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Preface

The China Council for International Cooperation on Environment and Development (CCICED) was established with the approval of the Chinese government in 1992. Consisting of senior Chinese and international officials and experts, it serves as a high-level advisory body with a mandate to conduct research and to provide policy recommendations to the Government of China on China's environment and development. The Council reports to the State Council and each year meets with a senior leader to discuss its recommendations.

Over the past 18 years, CCICED has witnessed significant change and marked progress in China in the field of environment and development policy. Over the Council's tenure, issues have evolved in number, complexity and significance from those discussed at the 1992 Rio UN Conference on Environment and Development to those environmental challenges such as climate change, which have become mainstream economic and political concerns throughout the world. CCICED continues to be a unique body, highly relevant to China's domestic needs and to fostering a better international understanding of China's contributions to global environment and development.

With ongoing support from the Chinese government, the governments of many other countries, and international agencies, CCICED has completed three phases. Phase I (1992-1996) carried out initial policy studies and research on key issues in the field of environment and development and disseminated and exchanged international experiences and information on successful policies. Phase II (1997-2001) shifted the focus from policy research to policy and project demonstrations. Phase III (2002-2006) was established with broader priorities and a number of major policy studies were conducted. Based on the successful experience of previous phases, Phase IV (2007-2011) has drawn support from a larger number of donors and has focused concerted attention on issues that will determine China's success in becoming regarded as an environmentally friendly society. Indeed, China has entered into a new era, and CCICED will play a major role in promoting China's strategic transformation on environment and development.

2009 was a difficult year for China as the global economic crisis developed with severe consequences for China and the world. China implemented one of the world's largest economic stimulus and industrial restructuring programs. The Government also invested heavily in environmental protection. 2009 marked New China's 60th Anniversary, and opportunities and expectations concerning China's participation in global economic, environmental, and development matters in coming decades are greater than ever before.

2009, the mid-year of CCICED Phase IV, was a very important year for the development of CCICED. In this year, five major CCICED task forces addressing issues related to energy and the environment completed their work. Their policy recommendations formed the basis for the Council's 2009 Recommendation to the Chinese Government and aroused considerable interest. Two new task forces commenced their work in the course of the year, on ecosystems services management and the sustainable development of oceans.

This volume, *Annual Policy Report 2009*, contains documents presented to, and the policy recommendations approved by, the CCICED's Annual General Meeting in November, 2009, for which the theme was "Energy, Environment and Development". This book includes the text of the Issues Paper, prepared as a discussion document addressing what a green prosperity future would entail for China, final reports submitted by the five task forces, and the final text of the Council 2009 Recommendations, which has since been forwarded to the State Council and other governmental agencies. The task force reports represent the views of the individual teams and not necessarily those of the Council as a whole, while the Recommendations reflect a consensus among CCICED members attending the 2009 Annual General Meeting.

The materials in this volume offer a great many options for China to consider as it continues to strengthen its governance of environment and development. We wish to share them within and outside of China in the hope that they will lead to a better understanding of the environment and development challenges facing China and China's contribution to resolving environmental issues domestically and internationally. Further information may be found on the CCICED web site (http://www.cciced.net/enccifced), including texts of task force reports on which these summary reports are based, and reports from past years.

We extend our thanks to those who support CCICED's work and China's environmental undertakings. We appreciate the financial and other support from the Government of China and generous donors, and the contributions of the many Chinese and international experts who conducted the research reflected in this volume. The invaluable assistance of the Chinese and International Chief Advisors and their group of experts, who provided guidance to the research work; the assistance of the International Secretariat Support Office at Simon Fraser University in Vancouver; and the advice of Council members, who volunteered their time and expertise in support of this undertaking, are all gratefully acknowledged.

The Secretariat of CCICED

March, 2010

Acknowledgments

The China Council for International Cooperation on Environment and Development (CCICED) carried out a series of policy research studies on relevant issues of energy and environment in 2009 with strong support of CCICED Chinese and International Members, experts, and scholars as well as partners. Reports on and recommendation from these studies were presented to the CCICED Annual General Meeting in November 2009. An Issues Paper was also submitted, which summarized current issues related to environment and development in China. Based on these documents, Policy Recommendations were prepared by the Council's scientific advisors and approved by the Council for submission to the Government of China. These documents are contained as chapters in this current volume.

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Contents

Chapter 1 Policy Recommendations to the Government of China 1

Chapter 2 China's Green Prosperity Future—Environment, Energy and Economy 20
Executive Summary..20
2.1 Introduction 24
2.2 Stimulus and Environmental Performance 28
2.3 Sustainable Consumption and Green Growth..39
2.4 Energy, Environment and Climate Change 47
2.5 Looking Ahead 67
2.6 Conclusion-Prospects for a Green Prosperity Future...76

Chapter 3 China's Pathway Towards a Low Carbon Economy 79
3.1 Preface...79
3.2 Global Shift to a Low Carbon Economy 80
3.3 Necessity and Urgency of Developing a Low Carbon Economy in China........86
3.4 Understanding Challenges and Opportunities 90
3.5 Scenarios for Low Carbon Economy up to 2050...94
3.6 Roadmap for China's Low Carbon Development-Based on
Five Pillars and Three Bases 96
3.7 Policy Recommendations 108

Chapter 4 Economic Instruments for Energy Efficiency and the Environment.............116
4.1 Preface...116
4.2 Environmental Taxation and Energy Efficiency 122
4.3 Green Credit 132
4.4 Environmental Pollution Liability Insurance..145

Chapter 5 Energy Efficiency and Urban Development—the building sector and the transport sector 156
5.1 Introduction 156

5.2 Controlling Urban-life Energy Consumption: a Priority 157
5.3 Decoupling urban-life energy use from income level increases in China 165
5.4 Policy Recommendations 187

Chapter 6 Rural Development and its Energy, Environment and Climate Change Adaptation 195
6.1 Preface 195
6.2 An Overview of Rural Energy, Environment, and Adaptation to Climate Change 195
6.3 Trends and Challenges in Rural Energy Use 198
6.4 The Environmental Effects of Rural Energy Use 205
6.5 International Experiences in Rural Energy, Environment, and Adaptation to Climate Change 209
6.6 Policy and Funding Options for Mitigating and Adapting to Climate Change in Rural Areas 212
6.7 Case Studies: How Rural China is Conserving Energy, Improving the Environment, and Tackling Climate Change while Addressing Rural Poverty 215
6.8 Policy Recommendations 222

Chapter 7 Sustainable Use of Coal and Pollution Control Policy in China 228
7.1 Status and Prospects of the Development and Utilization of Coal Resources in China 228
7.2 Strategic Targets and Constraints of Sustainable Use of Coal 233
7.3 Resources and Environmental Protection Strategies for Sustainable Coal Development in China 243
7.4 Strategies for Efficient and Cleaner Coal Utilization in China 251
7.5 Environmental Protection Strategies for Sustainable Coal Utilization in China 256
7.6 Main Research Findings 266
7.7 Policy Recommendations 272

AppendixⅠ Progress on Environment and Development Policies in China（2008－2009） 278

AppendixⅡ Name List of Council Members 307

Chapter 1 Policy Recommendations to the Government of China

The Third Annual General Meeting of the 4th Phase of the China Council for International Cooperation on Environment and Development (CCICED) took place on 11-13 November 2009 in Beijing with the theme of "Energy, Environment and Development".

The CCICED members warmly recognize the 60th anniversary of the People's Republic of China. This 60-year period represents a historical shift for new China, especially over the past 30 years of reform and opening—from poverty towards being well-off, from backwardness to prosperity, and from a closed society to integration into globalization. We note in particular and congratulate China on its major transformation towards human-centred and sustainable development strategies based on scientific development and harmonious approaches. We strongly encourage China to continue promoting its strategic transformation of environment and development, in order to achieve and sustain green prosperity as the basis of China's future development. While there still is a long way to go in exploring a new path for environmental protection with its own Chinese-characteristics, the results will strengthen China's admirable progress towards elimination of poverty, its commitment to build an environment-friendly society, and, indeed, towards defining in real terms the nature of ecological civilization. In the process China can contribute to solving global environmental concerns, including climate change.

CCICED appreciates the Chinese Government's efforts to address impacts arising from the global financial crisis. We applaud China for its continued progress in difficult times towards meeting 11th Five-Year Plan energy conservation and pollution reduction targets, and for highlighting green growth as a new approach. CCICED members recognize that now is the key time to design an environment and development strategy for the 12th Five-Year Plan. It is a critical testing period for China's sustained energy-saving and emission reduction efforts, and an important time to incorporate green economy including low carbon economy into the national development plan. Otherwise, China will be at risk of losing achievements of the 11th Five-Year Plan and of losing new growth opportunities.

We see a future in which it is necessary to address multiple crises involving the economy, energy, environment and climate change, and possibly other matters. Historical and practical experience has shown that the impacts of global financial crisis may be temporary. But the climate, energy and environmental crisis will present a significant and growing threat to the sustainable development of humankind and the globe's biodiversity and ecosystems—requiring global cooperation and common effort. The Council appreciates the new measures and targets put forward by the Government of China to address climate change; recognizes the gradually enhanced leadership of China's government in global affairs; and will pay close attention to the outcome of climate change negotiations in Copenhagen.

During the 2009 AGM, CCICED examined the findings and recommendations of five Task Forces covering key energy and environment issues including: low carbon economy, sustainable use of coal, urban energy efficiency, rural energy and environment, and economic instruments for energy efficiency and the environment. Based on these studies and further inputs at the AGM, seven policy recommendations are presented to the State Council. More detailed information on many of the recommendations is available in the individual Task Force reports.

1.1 Develop a green economy and speed up green transformation of economic development.

The current times provide a historic transformative opportunity to build a more satisfactory economy and environment relationship. Green growth and green economy are new global initiatives in the process of responding to the financial crisis and important components of the G20 consensus for economic recovery. Within China green growth should lead to a prosperous future economy consistent with the needs of the resource-saving and environment-friendly society called for by the Government of China. This new pattern of growth has implications for China's new emphasis on stimulating domestic consumption and for China's emphasis on higher value-added exports in future trade relationships. Furthermore, green growth is likely to be a more effective means to address multiple crises of the future including those involving energy, environment and climate change, and an important step towards the aspiration of an ecological civilization. Therefore, CCICED recommends**:**

From the perspectives of scientific development, ecological civilization and strategic consideration for long-term global competitiveness, China should

consider green economy as an important approach to promote transformation of its economic development mode, and should develop a national strategy for green economic development as soon as possible. While striving for a Low Carbon Economy that will address many energy and environment concerns, China should also take actions in the following six areas to promote a green economy:

(1) Strengthen the promotion of Circular Economy to increase resource efficiency. Circular Economy practices support green economy development by creating new wealth and resources through improved recycling and efficiency improvement, via the "Reduce, Reuse and Recycle" principles. China has many successful pilot demonstrations and substantial commercial experiences. Yet most sectors and rural areas are far from being eco-efficient in either use of energy or environmental resources when judged by international benchmarks. China should fully implement its Circular Economy Promotion Law that became effective this year, establish and improve relevant policy and regulations, and promote circular economy in all sectors.

(2) Increase R&D investment for advanced green technology, develop green industries and foster new green growth opportunities. China should substantially increase its investment in R&D and industries for energy-saving, renewable energy, clean energy, environmental industries, urban public transport, building energy, ecosystem protection and restoration, environmental infrastructure and waste recycling, and make green growth a key part of China's industrial and economic development strategies.

(3) Strengthen industrial restructuring to promote eco-reform of traditional industries. A key element of energy-saving and emission reduction tasks of China's the 11th Five-Year Plan is to phase out backward production capacity with high resource and energy consumption and high pollution emissions. So far, some industries, e.g., iron and steel, have already achieved this objective ahead of time schedule. Investment from the national stimulus package for tertiary industry and infrastructure in central and western regions has been significantly increased. However, there is still a large proportion of backward production capacity and overcapacity in China's industrial base, hence substantial risk and pressure for rebound of overproduction that could result in greater environmental deterioration. China should seize this historic time of economic stimulus as an opportunity to incorporate environmental considerations into its transformation of traditional industries and industrial restructuring. This could be done through stringent environmental admission standards and permits to operate, pollution emission standards and management instruments, and by speeding up green transformation of all major industrial sectors. In particular, in its adjustment and revitalization plans for key industries China should further increase requirements for environmental protection, resource and energy efficiency; strengthen the phase-out of environment-inefficient production capacity; and strengthen the green transformation of industrial structure.

(4) Develop rural green economy through environmental improvement of mainstream farming methods; introducing ecological and organic farming, low-carbon farming; and by improved management of ecosystem services. The unbalanced development between urban and rural areas includes not only income and development level disparity, but also differences in environmental quality, climate change adaptation capacity, as well as quality of life. In the development of green economy strategy and practice, China should pursue integrated rural and urban green development and avoid deepening rural and urban differences. Green economy development in rural areas should integrate low carbon pursuit into traditional ecological farming and organic farming, strengthen the management of land utilization, ecosystem services and biodiversity conservation, promote rural economic development and create jobs while reducing pollution discharge and greenhouse gas emissions.

(5) Advocate sustainable consumption and low-carbon lifestyle, enhance the role of the public and NGOs in green economic development. Recognizing the significant role of citizens and their consumption patterns in promoting green economy, it is important to raise public awareness for individual consumers and households, commercial enterprises, and industries–through resource-saving, low carbon, and environmental protection messages and action. Messages should emphasize modest levels of individual and household consumption that take into account embedded energy, high efficiency and low carbon; and certification regarding susta-inability, low carbon criteria, and environmentally-sound production for both goods and services. China should promote green procurement by government agencies at all levels, strengthen its legal basis, disclose relevant information, and encourage the role of NGOs in the communication and technical aspects of green consumption, and in green economy development. China should continue its 2008 “Green Olympics” experience. The 2010 Shanghai Expo, with its “Better City Better Life” theme and with more than 70 million visitors expected, offers an unprecedented opportunity to promote a low carbon lifestyle and build low carbon cities.

(6) Strengthen international cooperation and promote green economic development. Green development represents an emerging international consensus and follow-up sustainable development action concerning multiple crises including effects of this past year's financial tsunami and the challenges of climate change. It requires globally-coordinated efforts, with close co-operation between different countries and more joint efforts. The development of green economy needs to be built upon fair, equitable, orderly and free global trade practices, taking steps to avoid anti-trade protectionism, and expanding the number and value of environment and climate-friendly technology transfer arrangements. With enhanced overall capacity and increased sustainable development practical experience, China should play an increasingly important role in promoting global green development and in dealing with environmental challenges.

1.2 Develop Low Carbon Economy with consideration of both international and national contexts.

Low Carbon Economy (LCE) is now seen by international society to be a fundamental approach and important trend for addressing climate change. LCE also can become an important driver for China to align its economic development mode with energy and environment considerations. The essence of low carbon economy is to adjust energy structure in production and consumption, decrease the use of fossil fuel, develop renewable energy, increase energy efficiency, lower carbon emissions, and decouple economic growth from emissions of greenhouse gases (GHG) and other pollutants. Ultimately LCE must be designed to secure the realization of various key development objectives such as long-term sustainable economic growth, new employment opportunities, technological innovation and many other objectives. LCE needs to take into account impacts on, and provide benefits to vulnerable groups within society. Advocating and developing a Low Carbon Economy will be useful for China's overall efforts to control and reduce GHG emissions, to foster industrial and energy structural adjustment, and to pursue a new path for industrialization with low energy consumption, low GHG emissions and low pollution. Therefore, CCICED recommends:

Based on both the international and national contexts, China should develop a national Low Carbon Economic Development Plan as soon as possible including strategic objectives, specific tasks and measures. Low carbon pilot demonstrations should be initiated within key industrial sectors and within selected urban and rural locations. Low Carbon Economy lifestyles and opportunities should be promoted widely to China's citizens.

(1) Identify the strategic objectives of Low Carbon Economy. LCE in China should start with promotion of energy saving and energy efficiency, optimization of energy structure, development of low carbon energy and increase of carbon productivity. According to the overall objective of significant reductions of carbon intensity by 2020 over the 2005 baseline, China should establish a clear quantified target for low carbon economic development and strive for at least an annual 4%-5% reduction of carbon emission per GDP. The national target will need to be disaggregated on the basis of regional and sectoral characteristics.

(2) Develop and implement operational policy mechanisms. In order to achieve the objectives of low carbon economic development, China should focus on the reform and improvement of the following policies and approaches, based on market mechanisms, technical innovation, and institution-building: 1) implement continued reform of energy pricing; 2) increase investment oriented towards a low carbon economy; 3) consider introduction of a carbon tax when the time is right; 4) study and establish a voluntary carbon emission trading system to promote low carbon finance, technology transfer, and low carbon economy development through market mechanisms; 5) promote low carbon technology innovation and application within China's industrial base and pay special attention to the training of professionals; 6) incorporate low carbon development into urban and rural planning, and into planning for all major transportation systems including road, rail, air and sea shipping; 7) initiate LCE pilot efforts; and 8) improve the energy statistical system by introducing carbon emission statistics.

(3) Optimize energy structure and develop low carbon energy sources. China should pay close attention to development of strategic objectives for intensive, clean and high-efficient use of coal. Depending on costs of carbon capture and storage, as well as emission reduction, the proportion of coal in total energy consumption can be gradually lowered from the current 70% to 55%, 50% and less than 33% in 2020, 2030, and 2050 respectively. China also should vigorously develop low carbon energy sources, especially wind and nuclear power, and promote the commercialization of solar photovoltaic power generation, in order to achieve a full-scale, industrialized and commercialized low carbon energy mix by 2020. China should actively promote the building of nuclear power plants, which play an important role in controlling greenhouse gases emission and fighting global warming. Since safety is the ultimate condition of nuclear development, China should substantially enhance the capacity building of nuclear power plant safety supervision, thus ensuring safe, consistent, and healthy development of nuclear power plants.

(4) Establish an industrial system featuring low carbon emissions. In order to achieve this outcome, the following priorities should be considered: speed up industrial restructuring and upgrading; increase comprehensive utilization of resources and promote lower energy consumption and emissions; promote application of advanced mature technologies and develop advanced low carbon technology to increase energy efficiency; build up a support system for low carbon technology innovation, and improve the legal framework and other enabling mechanisms.

(5) Analyze the possible impacts on China's trade and economy of a climate change "border adjustment tax" and consider how implementation of low carbon economy initiatives might ease this threat.

1.3 Implement a national strategy for sustainable use of coal.

With an energy supply and consumption structure dominated by coal, plus rapid increase of energy demand, it is not surprising that China's environment has suffered severe air pollution and ecological damage, and presented great challenges to GHG emissions reduction. Currently, China has already promulgated national plans to speed up energy structural adjustment and to increase the proportion of renewable energy in total energy production and consumption. However, in the next 20 to 30 years, coal will still be a dominant energy source taking a leading role in the energy mix for China. The safety, efficiency and cleanness of coal exploitation and utilization are major issues for China to address in an urgent and comprehensive fashion. It is possible to speak of sustainable utilization of coal if these issues are solved satisfactorily. Therefore, CCICED recommends:

While ensuring national energy security and environmental protection, China should develop and implement a strategy for safe, highly-efficient and clean national coal exploitation and utilization in order to provide a long-term, stable energy foundation for green economic development.

