On a year-to-year basis, the cumulative total of energy saved by China between 1991 and 2004 by adjusting its economic structure and improving the efficiency of energy use is equivalent to 819 million tonnes of standard coal, or a reduction in carbon dioxide emissions of 1.864 billion tonnes.

Table 2.4: Comparing the Energy Consumption of Energy-Intensive Industrial Products (2007)

Energy consumption indicator	China			Advanced international level	2007 Gap	
	2000	2005	2007		Energy consumption	%
Coal consumption of thermal generators (grams of coal equivalent/kWh)	363	343	333	299	34	11.4
Comparable energy consumption of steel (large- and medium-sized enterprises) (kg coal equivalent/tonne)	784	714	668	610	58	9.5
AC power consumption of aluminium electrolysis (kWh/tonne)	15480	14680	14488	14100	388	2.8
Comprehensive energy consumption of copper metallurgy (kg coal equivalent/tonne)	1277	780	610	500	110	22.0
Comprehensive energy consumption of cement (kg coal equivalent/tonne)	181.0	167	158	127	31	24.4
Comprehensive energy consumption of plate glass (kg coal equivalent/weigh box)	25.0	22	17	15	2	13.3
Comprehensive energy consumption of crude processing (kg coal equivalent/tonne)	118	114	110	73	37	50.7
Comprehensive energy consumption of ethylene (kg coal equivalent/tonne)	1125	1073	984	629	355	56.4
Comprehensive energy consumption of synthetic ammonia (kg coal equivalent/tonne) (large-scale)	1699	1650	1553	1000	553	55.3
Comprehensive energy consumption of caustic soda (kg coal equivalent/tonne) (membrane method)	1435	1297	1203	910	293	32.2
Comprehensive energy consumption of sodium carbonate (kg coal equivalent/tonne)	406	396	363	310	53	17.1
Comprehensive energy consumption of calcium carbide (kg coal equivalent/tonne)	NA	3450	3418	3030	388	12.8
Comprehensive energy consumption of paper and paper boards (kg coal equivalent/tonne)	1540	1380	NA	640	650*	115*

*Source: Task Force on 2050 China Energy and CO2 Emissions, 2009, "2050 China Energy and CO2 Emissions Report", Beijing: Science Press. Notes: * denotes 2006 data. International advanced level is the average of the advanced countries in the world. The 2006-2007 energy consumption of steel, building materials, petrochemicals, paper and paper boards is estimated.*

Despite these achievements, China's low carbon technologies are still well behind those of developed countries overall. China ranks first in energy intensity among the world's major countries; its 2005 energy intensity was seven times that of Japan. Even compared with India, also a developing country, China was behind in energy efficiency. China's energy efficiency gaps are expressed not only in energy intensity, as shown in Table 2.5, but also in the energy consumption of nearly all energy-intensive industrial products. This is above the advanced international level, although the disparity has been narrowing. The AC power consumption of aluminium electrolysis and the comparable energy consumption of steel (large- and medium-sized enterprises) are not far below the advanced international level, while the energy consumption of all other products is more than 10 percent higher than the international level.

Table 2.5: Comparing Energy Intensity Levels

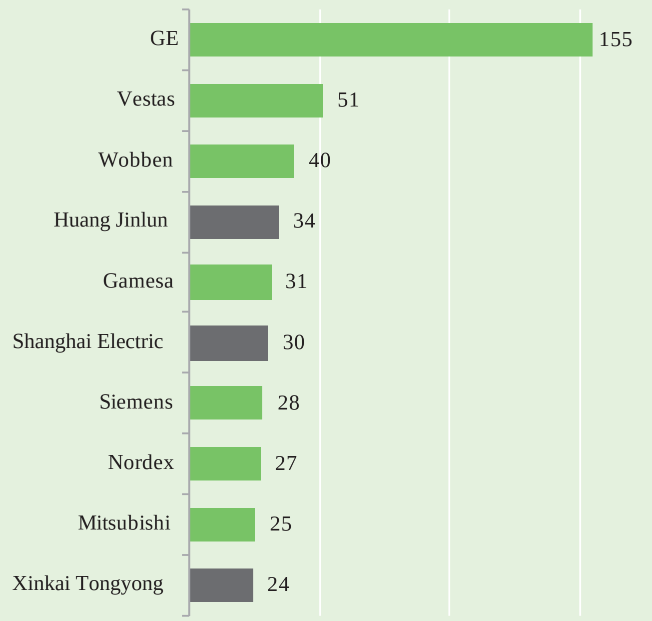
Unit: tonne of coal equivalent (tce) per 1 million US$

	2000	2005
China	743	790
United States	236	212
Japan	113	106
European Union	204	197
India	664	579
OECD	208	195
Non-OECD	603	598
World	284	284

Source: Task Force on 2050 China Energy and CO2 Emissions, 2009, "2050 China Energy and CO2 Emissions Report", Beijing: Science Press. Note: According to the 2000 US dollar value.

China has achieved impressive overall growth in renewable energy in recent years, but it has not acquired corresponding technological capabilities. For example, although the capacity of China's wind-driven generators has doubled every year in the past few years, and the domestic market share of China's wind turbine manufacturing enterprises is more than 50 percent, most applicants for renewable energy-related patents have been foreign enterprise subsidiaries in China. China's top three applicants for wind power patents are all developed country enterprises. Among the top ten, only three are Chinese. Although much wind power equipment is produced by Chinese enterprises, the real owners of the technologies are foreign companies (see Figure 2.24).

Figure 2.24 China's top applicants for wind power patents



Source: The Patent Database of the State Intellectual Property Office of China, 20 November 2009. Available at http://www.sipo.gov.cn/sipo2008/zljs/ (last accessed 18 March 2010)

The development of a low carbon economy and technologies, while major challenges for China, are also opportunities to undertake major reforms that are good for the economy and for human development. As the allowable space for carbon emissions shrinks, low carbon technologies will become the core of future international competitiveness. If it can make important breakthroughs in low carbon technologies, China will improve its technological competitiveness and provide green job opportunities that will help ease employment pressures.

China cannot narrow gaps with the developed world overnight. Against the backdrop of the increasing need to mitigate emissions, it should maintain its independent development of energy efficient and clean energy technologies, while engaging in technological cooperation and mutual support with the international community.

INTERNATIONAL TRADE AND EMBODIED ENERGY

The rapid growth in energy consumption and the emission of greenhouse gases in China not only reflects strong domestic demand, but also is closely related to China's position in global trade. In the process of economic globalization, some resource-intensive sectors have relocated to China, making China "the factory of the world." This results in the direct or indirect export of large quantities of energy resources. In 2005, China exported a net total of 700,000 tonnes of unprocessed aluminium, an amount equivalent to more than 10 billion kilowatt-hours of electricity.[28] More than 55 percent of Chinese exports are manufactured products with low added value. Resource- and energy-intensive products still account for a large proportion of these.

The concept of embodied energy reflects the energy consumption and environmental impact of economic activities from a perspective other than direct energy consumption. With the continuous advance of globalization, it is becoming increasingly common for large amounts of embodied energy and embodied emissions to flow between countries through import and export patterns, causing controversy over who actually "owns" the emissions.

In 2002, China's exports, imports, and net exports of embodied energy, were equivalent to 410, 170 and about 240 million tonnes of standard coal, respectively.[29] They accounted for about 16 percent of China's total primary energy consumption in that year. Net exports of embodied energy increased from 209 million tonnes of standard coal in 2001 to 631 million tonnes in 2006, a relatively stable and rapid growth trend. Preliminary estimates of The Energy Development Report of China 2006 show that China's indirect exports of energy are equivalent to more than 300 million tonnes of standard coal.[30] According to the United Kingdom's Tyndall Centre for Climate Change Research, the carbon emissions from China's 2004 net exports accounted for 23 percent of its total carbon emissions.[31] As a result of the net export of embodied carbon emissions, consumption-based emissions in China are less than actual emissions.[32]

In 2006, the exports of foreign-funded enterprises accounted for 58.2 percent of China's total exports. Foreign direct investment mainly goes to labour-intensive industries that are high-energy-consuming, high-pollution, low-value-added and low-technology industries. This is not conducive to the shift of industrial structure and economic growth that China needs to pursue a transition to a low carbon economy.

The Potential for a Low Carbon Model in China

The process of rapid industrialization and urbanization will continue for the foreseeable future in China. As the economy grows, the pace of urbanization will quicken, and energy and carbon demand will inevitably increase. Since GDP per capita, specifically in rural areas, is low, emissions will continue to rise to meet demand for improvements in the standard of living. Considering the development disparities between the different regions, the emissions of the central and western regions are expected to keep increasing for a longer time. At the same time, there may be opportunities for accelerating low carbon growth in the central and western regions, reducing carbon footprints while promoting social and economic development.

International and Chinese experiences confirm that human development does not necessarily raise greenhouse gas emissions. According to McKinsey figures from 2009, the economic development of China's eastern regions has already started to disconnect from energy consumption.[33] The energy intensity target and the forthcoming implementation of carbon intensity targets under the 11th Five-Year Plan show China's efforts to move towards a low carbon development path. Low carbon investments, improved productivity, the development of high-value-added industrial sectors and the rise of the service industry will all strongly promote growth and help the shift towards a low carbon society. Improvement of energy end-use technologies, construction of low carbon urban transport systems, and establishment of the low carbon-consumption concept will also contribute to future emissions cuts. Based on changing economic growth patterns, a low carbon-intensive human development model should be within China's reach.

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CHAPTER 3

EXPLORING CHINA'S LOW CARBON FUTURE

The move towards a low carbon economy has significant long-term implications for China's economic and social development. Whether the impacts will be positive or negative or a combination of these will depend on how the transition is carried out. This chapter explores different future scenarios for China's low carbon future, and looks at how various goals can be achieved, what technologies are needed, and what the costs and benefits are likely to be.

From a long-term perspective, and given the negative impacts of the current unsustainable growth model, a low carbon economy is the only choice for promoting human development. But the challenges of embarking on a low carbon path, at least in the short term, are considerable. China needs to proceed cautiously, but resolutely, in the face of pressures posed by its large population, the need to create jobs, and the imperative to improve living conditions for the large number of its population still living in poverty.

To maintain and improve upon its human development advancements and achieve its aspiration of becoming a moderately developed country by 2050 with a per capita GDP of at least US $15,000,[1] China will need to grow its economy at a certain pace over the coming decades. Growth in energy use will continue, with increased proliferation of energy-intensive products, more transportation use, and greater construction as important driving forces.

A Framework for Making Progress

Given these demands, progress towards a low carbon economy will require progress on four interrelated fronts: people, cities, technology and markets. People are central as consumers, producers and agents of change. China's cities are major players given ongoing urbanization. Technologies are important in achieving emissions reductions and shifting to a low carbon path. Finally, markets are key to the dissemination and commercialization of the technologies required for low carbon goals.

PEOPLE AND POPULATION

China's large population is one major challenge. It is generally assumed that the government will carry on with its existing policies on population, and that population growth will continue to increase gradually.

Aside from the numbers of people, lifestyle changes as people search for a higher quality of life also spur energy demand. There is easier access to luxury goods and services, modern household appliances and houses. With more affluence comes higher consumption of different foods, for example. Annual per capita consumption of dairy products in 1980 was 1.2 kilogrammes. By 2005, it was 26.7 kilogrammes.[2] In 1995, meat consumption was 25 kilogrammes per person, but it has more than doubled today, to 53 kilogrammes per person.[3] Raising livestock requires large amounts of water. The production of one kilogramme of wheat uses between 1,000 and 2,000 litres of water, while a kilogramme of beef calls for between 10,000 to 13,000 litres.[4] This adds greater pressure to China's already scarce water resources.

China will need to continue to educate its population on sustainable consumer choices and environmental awareness. The challenge, as elsewhere, will be to persuade consumers to purchase the most sustainable and efficient products, and not only focus on price. Of course, a consumer's willingness and ability to do this depends greatly on income.

CITIES AND URBANIZATION

While the rate of developed countries generally is 70 percent or more, [5] China's urbanization rate in 2008 was 46 percent.[6] The group of rural-urban migrants which make up China's "floating population", in 2009 estimated to be 150 million people,[7] are not included in these figures. At present, China is at an accelerated urbanization stage, with a rapidly growing urban population. In 20 years, China's cities will have added 350 million people to their populations, more than the entire population of the United States today.

Per capita urban-life energy consumption for buildings and road transport in China is comparable to levels in the United States in the mid-1950s, and Japanese levels in the late 1960s. If China follows urban consumption trends similar to those of countries in the Organisation for Economic Co-operation and Development (OECD) over the last century, dramatic increases in energy consumption can be predicted.[8] Relevant research on urbanization in China assumes that urbanization levels will reach 55 percent to 58 percent by 2020, and 68 percent to 80 percent by 2050.

Each percentage point increase in the urbanization rate means the shift of about 15 million people from the countryside to cities, accompanied by large-scale construction of urban infrastructure and services, including housing, roads, and water and sanitation systems. There is consequently a large leap in the consumption of steel and cement. Studies show that urban areas currently soak up 84 percent of China's commercial energy consumption.[9] Energy use related to the everyday consumption activities of people in cities grows at a rate of 7.4 percent per year, and will be responsible for increasingly bigger proportions of China's total conventional energy use over the next two decades. Because of this, the Government is giving attention to the construction of sustainable eco-cities, an area with great low carbon potential.[10]

One definition of an eco-city is "a city that provides an acceptable standard of living for its human occupants without depleting the eco-systems and biochemical cycles on which it depends."[11] Creating sustainable communities and low carbon cities will be a long-lasting challenge. With plans to build 50,000 high-rise residential buildings and 170 new mass-transit systems over the next 20 years,[12] China has a unique opportunity to construct eco-cities on a major scale. The alternative is being locked into inefficient and ultimately expensive systems for many years to come. Cities need energy-efficient buildings, and ecologically friendly water, power and transport systems. Their inhabitants must also be able to live and consume sustainably.

TECHNOLOGIES AND INDUSTRIAL STRUCTURE

Technology will play a major role in the transition to a low carbon economy. There are sufficient technological advances at this point that can make a substantial impact on emissions reduction, and create incentives for the next wave of necessary technological advances to deliver on the promise of sustainable, prosperous lives. Investing in advanced technologies now could avoid lock-in effects in the energy sector.[13]

China is already embarking upon a low carbon pathway and has become a leader in renewable energy technologies, yet like many other countries, it faces technological constraints. Moving forward, it will need to take measures such as eliminating outdated production capacities, adopting efficient energy-saving technologies, improving the energy infrastructure, making major efforts to develop renewable energies, strengthening the country's innovation and technological capacities through increased investments in research and development (R&D), and aggressively pursuing the commercialization and scaling up of carbon capture and storage (CCS).

At the same time, China needs to ensure that this shift is carried out not at the expense of human development, but in support of it. This will require a well-coordinated approach, so that low carbon investments simultaneously address pressing human development needs in an orderly transition. China has already implemented many measures that, in effect, have set the country on the path to lower carbon growth, such as through the specific goals for energy and resource intensity in its 11th Five-Year Plan.[14] But much more needs to be done, including through expanded research, to explore how this shift can best take place.

Among the areas targeted by China for change is its industrial sector. Its economic progress depends on intensive energy use and carbon production, but China is targeting it for restructuring while ensuring that it satisfies export sector and domestic consumption demands. Growth in domestic demand is expected to become one of the main pillars of the economy and a more important driver of economic growth by 2030. By that time, the competitive capacity of China's conventional manufacturing industry will likely weaken due to rapidly rising labor costs. In its industrial restructuring plans, China will need to introduce effective measures to ensure a gradually improved competitive capacity with a new generation of advanced industries and a more prominent role for the service sector.

THE ROLE OF MARKETS

Given its high rate of growth, the investment needs of China are immense. The energy investment needs alone, in the short, medium and long term are staggering. According to the World Energy Outlook (WEO), China is soon becoming the largest energy consumer in the world overtaking the United States which is now the largest consumer.[15] Despite its large coal deposits on which it now depends for a large portion of its energy needs, China needs to import increasing levels of natural gas, oil and most recently, also coal, making China, for the first time ever, a coal importing country. In addition to the needs in energy sources to meet its primary energy demands, China also needs to import technologies to keep its energy systems operating, technologies and equipment to upgrade and replace obsolete capital stock, and technologies and equipment to expand its industrial base. Much of this will come via investments from abroad as well as from domestic investments. According to the WEO, the projected cumulative investments in energy supply infrastructure alone will amount to $3.7 trillion (2006 US dollars) in the period 2006-2030.[16] It is expected that seventy five percent of these investments will need to go to the power sector. Many of these investments are and will continue to be funded by resources generated domestically. However, a large portion will need to be funded from resources attracted from investors and funding from abroad.

During the past twenty years, China's ability to attract foreign direct investment has been one of its major success stories. Since the early 1990s, China has been the destination of choice of all developing countries. Even in 2008 and 2009, during the peak of the financial crisis, the levels decreased but the foreign direct investment continued at high levels. The large scale of foreign direct and domestic investments for energy and related sectors, for industrial production and for infrastructure, presents both challenges as well as a major opportunity for China. Whether and to what extent China turns these large investments into opportunities rests on whether China is able to ensure that many of these are channeled to activities that promote low carbon development rather than investments in enterprises that will lock-in China in inefficient and obsolete production systems – systems that in turn will remain active for decades to come.

In order to ensure that these investments go to the "right" places, China has at its disposal a number of policies and policy tools to help leverage the many determinants of investments and particularly foreign direct investment in its favour and most importantly, to ensure that they are supportive of a lower carbon development. This is not always an easy task in China given its increasingly market-oriented and decentralized economy. In order to ensure that these policies and policy tools lead to the "right" outcomes, China would need to ensure that its pricing and taxation policies are supportive of low carbon development. And for this to happen, prices would gradually need to factor in the costs of environmental damage caused by various fuels. And taxes would need to gradually be introduced to provide signals to consumers and producers of the need to invest in clean technologies while meeting human development objectives.

During the past few years, China has also become a big magnet for the newly created so-called flexible or market mechanisms established in the context of the climate change regime and the parallel and voluntary carbon markets that have emerged as a result. The carbon market in China is the world's largest and most dynamic. It is one more tool that the country has at its disposal to promote its low carbon development goals.[17] China's share of the Kyoto Protocol's global market-based Clean Development Mechanism (CDM) is about 35 percent. This in turn gives China a 56 percent market share of CDM credits, or certified emissions reductions (CERs), as Chinese projects on average are larger than those in the rest of the world. On a quarterly basis, China added up to three times more CDM projects than even a large county like India to its pipeline in 2007 to 2008. Most of the pipeline projects are concentrated in eastern China. In the future, China would need to explore creating incentives so that more projects can also emerge n the western regions, where new impetus for development is more urgent.

The Chinese Designated National Authority and other involved institutions have been the backbone of the CDM market's development, and have transmitted a clear signal of political support attractive to international investors. To enhance security for sellers, China has set a carbon floor price of €8 per CER.[18] Market-oriented regulatory measures support technology transfer and the development of projects in priority sectors and regions. The former encompass renewable energy, energy efficiency, and methane recovery and utilization, coinciding with the country's general development goals. Taxation of CER revenues is an extremely efficient market control tool to steer project types and locations, and supports important developmental issues connected with carbon markets. A National CDM Fund, using tax revenues from existing CDM projects, stimulates the CDM market with financial incentives for new projects. These are selected based on their contribution to human, sustainable and low carbon development.

The carbon market is undoubtedly a profit-making business. This is both good news as well as bad news for some. Global buyers prefer projects generating high volumes of CERs, which means less attention to community-level projects where high human development dividends can be achieved. Nevertheless, within its portfolio, China has tried to prioritize projects that offer environmental and economic benefits, possess technical and financial capabilities, and are based on new technology. Some projects with social development dividends, such as biomass power and biogas power, are also interesting for CER buyers. More and more projects in this category should become part of the new portfolio so that China can take full advantage of these facilities.

In addition to the formally established compliance mechanisms, the voluntary markets have also experienced rise in China. This voluntary carbon market is still scattered, but demand and supply are increasing, especially after the establishment of different carbon exchanges, such as those in Tianjin, Beijing and Shanghai. Though much smaller than the compliance market, the voluntary market may have an increasingly attractive scope in China. This growth would be led by the private sector through the exchange of verified emissions reductions (VERs) across a wide range of technologies and project types. With fewer controls, prices in this market vary greatly, from US $1.80 to US $50 per tonne CO2 equivalent, but this does not appear to be impeding growth of the market. It along with the offsets from all sectors could grant China additional flows of funds for financing human development, especially in low-income communities.

Three Low Carbon Scenarios

At the end of the day, the question of course still stands: what will it take for China to adapt a low carbon path to development? To address this question, this report explores three scenarios: the Business As Usual (or the reference scenario), the Emissions Controls Scenario, and the Emissions Abatement Scenario (for an explanation of the scenario research, see Box 3.1). To explore these scenarios, this report utilized the Programme of Energy and Climate Economics (PECE) Technological Optimization Model (for an explanation of PECE model, see Annex 3.12 and Annex 3.13). PECE is one approach used for analyzing low carbon goals under different development scenarios, the technologies needed to achieve the goals and the corresponding costs. This approach has been selected to benchmark some of the issues involved in a low carbon strategy in China.

Box 3.1: How to Interpret Scenario Research and the PECE model

Scenarios provide glimpses of what the future holds under certain assumptions. A scenario is not a prediction, but an inference based on certain hypotheses. It is virtually impossible to predict greenhouse gas emission trends, as they are the result of a very complex dynamic system that comprises population dynamics, social and economic development, technological progress, and other factors. Depending on the assumptions made regarding these factors, quite different emissions trends are possible.

The PECE model has been applied in this report for the following three reasons. First, it is based on a bottom-up methodology which has been widely recognized as an approach to reflect information on technology options for GHG and pollutant abatement. Second, it may reflect a range of constraints in terms of change in the primary energy mix, penetration limits of specific technologies, and potential for energy service based on assumptions on future socioeconomic development and population change, given an objective function to reach established emission reduction targets with least cost by a standardized modeling exercise for optimization. Third, this modeling exercise may provide interlinked information on future GHG emission and corresponding primary energy mix, technology needs, incremental investment and abatement cost which are relevant for policy debates and roadmap development for future low carbon development in China. Furthermore, the PECE modeling process incorporates the assumptions and parameters which are consistent with the authors' understandings and knowledge on the storylines of socioeconomic development and corresponding energy service, technology change, and dynamics of primary energy mix in the context of the Chinese development agenda and circumstances. Moreover, based upon a comparison with other major modeling team in the world (see Annex 3.6 Comparison with similar research studies) the authors of this report find similarities and differences among different modeling exercises.

Source: Y. Matsuoka, et al., 1995, "Scenario Analysis of Global Warming Using the Asian Pacific Integrated Model (AIM)," Energy Policy, 23(4-5), pp. 357-371.

The scenarios explore the technological and incremental cost implications of three different policy objectives and their consequences for emissions, energy demand, electricity generation, and energy mix. All three scenarios use a common set of parameters and baseline assumptions, which include the following:

- With 2005 as the base year, and 2020, 2030, and 2050 as the target years, the research surveys the most cost-saving emissions reduction plan that meets demands for both energy supplies and emissions reduction.
- GDP growth rate over the next 50 years, the rate will decelerate from 9.5 percent at present to 5.5 percent between 2020 and 2030, and further to about 3.5 percent between 2040 and 2050 (see Table 3.1 and Box 3.2).
- Population will reach a peak of 1.54 billion between 2030 and 2040 and decrease to 1.50 billion by 2050 (See Annex 3.1 for details)
- Urbanization rate will be 70% by 2050 (See Annex 3.2)
- In terms of the economic structure, the proportion of agriculture (the primary sector) as a share of GDP will decrease, while the proportion of industrial sector (the secondary sector) will reach a peak (about 50 percent) between 2010 and 2015 and then begin to decrease thereafter. The proportion of tertiary service sector will rise to about 60 percent by 2050. (See Annex 3.3)
- The demand for various energy-intensive products is expected to reach a peak between 2020 and 2030 and then decrease, while the demand for buildings and transportation is expected to keep increasing (assumptions for the energy service can be found in Annex 3.4).
- Covering 388 technologies in the energy-intensive sectors of power, industry (steel, cement, chemical industry, and other industries), transportation, construction, etc., the research not only surveys the existing mature technologies and potential technologies likely to have a major positive effect on future emissions reductions, but also forecasts the future development trends of these new technologies as well as cost changes based on current R&D.

The scenarios are set according to the degree of emissions control while fully taking account of future demand for social and economic development,

Table 3.1: Assumptions on GDP in PECE

		2005	2010	2020	2030	2040	2050
GDP	(US $100 million, constant 2005 value)	23,601	37,154	70,400	120,253	186,750	263,429
GDP growth rate	%		9.5	6.6	5.5	4.5	3.5
Per capita GDP	(US $, constant 2005 value)	1,805	2,732	4,855	7,911	12,127	17,562

Box 3.2: A Lower Rate of Growth

The GDP growth rate is an important indicator affecting future emissions of greenhouse gases. During 30 years of reform, China's GDP has increased at a fast 9.5 percent on an average annual basis. It is generally assumed that this high rate of growth will continue for some time, but will eventually drop due to economic restructuring, a decreasing fertility rate and demographics, among other factors.

Based on the above considerations, the PECE scenario studies in this report sets a GDP growth rate that is lower than those adopted by many other studies, but still ensures a certain level to meet demand for employment and other human development needs

supply of energy services (including energy-intensive products), building area, passenger traffic volume and freight traffic volume, etc. They also incorporate end-use energy consumption and supply technologies. Below the three scenarios are summarized in separate boxes to provide an easily accessible overview of the principle conclusions of the scenarios, followed by a more detailed presentation of the scenarios according to the topics discussed, including CO_2 emissions, energy demand, electricity generation, and energy mix.

The Business As Usual (BAU) Scenario (Reference Scenario)

China's energy-related CO_2 emissions will increase rapidly to 11.4 billion tonnes in 2020, 13.9 billion tonnes in 2030 and 16.2 billion tonnes in 2050, and will not peak before 2050.

Policy Objectives – Under the Business as Usual scenario, policymakers recognize the primacy of economic growth and development, but imposes certain extra policies that include eliminating outdated production capacity, adjusting the economic structure, etc. Compulsory emissions reduction measures, such as collecting energy and carbon taxes are not put in place.

Technological implications - Current mainstream technologies, e.g. supercritical and ultra-supercritical technology are expected to become more efficiently and broadly used.

Energy Demand - Under the BAU scenario, energy demand will increase by 2.6 percent per year between 2005 and 2050, and reach 7.1 billion tonnes of coal equivalent by 2050—an overall increase of 220 percent. The average growth in demand between 2010 and 2020 is 4.3 percent, before slowing down and tapering off to an average 1 percent per year from 2030 to 2050. Under this scenario, coal will remain the dominant source of primary energy, but with a smaller share. Oil will still be the second largest fuel with lightly raised share. Demand for natural gas, nuclear power, and non-hydro renewable energy technologies will increase sharply, but their shares are still insignificant. The share of hydropower will remain almost constant.

Electricity Generation - More specifically, total electricity generation will rise from 2,494 terrawatt hours (TWh) in 2005 to 12,360 TWh by 2050. The share of coal and oil use in total electricity generation will decrease (the figures in relation to the demand for power generation and installed capacity under the different scenarios can be found in Annex 3.5). Coal-fired generation will grow 4.4 times between 2005 and 2050. Therefore the construction of 1,243 GW of new coal-fired capacity will be necessary. Natural gas-fired electricity generation will increase from 12.3 TWh in 2005 to 358 TWh by 2050.

Meanwhile the shares of non-hydro renewable energy, gas-fired generation and nuclear power will increase dramatically, to 6 percent, 2.9 percent and 8.5 percent in 2050, respectively. Given concens over energy security, electricity generation from nuclear power plants will rise sharply, from 60 TWh in 2005 to 1045 TWh. Renewable electricity generation, including hydropower, is projected to increase from 404 TWh to 2,109 TWh. Electricity generation from solar photovoltaic technology (PV) is currently very small, but growing fast and will approach 25 TWh.

Energy-related CO_2 emissions - As shown in Figure 3.3, under the reference scenario, China's energy-related CO_2 emissions will increase rapidly to 11.4 billion tonnes in 2020, 13.9 billion tonnes in 2030 and 16.2 billion tonnes in 2050, and will not peak before 2050.

The Emissions Control (EC) Scenario – exploring the maximum possible emissions reduction while achieving economic growth

Emissions under the control scenario will be lower by 3.2 billion tonnes in 2020, 5.1 billion tonnes in 2030 and 6.7 billion tonnes in 2050. It is still unlikely under this scenario that China's emissions will peak before 2050.

Policy Objectives - The Emissions Control scenario explores the maximum potential for reducing emissions without causing an economic recession. In this scenario, China implements a package of industrial and energy

structure policies to reduce growth related energy consumption, as its contribution to the global response to climate change by going.

Technological Implications – Under this scenario, to achieve its policy goals, China will adopt advanced mitigation measures, including improvements in energy efficiency and the development of renewable energy, and will make remarkable strides in emissions reduction without applying the expensive technologies of CCS, solar power generation, electric automobiles, etc. on a large scale

Energy demand - China's demand for primary energy will also increase until 2050, but at a slower rate, with the large-scale use of low carbon energy sources. Demand will increase by 2.1 percent per year and reach 5.7 billion tonnes by 2050. The proportion of coal in the primary energy mix will drop sharply to 44 percent. The share of non-hydro renewable energy and non-fossil fuel energy sources will increase[19].

Electricity generation - Total electricity generation will rise from 2,494 TWh in 2005 to 10,317 TWh by 2050. The electricity savings rate will reach 17 percent by 2050, compared with the BAU scenario. Coal-fired generation will only be at 601 GW by 2050. Non-hydro renewable energy sources will increase more sharply, accounting for 15 percent in 2050. Natural gas-fired electricity generation will increase from 12.3 TWh in 2005 to 482 TWh. Oil products have a marginal role in power generation and are ignored in this scenario. Electricity generation from nuclear power plants will rise sharply, from 60 TWh in 2005 to 1,930 TWh. Renewable electricity generation, including hydropower, is projected to increase from 404 TWh to 3,075 TWh. Electricity generation from solar photovoltaic technology (PV) will approach 137 TWh

Energy-related CO2 emissions - Compared to the reference scenario, emissions under the control scenario will be lower by 3.2 billion tonnes in 2020, 5.1 billion tonnes in 2030 and 6.7 billion tonnes in 2050. CO2 emissions intensity per unit of GDP will decrease by 51 percent in 2020, 69 percent in 2030 and 85 percent in 2050 over the 2005 level (see Figure 3.4). Emissions will increase by less than 700 million tonnes between 2030 and 2050; in 2050, per capita emissions will be 6.3 tonnes, or 74 percent of Japan's 1990 per capita emissions and 33 percent of the United States' 1990 per capita emissions. Considering the need for sustainable and stable social and economic development, and restrictions imposed by technology and clean energy supply capabilities, it is still unlikely under this scenario that China's emissions will peak before 2050.

The Emissions Abatement (EA) Scenario– exploring the maximum emission reduction potential after 2030

It is technologically possible for China's emissions to peak in 2030. But that this will be difficult without a large number of support measures and their effective implementation over the next few years. China would otherwise have to bear large social and economic costs

Policy Objective – Under the Emissions Abatement Scenario, policymakers set 2030, as the year China will reach peak emissions, while realizing the maximum possible reduction in emissions by 2050.

Technological Implications - Under this scenario, expensive low carbon technologies such as electric motors, fourth generation nuclear power as well as carbon capture and storage (CCS) are to become more widespread after 2030 under the EA scenario. Incentives to encourage new renewable technologies, particularly wind and solar power will be necessary.

Energy Demand - Demand will increase by 2 percent per year and reach 5.5 billion tonnes by 2050, much less than under the BAU scenario, with the large-scale use of low carbon energy sources, the proportion of coal in the primary energy mix will drop sharply to 36 percent, while the share of non-hydro renewable energy and non-fossil fuel energy sources will increase[20].

Electricity Generation - Total electricity generation will rise from 2,494 TWh in 2005 to 9,802 TWh, respectively, by 2050. The electricity savings rate will reach 21 percent by 2050, compared with the BAU scenario. Coal fired generation will amount to only 207 GW. The average gross efficiency of coal-fired generation (excluding combined heat and power) will increase more significantly under EA scenario, as new power plants are based increasingly on more advanced technologies. Non-hydro renewable energy sources will increase more sharply,

accounting for 23 percent, respectively, in 2050. Natural gas-fired electricity generation will increase from 12.3 TWh in 2005 to 542 TWh by 2050. Electricity generation from nuclear power plants will rise sharply, from 60 TWh in 2005 to 2,565 TWh in 2050. Renewable electricity generation, including hydropower, is projected to increase from 404 TWh to 3,845 TWh in 2050. Electricity generation from wind is estimated to reach 13 percent by 2050 under EA scenario. Electricity generation from solar photovoltaic technology (PV) will approach 262 TWh in 2050.

Energy-related CO2 emissions - Under the emissions abatement scenario, China will consider the technological choices that offer the maximum potential for emissions reduction after 2030. Research shows that it is technologically possible for China's emissions to peak in 2030, but that this will be difficult without a large number of support measures and their effective implementation over the next few years. China would otherwise have to bear large social and economic costs. Under this scenario, China's 2050 CO2 emissions would decline to 5.5 billion tonnes at most. Emissions intensity will decrease by 91 percent over 2005, and per capita CO2 emissions will fall to 3.7 tonnes.

ENERGY DEMAND

As is shown in Figure 3.1, China's future primary demand will keep increasing until 2050 under all three PECE scenarios. Under the BAU scenario, it will increase by 2.6 percent per year between 2005 and 2050, and reach 7.1 billion tonnes of coal equivalent by 2050—an overall increase of 220 percent. The average growth in demand between 2010 and 2020 is 4.3 percent, before slowing down and tapering off to an average 1 percent per year from 2030 to 2050. Under this scenario, coal will remain the dominant source of primary energy, but with a smaller share. Oil will still be the second largest fuel with lightly raised share. Demand for natural gas, nuclear power, and non-hydro renewable energy technologies will increase sharply, but their shares are still insignificant. The share of hydropower will remain almost constant.

Under the emissions control scenario (EC) and the emissions abatement scenario (EA), China's demand for primary energy will also increase until 2050, but at a slower rate. Under the EA scenario, demand will increase by 2 percent per year and reach 5.5 billion tonnes by 2050, much less than under the BAU scenario. Under both the EC and EA scenarios, with the large-scale use of low carbon energy sources, the proportion of coal in the primary energy mix will drop sharply, while the share of non-hydro renewable energy and non-fossil fuel energy sources will increase.[21]

In the BAU scenario, total electricity generation will rise from 2,494 terrawatt hours (TWh) in 2005 to 12,360 TWh by 2050. The share of coal and oil use in total electricity generation will decrease (the figures in relation to the demand for power generation and installed capacity under the different scenarios can be found in Annex 3.5). Meanwhile the shares of non-hydro renewable energy, gas-fired generation and nuclear power will increase dramatically, to 6 percent, 2.9 percent and 8.5 percent in 2050, respectively. Hydropower will experience a decrease during the same period. In the EC and EA scenarios, total electricity generation will rise from 2,494 TWh in 2005 to 10,317 TWh and 9,802 TWh, respectively, by 2050. The electricity savings rate will reach 17 percent and 21 percent respectively, in 2050, compared with the BAU scenario. Non-hydro renewable energy sources will increase more sharply, accounting for 15 percent and 23 percent, respectively, in 2050.

Under the BAU scenario, coal-fired generation will grow 4.4 times between 2005 and 2050. Therefore the construction of 1,243 GW of new coal-fired capacity will be necessary. This figure would be only 601 GW under the EC scenario and 207 under the EA scenario. The average gross efficiency of coal-fired generation (excluding combined heat and power) will increase more significantly under EA scenario, as new power plants are based increasingly on more advanced technologies. Supercritical and ultra-supercritical technology is expected to become more efficiently and broadly used under the BAU scenario, and integrated gasification combined-cycle plants (IGCC) as well as carbon capture and storage (CCS) are projected to become more widespread after

2030 under the EA scenario.

Natural gas-fired electricity generation will increase from 12.3 TWh in 2005 to 358 TWh, 482 TWh and 542 TWh by 2050 under BAU, EC and EA scenarios, respectively. It generally has lower capital costs and a shorter construction time than most other generation technologies. It also has lower CO_2 emissions per unit of electricity produced, compared with coal. Limited natural gas supplies and high natural gas prices, however, can be expected to constrain demand.

Oil products have a marginal role in power generation. They fueled only 2.5 percent of total electricity generation in 2005, in EC and EA scenarios its share can be almost ignored.

Electricity generation from nuclear power plants will rise sharply, from 60 TWh in 2005 to 1045 TWh, 1,930 TWh and 2,565 TWh in 2050 under BAU, EC and EA scenarios. Over the past few years, driven by concerns over energy security, China has announced ambitious targets to increase the share of nuclear power in the energy mix.

Renewable electricity generation, including hydropower, is projected to increase from 404 TWh to 2,109 TWh, 3,075 TWh and 3,845 TWh in 2050 under BAU, EC and EA scenarios, respectively. Under the EA scenario, its share of total electricity generation will rise from 16.2 to 39 percent during 2005-2050. This increase will be largely driven by incentives put in place to encourage new renewable technologies, particularly wind and solar power.

For non-hydro renewables, wind power has been growing rapidly in recent years. Electricity generation from wind is estimated to reach 13 percent by 2050 under EA scenario. Electricity generation from solar photovoltaic technology (PV) is currently very small, but growing fast and will approach 25 TWh, 137 TWh and 262 TWh in 2050 in the BAU, EC and EA scenarios, respectively. At present, most PV systems are installed in buildings rather than in central-grid power plants. This is likely to remain the case in the future, as central-grid PV generation is expected to remain expensive, despite cost declines. The economics of PV in buildings are much more favourable, as PV competes against grid electricity prices, which are predicted to increase over time. In the past few years, there has also been a surge in projects using concentrating solar power (CSP) technologies. This trend is set to continue, particularly in sunny areas, where CSP better competes with conventional technologies.