(1) Further emphasize the strategic role of coal in the national mid- to long-term energy strategy, and speed up the development of a new national coal strategy focused on sustainable use of coal. The development and revision of a new national coal strategy should plan for the safe, highly-efficient and clean utilization of coal based on the full life cycle of coal mining, transportation, final use, emissions and waste processing considerations; enhance the control and reduction of GHG emissions; control of the total coal consumption according to environmental and other criteria, and strengthen the supervision by central government.

(2) Improve governance of the Chinese coal value chain. The Chinese government should strengthen responsibilities and mandate of relevant agencies, improve coordination mechanisms to improve sustainability of the Chinese coal industry by:

1) coordinating the actions and policies of the various government agencies dealing with China's coal value chain; and 2) integrating the planning, investment and operation of the production, transportation and utilization phases of the coal industry within the overarching framework of a national energy policy that incorporates energy supply security, economic, environmental and social objectives. A critical aspect of this governance function is the emphasis on an integrated energy system policy that facilitates and provides incentives for the optimal development of mine sites, power plants, transmission lines and "smart" electrical grids and energy delivery systems, railways, coal ports, and facilities for CO_2 capture and storage.

(3) Promote green mining. A combination of technical, legal and economic policy instruments should be used to promote green mining, to minimize ecological and biodiversity damage, and to restore affected environmental conditions. There are 6 main areas to be covered: 1) concurrent mining and reclamation, particularly in the areas rich in both coal resources and food production; 2) minimization of mined-land subsidence and improvement of management; 3) water resource conservation and aquifer protection; 4) environmentally sound mining waste utilization and treatment; 5) improved risk management and ecosystem protection; and 6) safe mine closure and site restoration. China should broadly implement a payment system for coal mining rights, and fully collect the one-time charge for this right; speed up the reform of coal mine resource tax policy; changing from a specific tax to a compound tax, or move to a totally ad valorem tax levy, and increase the levy limit; establish an ecological compensation system for coal mining, and implement a damage restoration deposit system for environmental management.

The "one ballot veto" rule should be strictly applied in cases where proposed coal projects would not comply with environmental laws and regulations—meaning that projects are not able to circumvent the permitting process. The implementation of strategic environmental assessment needs to be strengthened in all coal mining areas but especially in ecologically vulnerable coal producing regions such as Shanxi, Shaanxi, Inner Mongolia and Ningxia.

(4) Develop a sound strategy for coal-fired power generation, with intensive, highly-efficient and clean use of coal. China should control growth rates of coal use to stay within environmentally sound and safe limits, and gradually reduce the proportion of coal in total energy consumption. Efforts should be accelerated for the development and adoption of advanced coal-fired power generation technology (e.g., ultra-superc-ritical and IGCC) to reduce coal consumption in power generation and to increase conversion efficiency to the highest international standards; promote technology and management for combined power, heat and cooling systems to increase the comprehensive utilization of coal resources in urban areas; optimize generator capacity structure to minimize efficiency loss during operation; promote price linkage of coal and electricity to regulate future power and coal supply/demand at the national level.

(5) Improve and enforce standards associated with processing and use of coal. Additional attention to environmental management is required along the entire coal value chain. Key areas for improvement of standards include: coal mine closure and land-subsidence management and land and water contamination, proper recovery and use of fly ash and gangue, and other valuable byproducts; coal washing in relation to thermal coal specifications; extension of existing emissions standards in power plants to include mercury, and volatile organic compounds (VOCs). As well there is a need to establish local carrying capacity assessments that may lead to restrictions on coal mining or use based on water conditions, and to set out regional caps on air pollutants.

(6) In heavily polluting situations, and based on the requirement of total emission control, establish pilot efforts for regional controls on total coal consumption, and strengthen pollution supervision for coal-fired power plants. China should develop coal consumption assessment standards based on regional environmental capacity, and implement total allowable coal consumption adjustment based on the requirement of total emission control in areas with significant air pollution, such as the Yangtze River Delta, Pearl River Delta and Beijing-Tianjin-Hebei region; implement simultaneous control of multiple pollutants, based on establishing systematic and scientific air quality standards and emission standards; develop a national clean air action plan, focusing on main issues in the next 20-30 years such as urban air quality, combined air pollution, regional air pollution and GHG emissions, etc.; strengthen enforcement of desulphurization in coal-fired power plants, and promote application of denitrification technology and improve emission standards; further reform and improve the pollution fee system and environmental subsidies for the price of electrical power; implement a user pay system based on emission indicators, and initiate an emissions trading pilot scheme for the power sector.

(7) Encourage technical innovation and promote technologies related to the sustainable use of coal. Actively promote technologies related to green mining and clean coal technologies. Develop CO_2 capture, utilization and storage (CCUS) technology suitable to China's situation and needs. Strengthen international cooperation for joint development of technologies and for transfer of technologies; and develop demonstration technology suitable to China's situation of widespread coal availability and use.

1.4 Take more innovative approaches to address the key energy and environment issues in urban development

Urbanization in China is occurring at a far more rapid pace as well as in total numbers of people, by comparison to any other country in history. The rising total demand for energy use by urban dwellers will shift the balance, currently dominated by industrial use. From future sustainable development perspectives, it is impossible for China to follow the urbanization process of those developed countries which feature high energy consumption and high pollution. The huge population migration of people from rural to urban areas plus limited resources, energy and environmental capacity will become bottlenecks to future urban and rural development in China unless per capita demand is kept to relatively modest levels. Therefore, in the next 10 to 20 years, the energy, environmental and climate change challenges related to urbanization will be major concerns in China's social and economic development. The current urbanization process in China has demonstrated that very rapid energy consumption increase and consequent environmental quality damage can reduce the quality of urban life. New innovative ideas and policies are needed to convert the present energy-intensive, pollution-intensive and carbon-intensive development path to sustainable development. Thus, CCICED recommends:

China should thoroughly assess its urbanization policies of the past 30 years, and identify an overall strategy for a new road of urbanization based on lower energy growth and carbon emissions, and on overall higher environmental and social quality of life. The new urbanization road should focus on improvements to the key areas of rapid energy consumption increase such as urban buildings and construction, transport and livelihood energy demands, urban consumer behavior and lifestyle, urban climate change awareness, and strengthened policies to facilitate sustainable urban development throughout China.

(1) Revise the current urban energy statistics system and establish a dedicated urban energy consumption statistics system with emphasis on energy consumption, especially the potential of energy saving from daily life activities as the key focus of urban energy saving. Urban energy consumption should be evaluated mostly based on actual rather than theoretical building energy consumption and daily commuting energy consumption.

(2) Reduce the scale and rate of urban construction and improve building qualities. In the future, per capita floor space (home, public building and commercial building combined) should not exceed 40 m^2. Given the current rate of development, this target will be met in about 5-10 years, instead of the original 25-30 year plan. It is recommended that the governments at various levels should tighten up the approval of new projects and establish strict control of total allowable construction volumes. In addition, it is also recommended that a property tax system should be implemented soon to manage irrational demand within the housing market. It also is important to establish sound demolition and management decrees for existing buildings.

(3) Explore a new road for urbanization by designating low carbon cities. Cities need a more compact mode for urban development. This should be incorporated into urban planning throughout the country. China should properly increase density of population within its cities, develop city groups, city belt or city functional groups on the basis on mega-cities or central cities, and optimize distribution of specialized functions; identify urbanization strategy focusing on large cities; speed up development and implementation of national city/township system plans and land use plans; conduct pilot projects on low carbon and low pollution cities with lower energy consumption.

(4) Develop energy efficiency policy for urban construction, promote energy-saving technology and standards, and construct "low energy and carbon buildings". China should gradually establish building energy efficiency standards for different regions and different types of buildings and, on this basis evaluate the energy consumption of buildings, decide on subsidies, support for individual technologies, and renovation for existing high energy consumption buildings; encourage developers and consumers to develop and purchase "low energy" and "low carbon buildings" through fiscal policy incentives; initiate low energy and carbon building pilot efforts; strengthen urban energy consumption supervision and audits; adopt certification for energy-saving products; improve efficiency of urban heat supply; and encourage utilization of new energy sources.

(5) Deepen reform of district heating networks in northern China and significantly reduce heating energy consumption. Dispatch adjustment, increased insulation and combined heating and power (CHP) plants are some of the best solutions for efficient urban building heating in northern China. They offer the potential of 30 to 50 percent energy savings. To encourage CHP development, the current district heating system must be reformed and district heating companies should have management of the secondary network for delivery to consumers, while the primary network is under control of the CHP plant. Pricing would be established by elimination of the connection fees in favour of charges by the secondary network management, which would have to demonstrate good services.

(6) Make mass transportation and

non-motorized transportation (NMT) a national strategic priority. A number of steps are recommended: intensify development of urban public transport, and increase share of public transport and control of unlimited growth of private cars; speed up rail transport and inter-city high-speed railway (cities with more than 2 million population should be encouraged to develop urban rail transport); promote vehicle fuel efficiency through mandatory fuel efficiency standards, and develop low carbon vehicles such as hybrid vehicle, electric vehicles; plan, construct and improve bicycle and walking pathways; develop enabling legislation and improve funding mechanisms, including a dedicated public transportation fund, to guarantee public transportation as a matter of the highest priority.

1.5 Strengthen policies for energy and environment in rural development including greater attention to climate change adaptation

China's large, scattered rural population—and varying natural conditions and level of economic development—make energy issues even more complicated in the countryside than in urban areas. Since the reform and opening-up, China's rural economy has been developing rapidly, and that development has brought significant challenges in energy use and climate change. First, total rural energy use has rapidly increased from 560 Mt of coal equivalent (Mtce) in 1995 to 730 Mtce in 2007 with an annual increase of 2.3%. In 2007, commercially produced energy only accounted for 23.2%; total rural household energy consumption was 350 Mtce. Straw and firewood accounted for the majority of non-commercially produced energy at 60% and 35%. In 2007, rural per capital energy consumption was 1.7 times that of urban levels but household energy consumption was only 40% of the urban levels. Second, environmental problems are getting more serious than before: from 1980 to 2004, total SO_2 emissions and CO_2 emissions from coal consumption increased about 4 times, and biomass and wood became a major source of indoor pollution. Finally, rural communities and resource users are very vulnerable to climate change impacts. In the meantime, from land use and forest perspectives, rural areas also hold the largest potential of carbon sequestration. Thus, CCICED recommends:

The Chinese Government should integrate rural energy and environmental issues into the strategic task of Building the New Countryside, strengthen management and adopt comprehensive strategies, develop clean and renewable energy sources in the rural areas and establish a comprehensive rural renewable energy service system and develop low-carbon and highly efficient agriculture; and pay attention to the policy measures on climate change adaptation for rural areas.

(1) Increase the role of rural energy development in the national energy strategy and national climate strategy. China should speed up the upgrading of rural electrical grids and increase efficiency of rural energy use; strengthen the development of energy-saving technology and new energy technology/products suitable for various rural regions; determine how to establish national rural energy financing mechanisms to promote sustainable energy construction in rural areas; improve rural renewable energy development plans and relevant regulations; develop rural biomass energy subject to local conditions; incorporate rural biomass facility, especially large or medium-scale methane facility, into national rural infrastructure plans; and meanwhile, strengthen rural environmental improvement to reduce health risks such as those associated with burning of coal for cooking and heating in homes.

(2) Adopt integrated measures to stimulate the development of clean and renewable energy sources. Growing rural use of commercial energy sources such as coal, petroleum products, and electricity results in significant pollution and GHG emissions. Developing clean and renewable energy sources such as biogas (marsh gas) and biomass for electricity generation could help relieve gaps between energy supply and demand, curb pollution, increase farmers' income, and control GHG emissions.

First, a rural renewable energy strategy and related laws and regulations are necessary both to improve the rural environment and to tackle climate change.

Second, the government should promote renewable energy technologies to bring them into widespread rural use. The government could do so by expanding its own investment in modern biomass facilities, and by providing subsidies and tax incentives to encourage private capital to invest in R&D for rural renewable energy technology. Only with government guid-ance can China fulfill the goal of fully commercializing its extensive renewable energy resources. A Rural Energy Construction Fund could promote sustainable energy development, while "transfer payments" could subsidize electricity use among farmers.

Third, China should spur the rural use of biogas by integrating the construction of biogas facilities into efforts to rebuild rural infrastructure, and to set up market mechanisms in support of biogas development.

Fourth, China should expand the use of renewable energy sources to provide heat and electricity for rural buildings. Rural buildings already account for a large proportion of energy use in China, and the amount of energy they consume is rising fast. Thus, it is important to strengthen the monitoring and evaluation of energy conservation technologies, subsidies, and the promotion of energy saving materials under the rural building energy saving policies. Greater reliance on renewable technologies to heat rural buildings can help to conserve energy. To promote that goal, it is now appropriate to scale up activities such as the use of solar and shallow geothermal technologies in rural buildings as part of the modernization of the Chinese countryside.

(3) Optimize land use to increase carbon sequestration potential and support the development of high quality low carbon, low pollution agriculture; introduce a new rural carbon sequestration compensation mechanism, with provision for fiscal transfers and possibly for international financial transfer mechanisms. China should maintain and increase forest, farmland and grassland carbon sequestration, and promote these GHG-reducing practices to a wider audience. The practices include afforestation, improved protection of natural ecosystems, low-till or no-till farming, improved grassland management, alternative varieties of animals and fodder, and more efficient use of fertilizer. The government should establish consulting services at all levels to ensure that farmers have access to energy-saving technologies and information on low carbon farming. The government should provide subsidies, insurance, and credits to advance these goals, especially in areas with fragile ecosystems and large numbers of farmers. A program that enables farmers to obtain credits for reducing GHG emissions through changes in production practices, and that markets and trades those credits, could achieve the dual goals of removing CO_2 from the atmosphere and providing new income sources to farmers and land managers. A low-emission, high-efficiency, recycling agricultural industry will help China reduce both pollutants and rural GHG emissions. Many good practices are available in China now. China should rely on a comprehensive, long-term strategy based on local circumstances to develop low pollution, low carbon high quality agriculture and to protect natural ecosystems, with subsidies to encourage investment in new technology and management approaches. National voluntary carbon trading mechanisms, and payments to impoverished farmers for reducing pollutants and GHG emissions are a cost-effective way to promote low pollution and low carbon practices while also contributing to the goal of alleviating poverty.

(4) Improve the capacity of farmers and rural regions to adapt to climate change. Enhancing farmers' ability to adapt to climate change is essential in order to sustain the rural economy, improve rural living standards, protect ecological services and biodiversity, and ensure food security. Towards these ends: 1) China should evaluate the speed and scale of potential disasters, with systems for monitoring regional climate change, and early warning systems; 2) authorities at all levels need to consider adaptation to climate change when creating development strategies, and bolster community-based disaster prevention and training; 3) China will need to adjust the structure of the nation's agricultural production and consumption; 4) China should import agricultural products with high resource input values in order to ensure self-sufficient supply of other foods and to relieve pressure on domestic resources and the environment; 5) as part of its climate change strategy, China should pay greater attention to the protection of biodiversity, including preservation of genetic material in national and international gene banks.

(5) Enhance the statistical analysis of rural energy use. To ensure that rural energy becomes an integral part of China's energy system, authorities need to strengthen their statistical analysis of rural energy end-use by both households and producers. First, authorities need to unify the definition of rural production, to ensure that statistics reflect actual energy use of township enterprises. Second, national officials need to bolster the ability of county governments to organize and manage energy statistics. Agricultural Bureaus, Forestry Bureaus, and other industry bureaus should then calculate and report statistics on local energy consumption under the guidance and organization of local statistics bureaus. The National Statistics Bureau can collect, check, and issue the overall results, to ensure the authority and authenticity of the nation's rural energy statistics.

1.6 Reform and improve econ-omic instrument policies for increasing the capacity of energy efficiency and for environmental management

For China, reducing the total amount of energy consumption and improving energy structure is a fundamental solution to balance energy and environment, but this will be a long and challenging process. Therefore, China should consider increasing energy efficiency as a priority task. International experience has shown that increasing the price of energy is a very important way to improve energy productivity, and that energy taxes are an effective way to increase energy prices. Pricing policy provides long-term incentives for limiting energy demand, promoting technical innovation and increasing energy efficiency. Environmental taxes are a significant economic tool and long-term incentive to protect the environment. Therefore, launching environmental tax reform will not only help to meet daunting environmental challenges but also help to better cope with climate change, develop a Low Carbon Economy, and improve the quality of China's economic growth. Also, the currently implemented Green Credit policy is a useful test for encouraging pollution control and energy efficiency through economic instruments. It reflects the concept of extending the economic incentives from end-of-pipe treatment to source prevention, and it already has achieved obvious progress. However, there are still many inadequacies in current Green Credit policies which affect the full effectiveness of policies and need further improvement. Furthermore, China is experiencing a period of frequent environmental pollution incidents. Yet there is a lack of policy concerning insurance for environmental remediation, responsibility and compensation. Therefore, CCICED recommends:

China should consider setting a substantial increase in energy productivity as a national target; reform and improve policies of pricing, energy and environment-related taxation and Green Credit; and establish an insurance system for environmental damage and pollution liability.

(1) Increase energy price as a long-term incentive to improve energy productivity. China should adopt a long-term, phased strategy to raise energy price continuously but in small steps, in line with the increase of the national energy productivity increase of the previous year, while disclosing relevant pricing information far enough ahead of time so that businesses and individuals can be properly prepared. The soft signaling effect of the announcement of these increases is crucial for triggering investments and changes of behavior, because this approach awards efficiency gains immediately. Energy pricing needs to be linked carefully with environmental tax reform in order to maximize its potential for energy and environment benefits, for example in the case of a carbon tax.

(2) Implement environmental tax system reform with a focus on improving existing environmental taxes and establishing new ones. China should speed up the implementation of environmental tax system reform in order to remedy the inadequacy of the present environmental tax and fee system and to create a smooth introduction of new environmental taxes, restructure existing tax categories and improve relevant policies involving economic instruments. Wastewater, air pollutants, solid waste and CO_2 should be among the first items addressed by environmental taxes. The reform and development of an environmental tax system should follow a step-by-step approach, with immediate study on stand-alone new environment taxes, improvement of other environment-related tax categories, and consideration of relevant environmental tax policies. The approach should be to “do the easy ones first, hard ones last”.

(3) Improve and strengthen Green Credit policy and fully utilize the role of financial institutions in environmental protection and energy-saving. China should strengthen the use of Green Credit to regulate investment and industrial behaviors, speed up the promulgation of robust policy for Green Credit to limit high energy consumption and high pollution projects; carry out market reform for energy-saving and emission reduction fund management and use; establish a national guarantee mechanism for energy-saving and emission reduction credits, and provide interest subsidies for key projects; direct and standardize Chinese enterprises' overseas investment through Green Credit policies; develop Green Credit policies to support medium and small-scale enterprises in their efforts for environmentally sound business development and practices; and establish an open and transparent mechanism for Green Credit implementation supervision and information disclosure.