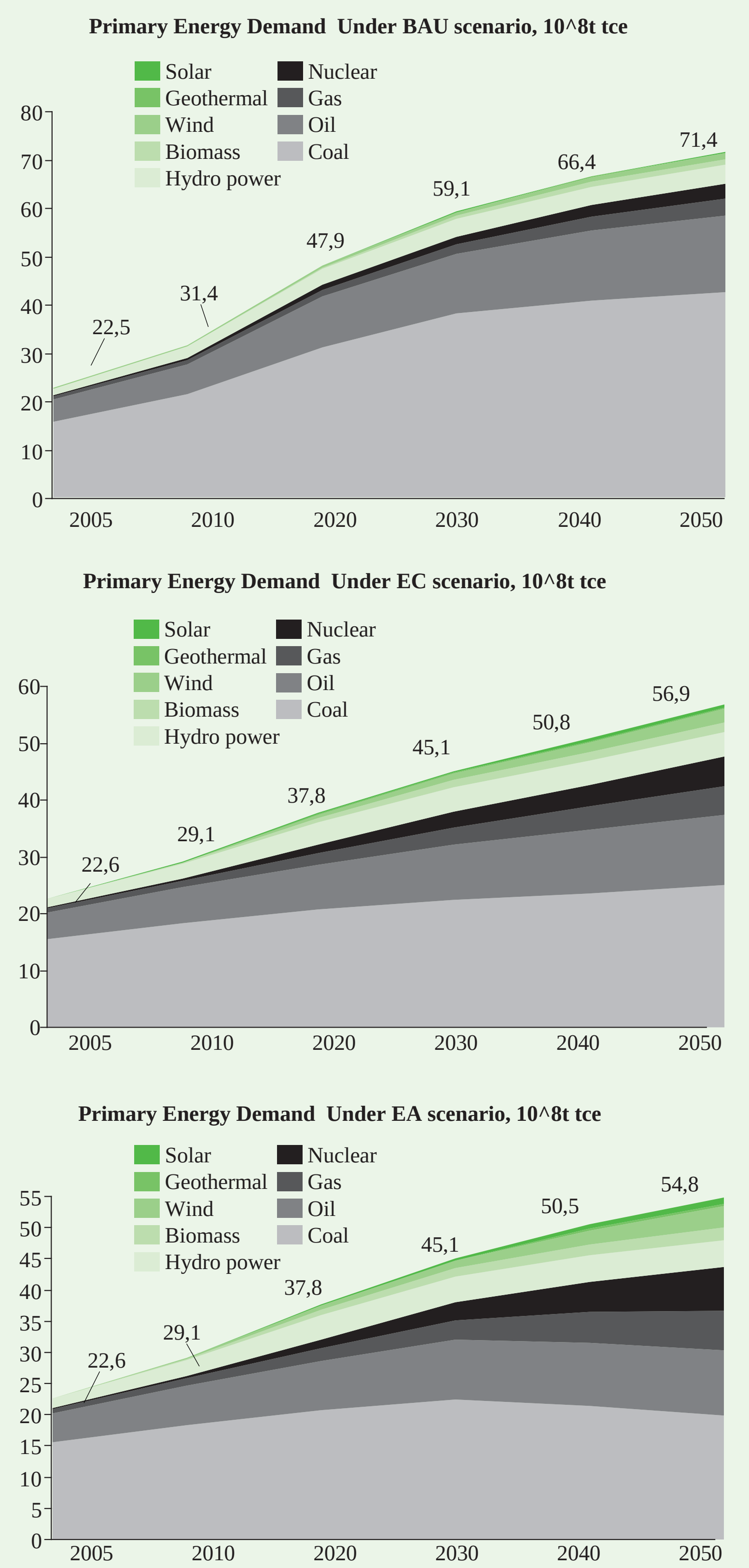
CO_2 EMISSIONS

Future CO_2 emissions under the three scenarios are shown in Figure 3.2. Under the reference scenario, China's energy-related CO_2 emissions will increase rapidly to 11.4 billion tonnes in 2020, 13.9 billion tonnes in 2030 and 16.2 billion tonnes in 2050, and will not peak before 2050. The Chinese Government will make some efforts to reduce emissions.

Under the emissions control scenario, China will adopt advanced mitigation measures, including improvements in energy efficiency and the development of renewable energy, and will make remarkable strides in emissions reduction without applying the expensive technologies of CSS, solar power generation, electric automobiles, etc. on a large scale. Compared to the reference scenario, emissions under the control scenario will be lower by 3.2 billion tonnes in 2020, 5.1 billion tonnes in 2030 and 6.7 billion tonnes in 2050. CO_2 emissions intensity per unit of GDP will decrease by 51 percent in 2020, 69 percent in 2030 and 85 percent in 2050 over the 2005 level (see Figure 3.3). Emissions will increase by less than 700 million tonnes between 2030 and 2050; in 2050, per capita emissions will be 6.3 tonnes, or 74 percent of Japan's 1990 per capita emissions and 33 percent of the United States' 1990 per capita emissions. Considering the need for sustainable and stable social and economic development, and restrictions imposed by technology and clean energy supply capabilities, it is still unlikely under this scenario that China's emissions will peak before 2050.

Under the emissions abatement scenario, China will consider the technological choices that offer the

Figure 3.1 Scenario of China's future demand for primary energy



maximum potential for emissions reduction after 2030. Research shows that it is technologically possible for China's emissions to peak in 2030, but that this will be difficult without a large number of support measures and their effective implementation over the next few years. China would otherwise have to bear large social and economic costs. Under this scenario, China's 2050 CO_2 emissions would decline to 5.5 billion tonnes at most. Emissions intensity will decrease by 91 percent over 2005, and per capita CO_2 emissions will fall to 3.7 tonnes. The overall scenario study did not integrate the positive compensating effects of reducing the negative externalities of the present industrial and economic growth model. Land use and land use change, two important considerations in any abatement effort, are also not taken into consideration. For comparison with other similar research studies, please refer to Annex 3.6.

Figure 3.2 China's future CO_2 emission scenario

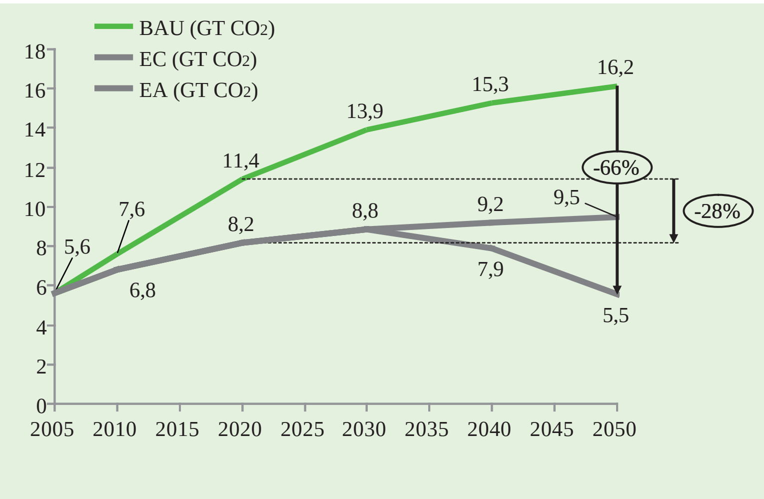
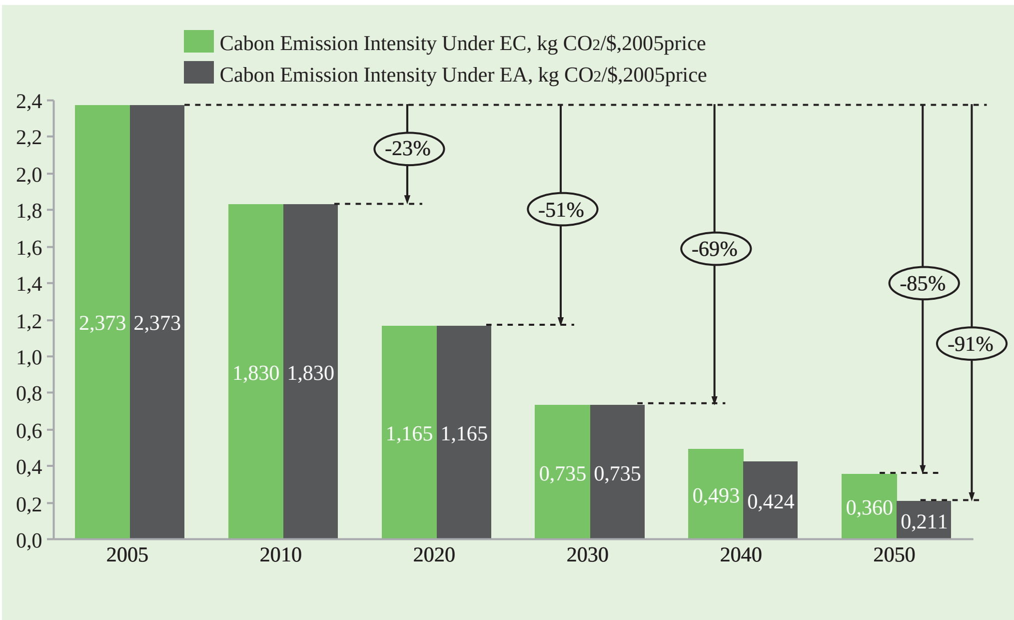


Figure 3.3 Changes in China's future CO_2 emission intensity per unit of GDP



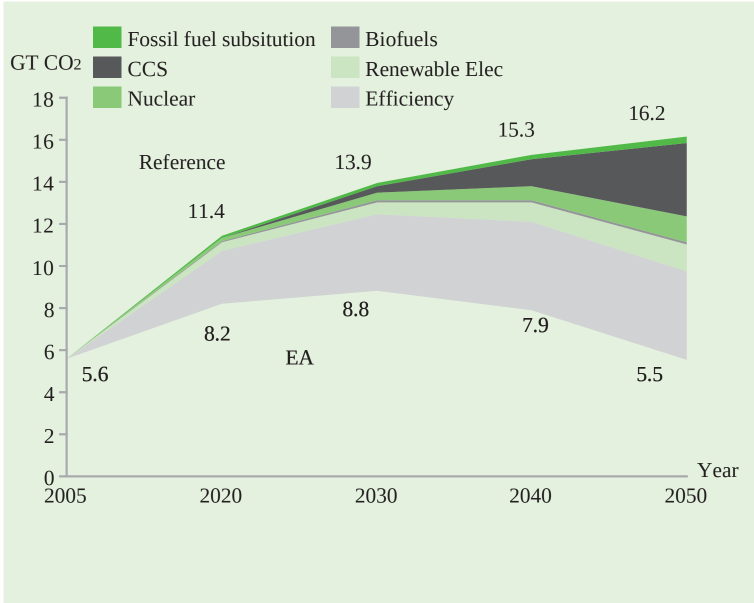
Future Technology Options

Technological advances will play an important role in addressing climate change[22] through energy conservation, environmental protection and emissions mitigation. This report assesses the present and future of existing advanced low carbon technologies such as for clean energy. The scenario analysis looks at the outcomes of various technology combinations and the emissions reduction potential of different technologies. It concludes that energy efficiency, CCS, renewable energy and nuclear power are very important in achieving a low carbon future.

Reduced emissions will amount to 10.7 Gt in 2050 under the emissions abatement scenario. Energy efficiency, including improved end-use efficiency (fuel and power efficiency) and enhanced fuel conversion efficiency, will contribute to 41 percent of the total reduction. Renewable energy will account for 12 percent, nuclear power for 10 percent, fossil fuel energy substitution for 3 percent, biofuel for 2 percent and CCS (including industries and power generation) for 32 percent (see Figure 3.4).

Sixty-two key specialized and general technologies are needed in six sectors—power generation, transportation, buildings, steel, cement, and chemicals and petrochemicals—to reach emissions targets under both the control and abatement scenarios. China currently lacks 43 of these core technologies. This emphasizes the need for China to advance R&D and demonstration of these technologies. It also indicates the necessity and importance to promote technology transfer from developed countries to China to speed up the deployment of clean technologies in the view to avoid lock-in effects of high carbon technologies. Annex 3.7 presents the preliminary needs for technology transfer identified in this report.

Figure 3.4 Sector-wise emission reduction potential



This report presents a list of the technologies needed for different sectors based on literature research and expert interviews (see Table 3.2). China was a late starter in developing climate friendly technologies and, as a result, is lagging behind in many of these vis-à-vis developed countries. Efforts have been made to introduce and draw upon advanced technologies from other countries to encourage faster growth of these technologies, but there is a long way to go in terms of technologies for energy efficiency, renewable energy utilization and adaptation to climate change. Some sectors do manufacture wind turbines, solar facilities and energy-efficient lamps, but these products are mainly for export because of their high cost.

China's energy efficiency is still below that of the developed countries; it was about 36 percent in 2005, 8 percent lower than the average level of developed countries. This is close to the level of Europe in the 1990s and Japan in 1975.[23] The wide gap between China and developed countries in technological terms is mainly in the development of key technologies, the number of inventions and patents, investment in and cost-effectiveness of scientific research, development of a top talent pool and establishment of supporting mechanisms (see Box 3.3).[24] Of 57 countries and regions in 2007, China was ranked 15th in terms of scientific infrastructure—an above-average level—and 27th in terms of technological infrastructure—a medium level.[25]

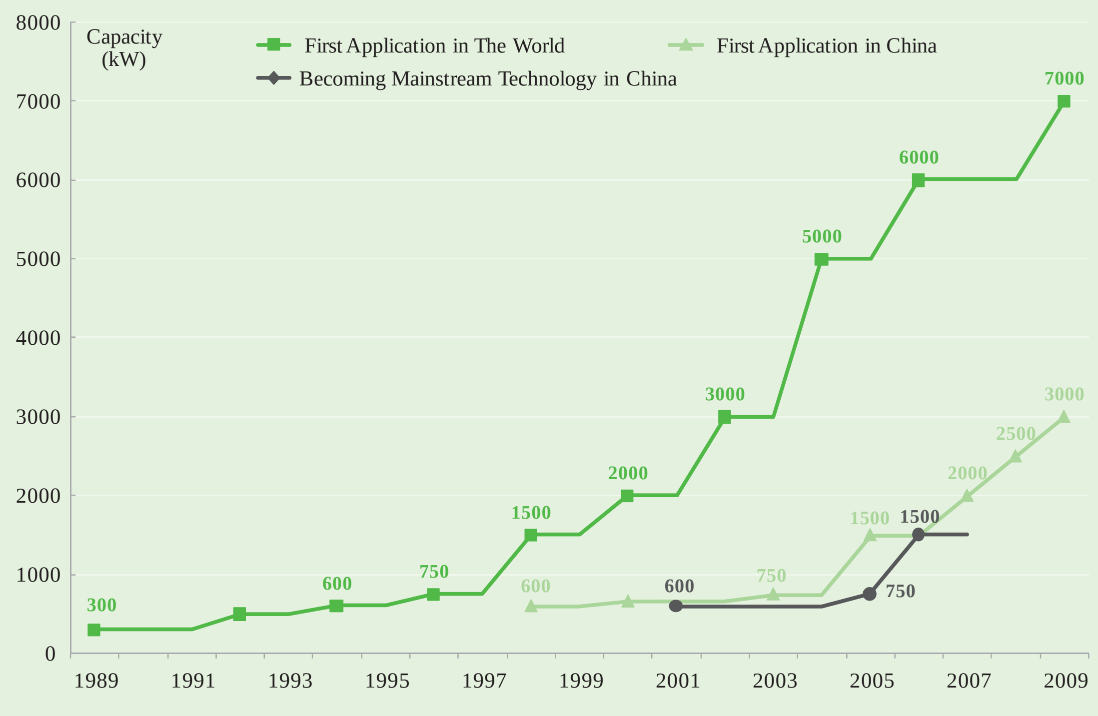
China relies heavily on imported core technologies, while being weak in materials, and control systems. The uneven development within industrial sectors has led to an imbalance in the application of technologies. Advanced technologies are seldom adopted because of the low level of production capacity. There are infrastructure gaps and deficient management systems, and the public policy framework remains inadequate.

China also has a long way to go in establishing a sound and mature national innovation system.[30] A policy framework for energy R&D is not yet in place, and there are no detailed rules for the implementation of existing policies. China is relatively weak compared to developed countries in terms of independent innovation, general R&D and design, and has not invested heavily in energy R&D. Environmental policies to promote innovation and technological development are not in line with industrial and technological policies. China does have a large R&D capacity for energy technologies, but much effort is needed to promote outstanding research and management talents. China also lacks a strong

Box 3.3: China's Pursuit of Technology: The Case of Wind Energy

China's wind power industry is developing rapidly through a boom in companies that manufacture wind power equipment. Domestic enterprises now make up over 70 percent of the Chinese wind turbine market. China has also seen a rise in the number of registered energy technology patents in the wind sector. Despite this progress, China is not among the global leaders in wind power technology development. Denmark, Germany, Spain, and the United States have long been on the forefront of technological development. Companies from these countries enjoy absolute advantages in new technology patents. Studies further show that most wind power technology patents are owned by the subsidiaries of foreign enterprises in China, and that Chinese companies also have a much lower rate of applications for invention patents, which are practically dominating the applications from foreign companies. This suggests that the technological level of Chinese enterprises is not growing with the number of registered patents. Another measure of the gap between China and developed countries is China's delay in starting the mass production of particular types of wind turbines. China began seven years later than the developed countries to mass produce 1.5 Megawatt (MW), 2.0MW and 3.0MW turbines. Technology transfer has promoted the development of China's wind turbines, but since the technology transferred has not been the most advanced, it has not been enough to close the gap between China and the world.

Gap in Wind Turbine Technology between China and Developed Countries



Source: Cui Xueqin, 2009, "Research on Mode and Performance of International Transfer of Climate Friendly Technologies," Beijing, Renmin University.
Source: Clean Energy Patent Growth Index, 2008, "Clean Energy Patent Growth Index 4th Quarter 2008". Available at http://cepgi.typepad.com/heslin_rothenberg_farley_/2009/02/index.html (last accessed 31 March 2010). Clean Energy Patent Growth Index, 2008, "Clean Energy Patent Growth Index 4th Quarter 2008". Available at http://cepgi.typepad.com/heslin_rothenberg_farley_/2009/02/index.html (last accessed 31 March 2010).
Source: Database of the State Intellectual Property Office of the People's Republic of China. Cui Xueqin, 2009, "Research on Mode and Performance of International Transfer of Climate Friendly Technologies," Beijing, Renmin University.

supporting system to facilitate the translation of technological advances into productive applications. There is a major need to strengthen the university system to produce specialized talents in strategic planning, business management, auditing and operation of the energy sector, as well as in specific energy segments such as renewable energy and biomass.

It will be difficult if not impossible for China to quickly bridge the gap in low carbon technologies without concerted actions. There is an urgent need to explore what policies and measures are needed and feasible to shift to a lower-carbon economy in the medium term. One component is more aggressive R&D related to energy efficiency and clean energy technologies. For this to be successful, international cooperation and even financial support from the international community will be necessary.

Table 3.2: Technology Roadmaps

	Immediate term (2010–2020)	Medium term (2020–2030)	Long term (2030–2050)
Power	Ultra-supercritical Large-scale onshore wind power generation Efficient natural gas-based power generation Third-generation large-scale pressurized water reactors Ultra-high-voltage power transmission technology Advanced hydropower technology	IGCC Large-scale offshore wind power generation Advanced geothermal power generation Solar photovoltaic Second-generation biomass energy	Low cost CCS Fourth-generation nuclear power Concentrating solar power Solar nanotechnology photovoltaic Large-scale electricity storage systems for intermittent power supply Low-cost hydrogen fuel cells Smart grids
Steel	Coke dry quenching Pulverized coal-injection technology Negative energy–based steelmaking Residual heat and pressure recovery Energy management center Coal moisture control Combined cycle power plant	SCOPE21 coking technology Smelting reduction technologies including COREX, FINEX, etc Advanced electric arc furnaces Hydrogen production from coke oven gas Waste plastic technology Ultra-thin Castrip Itmk3 (iron technology mark) iron making technology	Low-cost CCS technology
Transportation	Engine, transmission and vehicle technologies for better fuel economy in automobiles Advanced diesel vehicles Electrified railway Urban rail transport	Hybrid vehicles Information-based and intelligent transportation system High-speed railway	Fuel cell vehicles Efficient pure electric vehicles
Cement	Large-scale new suspension preheater kilns Efficient grinding Pure low-temperature waste heat power generation	Eco-cement Fuel substitution	Low-cost CCS technology
Chemicals	Large-scale synthetic ammonia plants Large-scale ethylene plants Ethylene feedstock substitution	Fuel and feedstock substitution	Low-cost CCS technology

Buildings	Light Emitting Diode New building envelope materials and parts Energy-efficient appliances Combined heat and power cogeneration Solar water heater	Distributed energy systems Heat pump technology Combined cooling, heating, and power systems Advanced ventilation and air-conditioning systems Low-cost and efficient solar PV buildings	Efficient energy storage technology Zero-energy buildings
General technologies	Frequency control technology Advanced electric motors	Frequency control technology Advanced electric motors	

Incremental investment and cost

Achieving the substantial improvements outlined in the emissions control and abatement scenarios in this report will require considerable incremental investment. It is estimated that China will need to invest US $9.5 trillion and US $14.2 trillion, respectively, under these two scenarios between 2010 and 2050. This is equivalent to annual investments of about US $240 billion for the first scenario and US $355 billion for the second. For other estimates of incremental investment, and incremental investment under the EC and EA scenarios, please refer to Box 3.4 and Annex 3.8, respectively.

As higher abatement targets are set, heavier incremental investments will have to be made. Most will not be made until after 2030. Between 2010 and 2030, annual incremental investment needs would be about US $185 billion for the control scenario and US $210 billion for the abatement scenario. After 2030, annual needs would grow rapidly and reach US $290 billion and US $500 billion, respectively. Many technologies that will contribute greatly to emissions reduction, such as CCS technology, efficient energy storage technology and the fourth generation of nuclear power technology, will be commercialized and applied extensively after 2030.

Some investments will bring economic returns, but a large proportion will also incur big economic costs. In particular, technologies such as CCS will not only call for significant incremental investment, but will also result in incremental costs from efficiency loss. Table 3.3 shows the incremental costs under the control and abatement scenarios. Under the control scenario, China will face an annual incremental cost of US $86 billion in 2020 to cut 3.2GT emissions, US $269 billion in 2030 to cut 5.1 GT emissions, and US$523 billion[31] in 2050 to cut 6.7 GT emissions. Under the abatement scenario, to cut emissions to 550 million tonnes in 2050, the incremental costs of that year will reach about US $1.6 trillion, equivalent to 6 percent of China's expected 2050 GDP. China will also need to gauge costs in other areas such as employment dislocation caused by the adoption of new technologies, administration, and information and transaction costs. The estimation of the cost might be different based on different assumptions of, e.g., the technology learning rates and discount rate (see Annex 3.9).

At the end of 2009, the Government declared that it would reduce CO2 emissions per unit of GDP by 40 to 45 percent by 2020 over 2005 levels. Two sub-scenarios were modeled under the emissions control scenario based on these intensity targets. When the intensity abatement target is set at 40 percent, 45 percent and 51 percent, total emissions cuts relative to the reference scenario are 1.4 GT of CO2, 2.2 GT and 3.2 GT, respectively. The incremental abatement cost rises from a negative value to US $30 billion per year and then rockets to US $86 billion per year (see Figure 3.5). The unit abatement cost also grows from a negative value to US $14 per tonne of CO2 and then soars to US$27 per tonne of CO2. For incremental

Table 3.3: Incremental Costs under EC and EA Scenarios

	EC scenario			EA scenario		
Year	2020	2030	2050	2020	2030	2050
Per capita emission t-CO2	5.6	5.8	6.3	5.6	5.8	3.7
Reduced carbon emission intensity (compared with 2005)	51	69	85	51	69	91
Total emission reduction Gt-CO2 (compared with Reference Scenario)	3.2	5.1	6.7	3.2	5.1	10.7
Incremental costs (USD 1 billion at constant prices 2005)	86	269	523	86	269	1584
Unit reduction cost (USD/t-CO2)	27	56	78	27	56	148
Share in GDP (%)	1.2%	2.2%	2%	1.2%	2.2%	6%
Cost per household (USD/ year)	182	538	1006	182	538	3046

Box 3.4 Other estimates of incremental investments

A McKinsey study shows that a considerable amount of incremental investment must be made to fulfill the great potential for improvement under the emissions abatement scenario.[26] It is estimated that China will have to make an average annual investment of €150–200 billion (or US$200–260 billion) from 2010-2030, equivalent to 1.5–2.5 percent of its GDP. The figures are quite close to PECE's estimates of the necessary incremental investment by 2030 under the emissions control and abatement scenarios. The McKinsey study also points out that one-third of the investment will bring about economic returns; one-third will incur low to moderate economic costs; and the remaining one-third will result in huge costs.

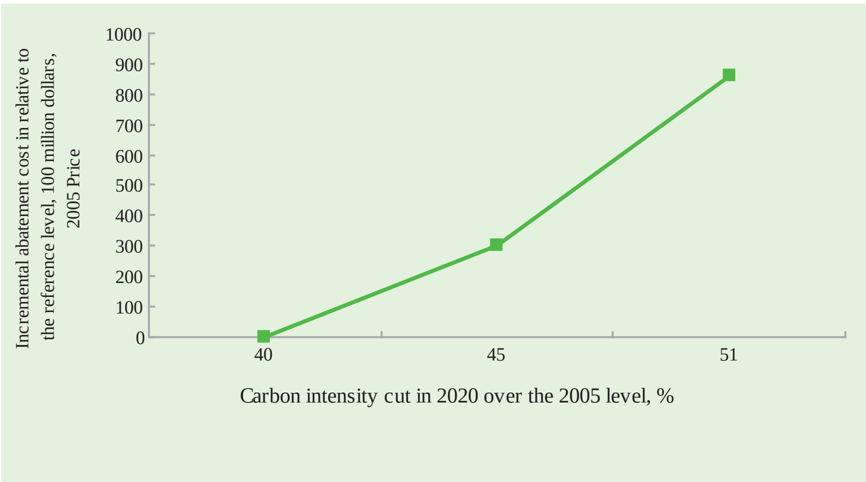
The International Energy Agency (IEA) has estimated the global additional investments to be made up to 2030 for different stages of technological development. To reach the global 450ppm abatement target, an additional cumulative investment cost: almost $2 400 billion over 2010-2020 and $8 100 billion over 2021-2030 will have to be made worldwide.[27] As estimated by IEA's Energy Technology Perspectives 2008, to realize the global CO2 emission reduction under the BLUE[28] scenario in 2050, the world will have to invest as much as US $45 trillion in 2050, three times the amount of incremental investment China will have to make under the emission abatement scenario estimated using PECE model.[29]

costs under the EC scenarios with 40 and 45% cuts in carbon, please refer to Annex 3.10.

Figure 3.5 shows that the 40 to 50 percent cuts in carbon intensity are a critical interval where the corresponding incremental costs are positive values and grow rapidly. The main reason may be that available negative-cost and low-cost technologies cannot efficiently cut carbon emissions. More emission reductions beyond 45 percent will require the adoption of expensive technologies and higher incremental investments. It is therefore proper and feasible for China to set its abatement target at 40 to 45 percent, even without technological and financial assistance from the international community. The target, which is not a binding international commitment, shows that China is willing to cut carbon emissions to its full capacity on condition that the cost is within reach.

Avoiding the critical interval, however, does not mean that there will be no costs at all. Even reaching the

Figure 3.5 Critical interval at which incremental abatement costs rise rapidly



target in the reference scenario requires substantial investment. The question then becomes who should pay. Controlling emissions may help the world slow climate change, but the costs need to be borne by the governments, enterprises and consumers of individual countries over a given period of time. It is this factor that drives the position of most developing countries in the ongoing climate change negotiations. They cite historical responsibilities for emissions, the need for an equitable deal, and the principles of the UN Framework Convention on Climate Change, which call on developed countries to support developing countries in their efforts (see Annex 3.11 and Annex 3.14).

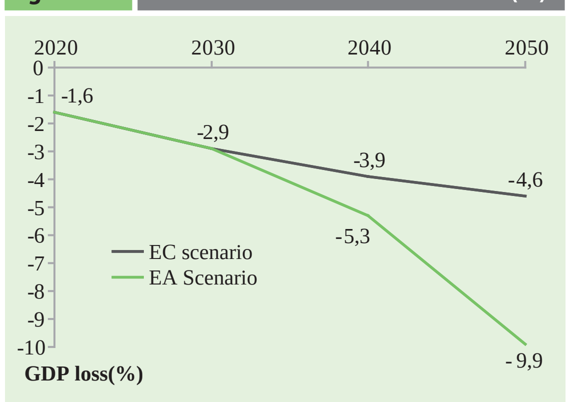
Human Development and the Low carbon Future

Despite China's fast development, it still has a large population living in poverty, and its per capita income remains low. Further development of the economy remains China's primary task. Many studies show that controlling emissions without proper policies to counteract the negative effects will have an adverse impact on China's economic development, reducing its per capita income and the living standards of both urban and rural residents. China has about 40 million rural poor living below the official Chinese poverty line of 1,067 RMB per year.[32] As the country urbanizes, the number of urban poor and disparities between rich and poor in the cities will also likely grow. Relative to World Bank estimates and the international poverty standard of 1.25 USD a day, the number of poor Chinese was 135 million people in 2004.[33] According to the same source, China's poverty line is low in comparison to other countries around the world.

As summarized in Figure 3.6, the findings of the PECE scenarios show that China's GDP loss in 2050 will reach 4.6 percent under the emissions control scenario and 9.9 percent under the emissions abatement scenario over the reference level in 2005 (totaling US $1 trillion and US $2.3 trillion, respectively, at constant 2005 prices, and equivalent to 46 percent and 97 percent of 2005 GDP). The corresponding GDP loss per ton of CO_2 will be US $158 and US $210, respectively.[34]

Other research has reached similar conclusions. After comparing several studies on the impact of reducing emissions on China's GDP growth, Wang Can et al. found that China's GDP loss will stand

Figure 3.6 GDP loss under the PECE scenarios (%)



between 0.78 percent and -0.66 percent over a 2020 reference level if CO_2 emissions are reduced by 10 percent, and between 0.2 percent and -2.1 percent if the cut reaches 20 percent.[35] A simulation study using the MARKAL-MACRO model, where carbon emissions reach 2,394 Mt by 2050[36] under a series

of abatement targets, has been adapted to simulate the macro impacts of emissions reduction. It shows that GDP losses escalate with the rise of abatement under different reduction schemes. The earlier the abatement constraint is imposed, the bigger the GDP loss will be.

The fast development of a low carbon economy requires significant investments, possibly through the diversion of resources that are badly needed in other areas associated with improved human development (see Figure 3.7 on current expenditures). A very ambitious shift to a low carbon target, therefore, may not be fully in line with human development priorities in the short run. What countries need to explore more thoroughly is whether and how this transition can be made without sacrificing human development investments. This is likely to require proper planning and measures to compensate for and/or mitigate their potential negative impacts on society and the economy. Emissions reductions carried out in a planned and gradual manner, possibly with a transition and building up over a longer period of time, may result in fewer negative impacts than abrupt and fast reductions.

Much work is being done to cost the negative impacts of climate change and to assess how addressing them in a timely way can counteract the costs of a low carbon shift. But more work is required to provide a better overall picture of what the real costs are for a country like China (see Table 3.4). While some positive synergies from low carbon development can be expected, estimating specific benefits and losses is more difficult, although it is possible. This is important for China, as aggressive action to advance to a low carbon economy, although costly in the short term, will be offset in the medium and long term through economic and social payoffs. While beyond the scope of this report, holistic analysis integrating abatement costs with all of these considerations and potential payoffs is urgently needed and should be part of a priority research agenda in China.

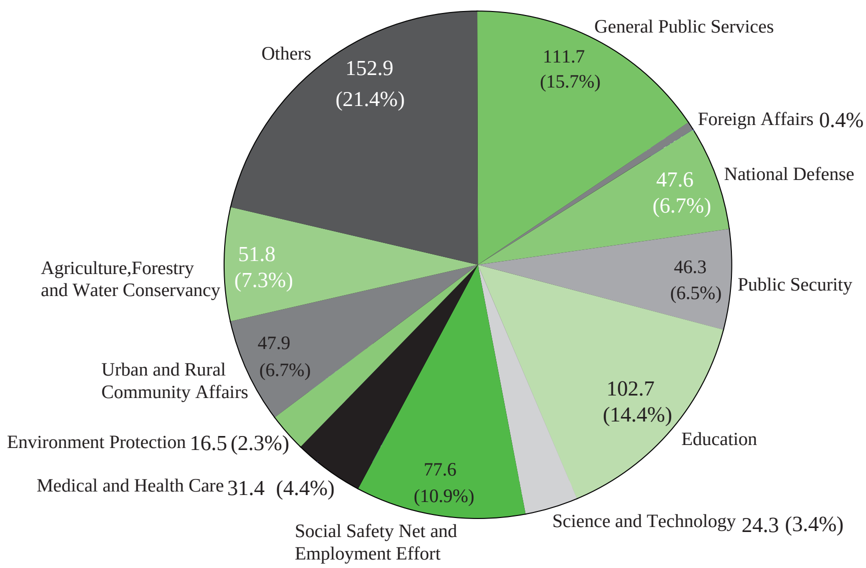
GREEN JOBS

One potential benefit from shifting to a low carbon economy could be the creation of green job opportunities in areas such as renewable energy, transportation and architecture.[37] As global markets for environmental products and services double their current annual value to reach US $2.74 trillion dollars by 2020,[38] they will fuel economic growth and generate new jobs.[39]

If an effective agreement can be reached in global climate change negotiations and more investment is made in green energy, 6.9 million jobs could be added to the renewable energy industry and 1.1 billion jobs to the energy conservancy industry by 2030. Investment in clean energy may also create job opportunities two to eight times faster than in fossil fuel industries. If traditional coal-fired power

Figure 3.7 **Major items of China's state expenditure (2008)**

Unit: US $1 billion at constant prices (2005)



Source: National Bureau of Statistics of P.R. China, 2009, "China Energy Statistical Yearbook 2009," Beijing, Statistics Press.

Table 3.4: Balancing the Costs and Benefits of a Low Carbon Future

Positive impacts (benefits)	Negative impacts (costs)
Mitigation of climate change risks and impacts Avoidance of lock-in effect Co-benefits through reduced pollution, better health and eco-system conservation Opportunity to support other dimensions of human development such as green job creation and better livelihoods Reduction in gender disparity Reduction in regional equity disparity	Direct financial costs Potential damages to the economy Other social costs such as the loss of jobs and livelihoods, opportunity costs, and further inequality among certain groups

generation of electricity was widely replaced by renewable energy generation by 2030, CO_2 emissions would fall by 10 billion tonnes, and 2.7 million new jobs would be created across the globe. If China continues its active policy to improve its energy structure, over 300,000 new jobs could be provided by 2020. [40]

Policies related to saving energy, reducing emissions and developing clean energy, such as from solar energy, biofuels, and wind power and hydropower, could also bring considerable job opportunities.[41] Table 3.5 provides an overview of the general development trend for green jobs in the future, with renewable energy, the recycling industry and the construction industry being among the major sources.[42]

In the short run, the low carbon shift may also cause significant unemployment in small- and medium-sized energy-intensive enterprises (see Box 3.5). It is estimated that during the 11th Five-Year Plan period, about 7,000 small power plants will be closed down, involving 400,000 employees.[43] Although newly created job opportunities may eventually offset such unemployment, numerically speaking, those who will get green jobs are not necessarily those who will have lost their jobs. Among the latter, those who are not well educated or skilled will need job-training and capacity development, a big challenge for China. People in areas where industries are highly concentrated will be particularly affected—mass job losses could have serious consequences for households, the local economy and the viability of communities. [44]

In many cases, government support to workers and enterprises will be essential. Constructive social dialogue will help ease social tensions, encourage cost sharing and achieve effective allocations of resources. Aside from retraining, workers and groups adversely affected by the transition need sufficient protection from proactive labour policies, income guarantees, retraining and capacity building, the nurturing of entrepreneurship, and investments in diversifying local economies and creating new jobs. These elements are part of the "Just Transition" framework established by the International Labor Organization for gradual transformation, including guidance for enterprises shifting to more sustainable development modes.[45]

ADDRESSING VULNERABILITIES

Policy measures to guide the development of a low carbon economy, such as carbon taxes and energy efficiency standards, could result in rising prices for energy and some consumer goods, thus adding to the burdens of poor and vulnerable groups. Research shows that many low carbon policies have adverse impacts on low-income population. [46] Knowing what these might be, could help government authorities introduce policies to counteract them.

The challenges start with the fact that low-income people would need to spend more on energy products. Second, an improved environment might increase the value of houses, benefiting home owners, but making houses expensive for aspiring purchasers. Third, a high-income population would attach a higher value to and benefit more from

Table 3.5: Green Job Trends

		Green potential	Current status of green jobs	Development space of green jobs in the long run
Energy	Renewable energy	Excellent	Good	Excellent
	CCS	Average	Not available	Unknown
Industry	Steel	Good	Average	Average
	Aluminium	Good	Average	Average
	Cement	Average	Average	Average
	Paper-making	Good	Average	Good
	Recycling	Excellent	Good	Excellent
Transportation	Low-energy-consumption vehicle	Between good and average	Limited	Good
	Means of public transportation	Excellent	Limited	Excellent
	Railway	Excellent	Negative	Excellent
	Airplane	Limited	Limited	Limited
Construction industry	Green building	Excellent	Limited	Excellent
	Building improvement	Excellent	Limited	Excellent
	Illumination	Excellent	Good	Excellent
	Energy efficient equipment and appliances	Excellent	Average	Excellent
Agriculture	Sustainable small-scale farm	Excellent	Negative	Excellent
	Organic agriculture	Excellent	Limited	Between excellent and good
	Environmental service	Good	Limited	Unknown
	Afforestation and Reforestation	Good	Limited	Good
	Agroforestry	Between excellent and good	Limited	Between excellent and good
	Sustainable forest management	Excellent	Good	Excellent

Source: UN Environment Programme, International Labour Organization and International Confederation of Free Trade Unions, 2008, "Green jobs: Towards Decent Work in a Sustainable, Low Carbon World." Available at http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/publication/wcms_098503.pdf (last accessed on 24 March 2010).