(4) Establish and improve environmental pollution responsibility insurance regulations and policy system. China should identify in relevant laws and regulations the principle of liability for environmental damage responsibility along the lines of "the responsible party pays", and determine the content of environmental pollution responsibility insurance; develop relevant standards and guidelines, including pollution damage compensation standards, environmental risk assessment criteria, contaminated site remediation standards and guidelines, etc.; regulate the stakeholders in the market of environmental pollution responsibility insurance; carry out pilot efforts to study the need for supporting laws and regulations for pollution responsibility insurance and compensation procedures; improve supervision mechanisms for this industry and establish technical support institutions.

1.7 Develop a green 12th Five-Year National Economy and Social Development Plan

From the perspective of transformative economic restructuring, environment and energy, scientific development and ecological civilization, the 12th Five-Year Plan period (2011 to 2015) is very important for China, especially in setting the stage for achieving its 2020 national strategic objectives. China will still remain strong in its industrialization process during the 12th Five-Year Plan period. The weakness of traditional industrial modes will be more evident. Environmental problems in both urban and rural development will stand out. Further stimulus of domestic consumption needs to be set into a sustainable consumption mode of development. Internationally, the global economic restructuring as a result of financial crisis will have some obvious impacts on China. And the global trends towards green growth, addressing climate change, and other matters such as resource and energy prices may affect China's outlook on trade and environment. In summary, compared with 11th Five-Year Plan period, there will be significant changes of both national and international context. Therefore, CCICED recommends:

Preparations for the 12th Five-Year Plan should give attention to strengthening China's capacity for sustainable development including incorporation of green economy including Low Carbon Economy as a key element of the Plan; promotion of green growth and future prosperity based on transformative environmental protection, energy efficiency and innovation as strategic priorities; laying down a solid foundation for a quick development mode change involving a new path of industrialization and urbanization; climate change adaptation and ecosystem protection in rural areas; and adaptation to the new round of global economic restructuring featuring green economy.

(1) Continue the mandatory targets for environmental protection and energy efficiency. Based on the 11th Five-Year Plan experience, China should continue to adopt mandatory targets for energy-saving and emission reduction as important tools to protect environment and increase energy efficiency; expand emission reduction to other pollutants, such as NO_x and heavy metals with major impact on environment and human health, and further raise the fuel economy standards of vehicles; develop carbon intensity indicators per unit of GDP as mandatory targets to control GHG emission. Models suggest that with some effort China can achieve at least a 20% carbon emission per unit GDP during the 12th Five-Year Plan.

(2) Incorporate the green economy concept in the 12th Five-Year Plan as a means to achieve sustainable development objectives. China should consider strengthening environmental management, increasing energy efficiency and addressing global climate change and adaptation as basic tasks for 12th Five-Year Plan development and implementation; expand the scale of Circular Economy; promote pilot efforts for Low Carbon Economy and other measures for addressing climate change, including industrial development, building construction, and information and communication systems characterized by low carbon emissions; improve green investment and development of environmental industries; facilitate structural changes and environmental upgrading of traditional industries; develop green economy in the rural areas; promote low-carbon lifestyle and sustainable consumption in urban and rural areas; and expand the scope and scale of public green procurement.

(3) Strengthen and improve energy and environmental technical innovation and supporting system, increase national investment in R&D, enhance safety supervision of nuclear power plants. China should accelerate the pace of acceptance, diffusion and commercialization of innovation technologies related to energy efficiency and to Low Carbon Economy. This requires building a stronger supporting system for energy and environment innovation. A national new energy research institution should be established with the intention of making it open to universities, business and other research organizations in order to create common platforms of energy technology, energy conservation and environmental protection. This research institution should have the ability to conduct basic research, technology development, testing, monitoring and certification; and the ability to improve research and pilot activities related to major energy and environmental needs especially for Low Carbon Economy topics. China has entered into the fast development stage of nuclear power plants. China should attach utmost importance to the capacity building of nuclear power plant safety and environmental supervision, thus safeguarding prospects for future nuclear power plant development.

(4) Place major energy, environment and green economy policies into overall fiscal and economic reform. China should improve the overall design and pilot implementation of key environmental taxes as a sound base of a fiscal system that can benefit resource and energy conservation and environmental protection in the 12th Five-Year Plan period. China should initiate the research and pilot activities that will provide the funding channel for forest, grassland, and agricultural land improvements for rural carbon sequestration. China should speed up the implementation of property taxes to regulate the rapid increase of urban buildings and to encourage an urban sustainable consumption mode.

(5) Improve information statistics on energy and environment performance. China should develop and standardize the monitoring system for energy conservation, emissions reduction, energy consumption for urban buildings and communication and GHG emissions; include better rural environment and energy information in national statistics system; improve and standardize national and local statistics, and improve supervision of statistics and information disclosure. Development of an improved basis for calculating carbon footprints is needed within various industrial sectors, communities, and for individuals and households. This is a task where government, business, communities and civil society organizations should all play a role.

(6) Improve management mechanisms of 12th Five-Year Plan and implement EIA for plans at various levels. While drafting and promulgating the 12th Five-Year Plan of social and economic development plan, China should also draft, approve and promulgate sectoral plans and ensure the concurrent implementation of both the national plan and sectoral plans to produce the best outcome. After the promulgation of the “Planning EIA Decree”, in order to ensure green development, China needs to conduct EIA on major development plans, sector development plan, regional and local development plans that potentially pose a major impact on the environment.

Chapter 2 China's Green Prosperity Future —Environment, Energy and Economy

Executive Summary

Of the multiple crises facing the world at present, those posing the greatest threat to environment and development include the 2008 financial meltdown and its economic consequences, climate change, and poverty. Crises breed both challenges and opportunity, a point well realized within China. Thus China is seeking to mitigate the impacts of the global economic downturn with a stimulus package that will shift emphasis towards domestic consumption and accelerated infrastructure development, while continuing to build a modern economy in both urban and rural areas. It hopes to continue its march towards 2020 goals for improving both income levels and quality of life, including becoming a more environment-friendly society. This Issues Paper, prepared for the CCICED 2009 Annual General Meeting, explores how China might achieve a Green Prosperity Future through linking its future growth to better environment, energy and economy relationships. It will be essential to do this in order to address global climate change.

The unprecedented level of international cooperation to deal with economic recovery has shifted attention to the role of the G20 group of nations including China and other emerging large economies. In the dialogue at the UN, in G8 and G20 meetings, and in many other international gatherings during this past year, concern has been expressed that economic stimulus should not be at the expense of the environment, and, indeed, that economic recovery should be based on *Green Growth*. G20 leaders and many other nations have pledged significant action to address climate change, including efforts based on energy efficiency improvement, shifts towards greater reliance on renewable energy, and on pursuit of a low carbon economy. These commitments to new approaches have to be long-term, certainly with a need to set goals to 2020, 2030 and 2050, with very substantial investment, innovation and capacity development.

China has given energy and environment high priority in its economic stimulus package, drawing on goals set for the 11th

Five-Year Plan. The overall approach to environmental protection should continue to be improved during the next few years of recovery period. Structural changes within 10 key industrial sectors are being undertaken, including environmental protection action and more efficient use of resources and energy. In cities and rural areas environmental improvements, including better planning and design of infrastructure are happening and it is critical to accelerate progress. China also hopes to gain international competitiveness through its investment in new green technologies and products for which there will be both domestic and international markets. However, the growing income levels of people will significantly raise the per capita levels of energy use and greenhouse gas emissions. Therefore, how domestic sustainable consumption issues are addressed will become a key matter for concern. Chinese citizens at present are savers rather than spenders and frugal in their consumption. But that is not a guarantee of future sustainability, especially depending on shifts in lifestyles and decisions regarding urban design, transportation and other infrastructure. Greater emphasis on energy productivity and structural shifts in the economy towards more emphasis on tertiary, service based industry is important.

This year five CCICED Task Forces will report their findings and recommendations on various aspects of energy and environment. The topics include: Sustainable Use of Coal, Urban Energy and Environment, Rural Energy and Environment, Economic Instruments for Energy and Environment, and Low Carbon Economy. These studies cover the most critical issues that China needs to address for continuing its high rate of economic growth, but gradually decoupling this growth from increases in energy use and from environmental degradation.

With more than three years of the 11th Five-Year Plan completed it is possible to examine where progress has been made, and what remains to be done. For example, of the mandatory targets related to energy and environment, it should be possible to meet the very important 10% reduction goal for SO_2 emissions a year ahead of schedule. However, to reach the goal of 20% energy reduction per unit GDP from 2005 levels will require further reduction levels of 5.89 % in 2009 and in 2010. Now that renewed levels of economic growth is definitely a strong prospect for China, the reliance on intensity indicators (tied to GDP) rather than total loading is dangerous in that absolute amounts of pollutants and energy use are still likely to be on the increase. Furthermore, many important pollutants such as NO_x , ground level ozone, mercury and other heavy metals, and POPs are not subject to targets, or even control strategies. Greenhouse gases and carbon reduction strategies were not incorporated into the 11^{th} Five-Year Plan.

Looking ahead, China can continue along the pathway of transformative change concerning environment and development. The opportunities associated with Low Carbon Economy in particular should provide both competitive advantages and improved quality to future growth. There are many specific topics that may be highlighted for consideration in the 12^{th} Five-Year Plan and beyond. In addition there are a number of specific drivers that should be taken into consideration in China's national planning and action for *Green Prosperity*. Those with direct links to environment, energy and economy include the following:

(1) Energy conservation and energy efficiency needs in a variety of sectors to bring energy intensity in line with, or better than, existing international norms.

(2) Reduction in energy intensity for urban buildings, infrastructure construction and operations, and urban transportation.

(3) Continued efforts to expand as rapidly as possible the use of renewable energy sources in China, focusing particularly on wind, solar, marsh gas (methane), and small-scale hydro.

(4) Specific actions related to international arrangements on energy, environment and climate change, including carbon pricing and possible trading, CDM, bilateral and multilateral agreements on technology transfer and partnerships, IPR, and investment arrangements.

(5) Adaptation needs concerning climate change.

(6) Mandatory targets for reduction in GHG emissions and carbon intensity of development.

(7) Continued improvement in environmental quality through more stringent reductions in pollutants covered under the 11^{th} Five-Year Plan mandatory targets, plus a broader range of pollution control (e.g., mercury from coal burning, NO_x).

(8) A system for reduction in total pollution load for some sectors and regions.

(9) Improved protection for ecological services, and eco-compen-sation.

(10) Environment and health targets designed to reduce or eliminate mortality and cases related to specific causes, and improvement in environmental safety associated with key sectors such as coal mining and various types of industrial sectors.

(11) Full achievement of the MDGs within China, including those related to environmental sus-tainability.

(12) Strengthening frameworks to improve green growth opportunities, including scientific R&D, innovation technology investment, institutional strengthening and capacity building related to advanced efforts that will provide China with new economic growth opportunities and export potential related to meeting international demand especially those related to environment and energy.

(13) Improvement to the statistical information base for both energy and for environmental performance.

Key themes where China must build new or revised policies are:

(1) Strategy for sustainable use of coal.

(2) Immediate and longer-term steps towards Low Carbon Economy and Development, including implementation in both urban and rural settings, in various industrial sectors, and shifts towards green growth for both domestic and export products.

(3) An energy productivity strategy, including a progressive, predictable approach to energy pricing and the use of an improved mix of regulatory and economic incentives.

(4) Carbon pricing, which may be based on carbon tax, cap and trade, or other arrangements.

(5) Targets for energy efficiency and energy-related environmental concerns, with some based on absolute amounts rather than intensity.

This Issues Paper has examined several global shifts of historical dimension taking place virtually simultaneously. On economic recovery and associated institutional changes there is a sense of optimism gradually emerging, in part due to the rapid action by political leaders to avert worst-case scenarios. The power sharing that is taking place in the restructuring of global institutions, and in the decision-making among the world's major economies is an outcome that would have hardly been believed possible only a year ago. China has strengthened its potential for international cooperation as a result.

The second great shift has been the depth of dialogue on the issue of climate change. Unfortunately getting a solid agreement about the best approach, with high levels of immediate action, is proving to be extremely difficult in the lead-up to Copenhagen. Whatever the immediate outcome, it is the start of a new way of thinking about our planet, and particularly about developing the Low Carbon Economies needed for the future.

The third shift is international cooperation concerning poverty reduction, and global capacity to address this serious problem. China's strides towards meeting its Millennium Development Goals present a remarkable success story, but one that is tempered by growing inequalities in wealth, and the realization that a fair part of China's population remains far too close to the poverty line. Yet China also can contribute much through expanded international cooperation throughout the developing world. The technologies that China is diffusing in its rural areas, its experience with renewable energy, and the advantages it brings in driving down the costs of production of many products are examples of unique contributions China can bring to many others in the world. Poverty is interlocked with climate change impacts and adaptation and with better environment and development relationships.

The fourth and hopefully very enduring shift is towards societies based on innovation that can more rapidly address the changing circumstances and demands on productive forces within national economies and globally. Green growth involves new forms of both production and consumption. It should influence all sectors of economic productivity, ranging from primary and secondary industries to the commercial, tourism, telecommunications and other aspects of modern tertiary activities. It is understandable that much of the focus on green growth currently centres around energy, environment, and climate change, but ultimately it is transformation of lifestyle, infrastructure design, and the way business is carried out that will determine better outcomes—a future of Green Prosperity.

Will China be the global leader in developing this new future? China's potential is great because it has the means to address key challenges and opportunities precisely at the point in time where it is building the infrastructure to house, transport, meet energy needs, water supply of its people at a better level; and because it is prepared to invest in social improvements, especially for health and education. China also has demonstrated its tremendous capacity to succeed in the global marketplace. With the great size of its domestic markets, its export marketing skills, and its ability to be adaptive, smart and fast, China has advantages that will be put to good use in coming years.

It is well to seriously consider the meaning of Ecological Civilization, a phrase used mainly in China. If nations can prosper at low levels of ecological damage—with a deeply felt respect for nature and the ecological services provided by the global commons and by the rich resources of the planet—then we might achieve an Ecological Civilization globally. China's leadership has called for this state of harmony between people and the planet, and we must presume that it will become a central part of China's on-going development philosophy. Other countries will have much to learn, and hopefully much to contribute, during this common journey towards a prosperous future.

2.1 Introduction

The multiple crises faced by China and the world call for new paths to prosperity. These pathways must align environment, economy and development in ways never before seen in the modern world. They must be resilient enough to address economic and financial upheaval; major environment, energy and climate change concerns; declining ecosystem conditions and ecological services; growing world demand for natural resources including water and food; unmet human development needs; and public health threats. These are among the *Common Challenges of the 21st Century.*[1]

The greatest challenge ever faced by the modern global economy occurred during this past year. It has been the most significant year for climate change negotiations. And, a very important shift in global relations is underway, with the emergence of the G20 this year as the major forum for shaping global economic decisions. In this year of New China's 60th Anniversary celebrations, and certainly in the coming decade, opportunities and expectations concerning China's participation in global economic, environmental and development matters are greater than ever before.

Our 2009 Issues Paper focuses on China's Green Prosperity Future because any future development pathway that fails to create a much improved relationship between environment and the economy ultimately will impoverish rather than enhance human well-being. This is true within China and elsewhere. Indeed, it is a fundamental point being stressed globally—at meetings of the G8, the G20 and in the United Nations General Assembly. Even in these harsh economic times, there has been a quite remarkable level of global resolve to continue efforts to address environmental protection. Much of this attention has focused on energy and environment, especially in relation to climate change. What has been most encouraging in the dialogue this past year among the world's leading economies is the recognition that between now and the mid-century there will be a revolution in how we capture and use energy to fuel our economy and meet human development needs. This, in turn, will influence the design of our communities, our food production, transportation and other key aspects of human existence, and will shape the next phase of globalization.

In meetings of the G20 and at the OECD this year, the call has been for a sustained and urgent effort for *green growth*, which is generally defined in terms of innovation and investment that will promote environmentally and socially sound economic development. Green growth is a means to an end—a prosperous, thriving society. A society of equitable distribution of wealth and opportunity, and one where the ecological support systems and services are well maintained. It is a society where people are satisfied with their way of life. In short, *Green Prosperity* is an aspirational outcome that deals with key quality of life factors, not only financial wealth and economic growth.[2] Both green growth and its outcome of green prosperity are inextricably linked to how the

[1] A phrase used by President Obama in commenting on why he is accepting the Nobel Peace Prize in order to empower all nations. October 9, 2009.

[2] Attempts to provide an index of prosperity along these lines have been started, notably the *Legatum Prosperity Index* based on *economic competitiveness* measured by 9 indicators and 12 indicators of *comparative liveability*. In the 2008 Prosperity Index, the leading nation was Australia, the USA and Germany ranked fourth and China ranked 54th. http://www.prosperity. com/ranking. aspx

world and how countries, including China, deal with their energy and environment relationship, and particularly on how countries build their pathways of *low carbon economy, low carbon development, and low carbon prosperity*. Whatever the term used, it is essential to decouple energy use from economic growth, and to minimize environmental impacts, including those of climate change.

China's leaders propose that, domestically and internationally, long-term transformative change should be towards *Ecological Civilization* [1]. This transformation must take into account China's enormous economic and social development challenges. These challenges include br-inging some 250 million Chinese citizens (mainly located in rural areas) above the World Bank poverty line standard of US$1.25 per day.[2] As well, the massive planned migration of people to cities creates enormous demand for construction of both public and private infrastructure, and for hundreds of millions of new employment opportunities. The dual goals of quadrupling China's GDP by 2020, while also seeking to build an environment-friendly society remain formidable challenges, even though progress has been made on both goals during the first three years of the 11th Five-Year Plan. Vice-Premier Li Keqiang has noted the need for new economic growth points, focusing attention on efforts to tackle climate change, developing clean energy, and strengthening environmental protection.[3]

An example of the resolve that is emerging is the "New Chinese Road towards Environmental Protection." Minister Zhou Shengxian in his thoughts about this New Road has laid out a clear set of needs:

1) a proper relationship between environment and economy with accelerated efforts for environmental protection; 2) a holistic perspective on environment fitted within a Chinese macro-strategy and conditions; 3) a precautionary system that places emphasis on pollution prevention and control; 4)cost-effective environmental measures that are efficient and practical in their application; 5) improved policies, standards and laws in order to create advanced production capacity within China; and 6) a

[1] This term was introduced in a speech by Hu Jintao at the 17th Part Congress in October 2007. A concise point of view from a 5 June 2009 speech by Minister Zhou Shengxian is that "ecological civilization is to mend the ills of industrial civilization, instill the concept and requirement of environmental protection into social and economic development and create a major line of defence that will effectively prevent environmental pollution and resource waste." For a detailed overview of the concept, see China Society for Hominology (eds.) June 2009. *Ecological Civilization, Globalization and Human Development.* Conference Proceedings. 388 pp. Sanya, China.

[2] Li Zhenmin, China Deputy Permanent Representative to UN speaking to the 5th Committee of 64th Session of the UNGA. China Daily 7 October 2009. *China Ready to Contribute More to United Nations.*

[3] China Daily 6 July 2009 *Making Chinese Officials See Green.*

more complete environmental management system in which public participation is the major social force and government takes a leading role for environmental protection. [1]

And internationally, there are new initiatives such as the Global Green New Deal promoted by UNEP and others.[2] China is very actively engaging with others on how to address climate change, and other energy and environment concerns.[3]

Internationally, however, during this time of economic stimulus and recovery, there is a perhaps grossly unfair perception that "as China goes, so goes the world". Some expectations are simplistic and overblown, for example, that China's shift towards greater domestic consumption will support renewed economic growth for the rest of the world, that China's efforts to improve global financial institutions will lead the way to stability, and that China, either single-handedly or with one or two other nations (e.g. the USA and/or India), can make-or-break a favourable outcome of the Copenhagen climate change negotiations.

International cooperation depends up-on complex alignments in which China is rapidly becoming a more important player, but one primarily still concerned with getting its own development directions right. As Liu Zhenmin noted to the UN in discussions concerning Chinese financial contributions: "in 2008, China's per capita GDP stood at US$3 000, ranked about 100th in the world and still far from the average per capita gross national income (GNI) of $7,119."[4]

China's growing prominence in the world, however, is not built so much around per capita measures, as around its overall performance. China currently leads the world in its rapid return during the past year to high economic growth rates (8% target). It is projected to become the leading exporting nation in the world, outpacing Germany. And China is now believed to be the leading contributor to global greenhouse gas emissions in large part due to its reliance on coal-burning. But China also is now a leader on production of solar panels and on installation of wind turbines. It leads on the production of batteries needed for electrical vehicles and for storage of renewably-generated electricity.

China is at a critical crossroads in its development pathway. If the transformative path towards green growth and prosperity is

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[1] See speech by Minister Zhou Shengxian, Minister of MEP. 5 June 2009. Actively Exploring a New Path to Environmental Protection with Chinese Characteristics under the Guidance of Ecological Civilization. Beijing, World Environment Day Forum.
[2] http://www.unep.org/greeneconomy/docs/ggnd_Final% 20Report.pdf
[3] Examples include the China-USA Energy and Environment Agreement, the dialogue underway via The Major Economies Forum on Energy and Climate, and the UN preparatory meetings on climate change since the Bali Action Plan was signed in 2007.
[4] China Daily 7 October, 2009. *China Ready to Contribute More to United Nations.*

followed to its fullest extent, the country should be able to meet its economic and social objectives and greatly improve its own environment and development—while con-tributing to improvement of the global env-ironment and to development opportunities for other countries.

This Issues Paper focuses on concepts and efforts within China and internationally for Green Prosperity, and how these efforts relate to environment, energy and renewed economic growth. The Paper examines: 1) economic stimulus and environmental performance; 2) some key issues for energy, environment and climate change, especially those such as low carbon economy addressed through CCICED task forces; 3) green growth and prosperity; and 4) the 11th Five-Year Plan performance to date, and some potential areas for CCICED recommendations concerning the 12th Five-Year Plan. The paper draws upon valuable conclusions and recommendations drawn from the CCICED Round Table held in April 2009.[1]

2.2 Stimulus and Environmental Performance[2]

2.2.1 G20 Leadership in Economic Recovery

The financial meltdown and global economic recovery effort has perhaps forever changed the landscape of international power sharing. This was acknowledged at the G20 Pittsburgh Summit—that from now on it will be the G20 rather than the G8 providing key directions for coordinated global economic action. Following the 2008 financial meltdown, most G20 nations rushed to put in place economic stimulus packages that would avoid disastrous financial ruin, and would stimulate renewed growth. From the start of this effort there were serious concerns about the environmental effects of short-term stimulus packages and also on the longer influence of deficit spending on a remarkable scale. As well, much has been written about the potential effects of the global financial crisis on development progress within poorer countries, and on the potential of the crisis to derail the global climate change negotiations.

At the London meeting of the G20 in April 2009, leaders[1] noted that:

We agreed to make the best possible use of investment funded by fiscal stimulus programmes towards the goal of building a

[1] CCICED 2009 Roundtable Meeting Proceedings. *Green Development: Opportunities for China in Times of Economic Challenge.* 79pp. 16-17 April, 2009.

[2] This section has been prepared in part from a background paper prepared for this Issues paper by Dr. Zhou Guomei and Dr. Yu Hai.

resilient, sustainable, and green recovery. We will make the transition towards clean, innovative, resource efficient, low carbon technologies and infrastructure…We will identify and work together on further measures to build sustainable economies…

This mantra was repeated during the latest G20 meeting in Pittsburgh, but with the addition of a proposal to develop a Framework for Strong, Sustainable and Balanced Growth. This Framework is intended to …move towards greener, more sustainable growth, [and] to phase out and rationalize over the medium term inefficient fossil fuel subsidies while providing targeted support for the poorest. The G20 Pittsburgh commitment provides the str-ongest support yet for green recovery including the pledges noted in Box 1. China is a signatory to these pledges.

That the efforts towards economic recovery have had a positive short-term effect on turning around a potentially devastating destabilization of the world economy appears certain. But there are still strong warnings concerning the fragility of today's situation, plus the additional concern that deficit spending in the years ahead will foreclose options for the coming generation. While it is encouraging that political leaders of the world's major economies agree on the need for a green recovery, for an end to destabilizing booms and busts, and for structural reforms, the path ahead may be fraught with practical macroeconomic and other difficulties too numerous to discuss here. What is clear is that China's position in the recovery is one of relative strength, and of significance to the rest of the world's recovery.

In fact, both China and the USA have been front and centre since September 2008, but for somewhat different reasons. China has demonstrated a more rapid recovery, and greater stability in its banking and financial system. The USA has plunged itself into a high level of indebtedness, even though it has undertaken major steps to avoid a repeat of what is now regarded as senseless folly on the part of its financial sector. It has supported huge recovery packages that place much of the funding into the hands of foundering industries such as the domestic auto sector. But the USA, along with Western Europe also has taken major steps towards an integrated recovery process that places major faith on innovation, especially towards green growth and transformation of energy-economy relationships.

[1] G20 Leaders Statement, 2 April 2009.

Box 2-1 Excerpts from the Statement by G20 Leaders at the Pittsburgh Summit, 25 September 2009

As leaders of the world's major economies, we are working for a resilient, sustainable, and green recovery.

Increasing clean and renewable energy supplies, improving energy efficiency, and promoting conservation are critical steps to protect our environment, promote sustainable growth and address the threat of climate change Accelerated adoption of economically sound clean and renewable energy technology and energy efficiency measures diversifies our energy supplies and strengthens our energy security. We commit to:

Stimulate investment in clean energy, renewables, and energy efficiency and provide financial and technical support for such projects in developing countries.

We, the Leaders of the countries gathered for the Pittsburgh Summit, recognize that concerted action is needed to help our economies get back to stable ground and prosper tomorrow. We commit to taking responsible actions to ensure that every stakeholder– consumers, workers, investors, entrepreneurs – can participate in a balanced, equitable, and inclusive global economy.

We share the overarching goal to promote a broader prosperity for our people through balanced growth within and across nations; through coherent economic, social, and environmental strategies; and through robust financial systems and effective international collaboration.

We have a responsibility to secure our future through sustainable consumption, production and use of resources that conserve our environment and address the challenge of climate change.

We have a responsibility to invest in people by providing education, job training, decent work conditions, health care and social safety net support, and to fight poverty, discrimination, and all forms of social exclusion.

We have a responsibility to recognize that all economies, rich and poor, are partners in building a sustainable and balanced global economy in which the benefits of economic growth are broadly and equitably shared. We also have a responsibility to achieve the internationally agreed development goals.

2.2.2 Environmental Spending in Stimulus Packages

Monitoring of environmental spending in stimulus packages has been relatively difficult to do since categorization of expenditures is somewhat arbitrary and commitments have shifted as plans were implemented. Lord Nicholas Stern suggested that at least 20% of recovery packages should be devoted to environment, especially for addressing climate change. Joseph Stiglitz proposed that at least 1% of stimulus packages should be directed to meeting the needs of poorer developing nations. And, of course stimulus packages have ranged from a relatively moderate commitment in relation to GDP to massive packages such as those of the USA and China.

The first major assessment of "eco-friendly" stimulus expenditure was carried out by HSBC in January 2009. This assessment noted that the leader was South Korea with almost the entire package focused on green growth. China's commitment was also noted as one of the highest at more than 35%, and USD 200 billion (4.8% of the 2008 GDP), figures that likely erred on the high side. It was higher than the USA which was USD 94 billion, about 12% of the package.[1] Green stimulus funding appears to be spent primarily on four areas of concern: *green infrastructure* including buildings, transportation; renewable energy; electrical grid; water & sewers; *environmental restoration* in rural areas, cities & industrial areas; *protection of ecosystem services* for sustainable land, water and air use; and *sustainability technologies from the R&D stage to commercialization* for new approaches for clean coal, advanced biofuel, solar, and many other energy-related technologies.

That stimulus packages can have positive and negative impacts on environment is a concern. A study by E3G and WWF[2] suggested that, of 5 countries surveyed, plus the EU stimulus efforts. Italy was the only country with a net negative impact due to its major focus on road-building. All 5 countries had some negative as well as positive environmental contributions. The EU contribution was considered exclusively positive, with a focus on renewables, electrical grid infrastructure and carbon capture and storage (CCS). This study did not include analysis of China's situation.

2.2.3 Environment and Development in China's Crisis Recovery

The key question for CCICED is what are the immediate impacts of economic stimulus on China's environmental protection? And, more generally, what longer-term consequences will there be for environment and development as a consequence of China's recovery strategy and actions.

2.2.3.1 *Economic Stimulus Efforts*

Without a doubt, China has launched a major environmental effort through its two-year stimulus plan. The overall plan gives priority to welfare projects, infrastructure construction, ecological protection, and post-quake reconstruction in Western China. The focus is to generate more income for citizens, particular poor groups so

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[1] These figures are from 3 April 2009 issue of The Economist, based on the HSBC study by N. Robins. February 2009. A *Climate for Recovery. The Colour of Stimulus Goes Green. See also naturenews 30 March 2009, based on Edenhofer & Stern Towards a Global Green Recovery.*

[2] E3G & WWF. April 2009. Economic/climate recovery scorecards.

as to ensure sound and fast economic development. Some funding will come from central government (29.5%); the rest (70.5%) will come from local governments, bank lending and the private sector. There are many initiatives specifically labeled as environmental contributions, and other elements that should have positive environmental effects. But early on there were concerns expressed that some projects might be undertaken without adequate environmental safeguards or environmental assessments. These problems have emerged at a significant level. Initiatives specifically earmarked as environmental (emissions reduction and ecological protection) amount to RMB 210 billion, about 5.25% of total stimulus spending (see Table 2-1.)[1] If all the other environment-related investment for structural reform, post-quake reconstruction and infrastructure construction, the total investment for environment protection in this package could be as high as 10%.

The environmental efforts undertaken via the stimulus effort in China are linked to the 11th Five-Year Plan, including the mandatory energy intensity (20% reduction per unit GDP) and pollution intensity (10% reduction per unit GDP) targets, the promotion of Circular Economy, the 2007 Climate Change Action Plan, and an improved economic incentives approach for environmental protection including greater attention to policies such as environmental taxation, green credit, green insurance, green securities, emissions trading, ecological compensation, as well as green trade.[2] The attention given to green credit is particularly important given that there has been a massive increase in the number of large loans during 2009.

Over the next three years from various sources China will raise a total of 1 trillion RMB for environmental protection, including the stimulus funds. As for current progress, the Central Government allocated RMB 12 billion from the newly-added RMB 100 billion investment budget in the fourth quarter of 2008 for emission reduction and ecological protection. In addition, the Central Government also arranged RMB 2.5 billion investment in ten large energy saving projects, circular economy projects, and industrial pollution control programs in key river basin areas.

[1] The major projects for environment protection include the following: to build 290 million mu forests; to expand water treatment capacity by 2.83 million t/d and increase garbage treatment capacity by 3 155 t/d; to build new pipeline network (water and sewage) 2 458 km; to cut COD by 65 thousand tons; to dispose chromium residue 320 thousand tons; to save energy by 6.16 million tons of standard coal; to save water by 120 million tons; and to recycle 2.7 million tons of waste.

[2] These aspects of China's efforts are reviewed in more detail in the background paper by Dr. Zhou and Dr. Yu.

Table 2-1 Elements of the 4-trillion RMB Economic Stimulus Package to the End of 2010.

Investment Theme	Investment Amount/ billion RMB	Proportion/ %
Total	4,000	100
Welfare housing projects for poor people	400	10
Infrastructure construction in rural areas	370	9.25
Key infrastructure like airports, railways and express ways, and grid facilities in urban areas	1,500	37.5
Social undertakings like medical care, education, and culture projects	150	3.75
Emission reduction and ecological protection	210	5.25
Innovation and industrial restructuring	370	9.25
Post-earthquake reconstruction	1,000	25

Source: National Development and Reform Commission.

All is not rosy, however. The huge economic stimulus could revive the energy-intensive, heavy-polluting sectors and result in overcapacity in low-end industries. Even though the environmental and ecological sectors will receive investment from the package, the proportion is merely 5.25%. And in terms of this year's central fiscal budget, the proportion of expenditure in 2009 for environmental protection has dropped from the previous 2.86% to 2.82%. If we consider the boom in fixed-asset investment, environment protection investment is only a small part, and its proportion to the overall investment generally has been on a downward trend from 2001-2005, a demonstration that investment in environment protection still lags behind economic growth.

Importantly, due to the current circumstances where economic growth stimulus is the predominant goal, many investment projects, even if they have passed environmental assessments, will likely pose some level of environment risk and threat in the longer term as they are so large-scale and concentrated. In February 2009, MEP investigated 71 project applications from 2008, which were either waiting for approval or had been refused. According to preliminary findings, 8 of these projects started the construction without approval and 3 projects even started operations without approval. So 15% of the projects violated the rules. In addition, the MEP conducted a sampled investigation into 118 project applications at the provincial and municipal level, and found that the rule-breaking rate was as high as 24%.

2.2.3.2 *Revitalization Plans for 10 Key Industries*

To address the bottlenecks in industrial operation and development, to secure future economic growth and job creation, as well as to promote industrial upgrading and structural adjustment, in early 2009, the State Council unveiled a total of ten industrial sector revitalization plans, covering steel, auto manufacturing, shipbuilding, petrochemical, textiles, light industry, non-ferrous metal industry, equipment manufacturing, electronic information industry as well as the logistics industry. These plans will be translated into reality from 2009 to 2011.

These ten industrial sectors are significant pillars for China's economy as they are major source of industrial output and fiscal revenue. They create huge numbers of job opportunities and play a key role in driving China's GDP growth. The aggregate number of employees in these ten industrial sectors amount to 100 million, and the livelihood of about 300 million rural people is related to these industries. The nine industries (excluding the logistic sector) contribute 80% of the total industrial added-value in China, accounting for roughly one third of the GDP. In addition, large enterprises in these industries pay around 40% of the total tax revenue to the government.

Reviewing the revitalization plans for 10 key industries reveals that most give full consideration to factors including structural adjustment, technical upgrading, environment protection, emission reduction, and cutting low-end manufacturing capacities, etc. The plans take into account the environmental effects in the process, and map out corresponding strategies and measures to prevent and try to address potential environmental problems and risks. In some plans, there are specific chapters and indicators for emission reduction.

For instance, the auto industry plan proposes that China should follow a structural reform approach, seek breakthroughs in developing environment-friendly new cars, increase the research capacity for such cars, encourage the innovation, technological renovation, and mass production of electric-powered cars, and launch a new energy-efficient car strategy. In addition, that plan also contains a number of "green policies" including new green tax revenue, green government expenditures and green standards, all intended to make environmental protection less burdensome.

By comparison with the industrial revitalization in developed countries, China's revitalization plans remain focused on traditional industries to a considerable degree. This is closely related with China's situation as the plans have to accommodate specific constraints in economic development and industrial structure, and also have to address the major social issues like job creation. Therefore, some industries included in the 10 plans still belong to energy-intensive, high-polluting and resource-dependent industries, such as iron steel and petrochemical. These industries have experienced over-expansion and over-capacity during recent years. Most are manufacturing low-end products that consume huge amounts of energy and resources, with heavy pollution. As they are relying on overseas markets, they have been heavily hit by the financial crisis. In terms of their total capacity, structure and geographical distribution, revitalization of these sectors will likely exert heavy pressure on environment, with uncertainties that may trigger significant environment risks in the future.

Table 2-2 Energy Saving and Environmental Content in 10 Key Industry Revitalization

10 key industries	Targets, tasks and measures for energy-saving and environment protection			
	Structural reform	Technical upgrading	Emission reduction	Cutting low-end manufacturing capacity
Auto	√	√	√	√
Iron steel	√	√	√	√
Electronic information		√		
Logistics				
Textile	√	√	√	√
Manufacturing	√	√	√	√
Non-ferrous metal	√	√	√	√
Light industry	√	√	√	√
Petrochemical	√	√	√	√
Shipbuilding				

(Information for Logistics and Shipbuilding is not available)

2.2.3.3 *Deepening Structural Economic Reform*

On May 19, 2009, the State Council distributed the *Opinion on Deepening Structural Economic Reform* (hereinafter 'the Opinion'), which was drafted by the NDRC. The Opinion is the overarching document to guide in-depth structural economic reform. It is aimed at overcoming obstacles, seizing opportunities, and addressing the most difficult issues in economic reform. The Opinion requires that China should identify opportunities in the crisis, move ahead with reform in key areas and address critical links with the purpose of expanding domestic demand, securing economic growth and benefiting ordinary households. This shift towards stimulating consumption on the part of citizens and domestic businesses is a complex matter from a sustainability perspective, as will be discussed later in this Issues Paper.

In effect the Opinion proposes institutional arrangements for meeting scientific development and social harmony objectives. Key areas for reform are shown in Box 2-2.