Box 3.5: A Better Environment, But a Poor Outlook for Employment

Closing down small coal-fired power plants will help improve the environment in neighbouring areas and reduce health problems caused by air pollution. Hebei province is one example of this. The National Development and Reform Commission of China approved the thermal power project of Xuanhua, Zhangjiakou in February 2009. Zhangjiakou has very cold winters, and people need heating for more than five months a year. The approved thermal power project involves building two 300,000-kilowatt coal-fired thermal power plants with a total investment of RMB 2.76 billion and closing small plants producing some 239,400 kilowatts. When the new plants are put into operation, it is estimated that sulphur dioxide ($SO_{2)}$ emissions will decline by 15,000 tonnes a year and soot discharges by 4,000 tonnes a year, a considerable improvement to the environment and the quality of life of the people in Zhangjiakou and other places in neighbouring Beijing.

The closing down of over 7,000 power plants will also lead to a serious problem of worker dislocation, however. It is estimated that closure will affect around 400,000 people. A power generation company in Shanxi, for example, will have to shut down 15 power plants with a total capacity of 800,000 kilowatts to build two new 600,000-kilowatt plants. The two new plants need only about 380 workers, but the laid-off workers from the 15 closed plants number 3,600, which means that over 3,200 people will become unemployed. Although the central government has allocated RMB 2 billion for remote provinces to restructure enterprises, subsidize laid-off workers and provide job training, no policies have been launched to address the employment of dislocated workers.

an improved environment than their low-income counterparts, who are more concerned with the struggles of daily life. A public awareness campaign to educate the latter about, for example, the health benefits of a low carbon society would be important. While increasing taxes on household energy consumption will impose regressive tax burdens on low-income people, a potential remedy is to use tax revenues as subsidies for low-income groups to mitigate these negative effects.[47]

The potentially negative impacts of a quick shift to a low carbon economy may be most keenly felt among women, who start at an economic disadvantage due to gender discrimination. Their overall income level is lower than that of men, leaving them less flexibility in adapting to either economic shifts or climate change. In remote and undeveloped areas, women still have very limited access to higher education and the advanced production technologies associated with more secure sources of income. In some cases, men in rural areas migrate to seek other job opportunities, leaving women at home with a double workload of domestic and agricultural tasks. A heavy economic burden on rural households will also affect the education of the younger generation, with girls more vulnerable to the loss of education opportunities.

Women may also find new job opportunities in a low carbon economy, such as in local energy production. Central and local governments can promote women's roles in decision-making and public participation mechanisms, so that women understand the changes taking place and have more equitable opportunities to participate and influence the choices being made. The women's exchange forum between mainland China and Hong Kong, Macao and Taiwan is one forum for broadening channels of information and knowledge sharing.

MANAGING SYSTEMIC RISKS

Over time, a low carbon economy can reduce the negative impacts of climate change on agriculture, water resources, ecological systems, biodiversity, human health and livelihoods, and the overall economy. The 2006 Stern Review on the Economics of Climate Change suggests without adequate and early action, the costs of climate change could reach 5 percent to 20 percent of GDP by the end of this century, the combined cost of both World Wars and the Great Depression.[48] In China, the 2005 drought in Ningxia Hui Autonomous Region extracted an estimated 1.27 billion RMB—2 percent of its GDP—in damages to 289,000 hectares of crops.[49] A determined programme of adaptation could help reduce such costs, which in theory could be deducted from the price of abatement.

Among the benefits of shifting to a low carbon economy would be the avoidance of huge "lock-in" costs. China is now in an early stage of industrialization and urbanization, and is faced with the task of massive infrastructure construction to eliminate poverty and meet people's needs for basic living. Fast-growing, energy-intensive industrial sectors fuel the economy, even as they add significantly to new global emissions. Production facilities procured as investments in these sectors are capital-intensive and have a long life cycle. This means that once inefficient and emissions-intensive technologies are in place, they will remain for a fairly long period of time, or huge replacement costs will occur. Further, the opportunity to sufficiently control greenhouse gas concentrations may be lost. Avoided costs would need to be deducted from any abatement costs.

IMPLICATIONS FOR POLLUTION AND HEALTH

In many cases, traditional air pollution and greenhouse gases have the same sources, which mean that technologies or policies preventing one may also be effective in eliminating the other. It is therefore possible to reduce costs and achieve synergy effects by tackling the two issues simultaneously.[50] For instance, if a sizeable proportion of the vehicle fleet in a city is electric or has high-efficiency internal combustion engine (ICE) technologies installed, car exhaust gases will diminish, meaning that both urban air pollution and carbon emissions will be mitigated.

The Greenhouse Gas-Air Pollution Interactions and Synergies (GAINS) model demonstrates that low carbon strategies result in lower emission of SO2, NOX and particulate matter (PM) at no additional costs (see also Box 3.6).[51] For achieving given targets on ambient air quality, the costs of air pollution can be further reduced by adopting climate friendly measures. A GAINS scenario shows that the additional costs of some climate friendly measures, such as energy efficiency improvements, co-generation of heat and power, fuel substitution and IGCC plants are more than compensated for by savings in air pollution control equipment. By selecting a smart mix of measures to simultaneously cut air pollution and greenhouse gas emissions, China could almost halve air pollution control costs as well as lower greenhouse gas emissions by 8 percent. One estimate found that lower fossil-fuel consumption could reduce local air pollution costs by around $10 billion in 2020 and in excess of $30 billion in 2030, relative to the reference scenario in this report.[52]

Climate change will influence people's health in a variety of ways and some groups, such as the poor, the elderly, and those with other health conditions, will be particularly vulnerable.[53] In turn, people's health is positively affected by emissions reductions in two ways. Reductions may mitigate health impacts that stem from the potential for climate change to cause more extreme natural events, lead to food shortages and foster the spread of epidemic diseases. There are also health synergies between the mitigation of climate change and air pollution. When less CO_2 is emitted, other pollutants from the same source, such as SO_2, are also reduced, benefitting people's health. GAINS estimates that each percent of CO_2 emissions reduction will typically reduce health impacts from fine particulate air pollution by one percent. Table 3.6 shows other health benefits in relation to CO_2 emissions reductions in different sectors in China.

Conclusion

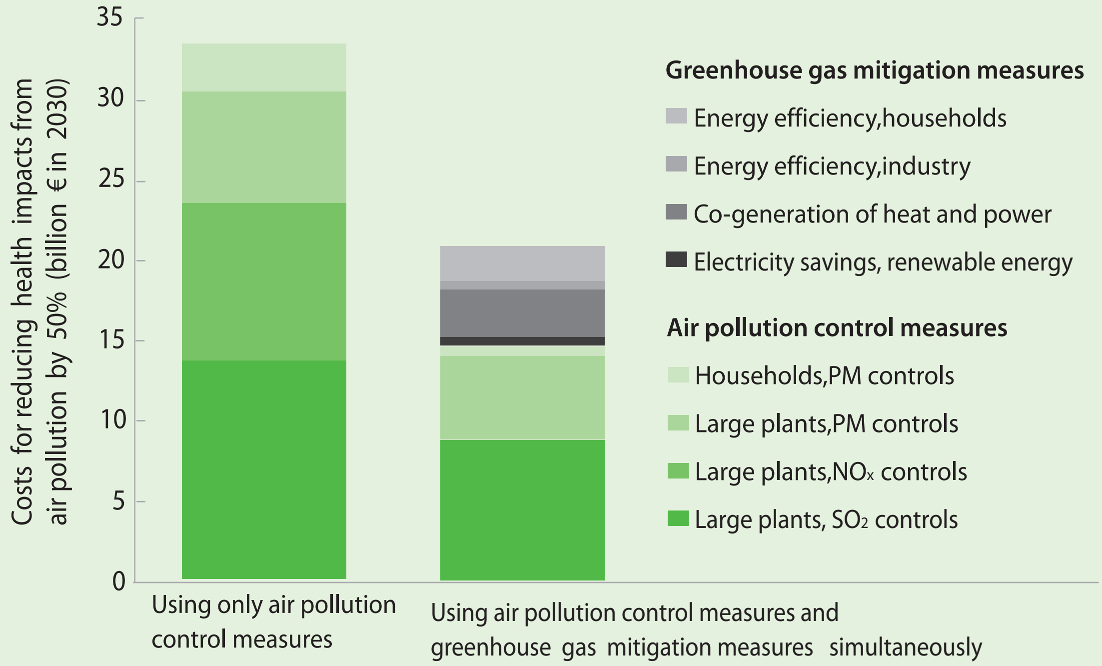
In the long run, a low carbon economy and society can improve the efficiency of energy and resource use, reduce emissions and mitigate the adverse impact of climate change. By investing more in environmental infrastructure, developing and utilizing new energy resources and improving energy efficiency, new engines of economic growth and job opportunities can be created, the economic growth model can be optimized, and the problem of environmental pollution and damage can be mitigated. China will be able to build an energy-saving and environmentally friendly society that also advances human development, helping to increase

Box 3.6: The Benefits of Taking on Both Air Pollution and Climate Change

According to the GAINS-Asia model developed at the International Institute for Applied Systems Analysis (IIASA), China can achieve a given target in ambient air quality and dramatically save costs by adopting a smart mix of measures to reduce air pollution and greenhouse gas emissions.

In the chart below, the left column shows the most cost effective way for halving negative health impacts from air pollution using only air pollution control measures. The right column shows how much more cheaply the same target can be reached using measures simultaneously to lower air pollution and greenhouse gas emissions. This cost saving also results in a nine percent reduction in greenhouse gas emissions.

The GAINS-Asia model integrates a number of established economic and environmental models developed by international experts at the following institutions: IIASA, the Energy Research Institute, The Energy Resources Institute and the Institute for Environment and Sustainability of the Joint Research Centre of the European Union.



Source: Markus Amann, Jiang Kejun, et al., 2008, "GAINS-Asia scenarios for cost-effective control of air pollution and green house gases in China."

equitable growth as well as reduce the vulnerability of different groups, including women, residents of certain regions, those employed in specific industries, and those most able to benefit from a reduction in negative impacts on health. To achieve this transition requires gradually investing various social and economic resources in a way that does not compromise the human development advances already achieved.

This report concludes that the extent to which China is able to achieve a low carbon development will depend on how its people, cities, technologies and markets are integrated into the process. Important determinants will therefore include the future size of China's population, as well as how and where these people live, consume, and interact; how sustainably urbanization takes place; what technologies are made available both for reducing and avoiding greenhouse gas emissions; and finally how markets contribute to the dissemination and commercialization of the technologies required for low carbon goals.

In this report, great attention has been paid to technologies examined and chosen on the basis of their potential contribution to achieving emissions

Table 3.6: Studies on Mitigation's Implications for Air Quality and Health

Author	Country	Target year	Sector	Delta CO_2 emissions	Impact on air pollutant emissions	Difference in health impacts	Health benefits (US$/t$CO_2$)
Wang and Smith, 1999	China	2020	Power sector	15% below business as usual		4,400-5,200 premature deaths per year	
		2020	Domestic sector	15 percent below business as usual		120,000-180,000 premature deaths per year	
Aunan, et al., 2004	Shanxi, China	2000	Cogeneration				32
			Modified boiler design				23
			Boiler replacement				32
			Improved boiler management				32
			Coal washing				86
			Briquetting				118
Kan, et al., 2004	Shangha, China	2010	All sources			608-5,144 premature deaths per year	
		2020				1,189-10,462 premature deaths per year	
Vennemo, et al., 2006	China	2008-2012	Power production Industrial boilers Steel-making Cement, Chemical industry	80 to 236 million tones of CO2 annually	SO2: 0.5 million to 3 million tonnes; TSP: 0.2 million to 1.6 million tonnes	2,700-38,000 lives saved annually (34-161 lives saved per million tonnes of CO2)	Avoided deaths: 4.1-20 All health effects: 5-44

Source: IPCC, 2007, "Climate Change 2007: Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change." Cambridge, Cambridge University Press.

reduction targets under three alternative scenarios. As shown, other than emissions reduction and thus the mitigation of climate change, the development of a low carbon economy and society will also likely bring about considerable co-benefits for the Chinese people. Acquisition of new technologies involve significant upfront investments and high operating costs, but in the long run, co-benefits of a low carbon development pathway will likely include a healthier population, green jobs creation, more sustainable cities and economic stimulus.

1 2005 constant value.

2 Access Asia Limited, 2006, "Dairy Products in China: a Market Analysis." Available at www.globalbusinessinsights.com/content/rbaa0032t.pdf (last

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3 Lane, Jim, 2008, "Meat vs. Fuel: Grain use in the U.S. and China," in Biofuels Digest. Available at www.ndcorn.org/files/ItsChina.pdf (last accessed 19 March 2010).

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7 World Bank, 2009, "From poor areas to poor people: China's evolving poverty reduction agenda - An assessment of poverty and inequality in China." Available at http://siteresources.worldbank.org/CHINAEXTN/Resources/318949-1239096143906/China_PA_Report_March_2009_eng.pdf (last accessed 17 March 2010).

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15 International Energy Agency (IEA) (2007). World Energy Outlook 2007. Paris: International Energy Agency.

16 International Energy Agency (IEA) (2007).

17 This section is largely based on the 2008 work of Marco Gemmer (Deutsche Gesellschaft fuer Technische Zusammenarbeit, GmbH, GTZ) and Tong Jiang (National Center on Climate Change, NCCC) in "BMU [German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety] CDM-JI Initiative Country Study China of the CDM Service Unit China." The authors appreciate the generosity of GTZ and the NCCC.

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19 In this study, photovoltaic (PV) generation is included for power plants if solar panels are used for large-scale centralized electricity production and for buildings if they are used on rooftops.

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21 Ibid

22 Intergovernmental Panel on Climate Change (IPCC), 2000, "Special Report on Emissions Scenarios," Cambridge University Press. IPCC, 2001, "Climate Change 2001: Mitigation of Climate Change. Contribution of Working Group III to the Third Assessment Report," Cambridge University Press.

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29 International Energy Agency (IEA), 2009, World energy outlook 2009, available at: http://www.iea.org/w/bookshop/add.aspx?id=388

30 Under the BLUE scenario, the global CO2 emissions will be reduced by 50% (from current levels) by 2050.

31 International Energy Agency (IEA), 2008, Energy Technology Perspectives 2008——*Scenarios and Strategies to 2050*, available at: http://www.iea.org/w/bookshop/add.aspx?id=330

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CHAPTER 4

THE POLICY AND INSTITUTIONAL CONTEXT

Addressing climate change in China is inextricably linked to the national priority of building a strong, resilient, and equitable society and economy. The many negative economic and social impacts from climate change that have already been felt in China are evidence of the urgent need to take action. Acting today would mitigate and, in some cases, help avoid negative consequences and the inevitably higher costs of dealing with them in the future. This would also guarantee a more sustainable and secure future.

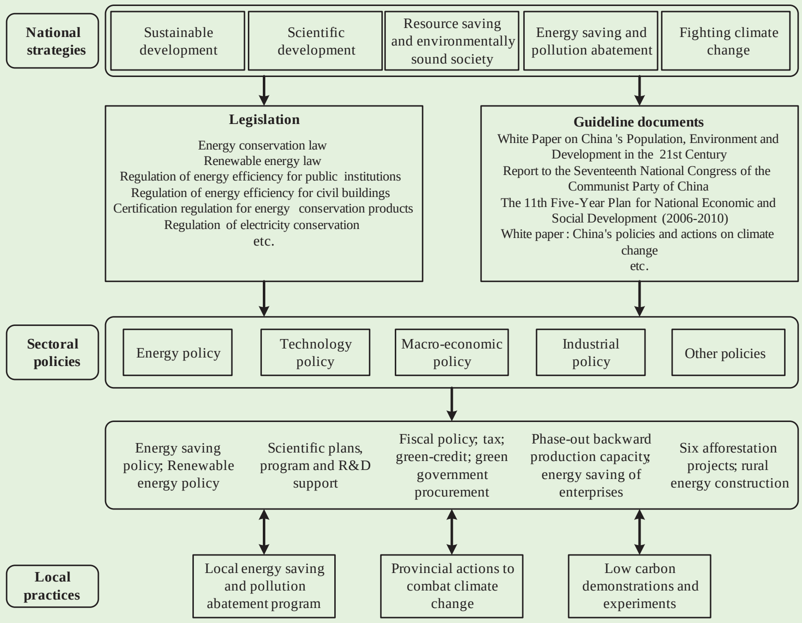
A strategic response to climate change is also integral to the foreign policy and trade agendas of China. It provides an opportunity to contribute to solving the world's most pressing problem, and to improve China's international standing as well as prospects in technology, trade and scientific knowledge. This is clearly recognized at the highest political levels, as demonstrated by the many policies and measures already in place to promote a shift to a low carbon economy.

China is advancing towards low carbon development within a three-tiered framework: national strategies, sectoral policies and local practices (see Figure 4.1). The strategies and policies are mainly formulated by central government departments charged with establishing broad principles to promote energy saving, energy efficiency and lower carbon consumption. Implementing the policies is in the hands of local governments, which must also ensure that their local development strategies are fully consistent with the policies and measures of the central government. One of the challenges to successful implementation is that many local governments are pushing rapid economic development, which often leads to investments and measures that are at odds with central priorities.[1] The lack of detailed implementation guidelines makes it hard to monitor compliance.

Low carbon Actions and Accomplishments

Many measures during the course of reform in China, some dating back to 1994, have aimed to make economic development

Figure 4.1 **China's policy framework for low-carbon development**



Source: Taskforce on NHDR 2009-2010, Renmin University of China

more sustainable. They include, among other things, the 1994 release of "China's Agenda 21—A White Paper on China's Population, Environment, and Development." In 2003, China put forward the "Outlook on Scientific Development," which called for saving resources and creating an environmentally friendly society. Other measures include the Energy Conservation Law (1997, revised in 2007), the Forest Law (1998), the Law on Renewable Energy (2005) and the Circular Economy Promotion Law (2009).

Particularly since 2006, a dozen of initiatives have been introduced for restructuring key industries and sectors. All have the objective of promoting energy savings and emissions reductions. Examples are the Enforcement Regulations of the Ten Major Energy Savings Projects of the 11th Five-Year Plan of the National Development and Reform Commission (NDRC), the joint National Policy for Energy Saving Technology (2006) of the NDRC and the Ministry of Science and Technology (MOST) among others.

The major performance improvements and successes resulting from these initiatives —reduced energy intensity, greater energy efficiency, more renewable energy and increased carbon sinks through reforestation—are well known and have been internationally praised.

Although some of the policies mentioned were not designed to directly address climate change, they have nevertheless contributed to lowering the rate of growth of greenhouse gas emissions and other serious impacts of China's high reliance on fossil fuel, particularly coal. Energy intensity has been reduced from 1.79 percent of 2006 to 4.59 percent of 2008. From 2006 to 2008 over 2005 level, the decline in the number of obsolete and outdated technology factories and power plants has included the closure of small thermal power-generation units with a total installed capacity of 34.21 GW. The same period also saw the phasing out of 60.59 million tonnes of outdated steel-making capacity, 43.47 million tonnes of iron-smelting capacity and 140 million tonnes of cement-production capacity.

China has increased its wind-power-generating capacity between 2000 and 2008 from 340 MW to 10 GW, its hydropower capacity from 79.35 GW to 163 GW, and its nuclear power capacity from 2.1 GW to 9.1 GW. The promotion of reforestation in China to build carbon sinks has raised forest coverage from 12 percent in 1980 to over 18 percent today. Great efforts to reduce agricultural and rural greenhouse gas emissions have yielded an impressive rise in the number of households using biogas digesters. These are now in place in some 26.5 million rural households, allowing a reduction in over 40 million tonnes of carbon dioxide (CO2) emissions.[2]

Recently, China has turned its attention to further leveraging its climate-related policies and promoting a more coordinated approach to climate change. In June 2007, it issued its National Climate Change Programme, one of the first climate change strategies by a developing country. The programme showed China's determination to link its actions against climate change to its national development priorities. Ambitious targets were introduced for lowering energy consumption per unit of GDP by 20 percent over the 2005 level; raising the proportion of renewable energy (including large-scale hydropower) in primary energy supplies; increasing the forest coverage rate to 20 percent; and increasing carbon sink capacity by 50 million tonnes over the 2005 level by 2010.

In October 2008, the Government issued its "White Paper on Climate Change—China's Policies and Actions for Addressing Climate Change." This clearly spelled out the priority given to climate change. It also provided a detailed account of China's policies and strategies for action, both domestically and internationally. The 2009 "Resolution of the Standing Committee of the 11th National People's Congress of China on Actively Responding to Climate Change" restates the priority that China gives to developing a low carbon economy and society, and to strengthening its laws and institutions accordingly. To be successful, China will need to pursue these two agendas simultaneously and in a mutually supporting manner.

Recently, the Government decided to dedicate a large portion of its economic stimulus package, some 210 billion yuan, to projects for energy conservation, the reduction of pollution and ecosystem protection. This amounted to 370 billion yuan for economic restructuring and technology renovation, and 400 billion yuan for new energy-efficient housing to be built with environmentally friendly materials.[3]

Provincial governments have been assigned energy-saving targets in the 11th Five-Year Plan, in accordance with the national 20 percent objective. These targets range from 12 percent in Hainan province and Tibet to 25 percent in Jilin province. Each provincial government takes responsibility for ensuring these objectives are achieved. To reduce energy intensity, most provinces have put forward detailed local rules and regulations designed to strengthen energy savings, and have created administrative offices to help implement them.[4] In 2006, Shaanxi, Hebei, Anhui, Henan and Liaoning provinces issued regulations on energy saving. Fifteen provinces in total have issued such regulations.

With funding from UNDP, Norway and the European Union, major efforts are also under way to develop provincial climate change programmes aligned with China's 2007 National Climate Change Programme. Some cities, such as Beijing, Baoding, Wuxi, Hangzhou and Tangshan, are actively pursuing strategies to formulate low carbon plans and become "low carbon demonstration projects."[5]

REDUCING ENERGY INTENSITY

China's energy intensity per unit of GDP has been decreasing since the launch of the 11th Five-Year Plan. In 2008, China's energy intensity fell to 1.102 per tonnes of coal equivalent (tce) per 10,000 yuan, a decline of 4.59 percent over 2007. From 2006 to 2008, energy intensity fell by 10.1 percent over the 2005 level. In the first half of 2009, it decreased again by 3.35 percent over the 2008 level. This means that by June 2009, China's energy intensity per unit of GDP had already decreased by 13.1 percent in three and a half years, making it highly probable that China will accomplish the projected 20 percent reduction objectives set under the 11th Five-Year Plan period.

As a result of the series of low carbon policies and energy-saving measures that came into effect between 2006 and 2008—particularly the administrative directives on energy saving—China's energy consumption per unit of GDP is estimated to have decreased by 290 million per tonnes of coal equivalent over the same period, equivalent to approximately 670 million tonnes of CO_2 emissions. China will likely reduce CO_2 emissions by at least 1.5 billion tonnes during the 11th Five-Year Plan period.[6]

Progress is being made in key energy-intensive industries, due to measures for saving energy, reducing emissions and phasing out obsolete production capacity. In 2007, in terms of energy use per unit of value added, emissions in the coal sector were reduced by 7.8 percent. They fell by 6.5 percent in the iron and steel industries, by 7.8 percent in the building materials sector, by 5.2 percent in the chemical industry, and by 0.7 percent in the textile industry, bringing the levels in these sectors much closer to those of developed countries.[7] The energy consumption of the most energy-intensive products is in continuous decline, but is still far from the 2010 target (see Table 4.1 for a comparison with Japan). With different energy-intensity targets assigned to each province, their performance has varied across the nation (see Table 4.2).

THE RAPID GROWTH OF RENEWABLE ENERGY

China has focused on renewable energy measures for several years. In 2005, the Renewable Energy Law provided a framework for pricing, special funding, special import facilities for equipment and provisions for grid management. In 2007, the National Mid- and Long-Term Plan for the Development of Renewable Energy specified that by 2010, renewable energy

Table 4.1: Present and Future Energy Consumption in China and Japan

Per unit of products

		1980	1985	1990	1995	2000	2003	2005	2008	2010	2020
Ethylene energy consumption (kgce/t)	China	2,013	-	1,580	1,277	1,212	890	700		650	600
	Japan	1,100	-	857	870	714	629				
Coal consumption of large and medium-sized power plants (gce/kWh)	China[a]	448	431	427	412	392	380	377	349	360	320
	Japan	339	338	338	331	316	312				
Comparable energy consumption of steel (kgce/t)	China[b]	1,201	1,062	997	976	781	726	714		685	640
	Japan	705	640	629	656	646	646				
Synthetic ammonia energy consumption (kgce/t)	China[c]	1,431	-	1,343	1,284	1200	-			1140	1000
	Japan	1,320	-	1,000	970	970	-				
Cement energy consumption (kgce/t)	China[d]	219	208	201	199	181	181	167		148	129
	Japan	136	123	123	124	126	128				
Energy consumption of rail freight (kgce/t)	China	147	119	84	74	73	-				
	Japan	123	126	86	87	90	-				

Notes: a: >6MW; b: Key enterprises; c: Large-scale installations; d: Large- and medium-sized state-owned enterprises

Source: Cui Minxuan, 2009, "Blue Book of Energy: Annual Report on China's energy Development (2009), Beijing: Social Sciences Academic Press. National Development and Reform Commission, 2004, "Mid and Long-term Special Program for Energy Conservation in China." Available at http://fourfact.com/images/uploads/China_Energy_Saving_Plan.pdf (last accessed 2 April 2010). State Electricity Regulatory Commission, 2009, "Annual report on electricity regulation 2008." Available at http://www.serc.gov.cn/zwgk/jggj/200904/W020090423388640605404.pdf (last accessed 2 April 2010).

Table 4.2: Reductions in Energy Intensity and Emissions

(2006-2008, over 2005)

Province	Energy intensity in 2008 (tce/RMB 10,000)	Actual reduction in 2008 (%)	Targeted reduction in 2008 (%)	Accumulated reduction from 2006 to 2008 (%)	Targeted reduction during the 11th Five-Year Plan period (2006-2010) (%)
Anhui	1.075	4.52	4.0	11.59	20
Beijing	0.662	7.36	5.0	17.53	20
Fujian	0.843	3.70	3.5	10.05	16
Gansu	2.013	4.53	4.5	10.82	20
Guangdong	0.715	4.32	3.5	10.05	16
Guangxi	1.106	3.97	3.5	9.47	15
Guizhou	2.875	6.11	4.1	11.51	20
Hainan	0.875	2.55	1.0	4.46	12
Hebei	1.727	6.29	4.5	12.83	20
Henan	1.219	5.10	5.1	11.71	20
Heilongjiang	1.29	4.75	4.5	11.43	20
Hubei	1.314	6.29	4.4	12.98	20
Hunan	1.225	6.72	4.0	13.88	20
Jilin	1.444	5.02	4.2	12.22	25
Jiangsu	0.803	5.85	4.4	13.04	20
Jiangxi	0.928	5.53	3.6	12.20	20
Liaoning	1.617	5.11	4.0	11.83	20
Inner Mongolia	2.159	6.34	5.0	12.79	22
Ningxia	3.686	6.79	4.0	10.98	20
Qinghai	2.935	4.18	4.0	4.79	17
Shandong	1.1	6.47	4.5	13.81	22
Shanxi	2.554	7.39	4.4	13.31	25
Shaanxi	1.281	5.92	4.0	13.23	20
Shanghai	0.801	3.78	3.6	11.67	20
Sichuan	1.381	3.55	4.2	9.76	20
Tianjin	0.947	6.85	4.5	14.84	20
Tibet		2.50	2.5	7.13	12
Xinjiang	1.963	3.15	4.0	7.13	20
Yunnan	1.562	4.79	4.4	9.97	17
Zhejiang	0.782	5.49	4.0	12.63	20
Chongqing	1.267	4.97	4.6	12.30	20

Source: Cui Minxuan, 2009, "Blue Book of Energy: Annual Report on China's energy Development (2009), Beijing: Social Sciences Academic Press. Wang Hongru, 2009, "Energy saving achievements in 2008 in 31 provinces in China." Available at http://politics.people.com.cn/GB/1026/10255431.html (last accessed 2 April 2010).

would account for more than 15 percent of the total primary supply and consumption of energy. To support this target, a plan for a new energy industry is being elaborated to support an investment of some 4,500 billion yuan in new energy development in China by 2020.

Under these policies, China has seen a significant increase in power generation using renewable energy.[8] In 2008, the amount of hydro, wind and nuclear power accounted for 18.8 percent of the total generated power in China. The installed renewable energy capacity accounted for 23 percent of the total (see Table 4.3).[9] The use of renewable energy allowed China to avoid emissions of 443 million tonnes of CO2 emissions between 2006 and 2008 (see Table 4.4).

China's share in the world's renewable energy market is also quickly rising. It has become the fastest-growing wind power market due to its domestic incentive policies, although some challenges exist, as discussed in Chapters 2 and 3, such as limitations on technological capabilities and innovation. According to the Global Wind Energy Council, China's installed wind power capacity accounted for 10.1 percent of the world's total in 2008. In this, it ranks just after the United States, Germany and Spain.[10] The amount of newly added installed capacity in 2008 represented 23.3 percent of the world total, second only to that of the United States (see Figure 4.3).

Table 4.3 China's Installed Renewable Energy and Power-Generating Capacities (2006-2008)

	Installed capacity (MW)			Power-generating capacity (100 billion kWh)		
	2006	2007	2008	2006	2007	2008
Hydro	128,570	145,260	171,520	4,167	4,867	5,633
Wind	1,870	3,304	8,940	27	56	128
Nuclear	6,850		8,850	543	626	684
Biomass	84	268	596	1.04	7.00	18.04

Source: Li Peijie, 2009, "The Research of the China Renewable Energy Policy." Beijing: Renmin University of China.
China Electricity Council, 2009, "Statistical information on electricity industry in 2008."

Table 4.4 Equivalent Carbon Emissions Reductions of Renewable Energy Power Generation

(g CO_2/kWh)

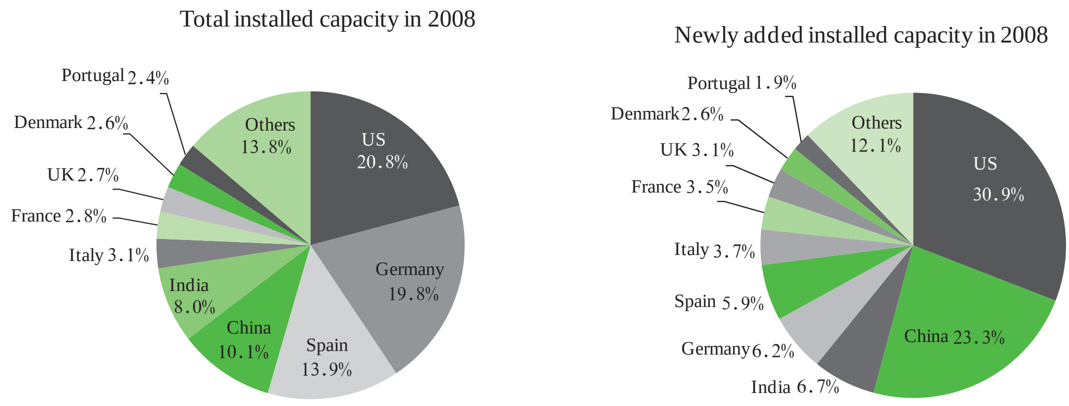
Power generation type	Hydro	Nuclear	Wind	Solar	Geothermal
Equivalent emissions reductions	265.2	264.3	236.3	235.3	263.7

Source: Cui Minxuan, 2009, "Blue Book of Energy: Annual Report on China's energy Development (2009), Beijing: Social Sciences Academic Press.

PHASING OUT OBSOLETE PRODUCTION

In the context of industrial restructuring linked to saving energy and reducing emissions, China has made some progress in phase out obsolete production capacities (see Table 4.5). By October 2008, China had closed coal-fired power plants with a total capacity of 34.21 million kW, equivalent to 65 million tonnes of reduced CO2 emissions.[11] By the end of 2008, China had reduced its aluminium electrolysis-based capacity by 1.05 million tones, ahead of the target for the industry in the 11th Five-Year Plan. Papermaking, alcohol, monosodium glutamate and citric acid have completed 84.2 percent, 59.1 percent, 82.5 percent, and 90.0 percent of their respective phase-out tasks.

Figure 4.2 China's share of the world wind power market



Source: GWEC, 2009, "Global Wind 2008 Report." Available at http://www.gwec.net/fileadmin/documents/Publications/Global%20Wind%202008%20Report.pdf (last accessed 30 March 2010).

ENHANCED HUMAN DEVELOPMENT

Low carbon policies have made a positive contribution to human development in many ways in China, such as by improving access to electricity, environmental quality and public health. These contributions have not been fully calculated and need more research. But some are easily observed, such as those related to energy access. The successful reform of the power industry in China has laid the foundation for developing renewable power generation in rural areas that draws on abundant biomass and solar energy sources (see Box 4.1).[12] Some poverty-stricken rural areas of China now have access to sufficient electricity and an improved quality of life.

Box 4.1: New Sources of Renewable Energy in Inner Mongolia

Inner Mongolia, China's third-largest province, is endowed with abundant renewable energy sources, making it one of the most favorable regions for generating clean energy from solar, wind and biomass sources. Properly resourced energy systems could generate wind power of 150 million kilowatts, accounting for 50 percent of the total wind power potential in China. Because of Inner Mongolia's high altitude and greater than average annual hours of sunlight, its total amount of solar radiation is high per square centimeter per year, making it second only to Tibet in solar energy potential. There is also great potential for developing biogas and biomass energy from abundant wood and extensive land suitable for energy crops.

Since 2000, Inner Mongolia has been developing renewable energy in its agricultural and pastoral areas in the context of China's Western Development Programme. From 2001 to 2005, it promoted the use of 800,000 square metres of solar water heaters, 10,000 square metres of solar greenhouses, 12,000 solar energy stoves and 816-kilowatt in PV. Five large wind farms have been built in Huitengxile, Dali, Xilinhot, Jurh and Shangdu, with a total installed capacity of 78,000 kilowatts. Around 153,000 household wind turbines, 70 percent of China's total, generate electricity for daily use. About 79,000 biogas digesters meet household energy needs. Some 2.2 million household stoves and more than 400,000 household heatable brick beds are energy efficient. Three large biogas projects and one straw gasification project now use animal waste and straw resources to reduce environmental pollution.

Source: Han Fang, Wang Guiping, Meng De, Feng Zhiguo, 2007, "Thoughts and Countermeasures on Renewable Energy Development in Inner Mongolia," in New Energy and Industrial [http://keji.eco.gov.cn/2/2/5/1/2009/0514/13062.html].

Table 4.5 Shutting Down Obsolete Production Capacity

Sector		Progress	Target
Power		By October 2008, China had shut down small coal-fired power plants with a total capacity of 3.421×107kW, including 3.14×106kW in 2006, 1.437×107kW in 2007 and 1.669×107kW in 2008.	5×107 kW
Iron and steel	Iron	By November 2007, 10 provinces had shut down a number of obsolete iron-making plants with a total capacity of 2.94×107t.	1×108 t
	Steel	By November 2007, 10 provinces had shut down a number of obsolete steel-making plants with a total capacity of 1.521×107t.	5.5×107 t
Electrolytic aluminium		By the end of 2008, 1.05×106 t of obsolete capacity had been phased out.	6.5×105 t
Ferro-alloy		In 2008, 1.2×106 t of obsolete capacity was phased out.	4×106 t
Carbide		In 2008, 1×106 t of obsolete capacity was phased out.	2×106 t
Coke		In 2008, 2×107 t of obsolete capacity of mechanic coke and 6×106t of manual coke was phased out.	8×107 t
Cement		In 2008, 5.3×107t obsolete cement plants were shut down.	2.5×108 t
Glass		In 2008, 6.5×106 weight boxes of obsolete flat glass were phased out.	3×107 weight boxes
Paper		By the end of 2008, 5.47×106t of obsolete capacity had been phased out.	6.5×106 t
Alcohol		By the end of 2008, 9.45×105t. of obsolete capacity had been phased out.	1.6×106 t
Monosodium glutamate		By the end of 2008, 1.65×105t of obsolete capacity had been phased out.	2×105 t
Citric acid		By the end of 2008, 7.2×104t of obsolete capacity in citric acid had been phased out.	8×104 t

Sources: Ministry of Industry and Information Technology, 2008, "Progress in China's industrial structural adjustment." Available at http://www.miit.gov.cn/n11293472/n11293832/n11293907/n11368223/11823500.html (last accessed 2 April 2010). Ministry of Industry and Information Technology, 2009, "Annual report on material industry in 2008." Available at http://www.miit.gov.cn/n11293472/n11295125/n11299425/12164560.html (last accessed 2 April 2010); Cui Minxuan, 2009, "Blue Book of Energy: Annual Report on China's energy Development (2009), Beijing: Social Sciences Academic Press. National Development and Reform Commission, National Energy Board, Ministry of Environment Protection, State Electricity Regulatory Commission, 2009, "Notice the country of shutting down small thermal power units." Available at http://www.nmgjn.com/news/law_show.asp?id=155 (last accessed on March 30 2010). Zhang Renwei, 2009, "Great contributions: to honor the reform and open of 30 years in the building material industry", China Cement, 2009, 1: 9-13. Lei Qianzhi et al., 2009, "2009 Cement Industry Mainstream: Structural Adjustment, Scientific Development", China Building Materials News 2009, 3: 4. Zhuang Chunlai, 2009, "Bright future of 2009—Interview with the President of the China Cement Association Lei Qianzhi'', China Cement, 2009, 1:5-8. Zhu Jianhong, 2009, "To promote the structural adjustment in China, keeping the economic development while phasing-out the obsolete production." People Daily, 4 May, 2009. Pan Yifang, Men Feng, 2009, "Study on Accelerating Washing out Lagging Capacity of the Iron and Steel Industry", Iron& Steel , 2009, 44(3): 1-5.

Challenges to Policy Effectiveness

There are few, if any, developing countries that have promulgated as many laws, policies and other measures to support low carbon development as China. These have led to many accomplishments, but they will remain only partially effective unless strong measures are introduced to deal with a variety of obstacles. These include limited integration and coordination of policies among sectors and regions; poor coordination between national, regional and local levels of policymaking; weak institutions at the regional and local levels; inadequate capacities at the regional and local levels; insufficient mechanisms to monitor and enforce implementation; and the lack of public awareness about the economic, social and environmental benefits of determined action on climate change.

A FRAGMENTED SYSTEM OF AUTHORITY

The shift to a market economy in China has resulted in a system with more actors and more diversified interests. Fragmentation among authorities, particularly in different sectors, often leads to bias in and sometimes contradictions between the policies of different government departments (see Table 4.6).[13] In some cases, fragmentation undermines the legal system.

China's energy legislation reflects the interests of each of the sectors concerned. At present, there are four major sectoral energy laws: the Coal Law (1996), the Electricity Law (1995), the Energy Conservation Law (1997, 2007 revised) and the Renewable Energy Law (2005). These were launched by different departments. The Energy Conservation Law and the Renewable Energy Law were revised and enacted in the same period, and their principles and aims show some consistency. But neither the Electricity Law nor the Coal Law have specific articles on energy saving and emissions reduction. A considerable number of articles in these two laws have, in fact, become obstacles to exploit energy efficiency, commercialization of the energy market and the development of renewable energy.[14]

The National Energy Administration, which is responsible for coordinating energy work, has insufficient administrative authority over China's powerful state-owned enterprises in such fields as energy (power and petroleum) and transportation (railway and civil aviation). The State Council's 2010 establishment of the National Energy Commission,[15] which is headed by Premier Wen Jiabao, is an attempt to set up an authoritative body to deal with different powers and interests distributed between different ministries.

LOCAL INTERESTS VERSUS CENTRAL AUTHORITY

Under China's current system of decentralization, particularly fiscal decentralization, local governments have been acquiring greater responsibility for their

Table 4.6: Departments Involved in Carbon Policies

Responsibility	Department
Macro-coordination and control	National Development and Reform Commission Ministry of Finance Ministry of Foreign Affairs
Pollution control	Ministry of Environmental Protection
Industry and construction	Ministry of Housing and Urban-Rural Development Ministry of Industry and Information Technology
Transportation	Ministry of Transport Ministry of Railway
Agriculture and forestry	Ministry of Agriculture State Forestry Administration
Industrial development	Ministry of Finance State Administration of Taxation National Development and Reform Commission Ministry of Industry and Information Technology Ministry of Agriculture
Technology	Ministry of Science and Technology Ministry of Environmental Protection National Development and Reform Commission

Note: Adapted from OECD, 2007, "OECD Environmental Performance Review of China," Beijing: China Environmental Science Press.

local economic development. In the division of responsibilities, the central Government is responsible for issuing legislation and local governments for implementing it. Without proper monitoring and enforcement mechanisms, implementation is often lax.

The 11th Five-Year Plan made it clear that the central Government places the highest priority on energy conservation and "scientific" development. But regional and local officials often see emissions reduction policies as hindering their economic development efforts. Their current performance appraisals are based on how well the economy is doing, not on how well low carbon policies are being put in place. Incentives for growth and prospects for higher fiscal revenues have blocked progress especially in certain industries that are both energy intensive and high in profits, such as coal-based power production, iron and cement. Incentives for policy implementation should be taken into consideration when policies are designed.

There is also evidence of cases where some local governments have directly interfered with the enforcement of environmental and safety laws.[16] This has triggered some unfortunate accidents, such as at the Xingeng Power Plant in July 2005, where fatalities occurred because of lax safety and construction regulations. The incident has spurred renewed efforts to better control power plant construction around the country.[17]

The conflict between local interests and central authority is also evident with small coal mines, a major source of employment and revenue generation for local populations and authorities. There are 28,000 coal mines in China. Only 2,000 are state owned, but their production amounts to 65 percent of China's total coal output. The remaining 26,000 mines are owned by townships and individuals. Their proliferation has caused production safety problems and the inefficient use of coal resources. Surveys show that the average coal recovery rate of state-owned mines is 45 percent, while that of township and individually owned mines is between 15 percent and 20 percent.

Although the central Government on many occasions has stressed the importance of improving resource management and closing down small coal mines, in reality this has been difficult if not impossible to enforce. The dilemma is how to regulate and control them without causing major upheavals in employment and earnings. In Loudi, a major coal production center in Hunan province with more than 1,400 small coal mines, closure of the mines would affect over 40 percent of the population.[18]

VARYING STANDARDS AND INSUFFICIENT CAPACITIES

Many of China's regulations provide a framework for action, without specifying details on how to carry them out. This complicates implementation. For instance, although the Renewable Energy Law has come into effect, and supporting regulations and technical standards have been released, it is often difficult for local authorities to execute some of the specific measures—such as to get power from new energy sources onto the grid, and apply the detailed rules for the government-guaranteed purchase of electricity generated from renewables. Constraints typically come from a lack of local capacities and implementation guidelines. [19] In some cases, the standards themselves are out of date (see Box 4.2).

As another example of obstacles to implementation, the State Environmental Protection Administration (elevated to the Ministry of Environment in 2008), the People's Bank of China and the China Banking Regulatory Commission in 2007 jointly issued the "Recommendations on the Implementation of Environmental Policies and Regulations and Credit Risk Prevention." These lay down specific provisions and requirements for the green credit policy. But most green credit standards are little more than guiding principles as they are not still specific enough. Without official regulations and no industry catalog on green credits and standards for environmental risk rating, it is hard for banks to develop appropriate oversight measures and internal implementation rules, which undermines the feasibility of the green credit system. Every bank has its own interpretation of the green credit policy and standards assessments.

In some cases, branches of the same bank may have different standards.[20]

Box 4.2: Standards That Are Behind the Times

Since 1994, China has launched 14 national standards for monitoring energy saving.[21] There are standards in place for monitoring individual equipment and systems, and for energy supply quality. The General Monitoring and Testing of Energy Conservation (GB15316), one of the major standards, lays down the technical specifications. Since the majority of existing standards were issued between 1995 and 1999, however, they are no longer fully applicable to today's technologies. Many have become obstacles to saving energy and reducing emissions.

Monitoring indicators and approaches vary for the same parameters. Different standards are set for precision, permissible error and degree of uncertainty of the measurement instrument, for example. Some indicators cannot be monitored at all. In the "Method for Monitoring the Energy Saving of Power Generating Units and the Grid Network," for instance, the standard on the capacity of wind turbines no longer conforms to current realities.

Source: Wang Lixin, Hanruiguo, Tianjun, Liu Yong, 2006, " The existing problems in the current national standards for monitoring energy efficiency," in Resources Economization & Environment Protection, 5, pp. 48-50.

OVER-RELIANCE ON COMMAND AND CONTROL INSTRUMENTS

Currently, most low carbon strategies and policies in China are based on command and control instruments, mainly regulatory directives. These have played an important role in environmental management, energy saving and improved energy efficiency, as they can provide very clear outputs and make it comparatively simple to monitor compliance. But the development of the market economy and the trend towards decentralization highlight their limitations, such as high costs and a lack of effective incentives.[22]

The will of the State does not necessarily translate into voluntary actions by local governments and enterprises. To achieve the abatement target during the 11th Five-Year Plan period, the central Government has tried to create controls for local governments by integrating the achievement of energy savings and emissions reductions into the administrative performance appraisals for local government officials. The local officials, in turn, use the same methods to exert control over key local enterprises. There is a problem, however, in that the incentives to save energy and reduce emissions are insufficient to counteract the lucrative connections between local enterprises and fiscal revenues, or the absence of an effective mechanism for phasing out obsolete industrial capacity.

China is still in the early stages of using market-based instruments to foster a low carbon economy. Pricing, financial and taxation mechanisms need to be improved. At present, the price of energy and resources do not fully reflect the scarcity of resources, and the supply and demand in the market. Oil and coal prices are still subject to government intervention. There is no great difference between the price of electricity generated from renewable energy (and new energy sources) and that generated from coal and natural gas. The prices of energy-efficient products are higher than those of ordinary products. All of these factors have prevented market forces from playing their role.

Compared with developed countries, China does not have effective tax adjustments and direct subsidies for energy saving and emissions reduction. An environmental tax and fuel tax is still at the experimental stage. Other options could be the provision of more subsidies for energy-saving products such as thermal-insulation materials; high-efficiency air-conditioning systems, doors and windows, and household appliances; and solar water heaters that meet the national standard.

WEAK MONITORING AND OVERSIGHT

Monitoring, reliable data and statistics are the foundations of decision-making, management and successful law enforcement. China has not yet established rigorous, scientific and unified statistical and appraisal systems to guide energy-saving and emissions reduction measures. The national monitoring system is not connected to local ones. Weak capacities in monitoring and collecting data mean a lack of quantitative information for decision-making, and prevent effective oversight of policy performance. At present, there are 145 energy-saving monitoring centres in China, most of which carry out oversight duties entrusted to them by the Government. These have weaknesses in staffing, budgeting, technology, equipment, operational specifications, and information collection and distribution.

Because of inadequate planning, unclear requirements and poor management, China's energy-saving statistics are unsatisfactory in terms of both accuracy and timeliness. Statistics mainly cover industrial enterprises designated in terms of conventional energy, primary industry and the building industry. Tertiary industry has yet to be appraised in terms of use of new and renewable energy sources. Important indicators such as the input and output of total regional energy consumption, energy efficiency and utilization efficiency have not yet been adopted.

Unsuccessful monitoring and enforcement is also attributable to weak capacities of the local and provincial departments carrying out these tasks. Most energy-saving "enforcement" departments are really monitoring institutions, as they have no national legislative mandate, making it is difficult for them to perform their enforcement duties. Law-enforcement departments often suffer from understaffing and lack of funding. Some even have to raise funds themselves because of lack of financial support from local governments.

LOW PUBLIC AWARENESS

Enterprises, residents and local leaders have limited awareness of the importance of saving energy and reducing emissions. Although public awareness about cutting carbon emissions has gradually been increasing, most local governments and enterprises still see no urgency in adopting a long-term policy for reductions. Although there is interest in some provinces and cities in developing low carbon measures, it is focused on using these opportunities for obtaining resources for project development. This may not be a legitimate motive, but it does offer an opportunity for demonstration projects that show how to lower emissions, create job opportunities, improve health conditions and enhance other human development outcomes.

Education and information dissemination need to play a greater role in persuading people of the merits of energy conservation and emissions reduction, and communicating the most effective ways of making this happen without forcing people to drastically change their lifestyles.

INADEQUATE INFORMATION DISCLOSURE AND PUBLIC PARTICIPATION

China has no systematic information disclosure system, and this creates a lack of transparency that impedes public participation in the development and implementation of policies. One result is that people often do not fully understand policies. Where public participation does exist, it is often on inequitable terms or does not provide adequate opportunity for public inputs. Little information on procedures and timing for public participation is available. Governments hold all public hearings, as both drafters and implementers of policies and regulations. This dual role makes it difficult to take a neutral stand on many issues, leading ordinary citizens to lose interest. All of these factors undermine policy implementation and constrain feedback that could be important in refining policies and measures.

INADEQUATE SUPPORT SYSTEMS FOR LOW CARBON POLICIES

Low carbon policies related to electricity, coal, household appliances, housing, agricultural capital and land are closely linked to people's daily lives and lifestyles. Changes that result, such as through higher prices or job losses, will exert considerable pressure on low-income residents. Even a rise of several yuan in the cost of electricity and heating will lower the living standards of vulnerable, low-income populations.[23] Yet policies do not always take these impacts into consideration, much less offer measures to mitigate harm.

According to a survey carried out by the task force of Liuzhou Price Bureau,[24] the rise in energy prices in 2007 added at least 250 million yuan in costs to Liuzhou. Consumers spent more on water, electricity, coal and gas. For low-income people, the per capita increase in monthly spending was 63 yuan, or 20.55 yuan more than in 2006. This amounted to 28.8 percent of their per capita monthly income as a whole, and exceeded 40 percent in one-quarter of the low-income households surveyed. About 78 percent of low-income households did not have enough income to cover the price hike.

Low carbon policies that promote the phase-out of obsolete production capacities and the return of farmlands to forest usually have no accompanying measures to ensure the re-employment of laid-off workers and the well-being of the farmers who no longer own any land (see Box 4.3). When low carbon policies are implemented in this way, opportunities are lost to derive new benefits and opportunities, including from technology and alternative sources of income.

Box 4.3: Closing Small Paper Mills

In August 1996, the Government announced that it would close down 15 types of small, highly polluting enterprises. By May 1997, about 64,083 of these enterprises had shut down, including 5,933 paper mills. As China's paper mills are located mainly in relatively underdeveloped provinces and cities such as Henan, Hebei, Shanxi, Shaanxi, Sichuan, Shandong and Anhui, these closures had an enormous economic impact.

Investments in paper mills built before 1994 were nearly recovered due to the low cost of investment and good sales of paper. Investments in paper mills built between 1994 and 1996 were mostly not recovered. Job losses hit the paper mill workers hard. About 250,000 people were in the papermaking business in areas around the Huaihe River Basin. Some local farmers also worked for paper mills during the non-farming season and sold raw materials for papermaking. After the closures, their incomes declined.

Source: Wang Jinnan, Ge Chazhong, Luo Hong, Zhou Ying, 2005, " Environmental policy cases after the assessment of closing down small paper-making policy in China,» Environmental Policy Research Series, Beijing, Environmental Science Press.

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2 Xie Zhenhua is President Hu Jintao's Special Representative on Climate Change and Vice Chairman of the National Development and Reform Commission of China.

3 NDRC informed the invest focus and capital calculation of the 4,000 billion Yuan investment plan, available at http://www.gov.cn/gzdt/2009-03/06/content_1252229.htm.

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5 Zhuang Guiyang, 2009, "Make low carbon city a main line, to build Green China" in Green Leaf, 1, pp. 62-66.

6 National Development and Reform Commission, National Energy Board, Ministry of Environmental Protection of the People's Republic of China, State Electricity Regulatory Commission, 2009, Notice to the country on shutting down small thermal power units." Available at http://www.gov.cn/zwgk/2009-03/13/content_1258402.htm (last accessed 1 April 2010).

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11 Cui Minxuan, 2009, "Annual Report on China's Energy Development 2009," Beijing, Social Sciences Academic Press.

12 J. A. Cherni, 2007, "Renewable energy policy and electricity market reforms in China," in Energy Policy, 35, pp. 3617-3629.

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14 Zhu Weitao, 2006, "On the "Electricity Law" changes—from the "Administration Act" to "the economic law of modern sense," in China Power Enterprise Management, 5, pp. 8-11.

15 Circular of the General Office of the State Council on Establishing the National Energy Commission, 2010, available at: http://www.gov.cn/zwgk/2010-01/27/

content_1520724.htm..

16 Liu Zheng and Liu Yangyang, 2007, "The fact that energy-consuming industries as electricity power will grow faster sounded the alarm for energy saving and emissions reductions." Available at http://env.people.com.cn/GB/5680189.html (last accessed 29 March 2010). Shihua Caixun, 2008, "To expand the right to increase the price differential would help curb high-energy-consuming industries." Available at www.in-en.com/power/html/power-0903090381224374.html (last accessed 29 March 2010).

17 Deng Yuwen, 2006. Available at news.xinhuanet.com/comments/2006-08/18/content 4975778.htm (last accessed 29 March). Gou Xinyu and Liu Changjie, 2006, "Xinfeng Power Plant Incident" Available at www.chinavalue.net/Article/Archive/2008/7/15/124219.html (last accessed 29 March). Wei Libing, 2006, "Xinfeng Power Plant incident raised new questions, the local interest weakening of central authority." Available at http://news.sohu.com/20060831/n245090084.shtml (last accessed 29 March 2010).

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21 Wang Lixin, Han Ruiguo, Tian Jun and Liu Yong, 2006, "The existing problems in the current national standard for monitoring energy efficiency" in Resources Economization & Environment Protection, 5, pp. 48-50. Present standards for monitoring energy savings in China can be classified into three types: comprehensive guidance for monitoring standards, monitoring standards for individual equipment and systems, and monitoring standards for quality.

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CHAPTER 5

RECOMMENDATIONS FOR POLICY TIMING AND SEQUENCING

Economic growth is a prerequisite for human development, but not if it degrades natural resources and endangers human well-being. In years to come, China will need to pursue a growth model that simultaneously achieves both low carbon and human development objectives. Given the inherent challenges and opportunities that lie ahead, selecting the right policies at the right times will be key to success. This chapter explores some of the options for policy choices and sequencing.

China has focused so far on making impressive improvements in energy efficiency, energy conservation, and renewable energy supply and use. It has accorded less attention to measuring the high costs associated with the current unsustainable growth model, and the negative impacts of climate change and pollution on human health and ecosystems. Taking action to mitigate negative these and other impacts should be part of the cost equation, as this can be an important offset to the costs of emissions abatement. Making the switch to a low carbon economy will require formulating policies that make these links.

The highest levels of China's Government have endorsed moving towards a low carbon path that can simultaneously advance human development. In doing so, a gamut of policies and instruments can help China build on existing progress by filling gaps and strengthening policy implementation. The timing and sequencing of the policies is crucial because of China's rapid growth. Some challenges will come from the relatively long period of time needed for identifying, formulating, approving, and issuing strategies and policies; from making the necessary institutional adjustments for proper and coordinated implementation; and from China's decentralized system.

But overcoming these and other challenges and acting in a timely manner could allow China to capitalize on some major opportunities (see also Box 5.1). China will make large investments in the next two decades to provide for a growing population with a burgeoning demand for food, energy and manufactured goods. Most of the energy-consuming assets needed between now and 2020 have yet to be built. China's success in moving towards low carbon development will be shaped by the types of investments, choices of technologies and organizational decisions that are made in the near future.

Box 5.1: Some Quick Wins

These are some of the areas where acting sooner rather than later will allow China to avoid being locked into energy-intensive technologies. The list is by no means exhaustive.

- **Between 2005 and 2020, electricity generation capacity will increase by about 600 GW, not including the replacement of obsolete equipment.**
- **During the next two decades, Chinese investors and consumers will be making decisions on capital stock that will dictate the energy mix systems that China will maintain for many decades to come, and, in some cases, for the rest of the century. This covers power stations, oil refineries, chemical plants, smelters, manufacturing entities, commercial and residential buildings, domestic appliances and other consumer products.**
- **Despite growth in the service sector, heavy industry is still likely, according to projections, to represent some 80 percent of the projected energy consumption of the industrial sector in 2020. Considering that the greatest potential for efficiency improvements is in a few large, energy-intensive industries, the possibility of crafting targeted programmes with high payoffs becomes even more attractive and urgent.**
- **Coal-fired power plants are expected to retain an approximately 70 percent share of the power generation capacity in China. According to a study by the Energy Sector Management Assistance Program of the World Bank, with the right policies and incentives, a demand-side management program could reduce energy demand by as much as 220 terawatt-hours, and consequently the capacity needed to meet this demand by some 100 GW.**
- **The energy consumption of transportation is projected to increase faster than that of any other sector. Moves to significantly increase mass transportation and a shift to highly efficient trucks and cars would make a major contribution to reducing consumption. The scope for reduction is immense given growth projections for the transportation fleet of China of 16 to 94 million vehicles between 2000 and 2020, which would represent about a tripling in the fuel demand of this sector.**
- **Residential and commercial building presents some of the most challenging but also potentially rewarding opportunities. Energy-saving measures here relatively recent, and as a result, only about 2 percent of urban building space conforms to established energy-efficiency measures. For every year that passes, China becomes locked into an estimated 700 million to 800 million square metres of building space that is highly energy inefficient, and which will be standing for decades to come. China's building sector accounts for about 28 percent of its total energy consumption. The housing sector will increase to a projected 20 billion square metres by 2020.**

Sources: Noureddine Berrah, Fei Feng, Roland Priddle and Leiping Wang, 2007, "Sustainable Energy in China: The closing window of opportunity," The International Bank for Reconstruction and Development/The World Bank. China Council for International Cooperation on Environment and Development (CCICED) Task Force on China's Pathway Towards a Low Carbon Economy, 2009, "Task force report on China's pathway towards a low carbon economy." Available at www.cciced.net/encciced/policyr/Taskforces/phase4/tflce/200911/P020091124512243707328.pdf (last accessed 24 March 2010).

Urgent Policies and Measures to Introduction of Policies for Low Carbon Development

A multitude of potential policies and measures are already available and many have already been introduced (though some need to be strengthened as they already exist) to promote a low carbon economy and society in China. These represent a set of policies that are more urgent for the near term:

- Strengthen coordination and integration of policies that deal with poverty alleviation, improvement of living standards through the provision and improvement of basic infrastructure, services and social security, reduction of GHGs, and adaptation to climate change
- Establish criteria to assess integration and coordination of policies and introduce these as tools for policy design and assessment.
- Identify areas where investments in development can be maximized through the achievement

of ancillary benefits in climate change and environment and create conditions to prioritize these investments.

- Clearly define the responsibilities of different stakeholders in emissions control on the basis on their socio-economic functions, legal authority, their capacities, and the direct role that they play in emitting emissions:
  - Enterprises should invest in abatement measures, adoption of cleaner technologies, and management improvements for better efficiency
  - Central government should be responsible for setting up national targets, developing regulatory frameworks, and issuing guidelines and standards for improving monitoring and enforcement
  - Central government should also be responsible for proving R&D support for clean technologies, as well as information and other policy infrastructure services
  - Local government should be responsible for monitoring and enforcement of climate policies and for the managing the financing for adaptation and public sector-funded R&D
  - Local government should also be responsible for implementing emissions control measure through their urban planning, operation of municipal infrastructure, local transportation systems, and land use optimization.
  - Government at all levels should set the example and standard for low carbon lifestyles through their procurement practices and environmental performance, both of which should be monitored and assessed for good performance.
- Substantially reform the current system of allocating national carbon intensity targets so that all stakeholders, including industrial associations, national, provincial and municipal governments, as well as consumer representatives, can participate in the policy-making process. In addition, strengthen efforts to encourage the participation of vulnerable groups including women, rural and other community residents as well as workers likely to be affected by changes to industries and sectors.
- Address regional disparities through a differentiated system of:
  - Provincial and municipal targets of carbon intensity control
  - Sectoral and enterprise targets of carbon emissions control
  - Payments for offsets and subsidies for emissions control and development
  - Spatial planning for land use
  - Priorities for investments and policy implementation
- Introduce an evolutionary low-rate carbon tax system as a learning process in sectors where costs of carbon abatement are not high or perhaps even negative and earmark the revenue to subsidize R&D on state-of-the art technologies and technologies for adaptation of vulnerable groups to climate change.
- Set the stage for the introduction of a cap and trade system in the medium and long term based on a national carbon intensity target, an enhanced system for monitoring and enforcement and enhanced capacity of governments, enterprise, and consumers.
- Establish a credible and robust system for GHG accounting and statistics as basis for policy making as well as for monitoring and enforcement, and
- Initiate a legislative process aimed at improving the integration and implementation of climate policies within a framework of a possible climate protection law.

A Broader Menu of Policies and Measures

POLICIES AND MEASURES FOR MITIGATION

- Strengthen the system to implement carbon intensity targets through a more robust accounting mechanisms

- Establish a more rigorous and scientific accounting system for carbon intensity through the following phased approach:

• Improve existing energy survey and accounting procedures, making energy statistics more accurate, reliable, and transparent, and enabling energy statistical system to better support carbon constraint targets and corresponding accounting procedures;

• Formulate and design a scientific and systematic mechanism for the assignment of intensity targets to key businesses, industries, and even enterprises rather than regions in order to improve the verifiability of carbon emissions reductions and provide a solid foundation for future emission trading;

• Set up supervision and certification agencies and strengthen the institutional capacity for financial support, measurement and verification, monitoring and tracking of carbon intensity and build up capacities of institutions to carry out these activities,

• With the help of external expert support, formulate practical and verifiable accounting procedures and mechanism for carbon targets while at the same time promoting uniform standards for these practices across regions, industries, and sectors,

• Establish national, regional, industrial, and corporate information disclosure and sharing mechanisms for carbon accounting; clearly specifying the entities responsible for disclosure, and the manner and contents of disclosure; and achieving greater transparency in how the constraint targets are reached.

• Introduce where needed and /or strengthen existing product and industry-specific carbon emission standards

- Conduct research on carbon management standards, international standards, carbon accounting methodology, carbon emission inventory and emission source survey, emission monitoring and control by business; promoting, in particular, product- or industry-specific research, and laying a solid foundation for the formulation of China's carbon emission standard;

- Formulate carbon emission standards and labeling systems for electricity, iron and steel, transport, cement, chemicals, building industries, and other energy-intensive industries or products that are deemed to be important emission sources;

- Establish industrial benchmarks and raise the threshold for market access to phase out redundant technologies, industries, and products, promoting R&D and dissemination of low carbon technologies, products, and industries, and prioritize, in the development strategy, energy-efficient and low carbon-emitting products and industries.

• Through a multi-sectoral approach, introduce low carbon incentive policies that would include taxation, fiscal, credit, and price policies, such as:

- Taxation policies in support of energy efficiency gains: Such policies may include increasing tax deduction for low carbon equipment and product R&D cost; exempting or reducing value-added tax (VAT), income tax, land use tax and other duties on important low carbon technologies or products or businesses engaged in related technological development and dissemination; imposing excise or environmental tax on energy-intensive, high-emitting products that do not comply with low carbon standards; modifying energy and resource tax schemes and replacing unit tax with value-added tax; and introduction of environment and carbon taxes;

- Fiscal policies in support of low carbon industries and technologies: Low carbon/ energy-saving current accounts should be established to better finance technological innovation, development, demonstration and dissemination, low carbon education, and development of related supervision and management systems and infrastructure. Low carbon product certification and government "green" procurement need to be promoted, and where appropriate, a low carbon product supply contract system needs to be fostered;

- Financing policies for more effective control and stimulus of the flow of funds: China could introduce more stringent loan review procedures for regulated industries; encourage an increase of energy-saving and low carbon projects in banks' loan portfolios; expand loan preferences for low carbon research, development and business projects; establish a full set of industrial and credit indicators in favour of energy conservation; periodically publish energy consumption and carbon emission white books; enhance guidance on bank loans; implement a structural spread policy for low carbon and other industries; expand special-purpose loans to meet the funding needs of low carbon businesses and new energy projects; gradually channel private investment into the low carbon/energy-saving field and provide clients with access to technology innovation funding, project design facilities, energy efficiency audit, and other services through energy and carbon emission contract management;
- Price policies fully reflecting market demand and supply and resource scarcity: The market-driven energy and resource-pricing mechanism need to be improved, and a differential pricing system in favour of low carbon industry needs to be enhanced, with particular emphasis on energy-efficient and renewable energy products.

POLICIES AND MEASURES FOR CARBON SINK ENHANCEMENT

Carbon sinks are an important element of a low carbon strategy. China has made great progress in reforestation and as a result, from 2006 to 2009, the reforestation area in China increased 15.13 million hectares.[1] This represents a large portion of carbon sequestration that is an offset to the current carbon dioxide emitted by industry. By one measure, the carbon sequestration capacity of China has recently increased from 190 to 260 million tonnes annually.[2] More recently, China has committed to increase its forest coverage by 40 million hectares and forest stock volume by 1.3 billion m3 y 2020 from 2005. [3] Policies in this area could include:

- Provide incentives, capacity development, and funding for the purpose of increasing carbon sequestration in arable land through better cropping and agricultural practices;
- Create incentives for retaining and increasing the potential of carbon sequestration of grasslands through better land-management practices;
- Promote an increase in the carbon sink capacity of forests by enhanced forest management practices

POLICIES AND MEASURES FOR THE ENHANCEMENT OF CO-BENEFITS AND MITIGATION OF NEGATIVE EFFECTS

It is often not recognized that policies to mitigate the negative impacts of climate change produce an enormous number of co-benefits that represent the avoidance of huge economic costs in the future.

- Introduce policies to reduce the effects of pollution on health:
    - The most important in this regard are the policies geared toward making improvements in pollution control with high payoffs in terms of improvements in health indicators. At present, there has been little research done in China to quantify these benefits and thus enable them to be considered as offsets to the high investments in addressing these problems. The interest of this to the low carbon economy and society is that in most cases, the only way to address them is through transformations in the energy system, both at supply as well as end use. Thus, a shift to a low carbon economy is, by definition, also beneficial to health indicators; and such policies should include the health of different

groups such as the young, elderly, those with underlying medical conditions and other vulnerable groups.

- Introduce policies and incentives to promote research on co-benefits:
    - More intensive research in this area would allow a better definition of the problem and a better identification of where policies would be most effective. According to a recent study, ambient air pollution caused by combustion to generate electric power is estimated to be the source of more that 26 percent of all adverse health impacts.[4] Non-metal mineral production such as the cement sector ranks second with some 12 percent of health effects, and transportation currently ranks third with around10percent. The types of policies available to address these problems are numerous and range from broader economic instrument policies such as pollution taxes, damage-based taxes, damage-based fuel taxes, and broader taxes designed to lower energy use of primary energy.

POLICIES AND MEASURE FOR THE PROMOTION OF INNOVATION AND TECHNOLOGY DEVELOPMENT

The shift to a low carbon economy in China requires thriving innovation and technological capacity, not only to help China make that shift smoothly but also to ensure that in so doing, it makes a quantum leap in technology and in gaining a competitive edge globally. It is recognized that China needs much work in this area. Introducing the right policies and incentives to make this happen is an urgent priority. Following is a potential menu of policies and measures.[5] This is only a sampling and far from being an exhaustive list:

- Introduce policies to promote investments in engineering, design, and management skills;
- Strengthen the mechanisms and institutions in support of innovation and coordination between academic and research institutions and businesses;
- Introduce low carbon economy standards;
- Improve the business environment and funding for venture capital and risk associated with innovation;
- Strengthen the intellectual property rights regime;
- Facilitate and encourage low carbon investments with proper joint venture rights for technology transfer;
- Introduce fiscal and other support schemes in support of innovation;
- Undertake and continuously update technology needs assessments so as to target policies, measures, and funding for technologies that are most promising both for their impact at the national level and internationally in terms of markets.

POLICIES AND MEASURES TARGETING REGIONAL NEEDS

Policy options vary according to region.

For developed regions, the priorities include:

- Strengthen the coordination and integration of economic development, low carbon economy, and human development strategies:
    - China needs to shift away from its GDP growth-driven development goals, give equal weight to sustainable development, low carbon economy, and human development in its socio-economic blueprint, and perhaps introduce the use of a composite indicator including all these three elements for the measurement of regional development (i.e., a Sustainable Human Development Index for China).
- Focus on optimizing economic structures:
    - Developed areas need to make strategic adjustments to: create an economic structure

based on low energy use, and low-emission and low-pollution principles that are essential for a low carbon economy; speed up these strategic adjustments; adjust priorities and directions for investment and export; curb the development of energy-intensive industries, in particular by reducing the share of the heavy chemical industry in the economy.

- Promote the development and application of advanced low carbon technologies:
  - Local governments need to take advantage of their technological and funding advantages, step up support for low carbon technologies, disseminate and apply leading-edge and well-proven technologies, improve energy efficiency, and reduce carbon emissions.

For less-developed areas, policy priorities could include:

- Promote the local economy while at the same time enhancing human development:
  - For less developed areas, economic development and improvements to the living standard remain the top priority. Less-developed areas should focus on formulating medium- to long-term strategies for economic and human development, improving local living standards, improving the delivery of public services, and monitoring negative impacts of climate change.
- Avoid lock-in effects in the economic development and infrastructure construction process:
  - Less-developed areas should refrain from following the path of their more developed counterparts, as doing so will produce adverse impacts on the environment. Instead, they should use advanced facilities, technologies, and planning approaches to avoid lock-in effects in infrastructure construction.

POLICIES AND MEASURES FOR CAPACITY DEVELOPMENT

One of the greatest weaknesses in China today is the lack of individual and institutional capacities for supporting a shift to a low carbon economy. China needs to build its capacity to develop a low carbon economy to foster socio-economic progress. To this end, it needs to make greater efforts in training, institution building, R&D and oversight, including acting on the following:

- Train and develop capacities of high-caliber professionals and build institutions in the low carbon field:
  - China needs to attract more technical and management talent and to develop a contingent of excellent researchers through international cooperation to provide a human resource pool to facilitate policymaking and implementation. Greater efforts need to be made in training personnel in the complexities of low carbon policies and strategies, particularly in educating policymakers about the theory and practice, and urgency and importance of a low carbon economy.
- Improve the development and application of low carbon technologies:
  - China needs to enhance systems and mechanisms for fostering innovation; promote the research and dissemination of such technologies as carbon capture and sequestration, alternative technologies, waste reduction/reuse/recycling, new materials, environmentally friendly consumption and ecological rehabilitation and biodiversity; and fostering of information sharing and the development of information networks;
- Build a benefit-sharing and co-benefit mechanism between sectors and regions:
  - A mechanism whereby sectors or regions benefiting from low carbon policies would compensate or subsidize those suffering a loss. China needs to ensure the equity of its low carbon policies, and prevent them from causing a fall in the living standards or earnings of low-income regions, industries, and communities or adversely affecting other vulnerable sectors or groups. A system of compensation could be a way of preventing

or mitigating this.

- Enhance the monitoring and implementation capacity of government at various levels:
    - More effort needs to be made by the central, provincial, and/or local governments in establishing oversight organizations, integrating existing resources, and providing an effective system for the implementation of low carbon policies. Uniform measures need to be introduced, as well as mechanisms involved in measurement, data collection, accounting, reporting, and verification regarding energy, GHGs, and pollutants, thereby putting the oversight capacity on a sounder footing.

POLICIES AND MEASURES FOR THE PROMOTION OF INTERNATIONAL TECHNOLOGY TRANSFER AND COOPERATION

Technology transfer and cooperation should be promoted, including tracking international technological developments, identifying and evaluating advanced and applicable technologies, conducting response analysis in technology transfer and cooperation, and promoting the assimilation and application of the technologies transferred.

POLICIES AND MEASURES FOR THE PROMOTION OF SUPPORTING LIFESTYLES AND PUBLIC AWARENESS

China needs to strengthen outreach and education programs in energy saving and emission reduction, raise public awareness about low carbon concepts, and promote public participation in environmental protection and in low carbon socio-economic development, including:

- Establish a robust public awareness-building mechanism:
    - Institutional arrangements need to be put in place to encourage the media (i.e., TV, radio, press and the Internet) to fully play their roles in outreach and education. Nationwide campaigns need to be launched to educate the public about low carbon concepts and to promote environmentally friendly consumption and lifestyles. Meanwhile, public awareness needs to be fostered of low carbon and energy-efficient products, technologies, approaches, and practices, and people should be encouraged to adopt low carbon practices.
- Raise government officials' consciousness of low carbon and energy-efficient practices:
    - The existing performance appraisal, review, and appointment system for officials needs to be reformed to shift the focus away from only economic growth and infrastructure construction. The criteria used in measuring their performance should include environment protection in addition to improvement in living standards and socio-economic progress, making them the true champions of low carbon development.
- Establish and improve the mechanisms for public involvement:
    - An appropriate mechanism needs to be provided for clearly specifying the rights and obligations of the general public including those groups most vulnerable to climate change in overseeing environmental issues and enabling them to voice their opinions and concerns.
    - The government needs to strengthen the systems for feedback from the community through a variety of arrangements, improve the existing rules governing hearings and review conferences, and ensure the fullest public involvement in scrutinizing the environmental management process.

1 State Forestry Administration, 2009 National Forestry Economic Operation Report. Available at http://www.forestry.gov.cn/portal/main/s/304/content-195991.html (Last accessed on 29 March 2010)

2 CCICED, November 2009

3 National Development and Reform Commission, 28 January 2010, "Letter including autonomous domestic mitigation actions."

4 Ho, Mum S. Ho and Chris P, Nielsen, ed., Clearing the Air: the health and economic damages of air pollution in China, Massachusetts Institute of Technology, 2007

5 World Bank, 2009, "World Development Report: Development and Climate Change." Available at http://siteresources.worldbank.org/INTWDR2010/Resources/5287678-1226014527953/WDR10-Full-Text.pdf (last accessed 30 March 2010).

CHAPTER 6

CHINA AT A CROSSROADS

China's achievements in human development have been remarkable as illustrated in this report. Nevertheless, the report also demonstrates that there is a need to decouple human development from high growth rates, to make growth more oriented around quality and efficiency, and to move towards a low carbon economy and society that takes human development into full account, including through adaptation to and mitigation of climate change.

Thus, the Chinese development seems to be at a critical cross-road where the business as usual model of its growth cannot be sufficient to the country's emerging challenges, needs and pressures. Consequently, future human development and the shift to a low carbon economy and society must be intimately linked through mutually reinforcing development patterns.

A principal vision of a low carbon economy and society is the recognition of its potential economic, social and political benefits, rather than just the associated costs.[1] The National Human Development Report attempts to assess these benefits for China, while realistically taking into account the costs. The report combines a set of analysis, assessment, scenarios and common visions regarding China's future low carbon development pathway. A basic premise is that the move to a low carbon economy and society is no longer a choice but a necessity, given the scientific evidence and broad acceptance of the threats from climate change. To support China in the transition to a lower carbon pathway this report presents six principal conclusions which are summarized below.

I. The Shift to A Low Carbon Development Pathway is an Imperative

China faces a dilemma and an opportunity. For the last 30 years, it has gone through one of the most remarkable transformations in the history of mankind. This has been made possible by a sustained high growth rate that has translated into human development opportunities for millions of people. Continued growth will help maintain what has been achieved and spread benefits to all corners of Chinese society. Given the resource and atmospheric degradation that it brings, the present model of growth is not sustainable in the medium and long term.