Box 2-2 Deepening Structural Economic Reform in China (May 2009 State Council)

- *Changing the government's role in managing the economy to tap vitality in market-based investment;*
- *Deepening the reform in monopoly industries to expand the investment scope and areas for private funds;*
- *Promoting reform in price mechanism for resource products and environment protection to shift the development pattern;*
- *Focusing on optimizing industrial structure and ownership structure to boost service sector and private sector development;*
- *Accelerating reform in welfare projects to increase people's consumption capacity and will;*
- *Deepening the reform in technological, educational, cultural and health care sectors to encourage the growth of social undertakings;*
- *Deepening the rural sector reform to establish sound mechanism for coordinated urban-rural development;*
- *Accelerating taxation reform to make the taxation regime more suitable for scientific development;*
- *Deepening the financial sector reform to build a modern financial system;*
- *Deepening the external-related economic sector to build an open economy; and*
- *Promoting the pilot programs for comprehensive reform to set examples for other areas to study and follow.*

The Opinion is important as a means to recognize the current difficulties and environmental risks, deepen reform in environment protection areas, and overcome long-term entrenched obstacles. Implementation should bolster environmental protection efforts and highlight various institutional and structural needs as noted below:

(1) Improving legal and regulatory framework to set up long-term mechanism for environment protection, such as amending the Law of Environment Protection.

(2) Participating in the reform of public utility sectors to increase investment in environmental and other infrastructure construction in these sectors.

(3) Improving the performance assessment indicators for emission and pollution reduction, and circular economy programs to create innovative approach for environment protection in the 12th Five-Year Plan.

(4) Deepening economic policy for environment protection, and integrating en-

vironment protection into economic development.

(5) Accelerating reform in the administrative arrangement for environment protection in rural areas, and

(6) Implementing relevant environment policies in environment-friendly and resource-conservation pilot program areas, to gain and distribute experience across the country.

2.2.3.4 *Additional Challenges and Opportunities*

In the short term, the financial crisis has reduced the break-neck speed of growth that has created negative environmental impacts. This is particularly true for some emissions, therefore helping to achieve pollution reduction targets. In highly industrialized areas such as the Yangtze River Delta and Pearl River Delta, many firms have shut down. In Qinghai Province the local energy-intensive sectors relying on Qinghai's power advantage were seriously affected. As the commodity prices plunged in the global market, production of many energy-intensive products was greatly reduced or suspended—as of mid-November 2008 the suspension rate on the production of iron alloy, silicon carbide, calcium carbide, and electrolytic aluminium in Qinghai was 71%, 46%, 83% and 15.5% respectively.

The demand and price for raw materials such as iron and steel have declined. Electric power consumption dropped for the first time in years, although consumption started to increase again by mid-2009. Central and local government agencies have increased investment in environment protection including infrastructure construction on water treatment plants and so on. All these factors have contributed to eased pressure on emission reduction.

In the medium term, the financial crisis could have certain negative impacts on China's environment protection. If the macro-economy remains sluggish and corporate sector profits stay thin, businesses may choose to sacrifice their environment protection efforts first. Maintaining their profits and jobs will be very high priority. Some firms that already have installed environment protection facilities may stop using them. This will in turn result in more pollution, possibly worsening future environmental crises.

With the need to stimulate employment, some measures taken earlier to change incentives towards improved energy and environment efficiencies may suffer. An example is the reinstatement of tax rebates on some energy intensive export products. China also could face non-tariff trade barriers on some exported products—protectionism masquerading as environmental safeguards by developed countries.

As in the case of other countries, actions taken by China in support of stimulating domestic consumption may be inconsistent with sustainable development strategies. Incentives for private automobile purchase are an important example.

The stimulus package has spurred new investment, much of it located in central and western China. These regions are becoming the new economic growth centres of China. Will they behave similarly to many eastern coastal areas in earlier days, placing growth ahead of environmental protection?

China has taken advantage of the decline in stock prices to purchase companies abroad, especially in various resources sectors. This is fully understandable, not only to take advantage of bargain prices, but, most importantly, to guarantee long-term supply access. But China is still at an early stage of setting out regulations to ensure these overseas investments are managed well from environmental and other considerations. It is a welcome development that Chinese banks that may provide funding are putting in place environmental considerations, and that new regulations are being prepared to regulate environmental aspects of overseas investment by Chinese firms. Corporate social responsibility requirements are needed on the part of Chinese firms wherever they operate.

China has affirmed that it will continue to be involved in African development efforts, no matter what the economic crisis may bring in the year ahead. China is in the fortunate position to do so not only for Africa but for other poor regions of the world, including some parts of Asia. The environment will need to be taken into account in these international cooperation efforts. Ultimately such a commitment could accelerate the transfer of green technology, experience in addressing climate change adaptation, and many other aspects of environment and development.

2.2.3.5 *Some Conclusions*

Firstly, China's environment protection is facing very daunting challenges to address the multiple crises of the recent past. To offset negative impacts, China has worked out one of the world's largest economic stimulus packages and comprehensive industrial revitalization plans. On one hand, this has brought opportunities for better environment protection, but on the other hand, it has created potential environment risks. In some cases, the risk may be even greater than the benefit of environmental improvements.

Secondly, at present, China's overall plans in response to financial crisis could be described as pro-growth, pro-con-sumption and pro-restructuring. An important aspect of these plans should be to pursue growth based on conditions of improving quality, optimizing structure, increasing efficiency, cutting energy use, and ensuring environment protection. This is, of course a huge and long-term challenge.

Thirdly, the multiple crises have

brought about historic opportunities for green innovation in both China and other major economies. Well established industries can become more eco-friendly; growth of new clean technology and industries will mushroom; and developing clean energy is a high priority of many governments. Most industrial countries would like to tap the opportunities provided by the multiple crises, promoting a new-round of economic restructuring with green economy and green policy initiatives. They will gain globally competitive advantages and at the same time help to secure their sustainable development. It is safe to say that developing a green economy has become an irreversible trend for key decision-makers in China, and is a direction that is essential for China's contribution to achieving global environment and development goals.

Fourthly, China is well placed to take advantage of these green growth opportunities, as this new concept requires economic restructuring of the type China proposes, along with continued social growth. The key point is that green growth can help China to achieve its strategic goal in environment protection while building a more diverse and efficient economy. There are important sub-themes to green growth, especially Cleaner Production, Energy Productivity and Efficiency, Circular Economy and Low Carbon Economy.

If we look at the issue of economic growth from a long-term perspective, and presume that the Central Government's policy package will deliver some sound reforms, with full implementation of various environmental protection measures, then China's economic restructuring could create a great longer-term success out of the crisis. In this case, the economic pattern in China will have impressive changes with significant shifts in economic structure, industrial structure and products mix. With a variety of environment-centred policy incentives, an array of technological advances, and a comprehensive process of environment management, China should be in a position to strengthen its efforts towards becoming a resource-conserving and environment-friendly society. The key is to identify the new and sustaining driving forces for economic growth, which could both help propel economic development and promote environment improvement and sustainable development.

2.3 Sustainable Consumption and Green Growth

2.3.1 Sustainable Consumption

The shifting emphasis in China from export-driven growth to a greater balance with domestic consumption presents an opportunity—even a necessity—to ensure that the new patterns of economic growth reflect a sustainable consumption pattern. This is not a simple undertaking by any means. The trap facing China is that of over-consumption, especially in the richer cities. Sustainable consumption is defined in various ways, for example, by Canada's Office of Consumer Affairs as *the use of goods and services required to meet basic needs and improve quality of life without placing at risk the needs of future generations*.

2.3.1.1 *Avoiding Over-consumption*

OECD notes that: It is resource use and environmental pollution that have to be brought to sustainable levels, not the consumption of products and services as such.[1] Yet, while energy and materials have been used more efficiently in recent times, the level of over-consumption in both goods, including houses and autos, and high energy consumption service industries such as those related to recreational travel has shot up.[2] The global economic downturn may have a significant influence on future levels, but the warning signals are clear—the ecological footprint of consumers in rich countries is already far too large and it is still growing.

The OECD has suggested that five general conditions are needed in a general framework for sustainable consumption:[3]

(1) A price structure for consumer goods and services that internalize environmental costs and benefits.

(2) A policy and regulatory framework that makes clear the priorities and direction of change.

(3) Availability of a range of environment-friendly goods and services.

(4) Technology and infrastructure that includes environmental quality criteria in the design and running of transportation networks, housing, waste management, etc.

(5) An educational, learning and information-rich environment that motivates and enables consumer action.

A combination of instruments could then be applied, along with life cycle analysis to determine points of intervention, with appropriate sustainable consumption indicators.

2.3.1.2 *China and Sustainable Consumption*

With its huge population and rapidly growing wealth, China will have a significant impact on global consumption, certainly driving up the total level in coming decades. But can this consumption be done in a fashion that is different than the OECD nations? This is a very difficult question to answer. It requires an examination of the

1 OECD. July 2002. *Towards Sustainable Household Consumption? Trends and Policies in OECD Countries.* Policy Brief, OECD Observer.

2 For example, vehicle stock in OECD countries totals 550 million, of which 75% are private autos. This total number is projected to grow by more than 32% to 2020, and with a 40% increase in kilometres driven. Municipal waste in OECD countries is projected to grow by 43% from 1995 to 2020. (OECD Policy Brief, 2002).

3 http://www.oecd.org/document/52/0,3343,en_2649_34331_ 35145204_1_1_1_1,00.html.

characteristics of Chinese consumers today, including structural issues in the economy that influence current behavior, and various policies or actions that might change consumer spending habits in the future. It also requires a look at the external influences on China. These influences include: global media and advertising; the limited level of access to the most highly advanced energy and material efficient durable products, and the positive influence of other nations that have made some progress in addressing sustainable consumption—Norway, Swe-den and the Netherlands, for example.[1] It is helpful that China has enunciated a philosophy of *Xiaokang*[2], where wealth and consumption should be modest and distributive.

China currently has the lowest domestic consumption level of any major economy, about 36% of GDP. This is a level half that of the USA and about 2/3 that of Japan or EU nations. In fact, consumption in China has dropped about 15% relative to GDP since 1990. Commonly it is believed that Chinese dedication to saving is the result of limited or inadequate social benefits such as pensions, health and education. Thus addressing these problems via new policies would help to stimulate a higher level of consumption by households. In addition, short-term measures such as those within China's stimulus package might hasten the transition, or at least signal the government's intent to place more emphasis on the growth of domestic consumption.

The McKinsey Global Institute recently published an interesting, in-depth study of the future of Chinese consumerism development which points out key barriers to increasing the level perhaps to as much as 50% of an expanded GDP, by 2025.[3] Whether this goal is reasonable from a sustainable consumption perspective is debatable，a key hypothesis of the McKinsey study is that if this expanded consumption goal were to be achieved, the actual pressure on the environment and natural resource use could be reduced since the intensity of water, land and fossil fuel use would be lessened as a consequence of a smaller burden from the export economy and other reasons. And, while China's overall share of world consumption would

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[1] See Cohen, M. J. 2004. Sustainable Consumption and Global Citizenship: An Empirical Analysis.Paper presented at the annual meeting of the American Sociological Association.

[2] Wikipedia notes that: "The vision of a *Xiaokang* society is one in which most people are moderately well off and middle class, and in which economic prosperity is sufficient to move most of the population in mainland China into comfortable means, but in which economic advancement is not the sole focus of society. Explicitly incorporated into the concept of a *Xiaokang* society is the idea that economic growth needs to be balanced with sometimes conflicting goals of social equality and environmental protection."

[3] McKinsey Global Institute. 2009. If You've Got It, Spend It: Unleashing the Chinese Consumer. Also, McKinsey Quarterly. August 2009. A Consumer Paradigm for China.

rise to between 11% and 13%, it would still be well below China's portion of world population.

The McKinsey study highlights structural change in the economy as the key element to accelerate change in domestic consumption. This is important and recognized by Chinese economists and leaders, even though it is a difficult matter to address. China is investing a large portion of its wealth in developing basic infrastructure for the nation, including transportation, water treatment, and other basics of cities and countryside areas, energy networks, etc. Much of this is public sector spending, and therefore opens to influence through green procurement policies. But investment in large-scale industrial development has a very large share of GDP. In fact it is believed that overinvestment has taken place in some sectors such as iron and steel. This part of the economy, especially in the case of state owned enterprises does not contribute as much to employment growth as does the growth of SMEs and the service sector. And therefore consumers do not have as much money for consumption. Furthermore, in poorer rural areas, household income in excess of meeting basic needs will be quite limited for years to come by comparison to urban areas.

The study suggests that without structural change towards a more balanced economy, China's domestic consumption will remain at a very low level, possible around 39% to perhaps 42% of GDP. Furthermore, some steps already taken, such as the current efforts to make home appliances available in rural areas at subsidized prices, are unlikely to make much of a long-term difference in consumption patterns.

If it is the creation of wealth through the creativity of small businesses and a flourishing service sector that is most needed, then attention will need to be given to mechanisms to make credit more freely accessible to both individuals (including families seeking to have their children enroll in expensive post-secondary education) and smaller enterprises. There are many ways to do so, but at the moment progress is slow, and access to money is still much easier for larger, state-owned businesses. According to the McKinsey analysis this transition will be key:

A more consumer-centric economy would allocate capital and resources more efficiently, generate more jobs, spread the benefits of growth more equitably—and grow more rapidly—than China will if it remains on its present course. The narrowing of the trade surplus and the Chinese consumer's larger contribution to global growth would make foreign ties more harmonious.

But a consumer-centric society is not necessarily a society of sustainable consumers. How can progressively wealthier Chinese citizens avoid becoming over-consumers in coming decades? There is ample evidence that some fraction of urban residents already fall into this category. North American, Japanese and European luxury auto makers certainly see Asian markets and especially China as a major market for their large vehicles, even if there are punitive taxes on such vehicles.[1] And whose rules should apply? Governments can only do so much to channel consumer behavior in desired directions.

Much has been written about whether Chinese cultural characteristics might or might not predispose people towards a conserver type of society. The current tendency towards frugality could well be reversed quite dramatically if some constraints are removed, as suggested by the McKinsey study. It must be presumed that if household income share of the national income increases significantly (currently it is 56%; by comparison US households get more than 70%), and if credit is easier to obtain, then people will enlarge their debt loads perhaps setting off buying binges. The auto industry in China has seen this development in the previous few years prior to the world financial and economic crisis, and most recently in August 2009, when 2,000 new vehicles per day entered the streets of Beijing, aided by the government stimulus efforts.

There are several urgent tasks for making the transition to an environmentally ultra-responsible consumer society in China a possibility.

The first task is to accelerate the pace of implementing green growth initiatives so that consumers will have a wider range of "green" products to choose from, at competitive prices; and in general, that any products purchased will have lower embedded energy, carbon and pollution costs related to production processes and material content. Governments at all levels within China can also assist through green procurement policies that are even more robust than today's.

The second task is to ramp-up public education and information campaigns that explicitly reveal the true cost of unsustainable actions, expose non-compliant businesses and poor performance on the part of administrators and others entrusted with protecting public goods, and that provide sufficient knowledge about what constitutes sustainable consumption. Some programs already are well established for green labeling but a broader range of efforts is needed, for example, related to major purchases such as apartments.

The third task is to continue developing and promoting green standards for all the main purchases that people are likely to make. As much as possible this should be done on a public participatory basis, and for both urban and rural settings.

[1] http://www.chinaluxculturebiz.wordpress.com/tag/porsche/.

The fourth task is to make China even more of a leader in the application of Circular Economy. Already China has made great inroads within the country and in transforming pathways for recycling globally. But the next generation of autos, in which China has a huge stake, should be super-easy to recycle completely. Building materials should be of a type and quality that minimizes embedded energy and can be reused or recycled with minimum cost and difficulty.

The fifth task is certainly to use design more effectively to promote sustainable development. This has still not been done to a desired level in the design of Chinese cities and there will be significant opportunities in development of the New Socialist Countryside. Utility infrastructure is one of the most important elements, for example, "smart electrical grids" and "smart metering."[1] Part of the need is engineering and architecture, but it is also in the design of management systems, institutional arrangements and incentive systems.

China's leaders have been promoting many aspects of sustainable consumption in recent years, and backing up rhetoric with action. Their efforts are quite impressive although sometimes inconsistent, but the task is very difficult, and likely to have major surprises in the years ahead. It should not be presumed that even with all the right economic moves and incentives that the desired move to sustainable consumption will occur smoothly. Therefore the processes to bring about this move must be as adaptive as possible and should maximize the involvement and commitment of both large and small scale enterprises, the financial sector, and community groups.

2.3.2 Green Growth

2.3.2.1 *International Perspectives*

The UN ESCAP defines *green growth as environmentally sustainable economic progress to foster low carbon, socially inclusive development.* ESCAP suggests five pathways for policy intervention: sustainable production and consumption, greening business and markets, sustainable infrastructure, green tax and budget reform, and eco-efficiency indicators.[2] Green growth in the Asia Pacific region and in other parts of the developing world needs to be pro-poor, with a major emphasis on sustainable livelihoods.

In a Financial Times article,[3] Mr. Ban Ki-Moon (with Al Gore) wrote that:

A successful [climate change] deal in

[1] The Economist. 8 October 2009. *Wiser Wires.*

[2] http://www.greengrowth.org/.

[3] Financial Times (London). 17 February 2009. *Green growth is essential to any stimulus.* http://www.huwu.org/sg/articleFull.asp?TID =92&Type=Op-Ed.

Copenhagen offers the most potent global stimulus package possible. With a new climate framework in hand, business and governments will finally have the carbon price signal businesses have been clamoring for, one that can unleash a wave of innovation and investment in clean energy. Copenhagen will provide the green light for green growth. This is the basis for a truly sustainable economic recovery that will benefit us and our children's children for decades to come.

This linkage of innovation, investment and green growth is essential not only for addressing climate change, but for most other pressing environment and development issues.

In June 2009 the OECD countries, plus several others, committed to development of national efforts and international cooperation on a green growth strategy. The OECD Council's Ministerial Declaration included several points noted in Box 1-3.[1] This is a significant statement that will lead to a reshaping of OECD perspectives on growth, since this new approach will be brought forward for further development during 2010-2011.

The remarkable rise of green growth as a major hope and objective for new economic growth and development among the richer countries is here to stay, and by no means is it restricted to Europe and North America. China has embraced the concept and in following sections, we will explore issues of implementation, with special attention to energy, environment and climate change.

2.3.3 Conclusions about Sustainable Consumption and Green Growth

Consumers with access to sizeable disposable income levels generally seek high energy and high resource and environmental-consumptive life styles. The additional burden on the planet is not generally within the power of the individual to fully address, except through life style choices and a conservation philosophy. In fact, with the constant influence of media and other communications there is a strong

Box 2-3 OECD Council Ministerial Declaration on Green Growth, June 2009

STRENGTHEN our efforts to pursue green growth strategies as part of our response to the current crisis and beyond, acknowledging that "green" and "growth" can go hand-in-hand.

ENCOURAGE green investment and sustainable management of natural resources…We will consider expanding incentives for green investment, in particular in areas where pricing carbon is unlikely to be enough to foster such private sector responses...Approaches to recognise the value of biodiversity should be encouraged through appropriate instruments and consistent with relevant international obligations. We are *resolved to share information on green investment flows and policies, and best practices.*

[1] http://www.olis.oecd.org/olis/2009doc.nsf/LinkTo/NT 00004886/$FILE/JT03267277.PDF.

ENCOURAGE domestic policy reform, with the aim of avoiding or removing environmentally harmful policies that might thwart green growth, such as subsidies: to fossil fuel consumption or production that increase greenhouse gas emissions; that promote the unsustainable use of other scarce natural resources; or which contribute to negative environmental outcomes. We also work towards establishing appropriate regulations and policies to ensure clear and long-term price signals encouraging efficient environmental outcomes. We call on other major economies to follow the OECD countries' lead.

ENSURE close co-ordination of green growth measures with labour market and human capital formation policies. We note that these can support the development of green jobs and the skills needed for them…

STRENGTHEN international co-operation. In this respect:

We recognise that special efforts need to be made at the international level for co-operation on developing clean technology, including by reinforcing green ICT activities, fostering market mechanisms, and augmenting, streamlining and accelerating financing and other support to developing countries in their fight against climate change and the loss of biodiversity, and support in their water management. We also recognise the need to ensure that each country pursues green growth policies, including to tackle climate change, in accordance with existing international agreements and based on the principles of free trade and investment.

We are resolved to make every effort to reach an ambitious, effective, efficient, comprehensive and fair international post-2012 climate agreement at COP15 in Copenhagen in December 2009… by which all countries will take measurable, reportable and verifiable nationally appropriate mitigation commitments or actions as well as adaptation actions, reflecting the principle of common but differentiated responsibilities and respective capabilities.

We recognise the importance of the liberalisation of trade in environmental goods and services in fostering green growth. We are resolved to ensure that measures taken to combat climate change are consistent with our international trade obligations.

We underline the special need to co-ordinate international development cooperation activities in order to help developing countries promote green growth.

compulsion towards consumption. Chinese consumers, with their exceptional behaviour towards saving rather than spending, and their relatively small share of the national GDP, perhaps stand a better chance than people elsewhere of avoiding the endless cycle of over-consumption that plagues western society. But this is by no means a certainty over the longer-term.

The great challenge is to build enabling mechanisms that help consumers to create and enjoy sustainable lifestyles with a relatively low material consumption but high satisfaction levels. This is a challenge that has failed in most western countries over the past few decades, and continues to fail at the present time. The greatest challenge lies ahead—with climate change as a driver. It is certainly too much to expect of China or many other developing countries that they should be the leaders, when industrialized countries are still consuming such a large portion of the earth's environmental resources. But the reality is that both should converge towards intermediate levels of consumption, largely decouples from harmful emissions and wasteful production techniques.

The hope, of course, lies with green growth. That is why the growing resolve towards this topic on the part of countries throughout the world and on the part of their leaders is so important at this transformative time for globalization and search for sustainable growth.

2.4 Energy, Environment and Climate Change

2.4.1 Crossroads for International Cooperation

The relationship between energy, environment and economy is at a crossroads that will test cooperation between rich nations and poor, will shape trade and consumption, and will determine whether and how well global society and individual nations address the pressing issue of climate change. Nations cannot claim to be sustainable without ensuring that their economic growth is eventually decoupled from energy consumption levels, especially from fossil fuel sources.

Those nations that have high existing per capita uses of energy must reduce these levels as quickly as possible, and seek sources and patterns of use that have a drastically lower level of Greenhouse Gas (GHG) emissions. Countries such as China, India and Brazil, already in a stage of rapid development and high economic growth, need the opportunities to become as eco-efficient as possible in energy use, but also to have access to energy sources and a share of GHG "space" sufficient to meet their expanding needs. No single nation, single region or grouping of countries can fully address the issues created by energy, environment and economy on their own. It is a vast concern demanding unprecedented levels of international cooperation.

In fact, the unprecedented level of global cooperation on tackling the financial and economic crisis has had the co-benefit of setting the stage for: 1) reaffirming the importance of addressing climate change, including innovations needed to hasten progress as well seeking agreement at forthcoming meetings, and 2) linking the outcomes more concretely to economic recovery based on green growth.

Global agreement on action for climate change is only part of the larger puzzle to be solved on energy and environment. But it is front and centre at the moment in part due to the urgency of seeking a robust accord to replace the Kyoto Protocol of the UN Framework Convention on Climate Change (UNFCC). The December 2007

Bali Plan of Action laid out the groundwork. This Plan of Action noted that:

All Parties should cooperate to build a low-carbon global economy that ensures continued growth and sustainable development, increases global supplies of secure, and affordable clean energy, and stren-gthens the capacity of all Parties to adapt to the adverse effects of climate change. All Parties shall support long-term cooperative action to achieve an aggregate reduction in global greenhouse gas emissions of at least 50% by 2050.

In December 2009 at Copenhagen, the hope is that a workable and effective follow-up agreement will be set in place for the next phase of implementation of the UNFCC. As Lord Nicholas Stern has said, the world can act now, pay less—or wait, and pay many times more, with greater damage arising from climate change. While the UNFCC Meeting of the Parties in Copenhagen will be an important event, it only marks the beginning of what will be a long journey. Fortunately it should be a path filled with new opportunity as human creativity, markets and innovations make their contributions. The situation might develop along the time frame shown in Box 2-4.

Another very useful way of looking at how to tackle energy and environment, and of the various options for addressing climate change, is the McKinsey Cost Abatement Curves.[1] These demonstrate that many of the energy efficiency actions needed are profitable (for example improved insulation of buildings and some transportation options). The curves also show the relative costs of most other proposed solutions including biofuels, CCS and reforestation. Some options would be very costly. The value of these curves, which have been prepared globally and for individual countries such as China, the USA and Germany, is that they point out many excellent opportunities that can be taken now, without the need to resort to international agreements, etc. For it is vital that nations and businesses have the flexibility and means to take action as swiftly and efficiently as possible.

This section of the Issues Paper highlights both challenges and opportunities that China, and really the world, face now and for the foreseeable future on making energy use compatible with sustainable development. While this part of the Issues Paper started with the globally urgent matter of addressing climate change, it is certainly but one of the key focal points on energy and environment. From China's perspective at present, perhaps the most significant question is how to ensure that relationships among energy, environment and economy become mutually supportive in ways that permit human development to

[1] http://www.mckinsey.com/clientservice/ccsi/costcurves.asp.

occur in a satisfactory fashion.

Box 2-4 Time Frame of Future Action on Environment, Energy and Climate Change

2010–2012 Fine-tuning Copenhagen Outcomes*. Global, regional & sectoral; ratification & national strategies.*

2010–2015 Emphasis on efficiency, cost effective solutions with increased tech transfer between rich & poor countries. *Maximum impact of economic recovery stimulus.*

2010–2020 S&T Energy and Environment investments lead to new, often disruptive technology options*. Useful to rich & poor nations.*

2013–2020 International agreements focus on major credibility & equity concerns*. Greater attention given to actual impact of accords on mitigation and adaptation success.*

2010–2030 Behavioral changes towards Low Carbon Economy. *A focus on new economic opportunities, and with greater integration among economic, social and environmental international accords.*

2030-2050 50% to 80% reduction in GHG emissions from the 1992 baseline achieved.

2.4.2 Energy and Environment in China

CCICED has examined energy and environment relationships in the past, especially through its Energy Working Group during earlier phases of CCICED.[1] The attention being given to the subject of energy and environment within the 11th Five-Year Plan, China's rapid overall increase in energy use, and the potential to gain competitive advantage in the low carbon economy of the future have led this year's CCICED AGM to focus on energy and environment. This effort has involved five task forces and a cooperative project within Ningxia Province.

Until the Beijing Olympics, relatively few people outside of China fully recognized the rapidity of change in China's energy and environment relationship, or of the many actions that are shaping it, hopefully towards a sustainable future. Yet over the past half decade, a large number of international cooperation initiatives have started in addition to the very substantial efforts China has undertaken entirely on its own. An example is the rapidly evolving relationship between China and the USA on environment and energy cooperation.[1]

[1] *Energy for Sustainable Development*, Vol. V. No. 4, published a Special Issue covering findings of the CCICED Working Group on Energy Strategies and Technologies, December 2001.

China will face: the possibility of future energy shortages, on-going and perhaps additional environmental and human health concerns related to energy use; energy efficiency and design concerns as it faces large scale construction of cities, transportation and utility networks; and high energy demands from the continued modernization and expansion of its industrial base and development in rural areas. There is a need, already well recognized by China's national leaders, to create a broad societal understanding that as China continues its economic growth, energy use cannot follow the profligate ways of industrialized countries. The Chinese people and businesses must have access to better energy alternatives, and that is where government, communities and enterprises need to provide the right mechanisms, incentives and goods and services to make sustainable choices possible.

There are three key pillars for improving energy and environment relationships in China. The first is sustainable use of coal, since this is such a key element in China's energy mix. The second is energy efficiency, for which there are co-benefits with the economy, health, and environment. There is a great deal of room for improvement, for example, China uses up to 3 times as much energy per unit of output as the USA and up to 9 times as much as Japan. The third is the longer-term transition towards a low carbon economy, which will drive green growth as well as assist in climate change mitigation. These three pillars need to be considered in both rural and urban areas and in relation to industrial and service sectors.

The transitions toward greater efficiency, developing new sources of energy and better ways of dealing with existing energy use, and toward a low carbon economy need to start now in China and in other major economies. There are five considerations that may help in this process, and to some considerable extent, China has made progress on each.[2]

A bottom-up approach, eventually moving towards a globally-homogenous system for energy and environmental action. It is not realistic for every country to adopt identical approaches towards environment and energy. Instead, coordination of varied autonomous efforts should be encouraged to achieve the best possible result. Diversity should be recognized and promoted. This is the basis for the principle of common but differentiated responsibility,

[1] An agreement for a 10 year cooperation effort on energy and environment was signed in 2008, and in July 2009 a further agreement on energy, environment and climate change was signed.
http://www.brookings.edu/papers/2009/09_us_china_energy_cooperation_lieberthal.aspx.

[2] This discussion is drawn from a paper prepared for the CCICED Chief Advisors Group and the CCICED Secretariat in the early planning stages for the work of the current task forces on various energy and environment topics. Zhang Jianyu and A. Hanson. 2007. *Framework on Energy and Environment Policy Studies.* Discussion Paper. 15pp.

but also of recognition that countries need to take into their specialized needs for energy security, available sources of energy, and socio-economic development requirements. It is also a means to maximize the value of the mosaic of local initiatives and creativity that will be unleashed in the years ahead through green growth and innovation strategies.

Institutional and management Innovation. Policy integration is an important need. Sectoral policies still drive most decisions in China, often with limited coordination and understanding of cross-sectoral impacts. Along with policy integration is the need for timely goal-setting so that appropriate staging of development can be achieved. Getting the right mix of regulation and enforcement, incentives and voluntary action is important, especially in an era when there are new mechanisms such as cap and trade, payment for carbon credits, and the possibility of new energy taxes and subsidies. Institutional and management innovation should be an important driver for new technology applications and acceptance, and be designed to take into account policy integration.

Promoting national efforts. China has set out major legislation and action plans related to renewable energy use, energy conservation, promotion of circular economy, and climate action over the past several years. At some point there will be carbon intensity reduction goals. As a follow-up to the 11th Five-Year Plan energy efficiency and renewable energy targets, there will be new goals in the next Five-Year Plan. All of these efforts will require careful monitoring and commitment to more rapid improvements. Most will help to satisfy energy security, efficiency, environmental, climate change efforts simultaneously.

Technical innovation. The bottom line for the various energy and environment technology introductions and improvements needed in China is that they should be good for the environment but also be more efficient and sometimes much more financially viable than what they replace. As well, they need to be socially acceptable and beneficial. Government's role in stimulating and guiding research and development is essential, and so is the development of an enabling framework, including appropriate laws and enforcement policies, standards, pricing and incentives. The private sector will become increasingly important as a means for rapid implementation. Fostering Chinese entrepreneurship in environment and energy technologies is a key role to be shared by both government and the private sector.

Improved international cooperation. The international enthusiasm for green growth based on energy, environment and climate change now must be turned into more productive cooperation. This is especially true for such major topics as developing clean and innovative use of coal, carbon capture and storage (CCS) of GHGs, smart electrical grids, and next generation biofuels, implementation of more robust energy and environment technology transfer arrangements, and carbon trading mechanisms. There is also a growing need for China to share the technology it is developing, for example, in rural biogas, with other developing nations.

Over a relatively short period (mainly 2006-2009) China has developed considerable analytical capacity on energy and environment issues, and coordinating mechanisms such as the Leading Group on Climate Change, chaired by Premier Wen Jiabao. The focus on mandatory targets in the 11th Five-Year Plan for energy efficiency and pollution control, on standards for industrial operations, buildings, auto fuel efficiency and emissions, and changes in energy pricing are all examples of where progress is being made on developing a new relationship between energy and environment.

Despite these efforts, the path ahead is still uncertain, especially as economic growth rates accelerate, and as domestic consumption increases. There is little doubt about China's will at the senior level of central government to take the issues of energy, environment and climate change very seriously. But what is needed is a high level of performance across a wide range of decision-makers at all levels of government, and within China's state owned enterprises and private sector interests. As well, at the community level and within universities, academies and the growing number of non-governmental organizations, these issues need to be given priority as action items.

In the remaining parts of this section of the Issues Paper we present a brief overview of China's energy use, some of the key issues associated with each of the five CCICED energy and environment task forces, and some general conclusions.

2.4.3 China's Energy Use

The energy use pattern of China is summarized in Figure 1. This flow diagram reveals the pervasive influence of coal, and also the degree to which industrial use of energy prevails. A comparison of this diagram with a similar one for the USA reveals a much more even spread of energy supply for the American case, and with coal use mainly restricted to power generation, while a large portion of petroleum use is for transportation. In China, residential and commercial energy uses take a smaller portion of the whole by comparison to the USA.

Even with the great amount of energy devoted to the production of goods for export, China's per capita energy use is still small by comparison to Europe, the USA and Japan. However, to a considerable extent, this low per capita energy use masks a number of important trends and differences within China. First, the difference between per capita energy use of urban dwellers and rural people are substantial. And even within cities there are major differences between relatively rich and poorer people. Second, within industrial sectors there also are substantial differences, particularly between small, older operations and new ones. The figures are striking in the case of steel mills, for example. Third, with the expansion of transportation networks and the emphasis on private car ownership, gasoline and diesel fuel use will increase substantially, with attendant supply and environmental issues. Fourth, China's dependence on coal is a key concern. While there are many decades, or even hundreds of years of supply, the environmental and health concerns of coal burning are very substantial. And, fifth, the efficiency with which energy is transformed and transported is an important consideration that requires much attention, including development of "smart grids" for electricity transmission, and building of ultra-efficient power generating facilities.

China has substantially reduced its energy intensity in relation to GDP over the past 15 years and particularly during the 11th Five-Year Plan. It will have to continue to do so for the foreseeable future. With efforts to quadruple GDP over the first two decades of the 21st Century, even with very dedicated efforts to decouple energy growth it is very likely that substantial energy use increases will take place. High, medium and low estimates by the International Energy Agency are noted in Table 2-3.

One key issue for CCICED is to suggest policy mechanisms through which China can make much greater progress on reducing the environmental impacts of this incremental energy use, including the impacts associated with energy sourcing, generation, emissions and waste disposal. These require policy innovation, innovations through the use of markets, and structural change in the economy.

Table 2-3 Estimation of China's Primary Energy Consumption (2005-2030)

(Oil equivalent: Mt)

	2005	2015			2030			Average Growth Rate 2005-2030		
		High Growth	Reference	Alternative Policy	High Growth	Reference	Alternative Policy	High Growth	Reference	Alternative Policy
Coal	1,094	2,037	1,869	1,743	2,910	2,399	1,842	4.0%	3.2%	2.1%
Oil	327	626	543	518	1 048	808	653	4.8%	3.7%	2.8%
Natural gas	42	125	109	126	276	199	225	7.8%	6.4%	6.9%
Nuclear energy	14	34	32	44	82	67	120	7.4%	6.5%	9.0%

	2005	2015			2030			Average Growth Rate 2005-2030		
		High Growth	Refer-ence	Alter-native Policy	High Growth	Refer-ence	Alter-native Policy	High Growth	Ref-erence	Alter-native Policy
Hydropower	34	63	62	75	100	86	109	4.4%	3.8%	4.8%
Bio-energy and waste	227	235	225	223	231	227	255	0.1%	0.0%	0.5%
Other renewable en-ergy	3	13	12	14	43	33	52	11.1%	9.9%	11.9%
Total	1,742	3,135	2,851	2,743	4,691	3,819	3,256	3.2%	3.2%	2.5%

Source: IEA World Energy Outlook 2007, reproduced in the CCICED Low Carbon Economy Task Force Report.

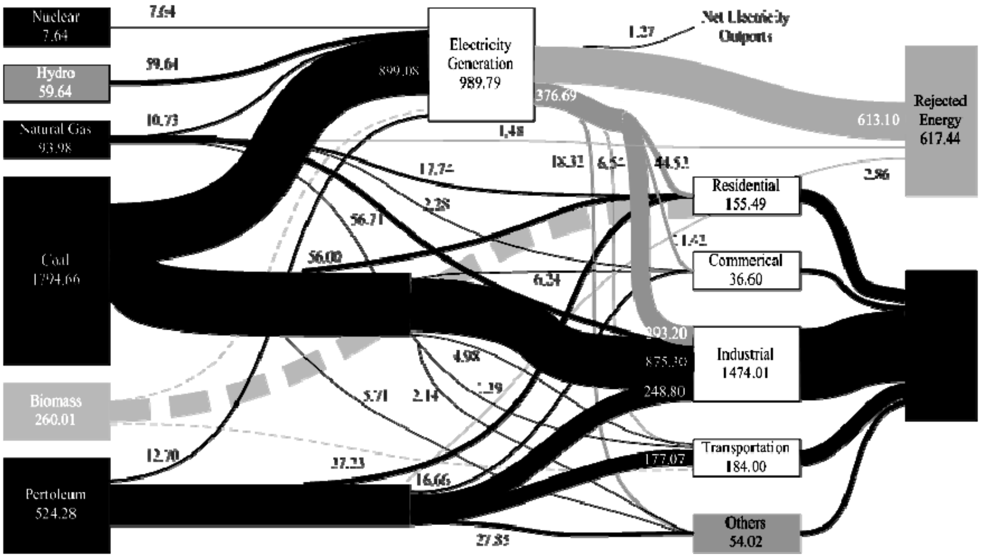

Figure 2-1 China Energy Flow Chart 2007

(-2 535 Mt of coal equivalent)

(This diagram was prepared by the China Energy Research Institute at the request of the CCICED Chief Advisors Group. A similar diagram for the USA is available from the Lawrence Livermore National Laboratory.)

The second issue is to identify policies for practical pathways for eliminating harmful emissions altogether, which is the promise of wind and solar energy generation, and for energy conservation practices that substantially reduce demand. This introduces design, information technology and many other S&T innovations that are being supported through China's Mid-term S&T Plan and other means.

The third set of issues are those associated with policies for management innovation, including the energy saving and environmental improvements possible thr-ough more efficient operations, and for car-eful attention to industrial performance and institutional reform.