The general consensus is that China is at a crossroads where these questions need to be resolved. The main argument of this report is that a gradual and smart shift to low carbon development modes is the best option for China to move forward. Many people, including those at the highest levels of the Government, think in even stronger terms that China has no other choice. There is also general agreement that the way in which this gradual shift takes place will make a difference in terms of whether it will result in sacrifices for many or opportunities for all. The risks could include damages to human development through job losses, higher prices and fiscal revenue shortfalls. The gains might be greater competitiveness in new technology, a smooth alignment of technological innovation to the occurring transition to the light industry and services' economy, an improved standing in the world, the extension of energy services, reduced harm to human health and the protection of vital ecosystems. The pillars of sustainability should move forward at the same time. Economic development cannot be separated from social well-being and environmental benefits

II. China's Human Development Achievements could Easily be Reversed by Climate Change

The human development achievements of China over the last three decades are impressive by any standards. The number of people in poverty declined by 500 million between 1981 and 2004.[2] The literacy rate, at 90.9 percent, is one of the highest in the developing world, as are average life expectancy levels at 73.5 years.[3] China is well on its way to meeting most of the Millennium Development Goals by 2015, and, in many cases, to exceeding them.[4] Other achievements, such as advances in renewable energy production and use, and improvements in energy intensity, indirectly contribute to human development.

Nevertheless, the negative impacts of climate change, if not tackled in a more concerted fashion, may jeopardize or even reverse many of these accomplishments. There has been much research in China on the harmful effects of climate change. This has concentrated mostly on ecosystems—mainly water—and on agriculture and crop yields. The fallout varies according to region, with some regions even benefiting from changed climatic conditions. But overall, the impacts are and will be negative, with adverse consequences for food security, human security and well-being in general. This research now needs to be extended into areas where less has been done, including on the effects on health of current energy systems, and broken down by different localities so that China can formulate effective policy responses. The diversity of the many provinces and municipalities in China is evident, such as when measured by economic indicators. These differences underscore the imperative for diverse policy objectives and priorities.

While the huge challenges facing China, including its very large population, mean that moving towards low carbon development cannot happen overnight, China is already proving that accelerated progress can take place if there is the political will to make it happen. Moving from there, a well-managed shift to low carbon development that allows China to maintain and increase its human development achievements will require more coordinated policies, strengthened policy implementation, and international support and cooperation.

III. Low Carbon Policies and Choices will Make Chinese Growth More Sustainable, Improving Inclusiveness and Human Development

In the shift to a low carbon development, economic benefits will include new business prospects, job creation and the growth of new international markets. From a human development perspective, one of China's most urgent challenges is to address the current disparities between regions, the discrepancies between urban and rural sectors, and between the genders, including challenges to reduce the vulnerability of workers, their families and communities as well as empower women and support the greater participation of women in low carbon decision-making policies. Among other issues, vulnerabilities related to these incongruities will reduce resilience to climate change and continue to undercut development prospects.

China can build on its existing successes in refocusing and rebalancing its growth model on human development issues. Growth that is more attentive to the efficiency and quality of products and services, as well as to the end uses, will be more sustainable and will better address the human development needs of the population. Although economic growth is an important means of achieving human development, it is not, in itself, sufficient as is reflected in the conceptual framework of "Xiaokang", a relatively well off society, initiated by the Chinese government.

Moving to low carbon patterns of development has the long-term potential to improve the lives of millions of Chinese offering alternative, safer and healthier, jobs, in a shift to light industry and services' industry. Increased attention to the environmental resources, to land changes, agriculture and forest resources could transform the cities as well as their own rural surrounding into sustainable areas, where higher quality of life could be experienced.

Educating people to low carbon products will enhance resources' conservation, improving the efficiency and provide the basis for a better distribution of energy and water within the country. Taking into account the 350 million people that are expected to move into the urban areas and cities in the next 20 years,[5] the potential to construct energy efficient and sustainable buildings is significant. At mid and long-term, it is necessary to pay attention to the vulnerable low income Chinese communities and provide tools and instruments needed to build up their resilience to the climate change risks and improve their preparedness. At the same time, additional resources are needed now to help communities adapt to those detrimental climate changes which are already inevitable.

IV. The Challenge of Providing for a Large and Growing Population is a Driver for a Greater Focus on Joint Low Carbon and Human Development Benefits

Every country needs to define its own development agenda. A shift to a low carbon economy needs to be placed within the context of national challenges, needs and priorities. In addition to a large and growing population, China faces a high rate of urbanization and industrialization. These are major challenges, but they are also opportunities for "getting things right" from the start and avoiding the negative consequences of adopting obsolete technologies, infrastructure and capital equipment that will remain in place for decades to come.

Social benefits should be given greater consideration in the shift to a low carbon economy, and China needs to strengthen its research programmes on the benefits of a low carbon economy and society as a whole. This will yield at least two important results: a better grasp of the magnitude and nature of the problems, and a better basis on which to formulate targeted policies with greater impacts. To list one example of the social aspect, the health effects of emissions are severe and costly; these burdens will only grow over time if emissions are not reduced. A well-targeted policy on reducing particulate matter emitted from power plants and other industrial activities, and to contrast urban air pollution could bring major benefits for many years to come.

Scenario work undertaken for this report shows the high costs of shifting to low carbon development. These are costs entailed in introducing new and often more expensive technologies to lower carbon emissions. China cannot divert resources to these at the expense of its population, e.g. social security. Expecting its population to make sacrifices would be counterproductive. To cover these huge costs of GHG abatement has implicate in design of domestic and international financing mechanism and short-term competitiveness of international trade. At the same time, more research is needed to refine the methodology for calculating the true costs of this shift, and demonstrating potential human development benefits that would offset the costs. So far, China is behind other nations in understanding this important aspect of the cost equation. Until more research is carried out, the tendency will be to focus only on the costs rather than on the benefits.

V. Weak Implementation and Enforcement Mechanisms Remain one of the Great Challenges for China

China has an impressive number of new laws and political statements aimed at reducing carbon emissions and increasing energy efficiency. The Climate Change Action Programme, the White Paper on a Sustainable Development Strategy, and resolutions in the Eleventh Five-Year Plan are accelerating the pace and quality of actions being taken.

Despite these efforts, however, the full potential of many policies and regulations is not being realized because of obstacles to implementation. China's decentralization process is both a strength and a weakness when it comes to hard policies on energy and low carbon development. Issues such as lack of coordination and compliance, and buy-in difficulties are well known. Addressing them will be difficult, but as long as they persist, China's potential to become a leader in technology, a clean environment and equitable human development will be difficult to realize. It is therefore necessary to strengthen capacities and institutions to integrate and coordinate policies among sectors and regions and at all levels, and to monitor and enforce implementation. Specific mechanisms for policy implementation should be identified and efforts carried out to strengthen policies, regulations, and institutions in order to achieve efficient policy implementation in China's priority areas.

VI. China's Innovation and Technological Platform Need to be Greatly Strengthened

Technologies will play major roles in a low carbon economy. This is already happening in China, where state-of-the-art technology is found in some of its industries, and renewable energy and transportation. Much of this technology is homegrown, but a significant amount is imported. China needs to strengthen its capacity for innovation, which remains limited for a variety of reasons that need to be tackled simultaneously. An in-depth technology needs assessment covering institutions and skills would be an important first step. Gaining a better picture of where the major weaknesses are and addressing them will be key to adopting many low carbon technologies.

A national technology platform could have the following objectives, among others: to help develop low carbon strategies for a selected number of sectors; to help determine investment needs; to identify and propose innovative financing mechanisms that facilitate the development, transfer, and diffusion of key technologies; to identify and address institutional capacity development needs as well as policy recommendations; to establish a portfolio of partnerships and joint ventures in key technologies; to set an agenda for cooperation with other developing countries; and finally to promote

establishment of an international innovative mechanism for technology transfer from developed to developing ecnomics.

1 CCICED Task Force on China's Pathway Towards a Low Carbon Economy, 2009, "Research on China's Pathway Towards a Low Carbon Economy "

2 World Bank, 2009, From poor areas to poor people: China's evolving poverty reduction agenda—An assessment of poverty and inequality in China,

3 Central Intelligence Agency, 2010, CIA World Factbook China pages. Available at www.cia.gov/library/publications/the-world-factbook/geos/ch.html (last accessed 17 March 2010). IEA/OECD, 2009, "World Energy Outlook 2009," Paris, OECD/IEA

4 Chinese Ministry of Foreign Affairs and the UN System in China, 2008, "China's Progress Towards the Millennium Development Goals: 2008 Report.".

5 McKinsey Global Institute, 2009, "Preparing for China's Urban Billion."

ANNEXES

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ANNEX 1.1 CARBON PRODUCTIVITY AND CARBON INTENSITY

Carbon productivity is the amount of GDP produced per unit of carbon dioxide equivalents (CO2e) emitted. Carbon intensity, as the inverse of carbon productivity, is the amount of CO2e per unit of GDP produced.

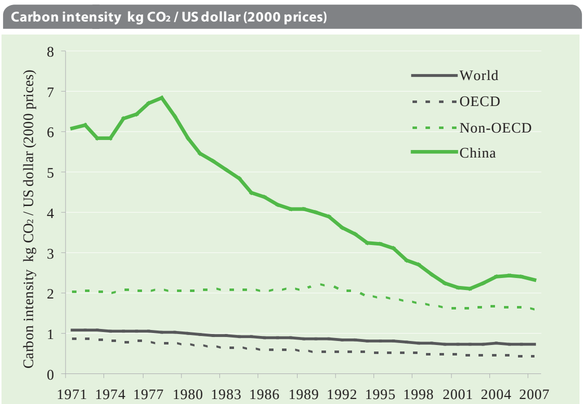
Carbon emissions are measured in metric tonnes of CO2 equivalents per year, i.e. millions of tonnes (megatonnes) or billions of tonnes (gigatonnes). CO2 equivalent is a measure of the Global Warming Potential (GWP) of the different greenhouse gases. As the GWP of the different gases differs greatly, CO2 is used as the reference gas against which the other gases are measured.

This UNDP China National Human Development Report 2009/10 makes abundant use of the concepts of carbon productivity and carbon intensity indicators in its text, graphs, and tables. The concepts can also be understood by looking to the graphs below.

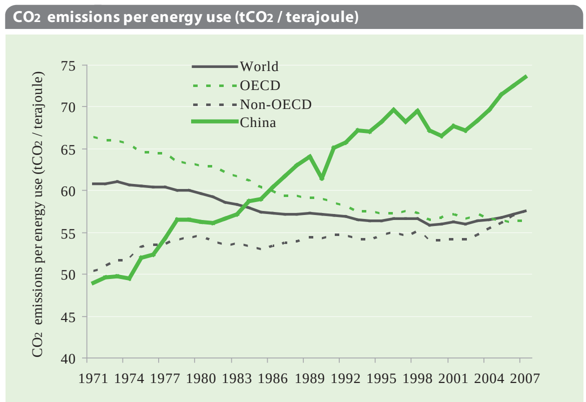
In the following figures, we see that Chinese carbon intensity had a steep gradual decrease from 1971 to 2007. This result was driven by the great GDP growth, however, rather than by a profound and widespread use of the best available low carbon technologies the way it happened in other developed parts of the world, with low GDP growth and a higher dissemination of technologies. That is why this trend coincides with an increase of carbon intensity registered in the same period.

Sources: McKinsey Global Institute, 2008, "The Carbon Productivity Challenge: Curbing Climate Change and Sustaining Economic Growth." Available at http://www.fypower.org/pdf/MGI_Carbon_Productivity.pdf (last accessed 29 March 2010). Schellnhuber, Hans Joachim, 2009, presentation at UNDP NHDR side event, UNFCCC Conference of the Parties, Copenhagen. Figures 1.1 and 1.2 are taken from this presentation.

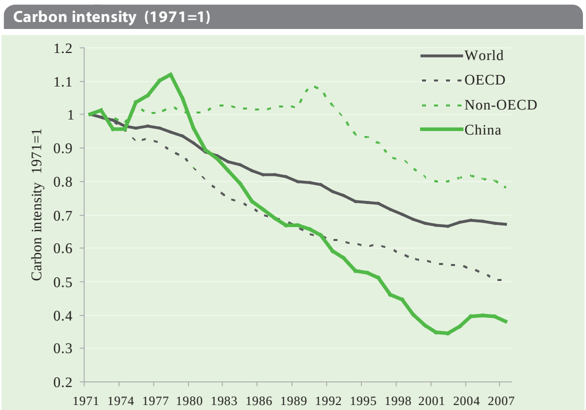
Carbon intensity kg CO_2 / US dollar (2000 prices)



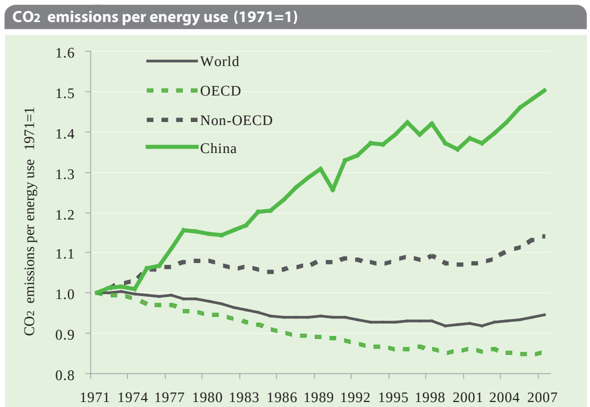
CO_2 emissions per energy use (tCO_2 / terajoule)



Carbon intensity (1971=1)



CO_2 emissions per energy use (1971=1)



Source: Schellnhuber, Hans Joachim, December 2009, "Solving the Climate Dilemma: The Budget Approach", presentation at UNDP NHDR side event at UNFCCC, 15th Conference of the Parties, Copenhagen.

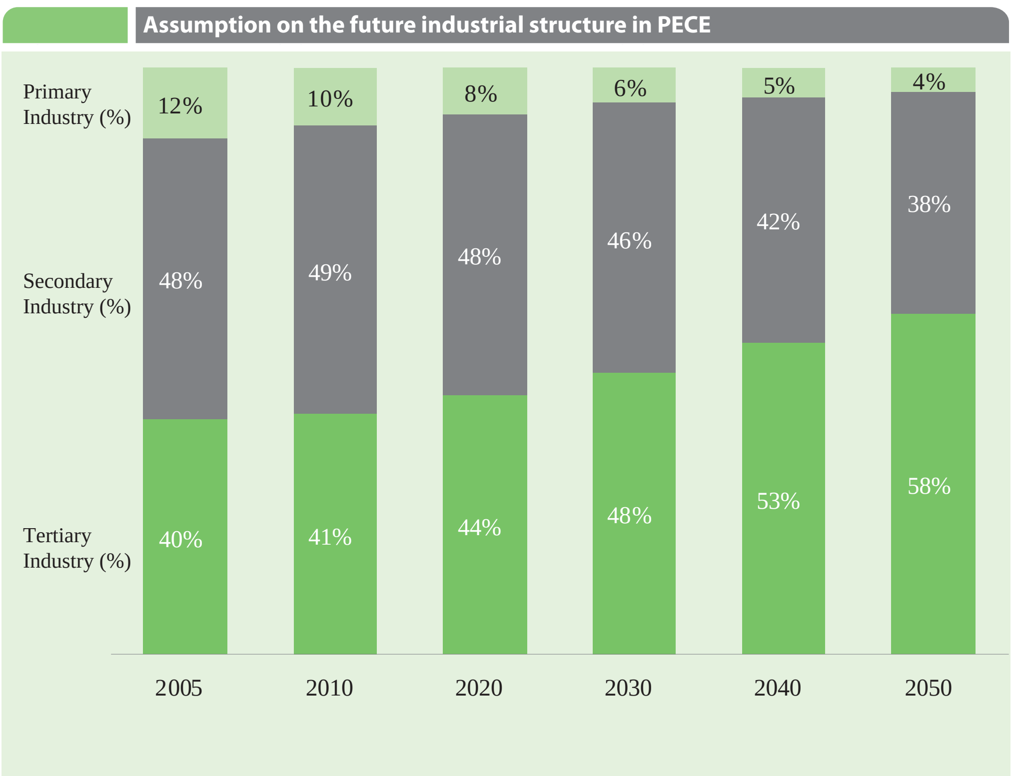
ANNEX 3.1: ASSUMPTIONS ON POPULATION IN PECE

		2005	2010	2020	2030	2040	2050
Population	million	1,308	1,360	1,450	1,520	1,540	1,500
Population growth rate	%		0.79	0.64	0.47	0.13	-0.26

ANNEX 3.2: ASSUMPTIONS ON URBANIZATION IN PECE

		2005	2010	2020	2030	2040	2050
Urbanization rate	%	43	48	56	62	66	70
Urban population	million	562	653	812	942	1,016	1,050
Rural population	million	745	707	638	578	524	450

ANNEX 3.3: ASSUMPTIONS ON FUTURE INDUSTRIAL STRUCTURE IN PECE



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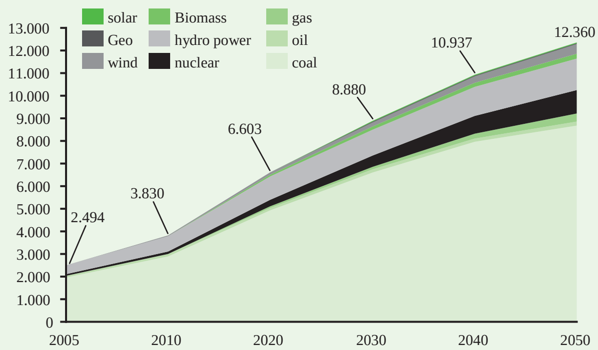
ANNEX 3.4: HYPOTHESES ON FUTURE DEMAND FOR ENERGY SERVICES IN THE PECE MODEL

		2005	2010	2020	2030	2040	2050
Steel Output	100 million tons	3.5	5.6	8.6	9.6	9.1	8.0
Cement output	100 million tons	10.7	14.3	17.9	17.2	15.1	12.9
Ethylene output	10,000 tons	756	1,162	1,893	2,196	2,355	2,432
Synthetic ammonia output	10,000 tons	4,596	5,075	5,717	6,222	6,639	7,013
Passenger traffic flow	100,000 person-kilometers	3,446	5,063	8,856	14,085	20,849	28,019
Railway	%	17.6	16.5	14.0	12.6	11.0	10.0
Road	%	76.3	77.1	78.0	75.8	73.3	71.7
Aviation	%	5.9	6.3	7.9	11.5	15.6	18.3
Shipping	%	0.2	0.2	0.1	0.1	0.1	0.0
Freight traffic flow	100 million ton-kilometers	9,394	14,454	24,686	38,337	55,398	72,660
Railway	%	22.0	22.8	23.5	22.6	20.3	18.3
Road	%	24.0	24.3	25.0	25.8	26.7	27.6
Aviation	%	0.1	0.1	0.2	0.3	0.4	0.6
Shipping	%	53.0	51.6	49.5	48.7	48.0	47.5
Pipeline	%	1.0	1.2	1.8	2.6	4.6	6.0
Number of motor vehicles	Vehicles/1,000 people	24	70	190	300	356	400
Average residential area							
Cities	m2	19.2	23.0	29.0	31.0	32.5	35.0
Countryside	m2	29.7	32.0	36.0	40.0	43.0	45.0
Public building area	100 million m2	57	83	130	161	182	200

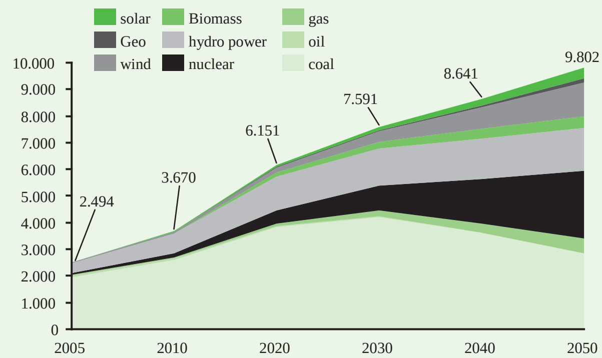
ANNEX 3.5: DEMANDS OF POWER GENERATION AND INSTALLED CAPACITY UNDER DIFFERENT SCENARIOS

Demand of power generation and installed capacity under different scenarios

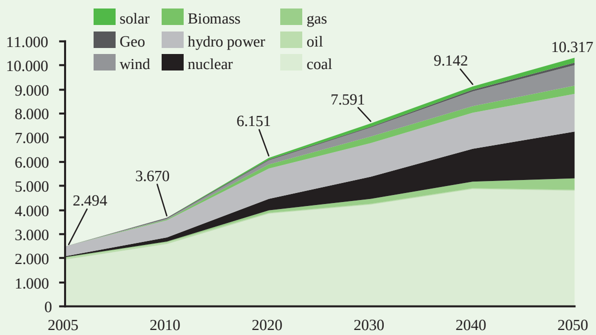
Power generation Under BAU scenario, TWh



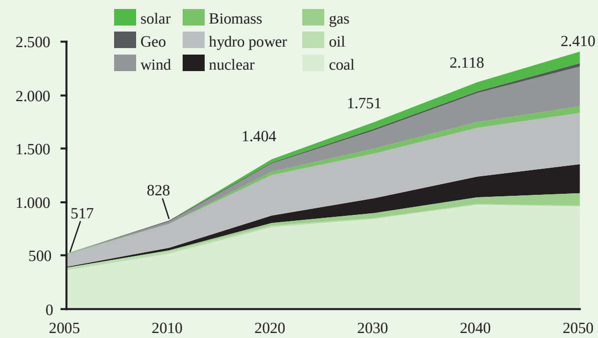
Power generation Under EA scenario, TWh



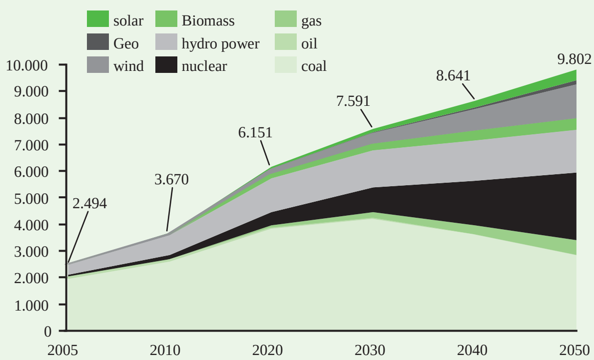
Power generation Under EC scenario, TWh



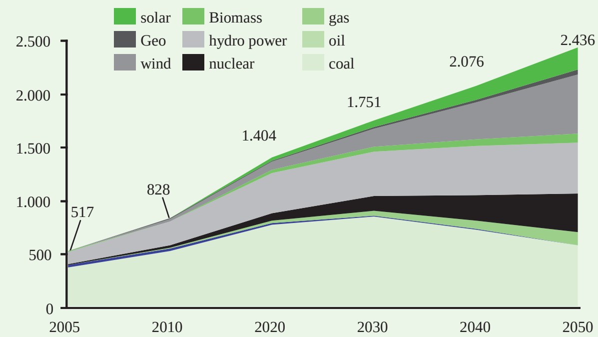
Installed Capacity Under EC scenario, GW



Power generation Under EA scenario, TWh



Installed Capacity Under EC scenario, GW



ANNEX 3.6: COMPARISON WITH SIMILAR RESEARCH STUDIES

CO_2 emissions under different scenarios (GT)					
	2010	2020	2030	2040	2050
PECE–Reference scenario a	7.6	11.4	13.9	15.3	16.2
ERI–Reference scenario b	7.8	10.2	11.7	12.9	12.7
EIA–Reference scenario c	7.7	10	12.4		
IEA-Reference scenario d	7	9.6	11.6		
PECE–Emissions control scenario a	6.8	8.2	8.8	9.2	9.5
PECE–Emissions abatement scenario a	6.8	8.2	8.8	7.9	5.5
ERI–Low carbon scenario b	7.1	8.3	8.6	8.8	8.8
ERI–Enhanced low carbon scenario b	7.1	8	8.2	7.4	5.1
IEA–Alternative policy scenario d	6.6	8.4	8.9		

Notes:

a. Scenarios of the PECE series, developed by the Energy and Climate Economics Project of Renmin University of China, are used in this report.

b. ERI (Energy Research Institute of the National Development and Reform Commission), 2009, The Road of China's 2050 Low carbon Development.

c. EIA (US Energy Information Administration), International Energy Outlook 2009.

d. IEA (International Energy Agency), the reference scenario quoted from World Energy Outlook 2009, the alternative scenario quoted from World Energy Outlook 2007.

ANNEX 3.7: LIST OF TECHNOLOGIES NEEDED FOR MITIGATION

Sector	Technology	Development in China and other countries	Development stage	Abatement potential (100 million tons of CO_2, under the EA scenario in 2050)	Incremental investment (US$100 million, under the EA scenario in 2050)
Power	Ultra Super Critical(USC) power generation technology (mainly the new-generation of efficient USC power-generation technology, high-temperature materials, and production technology for castings and forgings)	The technology is developing rapidly in China, with an import substitution rate of more than 80%. There is still room for efficiency improvement in USC power generation. R&D for a new generation of high-power USC units, with an efficiency rate of 50% is taking place EU and US [1], while key technologies for high-temperature materials, castings, and forgings are still controlled by OECD countries.	Diffusion/ demonstration	1.8	436
	Integrated gasification combined cycle (IGCC) power generation technology (mainly integrated design control technology, large-scale efficient coal gasification technology, and high-efficiency gas turbine technology)	As a new type of cost-effective clean coal technology, the new generation of IGCC has a high efficiency rate (more than 50%), and low pollution emission rate. With no project experience in this area, China lags behind in integrated design control, large-scale coal gasification and gas turbine technologies. As these technologies are of strategic importance to China, it must acquire them. However, in light of past failures in importing gasifies and gas turbines, as there has been no operation experience of high–efficiency, large-scale IGCC power generation projects abroad, it is important for China to do both joint and independent research so as not to become a "research lab" for foreign enterprises.	Demonstration /R&D	2.9	2,726

Sector	Technology	Development in China and other countries	Development stage	Abatement potential (100 million tons of CO_2, under the EA scenario in 2050	Incremental investment (US$100 million, under the EA scenario in 2050)
Power	Advanced nuclear technology (mainly the fourth-generation nuclear technology (i.e., new generation of fast reactor technology)	In view of the resource constraints of uranium and the problems of nuclear waste disposal, wide application of nuclear energy in China will be very limited, unless a breakthrough is made in the new generation of fast reactor technology. Compared with current thermal reactors, the new generation nuclear energy system is safer and more cost-effective, and nuclear fuels can be recycled. China needs to be actively involved in the collaborative research on the 4th generation reactor.	R&D	11.6	7,818
	Nuclear fusion technology	Energy from nuclear fusion is of revolutionary significance to future development; but its commercial prospects are still unclear. China should be closely involved and follow the latest R & D activities in the technology.	R&D	N/A	N/A
	Large-scale onshore and offshore wind power generation technology (mainly control system, turbine and blade design, new material for blade making (carbon fiber), blade detection, and bearing technology	To date, China has the production capacity of MW- level turbine and some components, but the key technologies of control system, turbine, and blade design are still imported from other countries.	Diffusion/ demonstration	6.8	6,854

Sector	Technology	Development in China and other countries	Development stage	Abatement potential (100 million tons of CO_2, under the EA scenario in 2050)	Incremental investment (US$100 million, under the EA scenario in 2050)
Power	High-efficiency thin-film solar cell (mainly manufacturing equipment, vacuum technology, and advanced technology)	China is short of thin-film cell production technology, and has nothing in the way of commercial technology (flexible solar energy production process) or production equipment and key equipment such as vacuum pumps. Countries like Switzerland, the United Kingdom, Italy, and Germany have these key technologies.	Diffusion/ demonstration	0.3	648
	Core technology of solar thermal power (including the Stirling machine, medium and low temperature solar heat conversion technology, etc.)	High cost is one obstacle to solar power. Its development is still at the key technological research and experimentation stage. Countries like Germany, the United States, and Spain have these key technologies.	Demonstration/ R&D	1.1	2,718
	Solar photovoltaic technology (mainly high-purity silicon production technology, key materials such as steel wire, the complete industrial chain of equipment manufacture, and technology for high-efficiency conversion from photovoltaic power generation)	The high cost of the solar cell is the major constraint to developing solar photovoltaic power generation. More than 90% of the high-purity raw materials used in the solar cell are imported from other countries. These imported raw materials are expensive and countries owning the technologies blockade them, which makes solar cells very expensive. China is also short of key materials and manufacturing equipment, which it needs to further improve conversion efficiency.	Diffusion/ demonstration/ R&D	1.8	3.501

Sector	Technology	Development in China and other countries	Development stage	Abatement potential (100 million tons of CO_2, under the EA scenario in 2050)	Incremental investment (US$100 million, under the EA scenario in 2050)
Power	Smart grid (mainly the key on-grid technology and the inverter technology)	At present, China does not have the key manufacturing inverter technology,, large-scale on-grid power plant experience, and a commercial operation model. The United States, Germany, and Japan are the main owners of these technologies in the world.	Diffusion	N/A	N/A
	Advanced geothermal power-generation technology	There has been related technology outside China, but China is still at the R&D stage of the technology.	Diffusion/ demonstration	0.7	511
	Second-generation bio-energy technologies (including production of fuel ethanol from lignocellulose, such as the technology of cellulose production and biomass technology)	The first-generation biomass energy technologies are unlikely to be widely used in China because of resource constraints, but cellulosic ethanol as the second-generation liquid fuel has wide application prospects. There have been many years of R&D experiences outside China, and many enterprises are planning/constructing demonstration plants, although there is no wide commercialization. The cellulose enzyme technology is one of the most critical.	Demonstration/ R&D	2.5	5883
	Energy storage technology	Wind and solar are intermittent energy sources, which will affect the stability of the power grid. Hence, the power grid has a limited capacity for these kinds of energy. Efficient storage technology thus needs to be developed. At present, this technology is in the hands of European countries and the United States, and is still at the R&D stage.	R&D	N/A	N/A

Sector	Technology	Development in China and other countries	Development stage	Abatement potential (100 million tons of CO_2, under the EA scenario in 2050)	Incremental investment (US$100 million, under the EA scenario in 2050)
Power	Hydrogen fuel cell technology	As the cleanest energy, hydrogen energy is an important trend. However, the development of hydrogen fuel cells is now constrained by its high cost. In China, the technologies are still at the R&D stage, and recycled fuel cell power generation and fuel cell vehicle technology are under development.	R&D	N/A	N/A
	CCS technology (including pre-combustion carbon capture technology and post-combustion carbon capture technology, and carbon storage technology)	In view of China's coal-based resource endowment, CCS technology will be of great significance to mitigation attempts. To date, there has been no commercial demonstration of CCS technology. The research is still at the preliminary stage, and there is still a long way to go for large-scale commercial implementation. China needs to do joint R&D and follow the latest developments. In addition, China needs to study both pre- and post-combustion carbon capture technologies.	R&D	20.1	13,849

Sector	Technology	Development in China and other countries	Development stage	Abatement potential (100 million tons of CO_2, under the EA scenario in 2050)	Incremental investment (US$100 million, under the EA scenario in 2050)
Iron and Steel	Coke dry quenching (CDQ)	By the end of May 2008, 57 CDQ units were in operation in China, accounting for 13.5% of the total coke production capacity (360 million ton). Most of the CDQ techniques in China were imported. Domestic metallurgical coke design institutes such as Capital Steel & Iron Design Institute and the Anshan Coking & Refractory Engineering Institute have the capacity for CDQ process design, and some, though able to manufacture CDQ equipment, still lack the capacity to design and manufacture high-pressure CDQ technology, which is in the hands of Japanese companies.	Diffusion	0.3	240
	Residual heat and pressure recovery technologies (such as sintering waste heat recovery technology, converter gas recovery (LT), converter of low pressure steam for power generation, hydrogen production from coke oven gas technology)	The residual heat and energy recovery in China's iron and steel sector is low (only 45.6%), while international advanced enterprises, such as Japan's Nippon Steel can have a recovery rate of more than 92%. There is thus great potential for China's iron and steel industry to improve its waste recovery rate.	Diffusion	0.95	943

Sector	Technology	Development in China and other countries	Development stage	Abatement potential (100 million tons of CO_2, under the EA scenario in 2050)	Incremental investment (US$100 million, under the EA scenario in 2050)
Iron and Steel	Steel production energy management center	Iron and steel enterprises in OECD countries have established energy management centers. China's large-scale iron and steel enterprises such as Baosteel, the Anshan Iron and Steel Company, have also established a number, but the popularity of this kind of energy management center is yet to be improved.	Diffusion	0.16	110
	Coal Moisture Control (CMC)	CMC has great mitigation potential and has developed by leaps and bounds in Japan, where the third-generation CMC technology is put into wide use. In China, however, only the second-generation CMC is widely used.	Diffusion	0.2	166
	CCPP (Combined cycle power plant) technology with low-calorific-value gas in iron and steel plants	Low-calorific-value gas turbines and some core components need to be imported, because they have only 10–20 years of service life and the cost is high. Joint-ventures such as NAC and GE are making gas turbines and core components, but can only make 50,000 kW ones. Those over 150,000 kilowatts need to be imported.	Diffusion	0.1	138
	New-generation of Coking technologies (such as SCOP21)	New coke oven technologies, such as Japan's SCOPE21, have a service life of 20–25 years, which are at the demonstration stage, and not yet commercialized.	R&D/ demonstration	0.48	1479

Sector	Technology	Development in China and other countries	Development stage	Abatement potential (100 million tons of CO_2, under the EA scenario in 2050)	Incremental investment (US$100 million, under the EA scenario in 2050)
Iron and Steel	Technology of injecting waste plastics into blast furnace	The research on the technology of injecting waste plastics into blast furnace started early and is now commercialized in Germany and Japan. Compared with foreign countries, China is still at the theoretical and feasibility study stage. Baosteel Research Institute, Baosteel Branch Ironworks, Anhui Technology University and Baosteel engineering company have been cooperating in the research and completed the industrial experiment of this technology in 2007.	Demonstration/ diffusion	0.16	318
	Smelting reduction technologies (including COREX, FINEX Technology)	Smelting reduction technology is based on direct coal coke and iron ore powder technology. As there is no coke, sintering, or pelletizing plant involved, the technology simplifies the iron-making process. There are dozens of technologies, but only COREX and FINEX have been tested and implemented industrially Baosteel has successfully introduced COREX technology, but no breakthrough has been achieved. Smelting reduction technology has very little value in reducing CO2 emissions, but is of great importance to environmental protection.	Demonstration/ diffusion	0.1	244

Sector	Technology	Development in China and other countries	Development stage	Abatement potential (100 million tons of CO_2, under the EA scenario in 2050)	Incremental investment (US$100 million, under the EA scenario in 2050)
Iron and Steel	Direct steelmaking technology using microwave, electric arc, and exothermal heating	The technology is a substitution process for the current sintering, coking, blast furnace and converter processes. The theoretical thinking is to heat the iron ore, coal, and lime with microwave, electric arc, and heat released from coal reaction, to the temperature of iron making, steelmaking and smelting, and get higher quality products. The technology was successfully developed in September 2003 in the United States, and can save 25% energy. There have been no research findings about this technology in China.	Demonstration/ diffusion	0.1	445
	Advanced electric arc furnace steelmaking (EAF)	EAF steelmaking process is an alternative to the long process of steelmaking. With the increase of steel scrap resources, China's iron/ steel ratio will decrease, and the proportion of EAF steel will rise. At present, there is still a certain gap between the EAF technology in China and international advanced technology.	Demonstration/ diffusion	0.9	2,253

Sector	Technology	Development in China and other countries	Development stage	Abatement potential (100 million tons of CO_2, under the EA scenario in 2050)	Incremental investment (US$100 million, under the EA scenario in 2050)
Iron and Steel	Itmk3 iron-making technology	Itmk3, the third-generation iron-making technology, is the high-temperature iron-making furnace. Carbon pellets at the bottom of the furnace would be in a quasi-molten state when reduced, so that there is no need to separate the slag iron (do not have to melt and then release), and formed iron (nuggets or pebbles). This kind of furnace is being developed. Two enterprises have been testing it. Kobe steel is collaborating with companies in the United States to make large-scale equipment (50,000 tons output), but many critical technical issues remain unresolved.	R&D/ demonstration	0.1	371
	Technology of thin strip continuous casting (Castrip)	Compared with traditional techniques, Castrip has great advantage in energy efficiency. The first industrial production line has been built in the United States, but China does not have this kind of technology.	Demonstration/ diffusion	0.3	1,217
	CCS Technology	To date, there has been no successful commercial demonstration. The technology is still at a preliminary study phase and yet to be developed. There is still a long way to go in term of large-scale application. China needs to do join-research in this area and to keep track of the latest progress in a long run.	R&D	2.6	2,955

Sector	Technology	Development in China and other countries	Development stage	Abatement potential (100 million tons of CO_2, under the EA scenario in 2050)	Incremental investment (US$100 million, under the EA scenario in 2050)
Cement	Large-scale new suspension preheater kiln (mainly automatic control device and level of integrated operation)	Although the number of NSP kiln is raised continuously, the proportions of old production processes such as shaft kiln are still high. There is still a wide gap between technologies used in China and advanced technologies in the world, especially in some key technologies, such as the automatic control device and the level of integrated operation.	Diffusion	0.6	1,054
	Eco-cement technology (taking combustible waste as an alternative fuel)	The substitution rate of secondary fuel in the cement industry is more than 50% in the Netherlands, Germany, and Switzerland. Although some academic institutions and some cement enterprises in Beijing, Shanghai, Guangzhou, and Sichuan have made numerous experiments and pilot projects, it has not been promoted nationwide. Hence, the utilization rate of alternative fuels in the cement industry is close to zero.	Demonstration/ diffusion	0.5	615
	Pure low temperature waste heat-power generation technology for NSP kilns	This technology has been greatly developed in China, but there is still room for further development, especially in the area of power generation efficiency.	Diffusion	0.3	577
	Efficient grinding technologies (such as advanced vertical centrifugal mill)	Efficient grinding technologies are the leading operations in cement grinding process, which need little space and consume little energy. However, they are not widely applied in China. There is still great potential for these technologies.	Diffusion	0.3	305

Sector	Technology	Development in China and other countries	Development stage	Abatement potential (100 million tons of CO_2, under the EA scenario in 2050)	Incremental investment (US$100 million, under the EA scenario in 2050)
Cement	CCS technology	To date, there has been no successful commercial demonstration. The technology is still at a preliminary study phase and still to be developed. There is still a long way to go in terms of large-scale application. China needs to do joint research in this area and to keep track of the latest progress in the long run.	R&D	1.3	1574
Transport	Motorcycle engine technology, power-train technology and lightweight vehicle technology to improve fuel economy	Traditional technologies in vehicle energy saving and fuel economy improvement now have large market shares. There is still a huge gap between these domestic technologies and advanced technologies in the world.	Demonstration/ Diffusion	6.4	10,240
	Advanced low-emission diesel engine technology and high-quality automotive diesel technology	The development of the light high-speed diesel engine, the improvement of diesel quality and quality assurance, make possible energy savings of 20–30%. At present, advanced diesel cars are at the stage of mature commercial operation globally but have limited presence in China. China needs to further improve its advanced low-emission diesel engine technology and high-quality automotive diesel technology.	Diffusion	1.8	3,366

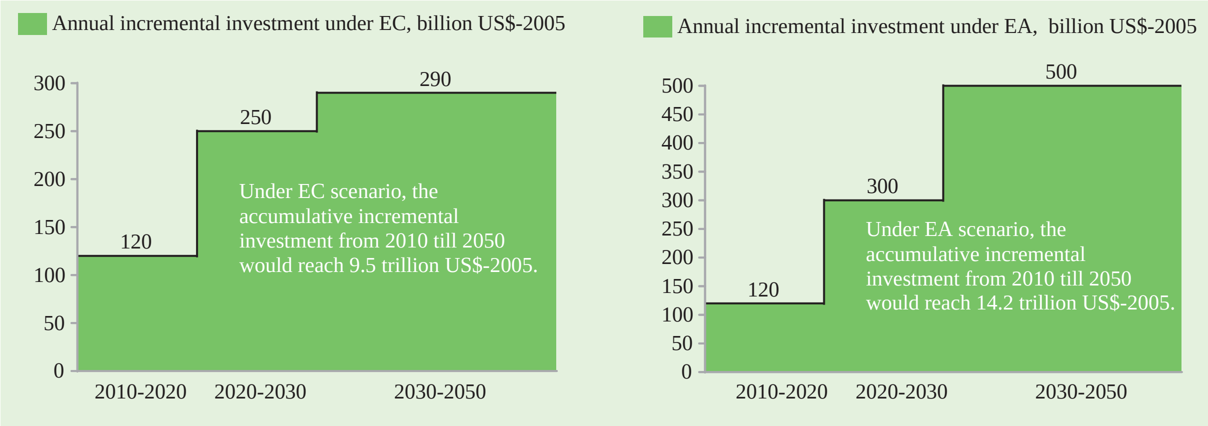
Sector	Technology	Development in China and other countries	Development stage	Abatement potential (100 million tons of CO_2, under the EA scenario in 2050)	Incremental investment (US$100 million, under the EA scenario in 2050)
Transport	Hybrid electric vehicle technology (mainly energy recovery efficiency improvement technology and matching control technology)	Global R&D of the hybrid electric vehicle started 30 years ago Now hybrid vehicles have been industrialized and commercialized. China's auto industry has begun to research, development, and manufacture hybrid vehicles, but still lags behind in recovery efficiency and technology for full hybrid vehicles.	R&D/ Demonstration/ diffusion	2.1	4,578
	High-performance pure electric vehicle technology (mainly the integration of technology and technology-wire)	Developed countries have developed series of pure electric cars, high-speed pure electric vehicles, pure electric buses, and electric touring buses. China needs to improve its technology integration and wire transport technology in the pure electric vehicle area.	R&D/ Demonstration/ diffusion	2.8	8,960
Buildings	LED technology	The United States, Japan, Germany and Taiwan are the most advanced in LED technology. The majority of patented technologies are in the hands of a small number of large companies, and the core technology has been securely protected. China is currently doing packaging and heat sink, and not acquiring core technologies.	R&D/ Demonstration/ diffusion	1.7	764
	New building envelope materials and parts	China has introduced and learned a number of technologies in external wall and roof insulation. Major technological breakthroughs have been made in external windows and glass curtain walls, but the level of technology diffusion is low. There is a huge gap between Chinese and foreign advanced companies in outdoor sunshading.	R&D/ demonstration/ diffusion	6.9	8,583

Sector	Technology	Development in China and other countries	Development stage	Abatement potential (100 million tons of CO_2, under the EA scenario in 2050)	Incremental investment (US$100 million, under the EA scenario in 2050)
Buildings	Regional combined heat and power (BCHP) technologies (such as heat, electricity and gas combined-cycle technology)	BCHP offers a solution for energy supply to large public buildings. Compared with direct access to grid electricity, the technology can save primary energy by 20~30%. Major technical obstacles include: high power efficiency, low-emission gas-fired power plant, and high-density, high-conversion efficiency thermal-driven air conditioning.	Demonstration/ diffusion	1.7	2,952
	Ground heat pump technology	Ground heat pump air-conditioning systems have developed rapidly in North American countries and the Nordic countries, but development of this technology in China is not yet mature.	R&D/ Demonstration/ Diffusion	0.9	3,543
	Advanced ventilation and air conditioning systems (such as independent temperature/ humidity control systems)	In recent years, an important development trend has been to use independent temperature and humidity control. This can avoid the use of dehumidification when condensing relative humidity in order to re-regulate heat caused by hot and cold offset temperatures. Cold source can also be used to absorb sensible heat, so as to substantially improve the efficiency of the cold source. At present, countries worldwide are active in a large number of related studies and pilot projects.	R&D/ Demonstration/ Diffusion	1.3	1,053

Sector	Technology	Development in China and other countries	Development stage	Abatement potential (100 million tons of CO_2, under the EA scenario in 2050)	Incremental investment (US$100 million, under the EA scenario in 2050)
General Technologies	High-power electronic devices, especially power semiconductor component technology	There is still a gap between the level of China's high-power electronics products and the foreign advanced level. Represented by Siemens and ABB, the European Union is in a leading position in the high-power electronics products and technologies. IGBT and IGCT devices have been the bottlenecks in China's electric and electronics industry, especially the high-power electronics industry.	Demonstration /Diffusion	0.5	1,340
	Permanent magnet DC brushless motor	The application of this technology in micro and small areas is relatively mature. Japan is the leader. In light of China's rare-earth resources, technology providers from OECD countries continue to cause problems in these areas.	Demonstration /Diffusion	N/A	N/A

ANNEX 3.8: INCREMENTAL INVESTMENT UNDER EC & EA SCENARIOS

Incremental investment under EC & EA scenarios



ANNEX 3.9: SETTING THE DISCOUNT RATE

There has been a long-standing debate on the choice of discount rate, which has a great deal to do with the value of incremental cost. Some argue that the rate should be set in strict conformity with theory, while others insist that the real rate that depositors and investors use in daily decision making should be adopted. Generally, discount rate is used to represent the rate of time preference. We need to distinguish following two situations: when we use discount rate to discounting further environmental benefits (or future environmental damage), many study suggest that a relatively low discount rate should be adopted to ensure the long-term environmental benefits (or damage) shall not be underestimated, e.g. most economist use discount rates ranging from 3-5% when trying to put a price tag on future damages and Nordhaus uses a discount rate of 3% in Dice Model. However, when we using bottom –up approach to estimate mitigation costs, in which discount rate are used to allocate present fixed investment cost to future, in such situation, a low discount rate may induce the underestimation of future cost and the proper discount rate may be the one that could at least be partially reflects the opportunity cost of capital. Generally, the discount rate is 4–5% in developed countries and 10–12%, or even much higher, in developing countries. A large number of studies use a lower figure and thus come to a lower abatement cost than those presented here, e.g. McKinsey (2009) uses the discount rate of 4% in analyzing China's abatement cost curve. Such discount rates do not reflect the private return on investment which is usually as high as 10–25%.

The scenario study used in this report argues however, that given that the majority of low carbon investment comes from the private and business sector, the discount rate should reflect, to some extent, the private need for the lowest return. Therefore, the discount rate adopted in this study is 12%, which is used by the World Bank and the Asian Development Bank in calculating investment costs and rates of return. It is recognized that the choice of discount rate has a bearing on the calculation of costs and this should be taken into account.

ANNEX 3.10: INCREMENTAL COSTS UNDER THE EC SCENARIOS WITH 40 AND 45% CUTS IN CARBON INTENSITY

Cuts in CO2 emissions per unit GDP in 2020 over 2005 levels, %	EC scenario1 ——40% cut	EC scenario2 ——45% cut
Per capita emissions, t-CO2	6.9	6.3
Total emission reductions in relative to the reference level, 1 billion t-CO2	1.4	2.2
Incremental abatement cost in relative to the reference level (US$1 billiona/year)	≤0[2]	≤30
Unit abatement cost, USD/t-CO2	≤0	14
Share of unit abatement cost in GDP (%)	≤0	≤0.4
Equivalent cost per household, US$/year	≤0	≤64

Note: a. US$ in this table is calculated at constant prices (2005).

ANNEX 3.11: ASSIGNING CARBON CUTS

Different countries have presented approaches to allocating carbon emissions entitlements. These include:
—European Union (2003): The national abatement targets should consist of the different targets set for different sectors such as civil society, heavy industry and power generation in order to achieve cost-effective emissions reduction for the country as a whole. The aim is to reduce CO2 emissions by 20 percent in 2020, 30 percent in 2030 and 50 percent in 2050 over 1990 level. The EU also calls on other countries to adopt such a strategy.
—United States (2002): The United States argues that the allocation of emissions entitlements should be linked to the scale of an economy, and that obligations should be determined based on an economy's energy intensity.
—Brazil (1997): Different quantified abatement targets should be set according for countries according to their historical emissions contributions to global climate change. All parties should share the burden of reducing emissions based on their share of past and current emissions.
Other proposals include:
—Contraction and convergence: The Global Commons Institute has suggested that all countries participate in global emissions reduction with quantified emissions targets. As a first step, all countries work together on emissions reduction to stabilize concentrations of emissions. As a second step, per capita emissions converge to an equal level for all countries within a given period. For example, if the threshold concentration level is set at 400 parts per million (ppm), all countries' per capita emissions rates should converge to between 1 and 1.4 tonnes.
—Common but differentiated convergence: This is similar to contraction and convergence, but with some variations. Developed countries' per capita emissions allowances converge within, for example, 40 years to an equal level for all countries. Developing countries' per capita emissions also converge within the same period to the same level, but convergence starts from the date at which their per capita emissions reach a certain percentage threshold of the (gradually declining) global average. Countries that do not pass this percentage threshold may sell their emission allowances through the CDM. The downside of this approach is that it does not consider the historical responsibility of developed countries, or that developing countries' per capita emissions are limited and will never exceed those of developed countries.
—One standard, two convergences: First, all countries' per capita emissions converge to the same level in 2100. Second, the accumulated per capita emissions of all countries are the same between 1990 and the convergence year. This approach takes into full consideration the principle of equity, but a very complex calculation will be needed to ensure that the two convergences happen at the same time.

—Human development-based carbon emissions: Since emissions have been central to development, which is a basic human right, emissions reduction should ensure equity among nations and individuals. Abatement targets should be set in line with the human development goals of the United Nations. The argument highlights the importance of equity.
—Stern's convergence and contraction: All countries' per capita emissions cap is 2 tonnes in 2050. Developed countries should take the lead in reducing emissions, and developing countries should start to set abatement targets in 2020. Such a scheme does not take into account historical responsibility.
—Greenhouse Gas Emissions Entitlement Fund: The rich and poor are given different carbon emissions entitlements based on the gap in per capita income. National obligations are determined according to the Responsibility Capacity Index, and an international fund is established to promote the emissions reductions of all countries, and poverty reduction and development for developing countries.

Sources: Global Commons Institute, 2006 "GCI Briefing: Contraction & Convergence." Niklas Höhne, Michel den Elzen and Martin Weiss, 2006, "Common but differentiated convergence (CDC): a new conceptual approach to long-term climate policy," in Climate Policy, 6(2) pp. 181-199. Pan Jiahua, 2002, "The Conceptual Framework and Empirical Data of Human-Development Analysis: The case of the need of carbon emissions capacity," in China Social Sciences, 6. Pan Jiahua and Zhu Xianli, 2006, "Human-Development Analysis and Its Application to International Climate Regulation Design: The Case of the Need of Energy and Carbon Emissions in China," in China's Population, Resource and Environment, 6. Pan Jiahua, 2008, "Carbon Budget and Its Implications in Terms of International Equality and Sustainability," in World Economics and Politics, 1. Chen Yin and Pan Jiahua, 2008, "The Comments and Interpretations on Stern Review," in Advances in Climate Change Research, 4. Sivan Kartha, Tom Athanasiou and Paul Baer, 2008, "A fair sharing of effort: Operationalizing the Greenhouse Development Rights framework," side event at the UN Framework Convention on Climate Change meeting in Bonn, 6 June. Available at www.ecoequity.org/GDRs (last accessed 31 March 20

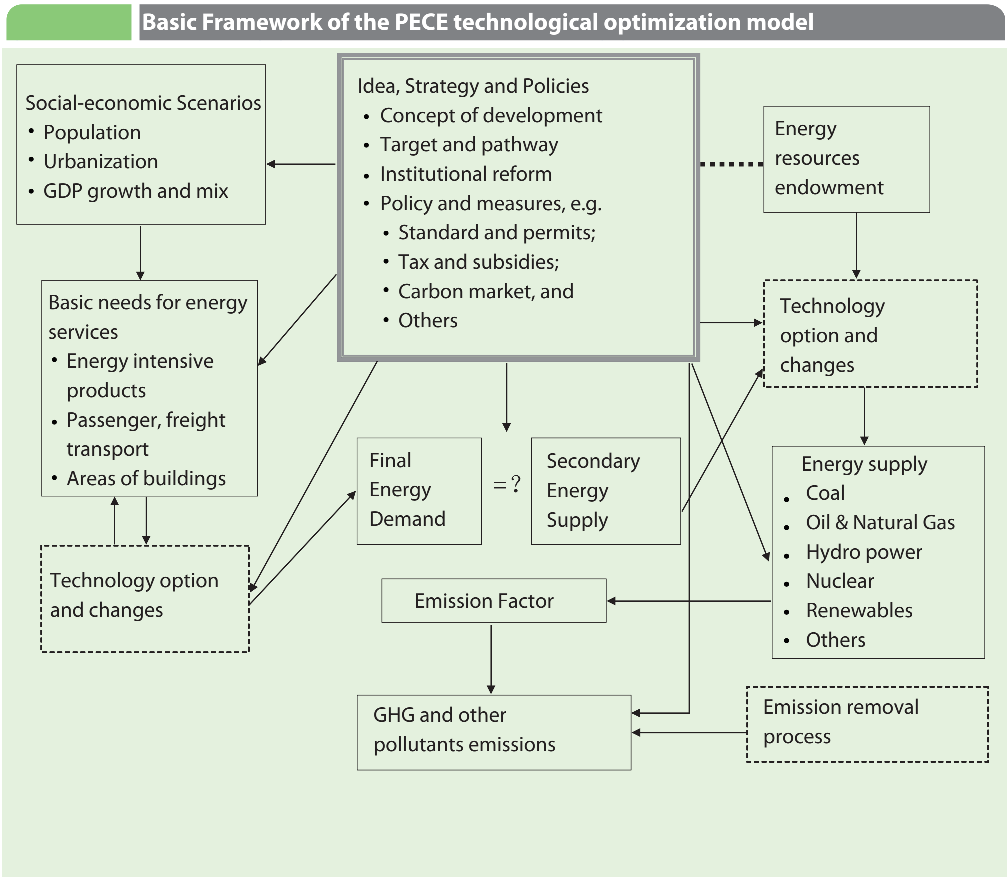
ANNEX 3.12: PECE TECHNOLOGICAL OPTIMIZATION MODEL

The PECE model is a bottom-up, non-linear model that calculates the most cost-saving choice of technological option under a series of restrictions (e.g., demand for energy services, restriction on energy supply, restriction on technological feasibility, etc.). The basic model framework is shown in Figure 3.1. The costs calculated in the model include fixed technological investments, operating costs, energy costs, taxes, expenses, subsidies, etc.

The characteristics and functions of this model are as follows:

- It can reflect the scenario research results of different hypotheses on driving factors determining China's low carbon future;
- It can provide optimized emission reduction plans (the minimum cost method);
- It can determine technological demand, investment in emission reduction and control, unit of emission reduction and control, total costs, etc., and thus establish a technological road map;
- It can be extended from the national to the local and regional level;
- It can also comprehensively reflect different policy variables. For example, it can reflect the impact of carbon taxes and energy taxes at different levels on emission reduction costs and investments. Meanwhile, information on the costs of emission reduction given by the model can also provide a basis of reference for fixing the carbon tax rate or energy tax rate, and can thereby be used to evaluate the price level of the carbon market.

ANNEX 3.13: BASIC FRAMEWORK OF THE PECE TECHNOLOGICAL OPTIMIZATION MODEL



ANNEX 3.14: CARBON BUDGET CONSTRAINTS

In embarking on a low carbon path, China's main concern is to develop a viable and sustainable economy that fulfills the needs of its people. It must also contribute global efforts to mitigate climate change. Both concerns are interdependent.

The debate on how countries should share responsibilities related to climate change is at the heart of the climate change negotiations under the UN Framework Convention on Climate Change. One way of analysing the obligations is through a carbon budget approach, under which the global allocation of emissions entitlements is based on the needs and requirements for basic development, domestic circumstances and capabilities, and historical responsibilities.

The setting of a long-term global abatement target is of fundamental interest for all countries. It would provide added incentives for more aggressive development of advanced energy technology and promotion of low carbon economic development. But the distribution of burdens in achieving it needs to be equitable. Whatever target is set needs to provide sufficient space for continued development.

Source: He Jiankun and Cai Qimin, 2008, "The discussion on the long-term goal of global emissions reduction of greenhouse gases," in Journal of Tsinghua University, 4.

1 IEA ETSAP, Technology Brief E01, 2009.10, Coal-Fired Power, available at www.etsap.org.

2 The negative incremental cost means from technology perspectives, the cost of the additional investment needs can be totally offset by the energy-saving benefit and would bring positive economic returns.

STATISTICAL APPENDIX

Table 1 Human Development Index (2008)

Region	Life expectancy index	Education index	GDP index	HDI
National	0.773	0.923	0.683	0.793
Beijing	0.852	0.968	0.854	0.891
Tianjin	0.832	0.962	0.833	0.875
Hebei	0.792	0.951	0.687	0.810
Shanxi	0.778	0.958	0.666	0.800
Inner Mongolia	0.748	0.920	0.742	0.803
Liaoning	0.806	0.964	0.737	0.835
Jilin	0.802	0.955	0.689	0.815
Heilongjiang	0.790	0.958	0.676	0.808
Shanghai	0.886	0.960	0.879	0.908
Jiangsu	0.815	0.921	0.776	0.837
Zhejiang	0.828	0.907	0.787	0.841
Anhui	0.781	0.860	0.608	0.750
Fujian	0.793	0.898	0.731	0.807
Jiangxi	0.733	0.936	0.612	0.760
Shandong	0.815	0.921	0.746	0.828
Henan	0.776	0.927	0.659	0.787
Hubei	0.768	0.923	0.661	0.784
Hunan	0.761	0.942	0.640	0.781
Guangdong	0.805	0.960	0.768	0.844
Guangxi	0.772	0.944	0.614	0.776
Hainan	0.799	0.916	0.637	0.784
Chongqing	0.779	0.924	0.645	0.783
Sichuan	0.770	0.899	0.618	0.763
Guizhou	0.683	0.860	0.526	0.690
Yunnan	0.675	0.871	0.585	0.710
Tibet	0.656	0.634	0.601	0.630
Shaanxi	0.751	0.919	0.647	0.773
Gansu	0.708	0.829	0.579	0.705
Qinghai	0.684	0.838	0.639	0.720
Ningxia	0.753	0.903	0.644	0.766
Xinjiang	0.707	0.953	0.661	0.774

Source: China Statistical Yearbook 2009

Table 2 HDI Rank and GDP Rank (2008)

HDI Rank	Region	HDI	GDP per capita rank	GDP per capita rank minus HDI rank
High human development				
1	Shanghai	0.908	1	0
2	Beijing	0.891	2	0
3	Tianjin	0.875	3	0
4	Guangdong	0.844	6	2
5	Zhejiang	0.841	4	-1
6	Jiangsu	0.837	5	-1
7	Liaoning	0.835	9	2
8	Shandong	0.828	7	-1
9	Jilin	0.815	11	2
10	Hebei	0.810	12	2
11	Heilongjiang	0.808	13	2
12	Fujian	0.807	10	-2
Medium human development				
13	Inner Mongolia	0.803	8	-5
14	Shanxi	0.800	14	0
15	Henan	0.787	17	2
16	Hubei	0.784	16	0
17	Hainan	0.784	23	6
18	Chongqing	0.783	19	1
19	Hunan	0.781	21	2
20	Guangxi	0.776	25	5
21	Xinjiang	0.774	15	-6
22	Shaanxi	0.773	18	-4
23	Ningxia	0.766	20	-3
24	Sichuan	0.763	24	0
25	Jiangxi	0.760	26	1
26	Anhui	0.750	27	1
27	Qinghai	0.720	22	-5
28	Yunnan	0.710	29	1
29	Gansu	0.705	30	1
30	Guizhou	0.690	31	1
31	Tibet	0.630	28	-3

Source: China Statistical Yearbook 2009

Table 3 Population by Region

Region	Total population (10000) (2008)	Population growth rate (2008)	Urban population rate		Dependency rate		Gender ratio (female=100)	
			2000	2008	2000	2008	2000	2008
National	132,802	5.08	36.22	45.68	42.56	36.72	106.74	103.13
Beijing	1,695	3.42	77.54	84.9	28.16	24.99	108.97	103.38
Tianjin	1,176	2.19	71.99	77.23	33.47	29.92	103.99	97.21
Hebei	6,989	6.55	26.08	41.9	42.21	32.98	103.67	103.96
Shanxi	3,411	5.31	34.91	45.11	47.06	35.28	107.28	102.93
Inner Mongolia	2,414	4.27	42.68	51.71	36.30	29.89	107.17	105.21
Liaoning	4,315	1.1	54.24	60.05	34.24	30.66	104.04	100.92
Jilin	2,734	1.61	49.68	53.21	33.00	27.16	104.92	102.37
Heilongjiang	3,825	2.23	51.54	55.4	32.14	27.92	104.60	102.28
Shanghai	1,888	2.72	88.31	88.6	31.09	26.49	105.74	100.18
Jiangsu	7,677	2.3	41.49	54.3	39.69	34.22	102.58	95.07
Zhejiang	5,120	4.58	48.67	57.6	36.83	32.75	105.57	103.62
Anhui	6,135	6.45	27.81	40.5	49.19	44.63	106.61	105.33
Fujian	3,604	6.3	41.57	49.9	41.96	38.39	106.36	101.24
Jiangxi	4,400	7.91	27.67	41.36	47.28	45.11	108.31	104.56
Shandong	9,417	5.09	38.00	47.6	40.61	33.94	102.53	100.13
Henan	9,429	4.97	23.20	36.03	49.03	38.25	106.58	102.27
Hubei	5,711	2.71	40.22	45.2	41.20	33	108.59	102.88
Hunan	6,380	5.4	29.75	42.15	41.76	37.33	109.02	107.1
Guangdong	9,544	7.25	55.00	63.37	43.31	35.19	103.82	105.09
Guangxi	4,816	8.7	28.15	38.16	50.06	45.37	112.68	109.21
Hainan	854	8.99	40.11	48	51.63	43.85	109.77	109.81
Chongqing	2,839	3.8	33.09	49.99	42.51	44.87	108.04	101.67
Sichuan	8,138	2.39	26.69	37.4	43.05	40.45	106.98	102.64
Guizhou	3,793	6.72	23.87	29.11	56.45	51.94	110.10	108.21
Yunnan	4,543	6.32	23.36	33	47.10	42.88	110.11	108.3
Tibet	287	10.3	18.93	22.61	55.52	40.09	102.62	94.65
Shaanxi	3,762	4.08	32.26	42.1	44.80	35.2	108.42	102.79
Gansu	2,628	6.54	24.01	32.15	47.06	40.46	107.59	102.39
Qinghai	554	8.35	34.76	40.86	44.82	40.03	107.06	101.61
Ningxia	618	9.69	32.43	44.98	49.05	41.55	105.28	103.71
Xinjiang	2,131	11.17	33.82	39.64	46.69	39.12	107.27	103.14

Note: Population in Hong Kong, Macao and Taiwan are not included; people in military service are included in the total population but not in the regions, total population is adjusted by the survey data in 2007, while the regional population numbers are not.

Source: China Statistical Yearbook 2001 and 2009

Table 4 Age Distribution and Dependency Ratio by Region (2008)

Region	Age(10,000 persons)			Percentage of the total(%)			Dependency ratio
	0-14	15-64	65 and above	0-14	15-64	65 and above	
National	204,088	862,020	112,413	17.32	73.14	9.54	36.72
Beijing	1,438	11,852	1,524	9.71	80.01	10.29	24.99
Tianjin	1,087	7,785	1,242	10.75	76.97	12.28	29.92
Hebei	10,115	47,362	5,504	16.06	75.20	8.74	32.98
Shanxi	5,602	22,752	2,424	18.20	73.92	7.88	35.28
Inner Mongolia	3,251	16,795	1,769	14.90	76.98	8.11	29.89
Liaoning	4,729	29,840	4,419	12.13	76.54	11.33	30.66
Jilin	3,029	19,475	2,260	12.23	78.64	9.13	27.16
Heilongjiang	4,408	27,116	3,163	12.71	78.17	9.12	27.92
Shanghai	1,332	13,324	2,198	7.90	79.06	13.04	26.49
Jiangsu	9,515	51,535	8,118	13.76	74.51	11.74	34.22
Zhejiang	6,435	34,576	4,889	14.02	75.33	10.65	32.75
Anhui	11,163	38,372	5,963	20.11	69.14	10.74	44.63
Fujian	5,764	23,473	3,247	17.74	72.26	10.00	38.39
Jiangxi	8,995	27,306	3,322	22.70	68.91	8.38	45.11
Shandong	13,245	63,440	8,285	15.59	74.66	9.75	33.94
Henan	16,848	61,415	6,643	19.84	72.33	7.82	38.25
Hubei	7,591	38,869	5,237	14.68	75.19	10.13	33.00
Hunan	9,611	41,978	6,059	16.67	72.82	10.51	37.33
Guangdong	15,835	63,402	6,477	18.47	73.97	7.56	35.19
Guangxi	9,453	29,753	4,045	21.86	68.79	9.35	45.37
Hainan	1,650	5,329	686	21.53	69.52	8.95	43.85
Chongqing	4,857	17,633	3,055	19.01	69.03	11.96	44.87
Sichuan	12,794	52,488	8,440	17.35	71.20	11.45	40.45
Guizhou	8,888	22,460	2,778	26.04	65.81	8.14	51.94
Yunnan	9,063	28,659	3,225	22.13	69.99	7.88	42.88
Tibet	566	1,839	172	21.97	71.39	6.68	40.09
Shaanxi	5,592	25,147	3,260	16.45	73.96	9.59	35.20
Gansu	4,899	16,902	1,939	20.64	71.20	8.17	40.46
Qinghai	1,088	3,576	343	21.73	71.42	6.85	40.03
Ningxia	1,266	3,909	358	22.88	70.65	6.47	41.55
Xinjiang	3,978	13,660	1,366	20.93	71.88	7.19	39.12

Source: China Statistical Yearbook 2009

Table 5 Population by Sex, Educational Attainment and Region (2008)

Unit 1,000 persons

Region	Population aged 6 and over	Male	Female	No schooling	Male	Female	Primary school	Male	Female
National	1,106,434	558,582	547,852	82,987	22,947	60,039	344,870	164,139	180,731
Beijing	14,174	7,197	6,977	472	95	377	1,898	891	1,006
Tianjin	9,710	4,778	4,932	424	120	304	1794	828	966
Hebei	58,608	29,736	28,872	2,939	796	2,143	17,335	8,070	9,266
Shanxi	29,058	14,675	14,383	1,193	350	843	7,429	3,427	4,002
Inner Mongolia	20,742	10,616	10,126	1,631	496	1,135	5,945	2,820	3,125
Liaoning	37,511	18,801	18,711	1,481	404	1,077	9,538	4,477	5,061
Jilin	23,694	11,942	11,752	1,094	340	754	5,988	2,812	3,176
Heilongjiang	33,148	16,751	16,397	1,433	408	1,025	8,835	4,094	4,741
Shanghai	16,358	8,165	8,193	675	133	542	2,299	1,010	1,289
Jiangsu	65,610	31,692	33,918	5,081	1,105	3,976	18,053	8,041	10,012
Zhejiang	43,524	22,093	21,431	3,928	1,029	2,899	14,405	7,072	7,333
Anhui	51,447	25,994	25,453	6,726	1,937	4,789	16,690	8,062	8,628
Fujian	30,264	15,140	15,124	2,990	555	2,435	11,161	5,193	5,968
Jiangxi	36,120	18,194	17,926	2,226	562	1,664	13,056	5,998	7,059
Shandong	79,888	39,721	40,167	6,200	1,573	4,627	22,367	9,899	12,468
Henan	78,498	39,220	39,279	5,552	1,690	3,862	19,928	9,268	10,661
Hubei	49,099	24,812	24,287	3,727	1,068	2,658	14,376	6,779	7,597
Hunan	54,063	27,830	26,234	3,140	877	2,264	17,181	8,322	8,859
Guangdong	80,550	41,035	39,515	3,268	696	2,571	23,203	10,639	12,564
Guangxi	39,706	20,684	19,022	2,206	584	1,623	14,055	6,759	7,296
Hainan	7,049	3,666	3,383	550	130	420	1,867	897	969
Chongqing	24,010	12,061	11,948	1,740	543	1,198	9,424	4,628	4,796
Sichuan	69,797	35,253	34,544	6,792	2,005	4,788	28,278	14,259	14,019
Guizhou	31,612	16,325	15,287	4,014	1,108	2,906	13,495	6,916	6,579
Yunnan	38,031	19,739	18,292	4,632	1,452	3,179	18,386	9,373	9,014
Tibet	2,385	1,159	1,226	818	302	516	1,131	614	517
Shaanxi	32,268	16,286	15,981	2,513	774	1,739	9,264	4,321	4,943
Gansu	22,262	11,200	11,062	3,530	1,116	2,414	7,901	3,946	3,955
Qinghai	4,643	2,335	2,308	704	213	491	1,877	942	935
Ningxia	5,095	2,585	2,510	458	137	322	1,673	798	875
Xinjiang	17,510	8,897	8,612	849	350	499	6,039	2,985	3,054

Table 5 Population by Sex, Educational Attainment and Region (2008)--continued

Unit 1,000 persons

Region	Junior secondary school	Male	Female	Senior secondary school	Male	Female	College and higher level	Male	Female
National	452,929	244,026	208,903	151,474	85,912	65,562	74,175	41,558	32,619
Beijing	4,499	2,428	2,070	3,319	1,720	1,600	3,986	2,062	1,923
Tianjin	3,587	1,855	1,731	2,404	1,196	1,208	1,501	779	722
Hebei	28,487	15,319	13,168	7,030	4,004	3,026	2,818	1,548	1,270
Shanxi	14,052	7444	6,608	4,292	2,416	1,876	2,092	1,037	1,055
Inner Mongolia	8,741	4,854	3,887	2,886	1,599	1,287	1,539	847	692
Liaoning	17,035	8,958	8,078	5,329	2,805	2,524	4,128	2,157	1,970
Jilin	10,600	5,604	4,996	4,219	2,215	2,004	1,793	971	821
Heilongjiang	15,695	8,309	7,387	5,206	2,872	2,335	1,980	1,070	910
Shanghai	5,576	2,842	2,735	4,101	2,145	1,956	3,707	2,036	1,670
Jiangsu	27,524	14,066	13,458	10,331	5,817	4,514	4,621	2,664	1,959
Zhejiang	15,581	8,530	7,052	5,461	3,100	2,361	4,148	2,362	1,786
Anhui	20,657	11,575	9,082	5,310	3,151	2,159	2,063	1,270	795
Fujian	10,414	5,971	4,443	3,925	2,353	1,572	1,774	1,067	706
Jiangxi	13,147	7,150	5,997	5,382	3,132	2,250	2,309	1,353	957
Shandong	35,484	18,932	16,552	11,468	6,786	4,682	4,369	2,532	1,837
Henan	38,750	20,225	18,525	10,565	6,049	4,515	3,703	1,988	1,715
Hubei	19,150	10,377	8,773	7,882	4,454	3,427	3,965	2,134	1,832
Hunan	22,059	11,818	10,240	8,165	4,615	3,550	3,519	2,198	1,320
Guangdong	34,729	18,368	16,361	13,684	8,108	5,576	5,667	3,224	2,442
Guangxi	17,974	10,046	7,928	4,163	2,540	1,623	1,308	756	552
Hainan	3,196	1,719	1,477	1,029	646	383	407	273	134
Chongqing	9,261	4,931	4,330	2,564	1,437	1,126	1,019	522	498
Sichuan	24,676	13,347	11,329	7,012	3,938	3,074	3,038	1,704	1,335
Guizhou	10,642	6,246	4,396	2,354	1,393	960	1,108	661	446
Yunnan	11,108	6,574	4,534	2,571	1,428	1,143	1,334	912	422
Tibet	315	186	129	80	38	42	41	19	22
Shaanxi	12,665	6,848	5,818	5,023	2,796	2,227	2,802	1,547	1,254
Gansu	7,283	4,061	3,221	2,550	1,502	1,048	999	575	424
Qinghai	1,231	724	507	483	261	222	347	195	152
Ningxia	1,918	1,069	849	656	363	293	390	218	171
Xinjiang	6,894	3,652	3,242	2,029	1,032	997	1,699	878	821

Note: Data in this table are obtained from the 2008 National Sample Survey on Population Changes. The sampling fraction is 0.887‰.