The fourth set of concerns relate to the need for international cooperation, especially regarding technology transfer and financing, a point that China has repeatedly made in its international interventions on climate change. China's success with the Clean Development Mechanism (CDM) demonstrates the strong capacity that has been developed to utilize international initiatives designed for addressing energy and environment. There has been much less interest on the part of China towards international cap and trade schemes related to GHG reductions.

2.4.4 Five Topics Examined by CCICED Task Forces

2.4.4.1 *Sustainable Use of Coal in China*

China is the number one coal using country in the world. As the IEA and many others have noted, there must be drastic improvements in coal use everywhere in the world, if it is to become a more environmentally acceptable energy source.[1] While a theoretical case can be put forward that China could drastically reduce its dependence on coal over the coming 30 to 50 years, the more likely scenarios suggest continued dependence and possibly a major increase in the total amount of coal used over the coming two or three decades. Over that time span, it is presumed that renewable sources of energy and various innovations to reduce energy intensity will eventually reduce China's coal demands. As well, coal will have to become a much cleaner energy source, stripped of harmful emissions and with its GHG emissions sequestered or utilized. But China is far from having this vision of coal use become reality. Indeed, it is doubtful if China or any other country on its own accord could succeed. While the USA for cost reasons pulled back from its massive FutureGen coal combustion project, China is pursuing a similar effort labeled GreenGen.[2]

Investment in China's efforts towards sustainable use of coal should be in the best interests of other countries in order to create the most environmentally benign and efficient technical and policy approaches. Everyone will benefit. Recognition of this point is spreading, with increasing levels of technical cooperation and joint ventures

[1] See, for example, IEA. 2009. *Cleaner Coal in China*. IEA, Paris. 320pp.

[2] According to the company's owners, which include leading power companies and coal companies, *GreenGen*'s *business goals include: coal gasification, oxygen production, hydrogen production, syngas purification, hydrogen turbine and fuel cells generation, carbon dioxide capture and sequestration; and also research on advanced materials, instrumentation and control technology, related technologies of applications development; advisory services, technology transfer, power plant construction, operation and management.* GreenGen's objective is to design, build and operate the first IGCC power plant in China in 2009 and a coal-based, near-zero-emission GreenGen power plant in China with independent intellectual property rights. http://www.greengen.com.cn/en/aboutus_02.htm.

involving coal. There is a growing capacity within China not only for necessary S&T but also for the investments and the enabling conditions for full scale deployment and commercialization of very advanced coal production, power generation, and chemical utilization facilities. Pilot efforts on carbon capture and storage (CCS), advanced underground coal combustion, and other innovations now underway likely will be mainstreamed over the coming 10 to 15 years.

The most immediate challenges are to make sure that available technology and improved management practises lead to safer, more efficient and cleaner coal production and use throughout the value chain. There is evidence of this happening, including a substantial decline in coal mining deaths, reduction in SO_2 emissions from power plants and boilers, and modernization of many mining, transportation and electrical generation facilities. But there is still a danger of technology lock-in, particularly if there is resurgence in power demand, and if there is any breakdown in the effort to make local officials responsible for meeting environmental quality, safety and other standards. Furthermore, some important pollutants related to coal use, for example heavy metals like mercury are still inadequately controlled.

What would a longer-term vision of sustainable coal use in China look like? The starting point is definitional. Two key conditions must be met for sustainability[1]: the energy system must have good pro-spects of enduring indefinitely in provision of high quality and sufficient levels of energy services; and must not impose unacceptable environmental, health or social impacts and risks. A nonrenewable energy source like coal where, if it is very abundant, could be considered as a sustainable source if its use helps to build conditions that will eventually permit use of alternative energy sources. For example, if coal use helps to support district heating that could also utilize heat from sewage water, or if wellhead coal burning helps to build a more efficient national power grid that can utilize solar, wind or local hydro energy.

A question of interest to China's coal industry and many others is what level of coal might be used sustainably? The 2.8 billion tons of coal production in 2008 is only a small fraction of the available resource, even though it places a tremendous demand on China's transportation capacity. But China's coal use currently does not fully meet environmental, health or safety criteria at any stage along the value chain, although improvements are being made and some facilities are exemplary. If coal production levels reach projected levels of 3.5

[1] These conditions have been suggested by the CCICED Task Force on Sustainable Use of Coal in China.

billion tons in 2020 and more than 4 billion tons by 2030, the challenges will become much greater. Once GHG emissions associated with coal are factored in, the task of achieving sustainable use become monumental since there are no fully proven, economically-viable large scale solutions for CCS available at present.

There are several key policy needs that must be addressed in order for coal production and use to be placed on a sustainable path: modernization and consolidation of coal-dependent enterprises; policies that encourage deployment of best available technologies and avoid technology lock-in to outmoded types; mechanisms for rapid development and commercialization of advanced coal technology, including advanced environmental technology such as CCS; policy changes to pricing and subsidies that work against efficient market mechanisms; and enforcement policies; and possibly new policies for cap and trade emissions systems and/or carbon taxes.

If China is able to bring about substantial use of its vast coal resources, it will contribute to its own energy and environment security as well as improving regional air and water quality, and helping to meet global climate change objectives. It is a remarkable challenge but the rewards to China will be of great economic value, since China will have access to a wide range of technologies and intellectual properties related to coal and other advanced energy uses, great improvement in management capacity of these energy systems, and marketable products and services for the international marketplace. Therefore, the coal sector in China will be one of the key demand areas for a strategy of green growth.

2.4.4.2 *Urban Energy and Environment*

Action at the level of cities and towns in China will make a crucial difference to China's energy saving and transformation to an environment-friendly society. Urban settings are the source of great innovation potential and the powerhouses that will help to fuel green growth in industry and commerce. Urban households likely will hold the key to sustainable consumerism in China. The massive migration of Chinese from countryside to city over the coming decades will create one of history's greatest construction efforts, including remarkable investments in environmental infrastructure, transportation networks and buildings.[1] The embedded energy in this construction is immense, but what is most important are the implications of urban design, and of the behavior of China's urban citizens. Will communities, businesses and urban residents continue or develop patterns of con-

[1] McKinsey & Company. February 2009. *Preparing for China*'s *Urban Billion.* 540pp. http://www.mckinsey.com/mgi/ publications/china_urban_billion/ and China Academy of Social Sciences. 200. City Blue Report Competitiveness.

servative energy use, or will they become more profligate as happens in most industrial countries? Will Chinese cities become not just energy efficient, but exemplary models of energy saving and innovation? What factors are the most important in determining these behavioural outcomes?

CCICED's Urban Energy Use Task Force has examined energy consumption in various Chinese cities, and compared these levels to cities abroad. Building energy use is of particular interest. The hypothesis is that Chinese behaviour is to minimize energy consumption from air conditioning and lighting, for example. Thus some older office buildings tend to have lower consumption than modern western-style office buildings, even though the latter have more advanced design characteristics. Yet in cities like Beijing and Shanghai it is the western styled buildings that now fill the horizon. Similarly, cities incorporating massive road networks into their structure are locking communities into high energy use for generations to come. So-called eco-cities are showcased within China but in reality these are not yet making serious inroads into overall energy conservation nationally.

The most critical areas of concern for energy and environment urbanization policy include the layout and design of new communities; the relationship between urban centres and surrounding suburban communities; regional design of transportation and public utility infrastructure and energy efficient buildings, including construction techniques and materials; and design of communities that promote low energy activities such as neighborhoods that provide for most shopping, recreational and other needs without driving. Provision of green space and urban forest areas such as much of the Beijing Olympic Park provide energy and environment benefits. Policies that reward such efforts need to be instituted throughout China.

China already is investing heavily in public transportation within and between urban areas, with some of the most advanced technology in the world being built, but it is failing to keep up with demand. Furthermore, purchase of automobiles is being encouraged as part of the overall plan for stimulating economic growth and specifically encouraging domestic consumption. While this plan is being shaped to include an emphasis on energy efficient and low emission vehicles, the overall energy consumption and the environmental impacts of private vehicles has continued to rise. Creation of an automobile culture in China is one of the most significant policy decisions taken anywhere in the world. It is hard to see how this decision has promoted sustainable development, especially since it is in part stimulated by incentives such as tax cuts. China already has surpassed the USA as the world's largest auto market.

Although small vehicles are the norm

and encouraged through some policies such as a progressive consumption tax on higher emission vehicles, China has become the largest market in Asia for luxury vehicles—larger than the market for Korea, Australia and Japan combined. J.D. Power Asia-Pacific has estimated that this market for vehicles above 400,000 RMB (USD 57,000) in price will reach almost 600,000 vehicles by 2015.[1] And it is a Chinese enterprise (Sichuan Tengzhong Heavy Industrial Machinery Company) that has offered to purchase the iconically-unsustainable Hummer brand from General Motors.

Urban energy and environment management systems in China, as elsewhere, will increase in extent and level of sophistication in the coming years. Examples include computerized traffic flow management that reduce traffic jams and unnecessary waiting at stop signals, smart electrical grids and interactive metering and management of electricity use, energy and methane capture from solid waste and from urban wastewater, LED lighting, mandated limits on cooling and heating of buildings, etc. Many of these innovations are in practice today within some Chinese cities, especially in support of both energy efficiency goals and air pollution reduction. Yet the policies regarding urban management are still not optimal, and they are not always enforceable across the many hundreds of cities within China.

Furthermore, creating the urban advances that will be required to address GHG challenges is a daunting task. Many cities elsewhere in the world, especially in some OECD countries, have been in the vanguard of climate change action. ICLEI-Local Governments for Sustainability, for example, notes that some 700 communities participate in its worldwide Cities for Climate Protection™ campaign. The ICLEI approach is to establish five milestones focused on practical policies that can be implemented largely through improvements in public infrastructure and buildings.[2] China does not appear to have a comprehensive urban climate change policy of this type in place covering all cities.

Urban and suburban areas are home to China's major technology innovation clusters, on themes such as wind and solar power, and also have invested heavily in green industrial parks where many of the sunrise industries powering green growth will be located. These parks themselves can be exemplars of energy efficiency and advanced pollution control. For instance, funded through China's economic stimulus

[1] T. Dunne. 2009. *China*'s *Luxury Vehicle Market: A Bright Future Ahead.* J.D. Power and Associates. www.jdpower.com accessed 23 August 2009.

[2] ICLEI's Five Milestones for addressing climate change: 1. Conduct a baseline emissions inventory and forecast. 2. Adopt an emissions reduction target for the forecast year. 3. Develop a Local Action Plan. 4. Implement Policies and Measures. 5. Monitor and verify results. www.iclei.org.

is an industrial park in the City of Hengyang, Henan Province, for the production of "environment-friendly" lead batteries. This technology has been developed by China Ritar Power Corp., a Shenzhen-based, NASDAQ-listed company that specializes in sale of such batteries in China and abroad, with a special interest in deep cycle batteries for wind and solar power and batteries for light electrically-powered vehicles.

The transformation of China from 46% to 70% urban population over the next two decades is perhaps also its greatest energy and environment challenge, especially since it will be accompanied by a rise in urban wealth that may or may not be accompanied by patterns of sustainable consumption. With over 200 cities expected to have populations of over a million by 2030, some 40 billion m^2 of building construction and perhaps 50,000 new skyscrapers, there will be enormous scope for innovation. The 2010 World Expo in Shanghai with its theme of "Better City, Better Life" will provide the perfect venue for both China and the World to take stock of progress on urban energy and environment and future opportunities for appropriate the 21st Century urban development.

2.4.4.3 *Rural Energy and Environment*

Building the 'New Socialist Countryside' offers the potential of improved energy availability, and economic development related to energy production and use. Most of China's poor and those who only marginally escape poverty live in rural areas. They are among the most vulnerable to climate change effects, and therefore their needs should figure prominently in both mitigation and climate change adaptation strategies. Rural areas are of course where many energy sources serving the country are located including coal mines, hydropower dams, energy biomass sources, and the new wind and solar energy farms. Therefore rural areas are vital to the solutions for many of China's energy and environment problems. Yet the rural regions for the most part are not fully equipped for the tasks—not having the education and scientific skills, or full access to the full range of technologies and enterprises that promise a new road ahead.

Rural people are still well behind urban dwellers in terms of their household income levels, and therefore cannot be expected to take full advantage of the current drive to create greater domestic consumption. Very likely, as their incomes rise, they may have different priorities on such expenditures. How their rising wealth, anticipated in coming years, will influence sustainable consumption in China is hard to predict. But at present rural dwellers help considerably with maintaining low per capita national energy use statistics low.

Rural residents have special energy needs, notably inexpensive, clean and healthy sources of energy for heating and cooking. Traditional use of coal and biomass fuel presents respiratory problems, especially for women and young children who spend longer periods indoors. Biogas is an ideal solution in some situations. Rural buildings generally are not being build to high enough energy efficiency standards. Another special need is off-grid electrical power, especially in remote western areas. The emphasis on solar and wind energy, and small scale hydro is therefore a good solution with the co-benefit of reducing coal burning. Rural populations benefit from dams that provide irrigation water and which also may guarantee access to reliable sources of electricity not only for household use but also for operating modern farm machinery, agricultural processing plants and cold storage. China has moved quite dramatically to meet these rural needs and therefore help meet its national Millennium Development Goals (MDGs).

The modernized rural countryside is intended to have more livelihood opportunities, including local industries appropriate to the regions, and to have greater, more efficient and productive agriculture. Also, given China's commitment to reforestation and grassland protection, more attention will be given to eco-compensation for ecological services. Some of the new occupations are related to biofuel production, to intensified agriculture, which requires more energy for fertilizer applications and other inputs, and to agribusinesses involving more specialized crops such as fruits, animal production, etc. The net result is higher energy use, sometimes accompanied by serious environmental impacts. Turning materials such as manure from a waste to a useful product such as biogas; plant stalks and other wastes into cellulosic ethanol; and reducing energy use associated with cultivation by low-till agriculture are examples of how energy and environment can be addressed in the context of modernizing China's countryside.

The issues of energy and environment in rural areas therefore fall very much within the purview of extension workers, local community leaders and county level officials. At this level there is much work to be done in order to build the necessary resolve and understanding of appropriate policies and to improve practical implementation.

The concerns of climate change may be even more important to address at this level. As noted recently by China's Ambassador for Climate Change Yu Qingtai[1]: *Around 150 million Chinese citizens are mired in poverty, based on a UN benchmark of those living on less than USD 2 per day…lifting tens of millions out of poverty must remain* [China's] *primary goal*. The real issue is how to ensure that poverty re-

[1] Reuters Wed. 5 August 2009, interview with Yu Qingtai in Beijing.

duction becomes part and parcel of China's climate change effort, with good progress on both topics.

Rural populations are vulnerable to the greater intensity of severe weather events such as typhoons, floods and droughts. It is farmers and herders who are most directly affected by the melting of glaciers and other effects in western China. Human, animal and plant diseases and pests may spread, and ecological effects including changes in vegetation zones, crop ripening and biodiversity, all need to be taken into account via a combination of adaptation and mitigation of effects. Rural climate adaptation strategies are therefore an essential need for all areas of rural China. Part of this need will be adequate mechanisms to compensate losses suffered by these residents and producers. Some of this compensation could be through international funds linked to REDD[1] or other mechanisms based on agricultural or forestry practices that lead to carbon sequestration. Climate adaptation is still at an early stage in China and elsewhere and the necessary policies still need to be developed.

2.4.4.4 *Economic Instruments for Energy and Environment*

CCICED has pressed for improved incentive-based regulation concerning energy and environment for many years. Recommendations on pricing, reduction and elimination of environmentally-perverse subsidies, and greater use of taxes have been proposed. China is gradually moving towards a greater use of these instruments, and bringing resource prices into line with those of international markets. But the job is far from done. Indeed to some extent what has so far emerged is a patchwork quilt. The quilt has a variety of patterns, a number of holes, and is quite ragged. In other words, incentive policies are characterized by inconsistencies in their application, offer easy ways to be circumvented, and lack enforcement.

In the coming years development of a system of market-based incentives and mechanisms will be required to address energy and environment problems that are, at their core, economic and financial issues. What is of crucial importance is to increase energy productivity—ability to squeeze more value from a given amount of energy use. Stronger incentives are needed to make this happen. A growing part of the effort will need to be directed towards climate change. We are seeing the emergence of a variety of proposals for cap and trade systems and for pricing and taxing carbon, for example. The incentives for taking action on specific environment and energy matters often are not yet large enough to be attrac-

[1] REDD is the UN Program for Reducing Emissions from Deforestation and Forest Degradation in Developing Countries. A special fund has been established for this purpose and REDD is under discussion for future international agreement.

tive within China, or elsewhere. But sometimes larger incentives may only reinforce what people are already prepared to do (e.g., subsidies for taking older high polluting gas-guzzling autos off the road in the USA and Europe), or do little to actually tackle the problem they are intended to address (e.g., first generation, highly-subsidized biofuels from grain or corn).

Policy failure involving energy and environment economics has been high throughout the world. There are a number of reasons why: politics trumps economic rationality, fierce lobby pressures, inadequate scientific knowledge or use of existing knowledge, and long histories of subsidizing hydrocarbon energy sources and uses. The recent announcement at the Philadelphia G20 Summit of a commitment to eliminate environmentally harmful hydrocarbon subsidies will be an extremely important test case.

A problem of reforming entrenched pricing and other financial support systems involving energy and environment is that there never seems to be a right time to do so. Otherwise, we might have expected much more support for emerging renewable energies over the past decades and public transportation, and less for fossil fuels, automobiles, etc. This has certainly been the case in North America and Europe, where artificially low energy prices held back energy technology development. The combined energy, financial and climate change crises is increasing the pressure for positive change of incentives, but certainly the signals are mixed, especially given the massive bailout of the automobile sector.

In the case of China, it is certainly true that there have been many more good suggestions made about market-based mechanisms than fully satisfactory action to date. One reason for limited action is that there are complex agendas, for example, the concern for stimulating domestic consumption while at the same time seeking sustainable development. Another is for maintaining social stability, which is threatened when prices rise suddenly. A third is to create fiscal mechanisms that avoid negative impacts on the poor, or on particular regions within China. Fourth, there has been a tendency in environmental programs everywhere in the world to resort to command and control first.

But what about the future? If it is reasonable to argue that without full application of market-based mechanisms the problems of environment, energy and climate change will remain intractable, then the question is not whether, but how a comprehensive system of incentives can be put into place. China cannot expect to undertake green fiscal reform totally on its own, since it must maintain competitive advantage in global trade, and it also must have access to the necessary technology solutions, etc., at fair prices. Furthermore, highly-volatile commodity prices internationally make green fiscal reform more difficult. And carbon pricing is a necessary part of GHG emissions reduction strategy nationally and, ultimately, globally.

The entire financial sector can participate in market-based approaches to environment and energy. Banks in China are beginning to add environmental conditions to their loans, and there are efforts to create environmental liability and compensation mechanisms within the insurance industry. Green securities measures are beginning to appear in China's stock markets. Industries from sectors with a history of heavy pollution must undergo an environmental inspection before making an IPO, and there are regulations demanding greater public disclosure of possible environmental effects of operations.[1] These are definitely works in progress, with a considerable potential for major improvements on their impact in the years ahead.