Source: China Statistical Yearbook 2009

Table 6 Final Consumption and Distribution by Region (2008)

Region	Final consumption (100 million Yuan)	Household consumption			Government consumption
			Rural residents	Urban residents	
Beijing	6,033.93	3,385.6	255.59	3,130.01	2,648.33
Tianjin	2,516.77	1,603.68	169.92	1,433.76	913.09
Hebei	6,769	4,576.73	1,466.47	3,110.26	2,192.27
Shanxi	3,002.67	2,104.67	617.24	1,487.43	898
Inner Mongolia	3,196.8	1,953.64	433.62	1,520.02	1,243.16
Liaoning	5,529.37	4,144.89	751.34	3,393.55	1,384.48
Jilin	3,049.19	2,075.65	493.1	1,582.55	973.54
Heilongjiang	4,260.96	2,692.15	655.76	2,036.39	1,568.81
Shanghai	7,004.32	5,122.05	255.71	4,866.34	1,882.27
Jiangsu	12,751.9	8,425.61	2,285.87	6,139.74	4,326.29
Zhejiang	9,614.22	7,071.58	1,662.06	5,409.52	2542.64
Anhui	4,831.68	3,906.57	1,277.89	2,628.68	925.11
Fujian	5,053.95	3,722.1	1,026.1	2,696	1,331.85
Jiangxi	3,279.89	2,522.19	806.58	1,715.61	757.7
Shandong	13,477.13	8,991.11	2,410.79	6,580.32	4,486.02
Henan	7,759.33	5,521.46	1,953.8	3,567.66	2,237.87
Hubei	5,892.03	4,225.38	1,217.95	3,007.43	1,666.65
Hunan	6,180.04	4,549.86	1,466.7	3,083.16	1630.18
Guangdong	17,637.61	13,665.86	1,806.14	11,859.72	3,971.75
Guangxi	3,856.73	2,924.38	923.81	2,000.57	932.35
Hainan	7,82.77	556.46	167.91	388.55	226.31
Chongqing	3,598.84	2,780.82	581.91	2,198.91	818.02
Sichuan	6,540.17	4,937.87	1,711.33	3,226.54	1602.3
Guizhou	2,260.76	1,672.03	577.25	1,094.78	588.73
Yunnan	2,908.08	2,048.36	789.86	1,258.5	859.72
Tibet	264.35	100.54	45.72	54.82	163.81
Shaanxi	3,022.6	2,361.89	659.06	1,702.83	660.71
Gansu	1,949.83	1,276.99	443.21	833.78	672.84
Qinghai	593.51	322.4	102.75	219.65	271.11
Ningxia	635.66	441.66	107.06	334.6	194
Xinjiang	2,246.09	1,171.05	340.69	830.36	1,075.04

Source: China Statistical Yearbook 2009

Table 6 Final Consumption and Distribution by Region (2008)--continued

Region	Final consumpiton=100		Household consumption =100		Urban-rural consumption ratio (rural consumption=1)
	Household consumption	Government consumption	Rural residents	Urban residents	
Beijing	56.1	43.9	7.5	92.5	2.2
Tianjin	63.7	36.3	10.6	89.4	2.6
Hebei	67.6	32.4	32.0	68.0	3.1
Shanxi	70.1	29.9	29.3	70.7	3.0
Inner Mongolia	61.1	38.9	22.2	77.8	3.4
Liaoning	75.0	25.0	18.1	81.9	3.1
Jilin	68.1	31.9	23.8	76.2	2.8
Heilongjiang	63.2	36.8	24.4	75.6	2.6
Shanghai	73.1	26.9	5.0	95.0	2.4
Jiangsu	66.1	33.9	27.1	72.9	2.3
Zhejiang	73.6	26.4	23.5	76.5	2.4
Anhui	80.9	19.1	32.7	67.3	3.1
Fujian	73.6	26.4	27.6	72.4	2.7
Jiangxi	76.9	23.1	32.0	68.0	1.5
Shandong	66.7	33.3	26.8	73.2	3.1
Henan	71.2	28.8	35.4	64.6	3.4
Hubei	71.7	28.3	28.8	71.2	3.0
Hunan	73.6	26.4	32.2	67.8	3.0
Guangdong	77.5	22.5	13.2	86.8	3.8
Guangxi	75.8	24.2	31.6	68.4	3.7
Hainan	71.1	28.9	30.2	69.8	2.8
Chongqing	77.3	22.7	20.9	79.1	3.9
Sichuan	75.5	24.5	34.7	65.3	3.2
Guizhou	74.0	26.0	34.5	65.5	4.7
Yunnan	70.4	29.6	38.6	61.4	3.5
Tibet	38.0	62.0	45.5	54.5	3.9
Shaanxi	78.1	21.9	27.9	72.1	3.7
Gansu	65.5	34.5	34.7	65.3	4.0
Qinghai	54.3	45.7	31.9	68.1	3.1
Ningxia	69.5	30.5	24.2	75.8	3.9
Xinjiang	52.1	47.9	29.1	70.9	3.7

Source: China Statistical Yearbook 2009

Table 7 Number of Health Care Institutions and Beds by Region (2008)

Region	Health Care Institutions (unit) Total	Beds of medical	Hospitals	Clinics	Center for disease control and prevention (epidemic prevention stations)	Women and childre care agencies	Beds of medical organizations (unit)	Hospitals and health centers (unit)
National	278,337	19,712	39,860	180,752	3,534	3,011	4,036,483	3,748,245
Beijing	6,497	529	123	4,355	31	19	86,153	81,894
Tianjin	2,784	247	181	1,435	24	23	46,054	41,142
Hebei	15,632	1,111	1,958	10,989	190	185	213,965	197,791
Shanxi	9,431	1,025	1,569	5,854	131	132	127,263	118,947
Inner Mongolia	7,162	471	1,329	4,168	137	115	81,068	73,205
Liaoning	14,627	854	1,062	11,277	133	111	182,972	166,501
Jilin	9,659	568	802	5,664	68	70	99,329	93,496
Heilongjiang	7,928	911	938	5,065	192	136	135,600	125,977
Shanghai	2,822	299		1,906	22	24	97,352	77,174
Jiangsu	13,357	1,094	1,429	8,290	168	104	236,541	222,108
Zhejiang	15,290	635	1,871	6,989	101	87	160,873	149,590
Anhui	7,837	720	1,845	3,854	127	119	159,724	150,593
Fujian	4,478	332	871	2,705	87	85	88,579	82,302
Jiangxi	8,229	491	1,545	5,023	137	111	105,106	93,890
Shandong	14,973	1,253	1,755	10,314	177	149	319,905	297,345
Henan	11,683	1,174	2,089	7,239	181	167	268,004	252,197
Hubei	10,305	593	1,203	6,871	110	99	167,673	153,920
Hunan	14,455	767	2,344	10,268	145	135	187,732	174,749
Guangdong	15,819	1,028	1,399	10,948	136	126	250,497	231,583
Guangxi	10,427	450	1,258	7,985	100	103	118,365	109,730

Table 7 Number of Health Care Institutions and Beds by Region (2008)-- continued

Region	Health care Institutions (unit)						Beds of medical organizations (unit)	Hospitals and health centers (unit)
	Total	Beds of medical	Hospitals	Clinics	Center for disease control and prevention (epidemic prevention stations)	Women and childre care agencies		
Hainan	2,220	187	311	1,544	27	25	21,889	20,672
Chongqing	6,265	355	1,041	4,579	43	40	81,950	77,918
Sichuan	20,738	1,144	4818	13,441	208	201	243,746	229,984
Guizhou	5,848	475	1,459	3,263	105	90	83,103	78,129
Yunnan	9,249	692	1,396	6,396	152	148	127,560	119,011
Tibet	1326	99	665	412	81	57	8720	8,344
Shaanxi	8,812	816	1,733	5,596	123	117	125,189	118,327
Gansu	10,534	377	1,333	8,140	104	100	76,581	72,315
Qinghai	1582	126	406	744	56	22	17,352	16,408
Ningxia	1629	148	239	1,056	25	22	20,891	19,750
Xinjiang	6,739	741	888	4,382	213	89	96,747	93,253

Source: China Statistical Yearbook 2009

Table 8 Incidence, Death Rate and Mortality Rate of Infectious Diseases (2008)

Item	Disease incidence (per 100,000 persons)	Death rate (per 100,000 persons)	Mortality rate (per 100 infectious disease patients)
Viral hepatitis	106.5371	0.08	0.07
Pulmonary tuberculosis	88.515	0.21	0.24
Dysentery	23.6528		0.02
Syphilis	19.4866		0.02
Newborn tetanus	0.1041	0.01	10.69
Measles	9.9479	0.01	0.08
Gonorrhea	9.9008		
Scarlet fever	2.1026		
Brucellosis	2.1015		
Malaria	1.9949		0.08
Typhoid and paratyphoid fever	1.1838		0.04
AIDS	0.7613	0.41	53.57
Hemorrhage fever	0.6841	0.01	1.14
Encephalitis B	0.2252	0.01	4.77
Schistosomiasis	0.2231		
Hydrophobia	0.1866	0.18	96.23
Pertussis	0.1807		0.04
Epidemic encephalitis	0.0698	0.01	11.93
Leptospirosis	0.0652		2.09
Anthrax	0.0254		0.3
Dengue fever	0.0153		
Cholera	0.0127		
HpAI			100
The plague			100
SARS			
Poliomyelitis			
Diphtheria			

Note: Units of incidence and death of newborn tetanus are ‰.

Source: China Statistical Yearbook 2009

Table 9 Death Rate of 10 Major Diseases in Urban Areas (2008)

No.	Cause of Death	Mortality (1/100,000)	Percentage (%)
	Total		92.55
1	Malignant Tumour	166.97	27.12
2	Heart Diseases	121.00	19.65
3	Cerebrovascular Disease	120.79	19.62
4	Diseases of the Respiratory System	73.02	11.86
5	Trauma and Toxicosis	31.26	5.08
6	Endocrine, Nutritional & Metabolic Diseases, Immune Disease	21.09	3.43
7	Diseases of the Digestive System	17.60	2.86
8	Disease of the Genitourinary System	6.97	1.13
9	Disease of the Nervous System	6.34	1.03
10	Infectious Disease(not including Respiratory Tuberculosis)	4.73	0.77
	Male Total		93.52
1	Malignant Tumour	204.00	30.00
2	Cerebrovascular Disease	127.78	18.79
3	Heart Diseases	123.45	18.15
4	Diseases of the Respiratory System	83.41	12.26
5	Trauma and Toxicosis	38.46	5.66
6	Diseases of the Digestive System	20.19	2.97
7	Endocrine, Nutritional & Metabolic Diseases, Immune Disease	18.72	2.75
8	Disease of the Genitourinary System	7.26	1.07
9	Disease of the Nervous System	6.62	0.97
10	Infectious Disease(not including Respiratory Tuberculosis)	6.11	0.90
	Female Total		91.45
1	Malignant Tumour	129.22	23.49
2	Heart Diseases	118.49	21.54
3	Cerebrovascular Disease	113.66	20.66
4	Diseases of the Respiratory System	62.44	11.35
5	Trauma and Toxicosis	23.92	4.35
6	Endocrine, Nutritional & Metabolic Diseases, Immune Disease	23.51	4.27
7	Diseases of the Digestive System	14.96	2.72
8	Disease of the Genitourinary System	6.68	1.21
9	Disease of the Nervous System	6.05	1.10
10	Mental Disorders	4.18	0.76

Source: China Statistical Yearbook 2009

Table 10 Death Rate of 10 Major Diseases in Rural Areas (2008)

No.	Cause of Death	Mortality (1/100,000)	Percentage (%)
	Total		93.53
1	Malignant Tumour	156.73	25.39
2	Cerebrovascular Disease	134.16	21.73
3	Diseases of the Respiratory System	104.20	16.88
4	Heart Diseases	87.10	14.11
5	Trauma and Toxicosis	53.02	8.59
6	Diseases of the Degestive System	16.33	2.65
7	Endocrine, Nutritional & Metabolic Diseases, Immune Disease	11.05	1.79
8	Disease of the Genitourinary System	5.70	0.92
9	Disease of the Nervous System	4.35	0.71
10	Infectious Disease(not including Respiratory Tuberculosis)	4.72	0.76
	Male Total		94.46
1	Malignant Tumour	204.59	29.32
2	Cerebrovascular Disease	140.76	20.17
3	Diseases of the Respiratory System	110.50	15.84
4	Heart Diseases	88.15	12.63
5	Trauma and Toxicosis	67.59	9.69
6	Diseases of the Degestive System	20.64	2.96
7	Endocrine, Nutritional & Metabolic Diseases, Immune Disease	9.71	1.39
8	Disease of the Genitourinary System	6.64	0.95
9	Infestious Disease(not including Respiratory Tuberculosis)	6.10	0.88
10	Disease of the Nervous System	4.37	0.63
	Female Total		92.60
1	Cerebrovascular Disease	127.31	23.85
2	Malignant Tumour	107.06	20.06
3	Diseases of the Respiratory System	97.66	18.30
4	Heart Diseases	86.02	16.12
5	Trauma and Toxicosis	37.90	7.10
6	Endocrine, Nutritional & Metabolic Diseases, Immune Disease	12.43	2.33
7	Diseases of the Degestive System	11.86	2.22
8	Mental Disorders	4.92	0.92
9	Disease of the Genitourinary System	4.73	0.89
10	Disease of the Nervous System	4.34	0.81

Source: China Statistical Yearbook 2009

Table 11 Main Indicators of National Economy and Energy Economy

Item	2000	2001	2002	2003	2004	2005	2006	2007
1. Gross domestic products (100 million Yuan)	99,215	109,655	120,333	135,823	159,878	183,085	210,871	249,530
Primary industry	14,716	15,516	16,239	17,068	20,956	23,070	24,737	280,95
Secondary industry	45,556	49,512	53,897	62,436	73,904	87,046	103,162	121,381
Tertiary industry	38,943	44,627	50,197	56,319	65,018	72,968	82,972	100,054
2. Investment in fixed assets (100 million Yuan)	32,918	37,214	43,500	55,567	70,477	88,774	109,998	137,324
Energy industry (State-owned)	2,840	2622	2,626	2,876	3,643	4,766	5,687	6,715
Coal mining and processing	199	199	233	310	420	624	759	836
Petroleum and natural gas extraction	365	375	158	236	301	279	387	586
Electricity, steam production and supply	2,130	1,861	2,082	2,158	2,640	3,451	4,042	4,611
Petroleum processing and coking	95	127	93	90	188	299	369	549
Gas production and supply	60	58	60	82	95	113	129	133
3. Total value of exports and imports (100 million Yuan)	39,273	42,184	51,378	70,484	95,539	116,922	140,971	166,740
Exports	20,634	22,024	26,948	36,288	49,103	62,648	77,595	93,456
Imports	18,639	20,159	24,430	34,196	46,436	54,274	63,377	73,285
4. Coal ensured reserves (100 million tonnes)	10,084	10,202						
5. Hydropower resource (100 million KW)	6.76	6.76	6.76	6.76			6.76	
Developable resources (100 million KW)	3.79	3.79	3.79	3.79			3.79	
6. Theoretical sea-energy reserves 10^9 KW	6.30	6.30	6.30	6.30			6.30	
7. Primary energy production (coal equivalent calculation)(*)million ton standard coal	128,978	137,445	143,810	163,842	187,341	205,876	221,056	235,445
Primary energy production (calorific value calculation)(**)	122,673	129,794	135,983	155,947	177,962	195,518	209,784	223,122
8. Total energy consumption (coal equivalent calculation) million ton standard coal	138,553	143,199	151,797	174,990	203,227	224,682	246,270	265,583
Total energy consumption (calorific value calculation)	132,469	135,765	144,155	167,273	193,990	214,466	235,156	253,488

Note: (*) Electricity is converted to TCE by average quantity of fuel used for power generation. (the same as in the following tables)

' (**) Electricity is converted to TCE by 104kwh=1.229TCE. (The same as in the following tables)

Source:China Energy Statistical Yearbook 2008 and China Statistical Yearbook 2008

Table 12 Main Indicators of Energy Consumption per Region(2008)

Region	Energy consumption per GDP		Energy consumption per industrial value-added		Electricity consumption per GDP	
	(tce/10,000 Yuan)	± %	(tce/10,000 Yuan)	±%	(kwh/10,000 Yuan)	± %
National	1.102	-4.59	2.189	-8.43	1375.29	-3.30
Beijing	0.662	-7.36	1.037	-12.68	719.61	-5.10
Tianjin	0.947	-6.85	1.053	-13.85	910.42	-10.49
Hebei	1.727	-6.29	3.315	-14.33	1492.81	-5.50
Shanxi	2.554	-7.39	4.885	-9.33	2288.87	-10.03
Inner Mongolia	2.159	-6.34	4.190	-14.12	1887.32	-10.20
Liaoning	1.617	-5.11	2.426	-8.42	1223.81	-8.17
Jilin	1.444	-5.02	1.979	-6.96	885.93	-7.45
Heilongjiang	1.290	-4.75	1.895	-6.63	865.90	-4.69
Shanghai	0.801	-3.78	0.958	-5.05	884.13	-3.28
Jiangsu	0.803	-5.85	1.265	-10.35	1149.44	-5.89
Zhejiang	0.782	-5.49	1.182	-9.19	1202.08	-3.60
Anhui	1.075	-4.52	2.338	-9.92	1106.81	-0.86
Fujian	0.843	-3.7	1.180	-10.05	1098.56	-4.98
Jiangxi	0.928	-5.53	1.941	-14.12	942.16	-5.13
Shandong	1.100	-6.47	1.698	-10.24	1001.08	-6.30
Henan	1.219	-5.10	3.079	-10.83	1266.23	-2.77
Hubei	1.314	-6.29	2.679	-12.72	1103.90	-5.63
Hunan	1.225	-6.72	1.983	-11.84	975.49	-9.92
Guangdong	0.715	-4.32	0.869	-11.32	1085.49	-6.17
Guangxi	1.106	-3.97	2.335	-10.35	1254.15	-1.92
Hainan	0.875	-2.55	2.609	-1.91	979.24	-2.12
Chongqing	1.267	-4.97	2.106	-10.41	1090.19	-5.04
Sichuan	1.381	-3.55	2.477	-5.46	1156.37	-6.15
Guizhou	2.875	-6.11	4.323	-11.59	2452.21	-7.89
Yunnan	1.562	-4.79	2.847	-9.78	1654.94	-2.92
Tibet	1.281	-5.92	2.009	-11.48	1256.02	-6.28
Shaanxi	2.013	-4.53	4.050	-5.66	2539.00	0.09
Gansu	2.935	-4.18	3.243	-6.53	4061.64	-2.67
Qinghai	3.686	-6.79	7.130	-12.23	5084.09	-10.91
Ningxia	1.963	-3.15	2.999	-4.26	1331.24	4.49

Source: "Main Indicators of Energy Consumption per Region 2008", Department of Comprehensive Statistics, National Bureau of Statistics, 2009-6-30, http://www.stats.gov.cn/tjgb/qttjgb/qgqttjgb/t20090630_402568721.htm, last accessed on 2010-4-6

Table 13 Energy Intensity by GDP

Year	Total Energy Consumption (tce/10^4 Yuan)	Coal (tonnes/ 10^4 Yuan)	Coke (tonnes/ 10^4 Yuan)	Petroleum (tonnes/ 10^4 Yuan)	Crude Oil (tonnes/ 10^4 Yuan)	Fuel Oil (tonnes/ 10^4 Yuan)	Electricity (10^4 kW·h/ 10^4 Yuan)
	GDP is calculated at 1990 comparable prices.						
1991	5.12	5.46	0.35	0.61	0.61	0.17	0.34
1992	4.72	4.94	0.34	0.58	0.57	0.15	0.33
1993	4.42	4.61	0.34	0.56	0.53	0.14	0.32
1994	4.18	4.38	0.31	0.51	0.48	0.12	0.32
1995	4.01	4.21	0.33	0.49	0.46	0.11	0.31
1996	3.88	4.04	0.30	0.49	0.44	0.10	0.30
1997	3.53	3.57	0.28	0.50	0.45	0.10	0.29
1998	3.15	3.08	0.26	0.47	0.41	0.09	0.28
1999	2.90	2.82	0.23	0.46	0.41	0.09	0.27
2000	2.77	2.64	0.21	0.45	0.42	0.08	0.27
	GDP is calculated at 2000 comparable prices.						
2000	1.40	1.33	0.11	0.23	0.21	0.04	0.14
2001	1.33	1.26	0.10	0.21	0.20	0.04	0.14
2002	1.30	1.21	0.11	0.21	0.19	0.03	0.14
2003	1.36	1.31	0.11	0.19	0.19	0.07	0.15
2004	1.43	1.36	0.12	0.22	0.20	0.03	0.15
2005	1.43	1.38	0.14	0.21	0.19	0.03	0.16
	GDP is calculated at 2005 comparable prices.						
2005	1.23	1.18	0.13	0.18	0.16	0.02	0.14
2006	1.20	1.17	0.14	0.17	0.16	0.02	0.14
2007	1.16	1.13	0.13	0.16	0.15	0.02	0.14

Source:China Energy Statistical Yearbook 2008

Table 14 Primary Energy Production and its Composition

Item	1995	2000	2004	2005	2006	2007
Primary energy production (10^4 tce) (calorific value calculation)	123,519	122,673	177,962	195,518	209,784	223,122
Primary energy production (10^4 tce) (coal equivalent calculation)	129,034	128,978	187,341	205,876	221,056	235,445
Raw coal(10^4 tonnes)	136,073	129,921	199,232	220,473	237,300	252,597
Crude oil(10^4 tonnes)	15,004	16,300	17,587	18,135	18,477	18,632
Natural gas(10^8 cu.m)	179	272	415	493	586	692
Hydro power(10^8 kW•h)	1,906	2,224	3,535	3,970	4,358	4,965
Nuclear power(10^8 kW•h)	128	167	505	531	548	621
As percentage of primary energy production(%) (calorific value calculation)						
Raw coal	78.69	75.65	79.97	80.55	80.80	80.87
Crude oil	17.35	18.98	14.12	13.25	12.58	11.93
Natural gas	1.93	2.95	3.10	3.35	3.71	4.13
Hydro power	1.90	2.25	2.47	2.52	2.59	2.73
Nuclear power	0.13	0.17	0.35	0.33	0.32	0.34
As percentage of primary energy production(%) (coal equivalent calculation)						
Raw coal	75.30	71.95	75.96	76.49	76.68	76.63
Crude oil	16.60	18.05	13.41	12.58	11.94	11.31
Natural gas	1.90	2.80	2.94	3.19	3.52	3.91
Hydro power	5.85	6.69	6.73	6.83	6.99	7.24
Nuclear power	0.39	0.50	0.95	0.91	0.87	0.91

Source:China Energy Statistical Yearbook 2008

Table 15 Primary Energy Consumption and its Composition

Item	1995	2000	2003	2004	2005	2006	2007
Total Energy Consumption (10^4 tce) (calorific value calculation)	125,763	132,469	167,273	193,990	214,466	235,156	253,488
Total Energy Consumption (10^4 tce) (coal equivalent calculation)	131,176	138,553	174,990	203,227	224,682	246,270	265,583
Coal (10^4 tonnes)	137,677	132,000	169,232	193,596	216,723	239,217	258,641
Petroleum (10^4 tonnes)	16,065	22,439	24,269	31,700	32,-535	34,876	36,570
Natural Gas (10^8 cu.m)	177	245	339	397	467	561	695
Hydro Power (10^8 kW•h)	1,906	2,224	2,837	3,535	3,970	4,358	4,853
Nuclear Power (10^8 kW•h)	128	167	433	505	531	548	621
As Percentage of Primary Energy Production(%)(calorific value calculation)							
Coal	77.40	71.02	71.63	71.31	72.76	72.97	72.82
Petroleum	18.30	24.28	23.24	23.39	21.74	21.25	20.64
Natural Gas	1.88	2.46	2.70	2.72	2.90	3.18	3.67
Hydro Power	1.84	2.08	2.11	2.26	2.30	2.31	2.57
Nuclear Power	0.13	0.16	0.32	0.32	0.30	0.29	0.30
As percentage of primary energy production (%)(coal equivalent calculation)							
Coal	74.60	67.75	68.38	67.99	69.11	69.40	69.50
Petroleum	17.50	23.21	22.21	22.33	21.00	20.40	19.70
Natural Gas	1.80	2.35	2.58	2.60	2.80	3.00	3.50
Hydro Power	5.71	6.23	5.93	6.20	6.26	6.40	6.50
Nuclear Power	0.39	0.46	0.90	0.88	0.83	0.80	0.80

Source:China Energy Statistical Yearbook 2008

Table 16 Total Energy Consumption by Region (10,000 tce)

Region	1990	1995	2000	2004	2005	2006	2007
Beijing	2,709	3,518	4,144	5,140	5,522	5,904	6,285
Tianjin	2,071	2,569	2,794	3,697	4,115	4,525	4,944
Hebei	6,124	8,990	11,196	17,348	19,745	21,690	23,490
Shanxi	4,710	8,413	6,728	11,251	12,312	13,497	14,620
Inner Mongolia	2,424	2,632	3,549	7,623	9,643	11,191	12,723
Liaoning	7,856	9,671	10,656	13,074	14,685	15,816	17,379
Jilin	3,523	4,109	3,766	5,603	5,958	6,622	7,346
Heilongjiang	5,285	5,935	6,166	7,466	8,026	8,727	9,374
Shanghai	3,175	4,466	5,499	7,406	8,312	8,967	9,768
Jiangsu	5,509	8,047	8,612	13,652	16,895	18,742	20,604
Zhejiang	2,580	4,580	6,560	10,825	12,032	13,222	14,533
Anhui	2,761	4,194	4,879	6,017	6,518	7,096	7,752
Fujian	1,451	2,280	3,463	5,449	6,157	6,840	7,574
Jiangxi	1,732	2,392	2,505	3,814	4,286	4,661	5,054
Shandong	6,830	8,780	11,362	19,624	23,610	26,164	28,554
Henan	5,206	6,473	7,919	13,074	14,625	16,235	17,841
Hubei	3,997	5,655	6,269	9,120	9851	10797	11861
Hunan	3,821	5,426	4,071	7,599	9,110	9,879	10,797
Guangdong	4,065	7,345	9,448	15,210	17,769	19,765	21,912
Guangxi	1,309	2,384	2,669	4,203	4,981	5,515	6,137
Hainan	121	303	480	742	819	911	1,016
Chongqing			2,428	3,670	4,360	4,723	5,217
Sichuan	6,353	9,525	6,518	10,700	11,301	12,539	13,685
Guizhou	2,133	3,183	4,279	6,021	6,429	7,045	7,692
Yunnan	1,954	2,641	3,468	5,210	6,024	6,641	7,173
Tibet	2,239	3,134	2,731	4,776	5,424	6,069	6,639
Shaanxi	2,172	2,738	3,012	3,908	4,368	4,743	5,100
Gansu	507	688	897	1,364	1,670	1,903	2,095
Qinghai	707	759	1,179	2,322	2,510	2,802	3,047
Ningxia	2,063	2,830	3,328	4,910	5,507	6,047	6,576

Source:China Energy Statistical Yearbook 2008

Table 17 Imports and Exports of Major Energy Products

Item	2000	2001	2002	2003	2004	2005	2006	2007
Import								
Coal(10^4 tonnes)	212	249	1,081	1,110	1,861	2,617	3,811	5,102
Coal(10^4 tonnes)				0.2	0.5	0.5		
Crude Oil(10^4 tonnes)	7,027	6,026	6,941	9,102	12,272	12,682	14,517	16,316
Gasoline(10^4 tonnes)							6.1	22.7
Diesel Oil(10^4 tonnes)	25.9	27.5	47.7	84.9	274.9	53.2	70.5	162.1
Kerosene(10^4 tonnes)	255.5	201.9	214.5	210.3	282.0	328.3	560.9	524.3
Fuel Oil(10^4 tonnes)	1,480	1,824	1,660	2,396	3,059	2,609	2,799	2,417
LPG(10^4 tonnes)	481.7	488.9	626.2	636.7	641.0	617.0	535.6	405.4
Other Petroleum Products(10^4 tonnes)	161.5	201.3	384.3	432.1	384.2	443.4	443.4	688.9
Natural Gas(10^8 cu.m)							9.5	40.2
Electricity(10^8 kW•h)	15.5	18	23	29.8	34.0	50.1	53.9	42.5
Coal(10^4 tonnes)								
Coke(10^4 tonnes)	5,505	9,012	8,384	9,403	8,666	7,172	6,327	5,319
Crude Oil(10^4 tonnes)	1,520	1,385	1,357	1,472	1,501	1,276	1,447	1,530
Gasoline(10^4 tonnes)	1031	755	766	813.3	549.2	806.7	633.7	388.4
Diesel Oil(10^4 tonnes)	455.2	572.5	612	754.2	540.7	560.0	351.0	464.3
Kerosene(10^4 tonnes)	55.5	25.6	124	224.0	63.7	147.6	77.6	66.1
Fuel Oil(10^4 tonnes)	198.9	182.2	170	201.7	205.0	268.7	371.1	448.1
LPG(10^4 tonnes)	33.4	44.1	64.0	76.1	181.7	230.0	258.1	379.7
Other Petroleum Products(10^4 tonnes)	1.6	2.1	5.6	2.4	3.2	2.7	15.1	33.8
Natural Gas(10^8 cu.m)	280.5	325.5	246.0	261.8	360.7	473.0	473.0	416.2
Electricity(10^8 kW•h)					24.4	29.7	29.0	26.0
Coal(10^4 tonnes)	98.8	101.9	97.0	103.4	94.8	111.9	122.7	145.7

Source:China Energy Statistical Yearbook 2008

Table 18 Imports and Exports of Energy Intensive Products

Item	2000	2001	2002	2003	2004	2005	2006	2007
Import								
Steel products(10^4 tonnes)	1,596	1,722	2,449	3,717	2,930	2,582	1,851	1,687
Iron and steel wire(tonnes)	336,300	353,771	427,554	465,540				
Copper and copper alloys(10^4 tonnes)	81	95	133	156	138	142	97	173
Aluminum and aluminum alloys(10^4 tonnes)	91	53	58	88	103	64	51	28
Zinc and zinc alloys(tonnes)	129,974	141,159	211,722	310,221				
Caustic soda(tonnes)	46,458	27,357	114,834	104,686				
Soda ash(10^4 tonnes)	13	7	29	30	20	7	14	4
Chemical fertilizers, manufactured(10^4 tonnes)	1,189	1,092	1,682	1,213	1,240	1,397	1,129	1,169
Paper pulp(10^4 tonnes)	335	490	526	603	732	759	796	847
Synthetic fiber suitable for spinning(10^4 tonnes)	100	92	104	106	99	84	62	51
Export								
Cement(10^4 tonnes)	605	621	518	533	704	2,216	3,613	3,301
Plate glass(10^4 sq.m)	5,592	6,123	11,359	12,427	14,464	19,925	26,433	30,917
Steel products(10^4 tonnes)	621	474	545	696	1,423	2,052	4,301	6,265
Iron and steel wire(tonnes)	190,122	224,484	310,992	401,235				
Copper products (tonnes)	144,484	123,790	171710	232879	390,023	463,560	559,122	499,678
Aluminum products(tonnes)	130,052	135,630	188,744	273,874	430,988	711,484	1,240,157	1,853,413
Zinc and zinc alloys(tonnes)	593,336	562,021	495,987	484,231	263,149	146,845	341,465	276,714
Paper and paperboard(10^4 tonnes)	65	68	74	114	101	167	305	422

Source:China Energy Statistical Yearbook 2008

Table 19a Emission of Industrial Waste Gas by Region

Region	Total volume of industrial waste gas emissions (10^8cu.m)					
	2002	2003	2004	2005	2006	2007
National	175,257	198,906	237,696	268,988	330,992	388,169
Beijing	2,966	3,005	3,198	3,532	4,641	5,146
Tianjin	3,677	4,360	3,058	4,602	6,512	5,506
Hebei	12,743	15,768	21,696	26,518	39,254	48,036
Shanxi	9,402	12,849	13,351	15,142	18,128	21,429
Inner Mongolia	5,998	7,961	13,518	12,071	18,415	18,200
Liaoning	10,462	12,774	13,015	20,903	27,195	23,946
Jilin	3,516	3,869	4,316	4,939	5,352	5,730
Heilongjiang	4,628	4,841	4,968	5,261	5,991	7,283
Shanghai	7,440	7,799	8,834	8,482	9,428	9,591
Jiangsu	14,286	14,633	17,818	20,197	24,881	23,585
Zhejiang	8,532	10,432	11,749	13,025	14,702	17,467
Anhui	5,119	5,383	5,934	6,960	8,677	13,254
Fujian	3,565	4,189	5,020	6,265	6,884	9,153
Jiangxi	2,612	3,202	3,972	4,379	5,096	6,103
Shandong	14,306	16,139	20,357	24,129	25,751	31,341
Henan	10,645	11,992	13,103	15,498	16,770	18,890
Hubei	6,440	6,707	8,838	9,404	11,015	10,373
Hunan	4,190	4,603	5,527	6,014	5,986	8,762
Guangdong	10,579	11,075	12,543	13,447	13,584	16,939
Guangxi	5,693	6,636	10,656	8,339	8,969	12,724
Hainan	528	533	634	910	860	1,115
Chongqing	1,979	2,277	3,541	3,655	6,757	7,617
Sichuan	7,287	6,634	7,466	8,140	10,553	22,970
Guizhou	3,515	3,477	4,182	3,852	8,344	10,356
Yunnan	3,659	4,197	4,940	5,444	6,646	8,082
Tibet	14	14	16	13	13	13
Shaanxi	3,424	3,861	4,374	4,916	5,535	6,469
Gansu	2,972	4,033	3,690	4,250	4,761	5,818
Qinghai	937	1,002	1,238	1,370	2,099	2,492
Ningxia	1,631	1,727	2,338	2,844	3,140	3,981
Xinjiang	2,512	2,934	3,806	4,485	5,053	5,797

Source:China Energy Statistical Yearbook 2008

Table 19b Emission of Industrial Waste Gas by Region

Region	Total volume of industrial waste gas emissions from fuel combustion (10^8cu.m)					
	2002	2003	2004	2005	2006	2007
National	103,776	116,447	139,726	155,238	181,636	209,922
Beijing	1,816	1,825	1,927	2,015	2,772	2,205
Tianjin	2,722	3,467	2,223	3,380	4,568	3,507
Hebei	7,079	8,147	11,556	13,142	19,251	25,643
Shanxi	5,786	7,191	7,976	8,565	10,424	12,865
Inner Mongolia	4,391	5,273	8,579	8,802	12,559	12,657
Liaoning	6,077	6,814	6,798	10,640	10,034	10,363
Jilin	2,375	2,456	2,761	3,405	3,380	3,886
Heilongjiang	3,787	3,943	4,110	4,276	4,748	5,981
Shanghai	3,288	3,377	3,603	3,564	3,326	3,514
Jiangsu	8,826	8,981	11,029	12,748	15,319	15,408
Zhejiang	5,921	7,208	8,223	8,148	9,216	11,542
Anhui	3,092	3,281	3,670	4,478	4,622	6,575
Fujian	1,845	2,379	2,819	3,284	3,676	5,626
Jiangxi	1,458	1,812	2,100	2,138	2,552	2,919
Shandong	8,987	10,314	12,355	14,333	15,417	16,642
Henan	6,536	7,093	7,728	9,180	9,584	10,609
Hubei	2,963	3,248	3,626	3,958	4,040	4,314
Hunan	2,048	2,497	2,750	2,826	2,916	4,046
Guangdong	6,575	6,934	7,805	9,213	9,725	11,682
Guangxi	2,425	2,937	7,223	4,370	4,087	6,755
Hainan	291	294	342	552	565	846
Chongqing	1,185	1,341	2,490	2,178	3,699	4,275
Sichuan	4,021	3,384	3,840	4,395	5,804	7,495
Guizhou	1,953	1,822	2,112	1,933	4,328	3,812
Yunnan	1,650	1,978	2,723	2,939	3,510	3,986
Tibet	9	9	10	13	12	13
Shaanxi	1,944	2,505	2,804	3,140	3,102	3,683
Gansu	1,598	2,292	2,191	2,648	2,850	2,589
Qinghai	241	312	324	345	452	610
Ningxia	957	1,022	1,273	1,625	1,628	2,123
Xinjiang	1,930	2,311	2,755	3,005	3,470	3,752

Source:China Energy Statistical Yearbook 2008

Table 20a Discharge and treatment of industrial waste water by region

Unit 10,000 tonnes

Region	Total volume of industrial waste water discharged					
	2002	2003	2004	2005	2006	2007
National	2,071,885	2,122,527	2,211,425	2,431,121	2,401,946	2,466,493
Beijing	18,044	13,107	12,617	12,813	10,170	9,134
Tianjin	21,959	21,605	22,628	30,081	22,978	21,444
Hebei	106,772	108,324	127,386	124,533	130,340	123,537
Shanxi	30,777	30,929	31,393	32,099	44,091	41,140
Inner Mongolia	22,737	23,577	22,848	24,967	27,823	25,021
Liaoning	92,001	89,186	91,810	105,072	94,724	95,197
Jilin	34,783	31,365	33,568	41,189	39,321	39,666
Heilongjiang	47,983	50,286	45,190	45,158	44,801	38,388
Shanghai	64,857	61,112	56,359	51,097	48,336	47,570
Jiangsu	262,715	247,524	263,538	296,318	287,181	268,762
Zhejiang	168,048	168,088	165,274	192,426	199,593	201,211
Anhui	64,577	63,525	64,054	63,487	70,119	73,556
Fujian	78,511	98,388	115,228	130,939	127,583	136,408
Jiangxi	46,119	50,135	54,949	53,972	64,074	71,410
Shandong	106,668	115,933	128,706	139,071	144,365	166,574
Henan	114,431	114,224	117,328	123,476	130,158	134,344
Hubei	98,481	96,498	97,451	92,432	91,146	91,001
Hunan	111,788	124,132	123,126	122,440	100,024	100,113
Guangdong	145,236	148,867	164,728	231,568	234,713	246,331
Guangxi	97,126	119,291	122,731	145,609	128,932	183,981
Hainan	7,170	7,181	6,894	7,428	7,351	5,960
Chongqing	79,872	81,973	83,031	84,885	86,496	69,003
Sichuan	117,638	120,160	119,223	122,590	115,348	114,687
Guizhou	17,117	16,815	16,119	14,850	13,928	12,101
Yunnan	33,696	34,655	38,402	32,928	34,286	35,352
Tibet	1,063	612	993	991	790	856
Shaanxi	30,496	33,526	36,833	42,819	40,479	48,523
Gansu	19,677	20,899	18,293	16,798	16,570	15,856
Qinghai	3,583	3,453	3,544	7,619	7,168	7,318
Ningxia	11,534	10,740	9,510	21,411	18,500	21,089
Xinjiang	16,426	16,417	17,671	20,052	20,558	20,960

Source:China Energy Statistical Yearbook 2008

Table 20b Discharge and treatment of industrial waste water by region

Unit 10,000 tonnes

Region	Total volume of industrial waste water meeting discharge standards					
	2002	2003	2004	2005	2006	2007
National	1,830,394	1,892,891	2,005,680	2,217,093	2,178,461	2,260,719
Beijing	17,745	13,015	12,442	12,740	10,098	8,898
Tianjin	21,898	21,571	22,482	29,962	22,925	21,382
Hebei	97,988	102,609	122,817	119,920	121,750	113,999
Shanxi	26,626	26,939	28,135	28,526	30,377	36,297
Inner Mongolia	15,759	15,076	13,968	16,634	21,416	18,437
Liaoning	80,819	81,704	86,234	99,917	88,007	87,969
Jilin	26,782	24,071	26,668	33,458	32,010	34,740
Heilongjiang	44,515	47,353	42,339	41,759	39,344	32,780
Shanghai	61,521	58,020	54,255	49,590	47,146	46,492
Jiangsu	251,997	241,765	256,210	288,936	280,457	261,745
Zhejiang	161,873	163,387	158,556	185,978	172,414	173,220
Anhui	61,827	60,908	62,076	61,816	68,097	69,711
Fujian	75,094	95,633	111,989	127,874	124,960	134,052
Jiangxi	35,786	41,642	48,720	49,726	59,739	67,044
Shandong	102,801	112,590	124,839	136,606	141,540	163,365
Henan	103,124	104,480	109,909	113,518	121,024	126,324
Hubei	82,930	80,848	83,591	80,926	82,930	85,215
Hunan	86,768	99,127	102,990	109,879	91,618	89,934
Guangdong	130,225	123,453	138,162	194,284	199,215	211,959
Guangxi	81,774	103,212	106,282	121,873	119,795	170,757
Hainan	6,712	6,741	6,464	6,954	6,956	5,640
Chongqing	71,372	73,663	77,560	79,507	81,146	63,533
Sichuan	93,045	98,313	103,048	108,195	97,456	104,780
Guizhou	9,720	9,411	9,374	10,054	10,006	8,703
Yunnan	22,186	24,172	28,697	26,659	30,568	31,997
Tibet						250
Shaanxi	25,491	29,138	33,737	39,704	36,118	46,652
Gansu	14,218	15,901	13,390	12,301	13,103	12,838
Qinghai	2,148	2,067	2,223	3,396	3,487	3,677
Ningxia	6,461	6,288	7,676	14,508	11,980	14,698
Xinjiang	11,189	9,794	10,847	11,893	12,556	13,629

Source: China Energy Statistical Yearbook 2008

Table 21 World Total Production of Energy

Unit: million toe

Country or Area	2002	2003	2004	2005	2006	Percent (%)
World	10,294.74	10,611.98	11,145.52	11,507.20	11,795.75	100.00
OECD Total	3,847.23	3,806.93	3,858.86	3,833.94	3,842.31	32.57
United States	1,666.04	1,634.52	1,647.02	1,629.89	1,654.23	14.02
Canada	383.87	285.93	397.44	402.09	411.74	3.49
Australia	254.49	253.89	259.02	268.19	267.79	2.27
Mexico	230.02	242.31	253.60	259.21	255.97	2.17
United Kingdom	257.95	246.60	225.43	205.16	186.62	1.58
France	134.65	136.48	137.31	137.12	137.02	1.16
Germany	134.51	134.64	136.19	135.28	136.76	1.16
Japan	98.67	84.00	95.01	99.89	101.07	0.86
Netherlands	60.52	58.44	67.66	61.90	60.77	0.52
Korea	34.92	37.94	38.27	42.93	43.73	0.37
Sweden	32.36	31.04	34.46	34.67	32.79	0.28
Spain	31.79	32.99	32.67	30.13	31.36	0.27
Italy	27.45	27.59	28.15	27.85	27.43	0.23
Belgium	13.25	13.70	13.75	15.64	15.48	0.13
Switzerland	11.58	11.79	11.82	10.88	12.15	0.10
NON-OECD Total	6,447.51	6,805.05	7,287.85	7,673.26	7,953.44	67.43
People's Rep. Of China	1,202.31	1,331.34	1,511.72	1,643.92	1,749.34	14.83
Russia	1,034.48	1,106.87	1,158.44	1,197.10	1,219.98	10.34
Saudi Arabia	474.78	530.53	548.71	576.70	570.71	4.84
India	436.45	394.22	407.41	420.29	435.64	3.69
Islamic Republic of Iran	236.39	263.69	278.72	302.61	309.33	2.62
Indonesia	244.64	254.79	263.23	276.66	307.70	2.61
Venezuela	203.55	178.83	195.32	204.54	195.55	1.66
Brazil	162.01	171.67	182.84	195.03	206.72	1.75
South Africa	143.07	153.47	157.46	158.78	158.68	1.35
Argentina	81.38	84.32	83.08	80.97	83.86	0.71
Egypt	60.88	64.43	64.66	76.59	77.83	0.66
Thailand	45.30	48.26	50.44	54.32	56.23	0.48
Chinese Taipei	11.62	12.53	12.40	12.27	12.18	0.10
Israel	0.72	0.75	1.76	2.12	2.66	0.02
Hong Kong, China	0.05	0.05	0.05	0.05	0.05	0.00

Source:China Energy Statistical Yearbook 2008

Table 22 TPES/Population (toe per capita)

Unit:toe per capita

Country or Area	2002	2003	2004	2005	2006
World	1.65	1.69	1.75	1.77	1.80
OECD Total	4.66	4.67	4.73	4.75	4.70
United States	7.97	8.28	8.40	8.47	8.27
Canada	7.94	7.84	7.92	7.89	7.74
Australia	5.91	5.70	5.91	5.78	5.65
Mexico	5.48	5.73	5.58	5.89	5.79
United Kingdom	5.66	5.66	5.62	5.90	5.90
France	4.87	4.99	5.41	5.05	4.90
Germany	4.33	4.38	4.41	4.40	4.31
Japan	4.24	4.34	4.44	4.42	4.48
Netherlands	4.19	4.21	4.22	4.19	4.23
Korea	4.09	4.04	4.17	4.14	4.13
Sweden	3.85	3.90	3.90	3.89	3.82
Spain	3.65	3.63	3.64	3.60	3.73
Italy	3.19	3.24	3.33	3.34	3.28
Belgium	2.99	3.14	3.14	3.17	3.13
Switzerland	1.53	1.56	1.59	1.70	1.69
NON-OECD Total	0.97	0.99	1.05	1.08	1.12
People's Rep. Of China	5.54	5.59	5.86	6.08	6.17
Russia	4.16	4.36	4.59	4.65	4.74
Saudi Arabia	4.25	4.42	4.47	4.59	4.75
India	3.05	3.09	3.02	3.06	3.02
Islamic Republic of Iran	2.51	2.58	2.79	2.72	2.74
Indonesia	2.41	2.47	2.58	2.65	2.65
Venezuela	1.99	2.10	2.22	2.29	2.44
Brazil	2.29	2.07	2.18	2.27	2.30
South Africa	1.49	1.57	1.65	1.64	1.77
Argentina	1.33	1.41	1.56	1.60	1.63
Egypt	0.95	1.06	1.22	1.32	1.43
Thailand	1.07	1.07	1.14	1.16	1.18
Chinese Taipei	0.76	0.78	0.79	0.80	0.80
Israel	0.75	0.78	0.79	0.84	0.84
Hong Kong, China	0.51	0.46	0.48	0.49	0.51

Source: IEA Statistics-Energy Balances of OECD Countries (2008), Energy Balances of Non-OECD Countries (2008)

Source: China Energy Statistical Yearbook 2008

Table 23 Energy Production Self Sufficiency(%)

Country or Area	2002	2003	2004	2005	2006
World	1.01	1.00	1.00	1.00	1.00
OECD Total	0.72	0.70	0.70	0.69	0.69
United States	2.27	2.25	2.28	2.22	2.19
Canada	1.48	1.52	1.53	1.47	1.44
Australia	1.54	1.47	1.48	1.47	1.53
Mexico	1.13	1.06	0.97	0.87	0.81
United Kingdom	0.77	0.72	0.82	0.75	0.76
France	0.73	0.71	0.71	0.70	0.71
Germany	0.61	0.61	0.65	0.66	0.64
Japan	0.51	0.50	0.50	0.50	0.50
Netherlands	0.43	0.44	0.44	0.40	0.43
Korea	0.39	0.39	0.39	0.39	0.39
Sweden	0.23	0.23	0.24	0.25	0.25
Spain	0.24	0.24	0.23	0.21	0.22
Italy	0.19	0.16	0.18	0.19	0.19
Belgium	0.17	0.18	0.18	0.20	0.20
Switzerland	0.16	0.15	0.15	0.15	0.15
NON-OECD Total	1.32	1.34	1.33	1.34	1.32
People's Rep. Of China	3.78	4.31	4.16	4.10	3.91
Russia	3.52	3.36	3.43	3.38	3.14
Saudi Arabia	1.81	1.89	1.85	1.91	1.81
India	1.67	1.73	1.80	1.82	1.80
Islamic Republic of Iran	1.52	1.53	1.53	1.57	1.72
Indonesia	1.45	1.41	1.32	1.28	1.21
Venezuela	1.26	1.30	1.22	1.24	1.22
Brazil	1.16	1.17	1.14	1.25	1.25
South Africa	0.99	0.98	0.95	0.96	0.93
Argentina	0.85	0.89	0.87	0.90	0.92
Egypt	0.82	0.80	0.78	0.78	0.77
Thailand	0.54	0.54	0.52	0.54	0.54
Chinese Taipei	0.12	0.13	0.12	0.12	0.11
Israel	0.04	0.04	0.09	0.10	0.13
Hong Kong, China					

Source:China Energy Statistical Yearbook 2008

Table 24 General Meteological Disasters (2008)

Region	Corp Area (10^4 Hectare)		People		Direct economic loss (10^8 Yuan)
	Affected	Failure	Affected(10^4)	Death (including missing) (persons)	
Beijing	3.3	0.3	42.2	0	7.4
Tianjin	8.5	1.7	58.3	11	3
Hebei	115.2	14.8	996.5	35	45.4
Shanxi	216.4	18.5	686.3	41	80.1
Inner Mongolia	249.7	15.2	565.9	62	97.3
Liaoning	53.9	6	381.1	29	8.3
Jilin	58	5.1	277.5	17	12.5
Heilongjiang	236.7	10.2	961.9	9	94.5
Shanghai	2.8	0	4.9	5	3.2
Jiangsu	49.7	5.1	623.8	54	54.9
Zhejiang	107.5	6.2	3,148.7	36	240.6
Anhui	127.7	10.2	2,225.5	123	189.7
Fujian	23.1	0.9	406.3	23	62.8
Jiangxi	237.6	49.8	3476	55	329.7
Shandong	67.2	5.7	647.6	14	28.2
Henan	96.7	5	603.4	62	32.8
Hubei	403.3	40.1	4384	103	221.9
Hunan	447.4	60.9	5,074.3	103	413.4
Guangdong	160	16.2	2,536.7	118	240.1
Guangxi	230.6	15.8	3,494.5	126	356.5
Hainan	36.6	1.8	853.9	31	23.4
Chongqing	66.2	6.1	1154.1	50	30.4
Sichuan	141.2	6.7	1,633.8	137	110.7
Guizhou	176	26.4	3,453.4	201	222.7
Yunnan	146	18.9	2,390.6	422	98.7
Tibet	5.4	2.1	75.3	21	4.5
Shaanxi	104.7	6.6	615.7	49	32.1
Gansu	133.4	14.5	1,503.5	25	119.1
Qinghai	12.2	1.7	159.5	9	14.6
Ningxia	66.7	7.2	318.4	10	15.9
Xinjiang (including the Xinjiang Production and Construction Corp.)	217.2	23.9	435.4	37	50.1
National	4,000.4	403.3	43,189	2,018	3,244.5

Source: China Meteorological Disasters Statistical Yearbook 2009

Table 25 Rain Floods (Landslide and Debris Flow) Disasters (2008)

Region	Corp Area (10^4 Hectare)		People		Accomodation (10^4 buildings)		Direct economic loss (10^8 Yuan)
	Affected	Failure	Affected(10^4)	Death (including missing) (persons)	Collapse	Damage	
Beijing	0.2	0	2.4	0	0	0	0.3
Tianjin	0.5	0.1	2	2	0	0	0.1
Hebei	5.5	1.1	78	15	0.1	0	4.9
Shanxi	5.7	1.1	1.4	31	0	0.6	0.8
Inner Mongolia	43.4	5	117.1	35	1.1	0	31
Liaoning	17.3	1.1	33.4	0	0.3	2	4
Jilin	5.2	0.5	13.3	0	0	2.7	2.2
Heilongjiang	16	0.7	40	2	0.1	2	4.3
Shanghai	0.7	0	4.9	0	0	0	0
Jiangsu	10.1	2	120.7	0	0.2	0.2	8.7
Zhejiang	23.3	1.7	320.1	0	0.3	0.8	44.8
Anhui	30.2	2.8	510.5	1	0.8	0	25.2
Fujian	5.8	0.3	37.4	0	0	0	9.8
Jiangxi	89.4	12.4	901.9	9	1.6	4.2	51
Shandong	12.1	2.8	122.3	3	0.5	3.4	8.5
Henan	7.4	0.2	47.9	1	0.3	1	4
Hubei	118.5	14.3	1,635.1	38	2	10	70.5
Hunan	67.2	9	1,234.7	23	6.8	17.5	100.7
Guangdong	41.5	4.7	745.5	17	0.3	2.6	46.6
Guangxi	64.2	7.6	1,382.8	80	7.4	17.8	95.4
Hainan	9.3	0.8	263.1	0	0.1	0.2	6.2
Chongqing	9.2	0.9	518.3	31	1.2	2.6	10
Sichuan	26.3	2	767	106	4.6	7.5	43.7
Guizhou	18.8	2.2	547.1	136	1.2	3.1	18.8
Yunnan	14.1	1.7	739.6	298	6.7	8.9	30.5
Tibet	0.6	0.1	22	7	0.3	0.4	2.8
Shaanxi	13.5	0.9	57	43	0.2	3.1	9.2
Gansu	7.8	0.9	71.4	12	0.7	1.7	10.3
Qinghai	1.4	0.3	12.5	7	0.1	2.1	3.6
Ningxia	0.5	0.1	10.6	4	0	0.2	0.5
Xinjiang (including the Xinjiang Production and Construction Corp.)	2.8	0.1	12.6	14	0.2	0.4	3.3
National	668.2	77.2	10,372.4	915	37	94.9	651.8

Source: China Meteorological Disasters Statistical Yearbook 2009

Table 26 Drought Disaster (2008)

Region	Crop Area (10^4 Hectare)		People		Direct economic loss (10^8 Yuan)
	Affected	Failure	Affected (10^4)	Water shortage(10^4)	
Beijing	0.8		8		0.2
Tianjin	2.4	0.1	35	35	
Hebei	62.9	5.3	379.6	37	6.2
Shanxi	191.7	15.3	480	103	67.6
Inner Mongolia	165.8	3	386.5	91	45.6
Liaoning	32.1	4.5	272.9	84	1.4
Jilin	46.6	3.9	2	2	9.6
Heilongjiang	159.7	5.3	736.2	57	78
Shanghai					
Jiangsu					
Zhejiang	2.3	0.2			
Anhui					
Fujian	0.4	0.1			
Jiangxi	12.8	0.7	20.5	1	0.4
Shandong	25.6	0.6	247.9	32	6.2
Henan	58.4	3.5	300.9	15	7.6
Hubei	2		1	1	
Hunan	48.6	4.2	350.5	48	14.1
Guangdong	7.1	0.7	3	3	
Guangxi	22.4	1.7		36.3	
Hainan	8.1	0.2	118.8	10	4.4
Chongqing	15.6	0.4	8	40.7	
Sichuan	10.7	0.3	46	46	0
Guizhou	3	0.1	101.5	2.8	0.5
Yunnan	47.5	4.2	269.3	143	4.5
Tibet			28	28	
Shaanxi	47.8	2.5	209.2	77	7.1
Gansu	78.4	5.4	603.6	91	18.7
Qinghai	6.6	0.6	58.6	18	6.7
Ningxia	49.4	4.2	152.0	84.9	8.2
Xinjiang (including the Xinjiang Production and Construction Corp.)	105	14.3	263.4	59	29.9
National	1,213.7	81.2	5,082.4	1,145.8	316.9

Source: China Meteorological Disasters Statistical Yearbook 2009

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Table 27 Hail and strong winds, lightonnesing disasters (2008)

Region	Corp Area (10^4 Hectare)		People		Accomodation (10^4 buildings)		Direct economic loss (10^8 Yuan)
	Affected	Failure	Affected(10^4)	Death (including missing)(persons)	Collapse	Damage	
Beijing	2.3	0.3	31.8				6.9
Tianjin	5.6	1.5	21.3	0	0	0.1	2.9
Hebei	44.9	7.8	520	19	0.1	0.1	32.1
Shanxi	10.9	1.6	154.9	10	0.1	1	9.6
Inner Mongolia	32.4	6.3	39.3	23	0.3	0.6	17.6
Liaoning	3.2	0.4	65.8	27	0.1	1	2.4
Jilin	6.2	0.7	260.8	17	0	0.1	0.7
Heilongjiang	49.4	3.5	148	7	1.4	2.1	10.3
Shanghai	0.1	0	0	3	0.1	0.2	1.6
Jiangsu	7.8	1.8	178.4	23	0.5	2.4	11.4
Zhejiang	6.7	0.1	43.2	14	0.1	2.9	3
Anhui	5.7	0.5	91.3	20	0.4	1.8	2.7
Fujian	4.7	0	9.1	20		2.7	1.1
Jiangxi	7.2	0.6	209.7	28	1.1	3.3	5.3
Shandong	26	2.2	250.7	11	1	0.6	10.6
Henan	17.1	1	199.6	23	0.2	2.6	10.4
Hubei	33.8	4.4	468.1	51	1.8	11.4	37.2
Hunan	13.2	1.7	101.6	22	1.3	5.9	24.9
Guangdong	0	0	0	29		0	0.8
Guangxi	4.2	0.5	27	23	0.1	2.5	0.4
Hainan	0	0	0	13		0	0.1
Chongqing	11.7	1.4	128.5	15	0.4	2.9	2.9
Sichuan	39.8	0.6	20.8	26	0.3	1.1	3.8
Guizhou	5.2	0.9	150	35	0.1	2.1	5.1
Yunnan	12.5	2.2	85.2	63	0.2	4.1	4.6
Tibet	1.5	0.4	1.8	3		0	0.1
Shaanxi	16.7	1.2	164.5	4	0.2	0.9	11.2
Gansu	16.1	2.3	265.6	12	0.1	2.4	33.4
Qinghai	1.1	0.1	17.3	2	0.8	1	0.7
Ningxia	10.2	2.6	39.2	3	0.2	2.1	2.5
Xinjiang (including the Xinjiang Production and Construction Corp.)	22.1	1.3	29.1	3	0.2	1.3	2.6
National	418	47.5	3,722.8	549	11	59.2	258.6

Source: China Meteorological Disasters Statistical Yearbook 2009

Table 28 Tropical Cyclone Disasters (2008)

Region	Corp Area (10,000 Hectare)		Collapsed Accomodation (10,000 buildings)
	Affected	Failure	
Beijing			
Tianjin			
Hebei			
Shanxi			
Inner Mongolia			
Liaoning			
Jilin			
Heilongjiang			
Shanghai			
Jiangsu	14.2	0	0
Zhejiang	13.9	0.2	0.1
Anhui	22.3	2.3	1.1
Fujian	8.9	0.4	0.3
Jiangxi	7.7	0.7	1.2
Shandong	0.3	0	0.1
Henan			
Hubei			
Hunan	1.3	0.1	0.1
Guangdong	68	8.7	6.5
Guangxi	69.7	1.9	2.3
Hainan	11.9	0.2	0
Chongqing			
Sichuan			
Guizhou			
Yunnan	12.8	0.1	1
Tibet			
Shaanxi			
Gansu			
Qinghai			
Ningxia			
Xinjiang (including the Xinjiang Production and Construction Corp.)			
National	231	14.5	12.8

Source: China Meteorological Disasters Statistical Yearbook 2009

Table 28 Tropical Cyclone Disasters (2008)--continued

Region	People			Direct economic loss (10^8 Yuan)
	Affected (10,000)	Death (including missing)	Emergent resettlement (10,000 persons)	
Beijing				
Tianjin				
Hebei				
Shanxi				
Inner Mongolia				
Liaoning				
Jilin				
Heilongjiang				
Shanghai				
Jiangsu	79.4	1	0	7.1
Zhejiang	403.5	0	117.3	18.5
Anhui	281.4	12	9.5	29.5
Fujian	192.2	3	110.3	21.1
Jiangxi	133.8	6	8.7	9.4
Shandong	1.6		1.3	0.1
Henan				
Hubei				
Hunan	37.1	12	0.4	1.7
Guangdong	1,369.2	72	98.5	159.1
Guangxi	870.4	21	112.8	60.7
Hainan	267.8	18	31.7	5.5
Chongqing				
Sichuan				
Guizhou				
Yunnan	155.1	34	1.7	8.3
Tibet				
Shaanxi				
Gansu				
Qinghai				
Ningxia				
Xinjiang (including the Xinjiang Production and Construction Corp.)				
National	3,791.6	179	492.2	320.8

Source: China Meteorological Disasters Statistical Yearbook 2009

Table 29 Snowstorm and Low-temperature Refrigeration Disasters (2008)

Region	Corp Area (10,000 Hectare)		People		Accomodation (10^4)		Direct economic Loss (10^8Yuan)
	Affected	Failure	Affected (10^4)	Death (including missing)	Collapsed	Damaged	
Beijing	0	0		0	0	0	0
Tianjin	0	0	0	0	0	0	0
Hebei	1.9	0.7	18.9	0	0	0	2.2
Shanxi	8.1	0.5	50	0	0	0	2.1
Inner Mongolia	8.1	0.9	23	4	0	0	3.1
Liaoning	1.3	0	9	0	0	0	0.5
Jilin	0	0	1.4	0	0	0	0
Heilongjiang	11.6	0.7	37.8	0	0	0	2
Shanghai	2	0	0	2	0	0	1.6
Jiangsu	17.7	1.2	245.3	7	0.9	1.7	27.8
Zhejiang	61.3	4.1	2,381.9	9	0.4	1.4	174.3
Anhui	69.5	4.7	1,342.3	13	9.1	17.3	132.3
Fujian	3.3	0.1	167.6	0	0.1	21.3	30.9
Jiangxi	120.5	35.3	2,210.1	7	5.2	19.4	263.6
Shandong	3.2	0.1	25.1	0	0	0	2.8
Henan	13.8	0.3	55	0	0.4	0.7	10.8
Hubei	249	21.5	2,279.8	13	9.8	17	114.2
Hunan	317.1	45.9	3,350.3	26	6.7	30	272
Guangdong	43.3	2.1	419	0	0.2	0.1	33.6
Guangxi	70.1	4.1	1,214.3	2	5.9	7.2	200
Hainan	7.4	0.6	204.2	0	0	0	7.2
Chongqing	29.8	3.3	499.3	4	0.4	1.4	17.5
Sichuan	64.4	3.8	800	5	2.2	11.5	63.1
Guizhou	149	23.3	2,654.8	30	3.1	12.8	198.3
Yunnan	59.1	10.7	1,141.4	27	3.9	19.7	50.8
Tibet	3.3	1.7	23.5	11	0.2	0.6	1.6
Shaanxi	26.7	2	185	0	0.4	0.9	4.6
Gansu	31.2	6	562.9	1	0.2	3	56.8
Qinghai	3.1	0.8	71.1	0	0	0	3.6
Ningxia	6.6	0.4	116.6	3	0.3	0.9	4.8
Xinjiang (including the Xinjiang Production and Construction Corp.)	87.3	8.2	130.3	17	0.2	1.2	14.3
National	1,469.5	182.8	20,219.9	181	49.6	168.1	1,696.4

Source: China Meteorological Disasters Statistical Yearbook 2009

Table 30a Environment Pollution and Destruction Accidents by Time

Year	Number of Pollution and Destruction Accidents (time)						Direct economic Loss (10,000 Yuan)	Reparations and Fines on Pollution Accidents (10 ,000 Yuan)
	Total	Water pollution	Air pollution	Solid wastes pollution	Noise and Vibration Pollution	Others		
2000	2,411	1,138	864	103	266	40	17,807.9	3,682.6
2001	1,842	1,096	576	39	80	51	12,272.4	3,263.9
2002	1,921	1,097	597	109	97	21	4,640.9	3,140.7
2003	1,843	1,042	654	56	50	41	3,374.9	2,391.5
2004	1,441	753	569	47	36	36	36,365.7	3,963.9
2005	1,406	693	538	48	63	64	10,515.0	3,082.1
2006	842	482	232	45	6	77	13,471.1	8,415.9
2007	462	178	134	58	7	85	3,278	807
2008	474	198	141	45		90	18,186	927

Source: China Statistical Yearbook 2009

Table 30b Environment Pollution and Destruction Accidents by Region (2008)

Region	Number of Pollution and Destruction Accidents (time)						Direct economic Loss (10,000 Yuan)	Reparations and Fines on Pollution Accidents (10,000 Yuan)
	Total	Water Pollution	Air Pollution	Solid Wastes Pollution	Noise and Vibration Pollution	Others		
Beijing	37	2	9	25		1		
Tianjin								
Hebei	10	8				2	6,112	30
Shanxi	5	1	1			3		
Inner Mongolia	5	1	4				15	20
Liaoning	2	1		1			7,150.11	
Jilin	10					10	150	140
Heilongjiang	6	1	4			1	120	
Shanghai	86	6	46	12		22		52
Jiangsu	11	6	5					
Zhejiang	64	33	9			22	73.8	13.6
Anhui	16	9	7				1,440.7	130
Fujian	1		1					
Jiangxi	19	12	7				587.62	55
Shandong	10	5	1	2		2		
Henan	12	6	2	1		3		
Hubei	33	24	3	1		5		
Hunan	6	4		1		1	410	38
Guangdong	4					4		
Guangxi	39	30	9				323.6	96.6
Hainan								
Chongqing	21	14	6			1		
Sichuan	2					2		
Guizhou	10	4	1			5	14.7	16.7
Yunnan	4	3				1	1,707.3	
Tibet								255
Shaanxi	15	13		2			14.55	72
Gansu	37	11	24			2	62.2	8.3
Qinghai	2	2					4	
Ningxia	1	1						
Xinjiang	6	1	2			3		

Source: China Statistical Yearbook 2009

APPENDIX

Table 31a Areas Covered and Affected by Natural Disaster by Time

Unit:1,000 hectare

Year	Areas covered	Areas affected	Percentage of disaster areas affected to areas covered (%)	Flood		Drought	
				Areas covered	Areas affected	Areas covered	Areas affected
1978	50,790	24,457	48.2	2,850	2,012	40,170	17,970
1980	44,526	29,777	66.9	9,146	6,070	26,111	14,174
1985	44,365	22,705	51.2	14,197	8,949	22,989	10,063
1990	38,474	17,819	46.3	11,804	5,605	18,175	7,805
1991	55,472	27,814	50.1	24,596	14,614	29,414	10,559
1992	51,333	25,859	50.4	9,423	4,464	32,980	17,049
1993	48,829	23,133	47.4	16,387	8,611	21,098	8,657
1994	55,043	31,383	57.0	17,329	10,744	30,425	17,049
1995	45,821	22,267	48.6	12,731	7,630	23,455	10,401
1996	46,989	21,233	45.2	18,146	10,855	20,151	6,247
1997	53,429	30,309	56.7	11,414	5,840	33,514	20,012
1998	50,145	25,181	50.2	22,292	13,785	14,236	5,060
1999	49,981	26,731	53.5	9,020	5,071	30,156	16,614
2000	54,688	34,374	62.9	7,323	4,321	40,541	26,784
2001	52,215	31,793	60.9	6,042	3,614	38,472	23,698
2002	47,119	27,319	58.0	12,378	7,474	22,207	13,247
2003	54,506	32,516	59.8	19,208	12,289	24,852	14,470
2004	37,106	16,297	43.9	7,314	3,747	17,253	8,482
2005	38,818	19,966	51.4	10,932	6,047	16,028	8,479
2006	41,091	24,632	59.9	8,003	4,569	20,738	13,411
2007	48,992	25,064	51.2	10,463	5,105	29,386	16,170
2008	39,990	22,283	55.7	6,477	3,656	12,137	6,798

Source: China Statistical Yearbook 2009

Table 31b Areas Covered and Affected by Natural Disaster by Region (2008)

Unit:1,000 hectare

Region	Areas covered	Areas affected	Percentageof disaster areas affected to areas covered (%)	Flood		Drought	
				Areas covered	Areas affected		
Beijing	30.8	25.1	81.4			8.1	5
Tianjin	79.7	54.0	67.8			23.73	6.7
Hebei	1,151.5	833.7	72.4	54.5	28.97	629.2	480
Shanxi	2,163.5	1,007.3	46.6	56.5	22.7	1,917.3	906.7
Inner Mongolia	2,496.7	1,317.8	52.8	434.0	158.78	1,658	938
Liaoning	538.9	298.8	55.5	173.2	35.6	321.3	236
Jilin	579.7	244.0	42.1	51.7	29.45	466	165
Heilongjiang	2,367.1	1,344.5	56.8	159.4	53.1	1597	930
Shanghai	21.0	8.0	38.1				
Jiangsu	497.0	274.6	55.2	100.7	95.06		
Zhejiang	1,074.9	518.6	48.2	233.1	134.3	22.7	9.3
Anhui	1,277.1	620.8	48.6	301.5	202		
Fujian	230.6	82.1	35.6	57.7	23.7	4.43	1.8
Jiangxi	2,376.2	1,142.4	48.1	812.0	255.39	128	45.7
Shandong	672.3	233.8	34.8	121.4	81.6	256	87.5
Henan	966.7	652.9	67.5	73.7	52.28	584	376
Hubei	4,032.8	2,658.7	65.9	1,179.9	930.91	20	14.2
Hunan	4,473.7	2,842.5	63.5	666.2	279.34	486	160.4
Guangdong	1,599.7	793.8	49.6	415.0	233.81	71	40
Guangxi	2,305.7	1,128.9	49.0	642.1	555.59	223.75	127
Hainan	365.9	172.2	47.1	92.6	78.57	80.5	20.7
Chongqing	662.0	399.2	60.3	86.1	46.5	155.79	93.2
Sichuan	1,411.8	636.6	45.1	206.1	105.31	106.7	35.3
Guizhou	1,759.7	1,049.6	59.6	185.9	122.1	30.4	17.7
Yunnan	1,459.7	882.0	60.4	120.6	55.2	475	359
Tibet	53.9	36.4	67.5	5.2	3.91		
Shaanxi	1,046.8	502.3	48.0	134.1	14.68	478	341
Gansu	1,334.1	840.7	63.0	71.3	35.6	783.5	573.4
Qinghai	122.3	73.3	59.9	9.8	1.3	66.4	44.5
Ningxia	666.6	282.7	42.4	4.5	3.6	494	223
Xinjiang	2,171.7	1,326.1	61.1	27.7	16.26	1,050	560.5

Source: China Statistical Yearbook 2009

Table 32 Energy Fund Allocation/Loan in Rural Area (2007)

Item / Region	Total (10^4 Yuan)		Provincial level(10^4 Yuan)		Prefectural level(10^4 Yuan)	
	Allocation	Loan	Allocation	Loan	Allocation	Loan
Beijing	452,493	13,482	204,081	761.9	93,377	5,557
Tianjin	39,741.		24,129		8,894	
Hebei	554.4					
Shanxi	6,589	130	2,578		588	
Inner Mongolia	45,731		20,863		8,442	
Liaoning	7,932		1,050		145	
Jilin	17,028	1,504	9,657	690	4,504	64
Heilongjiang	170.2					
Shanghai	13,045		10,000		1,050	
Jiangsu						
Zhejiang	14,141		10,237		1,205	
Anhui	20,773		5,040		2,710	
Fujian	2,391		389.4		303	
Jiangxi	6,576	40	4,330		758.5	
Shandong	3,034		1,054		417.8	
Henan	39,804	159.2	10,172	70	11,586	80
Hubei	36,409		1,571		10,678	
Hunan	42,596	5,118	25,000		9,629	
Guangdong	10,767		4,541		1,431	
Guangxi	9,199		6,000		1,213	
Hainan	18,286	3	15,021		1,366	
Chongqing	3,448		500		2,200	
Sichuan	1,796		905			
Guizhou	40,187		16,520		10,443	
Yunnan	35,100	5,901	15,728		7,927	4,865
Tibet	17,049	621.7	11,591		3,742	548
Shaanxi	1,301		975.8		163	
Gansu	12,608		4610		3,219	
Qinghai	2,296	4.9	138.9	1.9	249	
Ningxia						
Xinjiang	783.6		321.5			
Beijing	3,175		1,159		516.3	

Source: China Rural Energy Yearbook 2000-2008

Table 32 Energy Fund Allocation/Loan in Rural Area (2007)--continued

Item / Region	County Level(10^4 Yuan)		Township Level(10^4 Yuan)		Self fund raising (10^4 Yuan)	
	Allocation	Loan	Allocation	Loan	Fund	Labor input
Beijing	124,895	7,039	30,139	123.4	673,636	215,190
Tianjin	6,718				11,961	520
Hebei	554.4					
Shanxi	2,920	130	502.6		83,238	15,466
Inner Mongolia	14,446		1,963		15,217	5,376
Liaoning	6,735		1.5		12,971	4,244
Jilin	2,080	690	786.4	60	10,138	1,722
Heilongjiang	170.2				582.6	582.6
Shanghai	1,431		563.8		3,662	6,494
Jiangsu						
Zhejiang	2,356		343		9,260	1,975
Anhui	10,703		2,320		31,363	1,672
Fujian	1,313		385.6		10,149	6,564
Jiangxi	1,088	40	399.3		9,038	2,209
Shandong	1,325		237.1		11,573	6,839
Henan	12,717	9.2	5,330		38,139	12,071
Hubei	16,826		7,334		101,485	22,956
Hunan	3,387	5,058	4,581	60.4	80,579	32,540
Guangdong	3,741		1,054		19,419	8,018
Guangxi	1,713		273.1		10,070	610.1
Hainan	1,567		332.3	3	31,810	11,846
Chongqing	520		228		2,602	1,992
Sichuan	818.6		72		14,608	6,796
Guizhou	12,724		500.5		18,386	11,258
Yunnan	9,365	1,036	2,080		45,186	21,958
Tibet	1,496	73.6	220.9		15,932	10,030
Shaanxi	162.6				487.9	813.2
Gansu	4,549		230.7		49,650	9,155
Qinghai	1,600	3	307.9		22,229	9,251
Ningxia						1,946
Xinjiang	462.2				6,754	
Beijing	407.1		93		7,142	287.2

Source: China Rural Energy Yearbook 2000-2008

Table 33 Energy Administration in Rural Area(2007)

Item / Region	Total	Divided by administration area				Divided by personnel education level		
		Provincial	Prefectural	County	Township	Undergratuate and above	College	High school and below
Beijing	35,304	505	1,984	15,018	17,797	6,364	14,247	14,693
Tianjin	200	9		137	54	55	37	108
Hebei	54	3		51		8	24	22
Shanxi	1,407	24	101	724	558	292	520	595
Inner Mongolia	1,284	32	74	595	583	342	578	364
Liaoning	1,688	34	136	604	914	364	489	835
Jilin	1,184	20	58	302	804	155	405	624
Heilongjiang	445	8	57	380		118	136	191
Shanghai	1,124	26	42	455	601	346	467	311
Jiangsu								
Zhejiang	685	4	52	439	190	153	234	298
Anhui	454	22	66	304	62	151	155	148
Fujian	782	30	61	515	176	154	357	271
Jiangxi	603	15	38	322	228	143	223	237
Shandong	1,537	2	41	515	979	147	457	933
Henan	1,907	8	81	846	972	574	708	625
Hubei	2,642	32	216	1,171	1,223	374	1,254	1,014
Hunan	1,882	20	161	721	980	219	752	911
Guangdong	879	15	90	678	96	197	415	267
Guangxi	1,752	15	62	380	1,295	351	880	521
Hainan	2,193	38	70	777	1,308	289	821	1,083
Chongqing	119	9	11	99		55	51	13
Sichuan	732	6		269	457	174	336	222
Guizhou	2,160	32	135	979	1,014	442	786	932
Yunnan	2,591	11	54	665	1,861	403	1,430	758
Tibet	2,839	13	85	794	1,947	216	1,032	1,591
Shaanxi	15	5	10			15		
Gansu	2,370	7	75	1,004	1,284	207	885	1,278
Qinghai	1121	26	98	803	194	230	476	415
Ningxia	192	5		187		80	112	
Xinjiang	278	21	42	198	17	65	130	83
Beijing	185	13	68	104		45	97	43

Source: China Rural Energy Yearbook 2000-2008

Table 34 Per Capita Annual Income and Engel's Coefficient of Urban and Rural Households

Year	Per capita annual disposable income of urban households		Per capita annual net income of rural households		Engel's coefficient of urban households(%)	Engel's coefficient of rural households(%)
	Value (Yuan)	Index (1978=100)	Value (Yuan)	Index (1978=100)		
1978	343.4	100.0	133.6	100.0	57.5	67.7
1980	477.6	127.0	191.3	139.0	56.9	61.8
1985	739.1	160.4	397.6	268.9	53.3	57.8
1990	1,510.2	198.1	686.3	311.2	54.2	58.8
1991	1,700.6	212.4	708.6	317.4	53.8	57.6
1992	2,026.6	232.9	784.0	336.2	53.0	57.6
1993	2,577.4	255.1	921.6	346.9	50.3	58.1
1994	3,496.2	276.8	1,221.0	364.3	50.0	58.9
1995	4,283.0	290.3	1,577.7	383.6	50.1	58.6
1996	4,838.9	301.6	1,926.1	418.1	48.8	56.3
1997	5,160.3	311.9	2,090.1	437.3	46.6	55.1
1998	5,425.1	329.9	2,162.0	456.1	44.7	53.4
1999	5,854.0	360.6	2,210.3	473.5	42.1	52.6
2000	6,280.0	383.7	2,253.4	483.4	39.4	49.1
2001	6,859.6	416.3	2,366.4	503.7	38.2	47.7
2002	7,702.8	472.1	2,475.6	527.9	37.7	46.2
2003	8,472.2	514.6	2,622.2	550.6	37.1	45.6
2004	9,421.6	554.2	2,936.4	588.0	37.7	47.2
2005	10,493.0	607.4	3,254.9	624.5	36.7	45.5
2006	11,759.5	670.7	3,587.0	670.7	35.8	43.0
2007	13,785.8	752.3	4,140.4	734.4	36.3	43.1
2008	15,780.8	815.7	4,760.6	793.2	37.9	43.7

Source: China Statistical Yearbook 2009

Table 35 Floor Space of Newly Built Residential Buildings and Housing Conditions of Urban and Rural Residents

Year	Floor space of newly built residential buildings in urban areas (100 million sq.m)	Floor space of newly built residential buildings in rural areas (100 million sq.m)	Per capita floor space of residential buildings in urban areas (sq.m)	Per capita floor space of residential buildings in rural areas (sq.m)
1978	0.38	1.00	6.7	8.1
1980	0.92	5.00	7.2	9.4
1985	1.88	7.22	10.0	14.7
1986	2.22	9.84	12.4	15.3
1987	2.23	8.84	12.7	16.0
1988	2.40	8.45	13.0	16.6
1989	1.97	6.76	13.5	17.2
1990	1.73	6.91	13.7	17.8
1991	1.92	7.54	14.2	18.5
1992	2.40	6.19	14.8	18.9
1993	3.08	4.81	15.2	20.7
1994	3.57	6.18	15.7	20.2
1995	3.75	6.99	16.3	21.0
1996	3.95	8.28	17.0	21.7
1997	4.06	8.06	17.8	22.5
1998	4.76	8.00	18.7	23.3
1999	5.59	8.34	19.4	24.2
2000	5.49	7.97	20.3	24.8
2001	5.75	7.29	20.8	25.7
2002	5.98	7.42	22.8	26.5
2003	5.50	7.52	23.7	27.2
2004	5.69	6.80	25.0	27.9
2005	6.61	6.67	26.1	29.7
2006	6.30	6.84	27.1	30.7
2007	6.88	7.75		31.6
2008	7.60	8.34		32.4

Source: China Statistical Yearbook 2009

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