Better balancing is needed among co-mmand and control regulation, use of economic instruments for environmental cost internalization, and voluntary measures. This balancing demands fundamental rethinking of environmental laws and regulations, new standards, and strong monitoring and enforcement. These are challenges that need to be addressed quite urgently, for China's framework has been designed in an era when administrative measures and command and control were the predominant elements. However, it must be emphasized that this does not mean a new era of less regulation. In fact, it should be a time for more efficiently applied and enforced regulation, sometimes called *smart regulation*.

2.4.4.5 *Low Carbon Economy (LCE)*

CCICED has been exploring the potential value of Low Carbon Economy to China since April 2007, when it convened an exploratory workshop that attracted considerable Chinese and international interest. Since that time, LCE has become a topic of considerable interest in many OECD countries, and within China. Statements by Chinese leaders have demonstrated support. At the 15th APEC Economic Leaders Meeting held in Australia in September 2007, President Hu Jintao indicated to APEC members that:

> We should improve energy mix, upgrade industries, promote low-carbon eco-nomy, build an energy-conserving and environment-friendly society and thus address the root cause of climate change…We should step up research and development as well as the application of energy efficient technologies, environmental protection technologies and low carbon energy technologies, increase capital investment in these areas, and boost technological cooperation and transfer of technologies.

[1] http://www.climateintel.com/2008/03/04/china%E2%80%99s-green-securities-policy/.

Since that time, this subject has rapidly gained ascendancy with senior policy makers.

Recently, the topic has been discussed at a cabinet meeting of the State Council in mid-August 2009 where it was noted that several key tasks would have to be undertaken to cope with climate change, including: developing a green economy by cultivating new economic growth with low-carbon emissions and speeding up the construction of low-carbon industrial architecture and transportation systems.[1] Furthermore, the meeting noted that governments at all levels would have to incorporate climate change measures into their development plans. This has been interpreted as a signal for incorporating LCE into future Five-Year Development Plans. On August 27, 2009 the Standing Committee of the 11th National People's Congress (NPC) passed a resolution on climate change that states: China should make carbon reduction a new source of economic growth, and change its economic development model to maximize efficiency, lower energy consumption and minimize carbon discharges.

At the UN Climate Change Summit on 22 September 2009, President Hu made the following commitment for action on energy, environment and low carbon economy[2]:

In the years ahead, China will further integrate actions on climate change into its economic and social development plan and take the following measures: First, we will intensify effort to conserve energy and improve energy efficiency. We will endeavor to cut carbon dioxide emissions per unit of GDP by a notable margin by 2020 from the 2005 level. Second, we will vigorously develop renewable energy and nuclear energy. We will endeavor to increase the share of non-fossil fuels in primary energy consumption to around 15% by 2020. Third, we will energetically increase forest carbon sink. We will endeavor to increase forest coverage by 40 million hectares and forest stock volume by 1.3 billion cubic meters by 2020 from the 2005 levels. Fourth, we will step up effort to develop green economy, low-carbon economy and circular economy, and enhance research, development and dissemination of climate-friendly technologies.

LCE is rapidly moving from being a theoretical concept debated by academics and others in China towards becoming a principal driver of future green growth in China. It is therefore an immensely important topic that requires careful study for its economic, social and environmental implications. Of particular concern is the macroeconomic impact of such a major shift, and also just how quickly it should initiated? Some would argue that the shift is well un-

[1] http://www.china.org.cn *China Underscores Climate Change Strategy*. 13 August 2009. Quoted from MEP website media service.

[2] http://www.china-un.org/eng/zt/hu2009summit/ t606111.htm.

derway with China's growing commitment to renewable energy and to the energy efficiency goals of the 11th Five-Year Plan and other initiatives including energy technology commitments in the economic stimulus package. But these are only starting points for what will be a long-term effort that must involve not only China but also strategies implemented by many other countries.

The American Progress Institute, for example, suggested 10 policy steps to move the USA towards a LCE[1]:

(1) Create an economy-wide, greenhouse-gas-emissions cap-and-tra-de program;

(2) Eliminate Federal tax breaks and subsidies for oil and gas;

(3) Increase vehicle fuel economy;

(4) Increase production and availability of alternative low-carbon fuels;

(5) Invest in low-carbon transportation infrastructure;

(6) Improve efficiency in energy generation, transmission and consumption;

(7) Increase the production of renewable electricity;

(8) Use carbon capture-and-storage systems to capture and bury the carbon emissions from burning coal;

(9) Create a White House National Energy Council and make the Federal government a low-carbon leader;

(10) Lead efforts to advance international global warming policies.

Great Britain has introduced legislation, strategies and transition plans that would lead towards a Low Carbon Economy. Other European countries and the EU are at various stages of the same.

Based on these and other efforts, the common elements of a LCE approach are to: 1) articulate a definition appropriate for the country that decouples economic growth from carbon content; 2) link the effort clearly to climate change mitigation but also to competitive advantage in the form of green growth; 3) create a strategic roadmap of key intervention points and potential outcomes; 4) focus on sectoral shifts including an industrial plan, an energy and environment plan, etc.; 5) estimate costs and revenue sources over a defined time frame of 20 to 30 years at least; 6) define necessary science and technology needs; 7) set out a LCE transition plan; and
8) build public and private sector understanding, support and participation for LCE initiatives.

Policies, legislation and regulations, incentives and institutional arrangements to support LCE are still more or less at an early stage, although certainly rapid progress will be needed. Most importantly, LCE ultimately must be tied to pricing of

[1] J. Podesta, T. Stern and K. Batten. November 2007. *Capturing the Energy Opportunity Creating a Low-Carbon Economy* American Progress Institute. 88pp. http://www.americanprogress.org.

carbon and then to workable mechanisms such as carbon taxes, cap and trade or other means to reduce GHG emissions.

Some issues about applying LCE within China include the following questions:

(1) Is it more appropriate to focus on Low Carbon Development rather than LCE?

(2) How can the transition to LCE improve development that favours poorer people and regions, and avoids negative impacts on them?

(3) Is use of coal as a main energy source compatible with LCE, especially if economically-viable solutions to carbon capture and storage from coal uses can be developed?

(4) Is it necessary for China to develop cap and trade or other limiting targets as part of a national or global LCE?

(5) What are the best means for China to finance LCE?

(6) How can access to needed LCE technologies be improved, including both domestic and international sources?

(7) What would provincial and municipal LCE strategies look like?

There is a need to provide some assurance to decision makers that deciding to move towards a LCE will have manageable economic impacts, and, hopefully, rising economic benefits. This requires substantial on-going scenario development using credible macroeconomic models. As well, employment costs and benefits, impacts on poorer people within society, and regional or sectoral impacts need to be carefully considered. Fortunately there are co-benefits such as pollution reduction that can be gained through LCE investments and these need to be carefully identified and calculated. Thus China, and many other countries will need to undertake on-going socio-economic analysis, and assessment of environmental and other benefits, especially during the early stages of constructing and implementing LCE strategies.

On the basis of these assessments and analyses it will be possible to undertake corrective and adaptive measures. The important point is to start small but soon on creating a Low Carbon Economy. Pilot projects and other experimental efforts will be valuable in the immediate future, but certain essentials are also needed soon. These essentials include a national strategy for LCE that can be readily understood by the public, enterprises, and people at all levels of government; mechanisms for pricing of carbon and setting of carbon reduction intensity targets, a roadmap with strategic points for initial intervention, and an incentives-based system to promote rapid change of technologies, institutions and management systems towards new approaches.

2.5 Looking Ahead

This AGM comes at a time when inputs into the 12th Five-Year Plan are desirable, and also in the aftermath of the difficult first year of the financial crisis. Therefore it is a good point in time to consider mid-term assessment of what has been accomplished on the mandatory environment and energy goals in the 11th Five-Year Plan, progress on other environmentally-related objectives, and on sustainable development progress. This performance should set the stage for defining objectives of the 12th Five-Year Plan. A variety of task force recommendations have come forward over the period of CCICED's Phase 4 that may be relevant to the 12th Five-Year Plan. In the final part of this section of the Issues Paper we lay out a number of suggestions, mainly as a summary for discussion during the AGM.

Some of the important questions: Can China meet or surpass relevant environment and energy goals? Which ones are most likely to be in trouble and why? If the goals are met across the board, are the results credible, given the problems of statistical data, and the pressure on lower administrative jurisdictions to be judged favourably? What are the most significant outcomes that appear to be emerging from the 11th Five-Year Plan and who/what will they benefit most? Are there significant social groups that have not benefited? What can be changed at this midpoint in order to strengthen eventual outcomes? Has the experience of the 11th Five-Year Plan been transformative? How can the 11th Five-Year Plan experience be useful for setting goals and approach of the 12th Five-Year Plan? We will not try to answer all these questions here. But they should be kept in mind as potential issues, not only for the current Five-Year Plan, but also future ones.

2.5.1 11th Five-Year Plan

2.5.1.1 *Meeting China's 11th Five-Year Plan Mandatory Environment and Energy Goals*[1]

In 2007 a CCICED Task Force[2] noted that meeting energy and environment targets[3] would be difficult due to the very high economic growth rates and the relatively slow progress made during the first two years of the 11th Five-Year Plan, even though there also were expressions of hope that vigorous action would lead to success. Of course much has changed since that time: lower economic growth rates in 2008/09; lower imports and exports since September 2008; lower FDI; shift to domestic consumption; efforts to shift from low-value, high embedded carbon exports;

[1] This section draws upon a background paper prepared for this Issues Paper by Chen Gang and Wang Xiaowen. *Mid-term Assessment of Obligatory Indicators for Energy Conservation and Emission Reductions in 11th Five-year Plan Implementation.*

[2] CCICED Task Force on China's the 11th Five Year Plan Environment and Development Performance.

[3] The Chinese Government has required that the energy consumption per unit of GDP should be cut by 20% from 2005 to 2010, and the total pollution discharge should be reduced by 10%. These two targets are binding ones on all levels of governments.

and improvements to rural social spending and economy. Government leaders have vigorously pressed all provinces and levels of government to achieve the 11th Five-Year Plan targets established for particular regions and sectors. The effort appears to be having some good results and there now is the possibility that even the most difficult targets might be reached.

According to official statistics, by the end of 2008, the total energy consumption per unit GDP had been reduced by 10.1%. And the total discharge of SO_2 and COD were reduced by 8.95% and 6.61% respectively. In the first half of 2009, there were further reductions of 5.46% and 2.46% for SO_2 and COD, and 3.35% for energy intensity. While these results are very encouraging, there are still significant worries about overall energy and environmental performance. MEP indicates that the average SO_2 atmospheric concentration in key cities went down by 15.8 percentage points compared with that of 2005. And the accumulated energy saving is 290 Mt of coal equivalent over the past 3 years, equivalent to the reduction of 660 Mt of CO_2. However, as recently described in a speech by Minister Zhou Shengxian, environment conditions remain *very serious* within China and form a *grave situation* globally.[1] China believes that by continuously improving its own environment, it also will be improving the global situation.

Two years remain to accomplish the obligatory environmental and energy indicators. Assuming emissions are reduced at a fixed rate over the two years and the obligatory indicators are realized as due by 2010, the fixed rate can be calculated.[2]

For COD, a year-on-year reduction of 1.83% should be made in 2009 and 2010 in order to achieve the indicator goal, annual COD reduction should be 8.32% and 10% in 2009 and 2010 respectively in relation to the baseline year of 2005. The somewhat unfavorable situation for COD reduction is due to several factors: first, new industrial emissions continue to increase rapidly, where pulp & paper, brewery and textile industries, which contribute over 60% of COD emissions, remain on a fast track of growth; secondly, the engineering of emissions reduction is lagging—the construction of water projects with a daily treatment capacity of 6.8 Mt at urban sewage treatment facilities required by the 11th Five-Year Plan is running far behind schedule; and thirdly, the progress in structural emissions reduction is less than ideal, where essential advances have not been made in closing down backward production capacities for pulp & paper,

[1] http://www.english.mep.gov.cn/Ministers/Activities/200909/t20090929_161949.htm.

[2] Calculations are from the background paper by Chen Gang and Wang Xiaowen.

brewery, MSG and citric acid.

For SO_2, a year-on-year reduction of 0.58% is needed in 2009 and 2010. The annual reduction should be 9.5% and 10% in 2009 and 2010 respectively in relation to the baseline year of 2005. It is believed that the SO_2 goal could be met a year ahead of schedule. There are several reasons for this optimistic outlook. First, the pressure from newly added emissions sources has somewhat eased. Power generation, steel production and non-ferrous metal production, which contribute over 70% of industrial SO_2 emissions, have for the first time dropped or stayed even. Secondly, engineering emissions reduction has been progressing steadily with 82 desulphurization systems newly installed at coal thermal power plants—an installed capacity of 3.6 million kW, which is 72% of the annual plan. Thirdly, major advances have been made in structural emissions reduction, where 3,382 small thermal power generation units with an installed capacity of 19.89 million kW were shut down over the first 6 months—some 54.07 million kW accumulatively, a planned shutdown that was accomplished one and a half years ahead of schedule. And fourthly, the effects of emissions reduction supervision have started to show.

For each unit of GDP, the energy consumption should be reduced by 5.89% in 2009 and 2010 year on year, and the annual reduction should be 15% and 20% in 2009 and 2010 respectively in relation to the baseline year. These are very difficult goals to achieve.

2.5.1.2 *Progress towards Sustainable Development*

The 11th Five-Year Plan addressed many aspects of sustainable development, which is, of course, a more complex topic than environmental protection on its own. An independent review of the 11th Five-Year Plan progress was released by The World Bank in mid-December 2008.[1] It concluded that:

(1) Economic growth has far exceeded expectations;

(2) Considerable progress has been made toward the 11th Five-Year Plan's most important social objective: Improving basic public services in social protection, education, health, and conditions in rural areas, even though income disparities between rural and urban areas continue to widen; and

(3) Progress on the environmental objectives has been mixed: insufficient progress had been made in energy conservation, but improvements were seen in reducing air and water pollution, treating industrial solid waste, increasing the efficiency of water use, and expanding forest coverage.

Furthermore, the Bank concluded that

[1] World Bank China Office. 18 December, 2008. *Mid-term Evaluation of China*'s *11th Five-Year Plan*. Report No. 46355-CN.

the economic structure had shifted further towards dominance of the industrial sector, and, within the industrial sector, the energy intensive heavy and chemical industry had gained further dominance. The lack of re-balancing the overall economy had offset in part the gains at the micro level. The efficiency improvements gained through mandated efficiency standards and closure of inefficient capacities would become harder to tap in the future. Without making more fundamental changes in the economic and industrial structure, it was viewed as unlikely by the Bank that the 11^{th} Five-Year Plan's 20% reduction target in energy conservation could be achieved.

The Mid-term Report on the 11^{th} Five-Year Plan Implementation reported to the NPC by NDRC points out that the overall progress has been good. In terms of fulfillment of the main socioeconomic development indicators, expected progress had been achieved for most of the 22 main indicators. 10 of the 14 indicators reflective of economic growth and livelihood improvement had been as expected or better, while progress was less than expected for 3 of the 4 economic structure indicators besides the rate of urbanization. Progress greater than required has been achieved for 5 of the 8 obligatory indicators, while forest coverage failed to be accurately assessed due to inadequate annual data, and advances in the 2 indicators for energy conservation and emission reductions were lagging.

There are a number of other environmentally-related goals where good progress has been achieved according to the NDRC assessment. For example, water consumption per 10,000 RMB industrial production growth was reduced by 16% by 2007, accomplishing 53% of the goal, and the effective utilization coefficient was increased by 0.02 for agricultural irrigation, reaching the 11^{th} Five-Year Plan requirement. Goals for comprehensive utilization of industrial solid wastes were achieved ahead of schedule.

2.5.1.3 ***Regulated Projects and Activities***

Over 1,100 paper factories causing severe pollution, 16.69 million kW of small thermal units, 14 Mt capacity of obsolete iron factories and 6 Mt capacity of backward steel factories were shut down through regulatory action in 2008. Meanwhile, some of the backward production facilities in non-ferrous metal, cement, coke, chemical engineering and dye printing were closed down. Factories generating excessive pollution and backward productivities in pulp & paper, leather making, dye printing and brewery were shut down around Lakes Taihu , Chaohu and Dianchi as well as along the key water systems.

The MEP reviewed and responded to 365 projects between December 2008 and May 2009, accounting for a total investment of 1 442.8 billion RMB. It suspended or did not respond to 29 chemical, oil, steel or thermal power generation projects worth 146.7 billion RMB to prevent launching of 2H1R (Heavy energy consumption, heavy pollution and resource-related), duplicated or access productivity projects. There is the worry that if such 2H1R projects are launched or go into operation thanks to economic interests or local protectionism, they will cause severe damage to the public, environment and health.

2.5.1.4 *Innovation Technologies*

China's commitment to green growth has shown some solid results over the years of the 11th Five-Year Plan. This is partly the result of the large S&T investment, but also from the realization that opportunities can be quickly realized with the right combination of technology. This subject has been discussed in considerable detail by the CCICED Sustainable Development Innovation Task Force which reported to the 2008 AGM.

2.5.1.5 *Conclusions*

The 11th Five-Year Plan will set a new baseline for action on environment and energy within China. Clearly the process has not been easy, and to some considerable extent success has been dictated by external factors, especially the economic turn-down of the past year. But it is also clear that momentum is building, and that the use of mandatory targets on environment has been a positive feature in this process. There are concerns about how accurately current statistics represent reality across the vast reaches of China. But it is highly encouraging news that substantial progress is being made on both energy and environment indicators.

With renewed economic growth definitely a strong prospect, the reliance on intensity indicators (tied to GDP) rather than total loading is dangerous in that absolute amounts of pollutants and energy use are still likely to be on the increase. Furthermore, many important pollutants such as NO_x , ground level ozone, mercury and other heavy metals, and POPs are not subject to targets, or even control strategies. Furthermore, GHG and carbon reduction strategies were not incorporated into the 11th Five-Year Plan.

The social and economic impacts of the environmental results so far of the 11th Five-Year Plan do not appear to be systemically tracked. Thus it is difficult to know the extent of impacts on either rural or urban areas in the different regions of China. Also, while in general it might seem to be a safe assumption that environmental improvement in China is good for the whole planet, this is still an untested hypothesis in the minds of many people abroad. The reason for this is in part the credibility issue that China actually can make such quick progress on environmental clean-up. Therefore it would be useful for China to devote greater effort to scientifically measure how its domestic improvements directly affect the global environment.

2.5.2 Environment and Development Highlights for the 12th Five-Year Plan

Broad guidelines for the next Five-Year Plan are already under consideration, with various research efforts underway. The MEP and others have set out some initial guidelines for research on national environmental protection, shown in abridged form in Box 2-5. There are other topics relevant to the theme of this Issues Paper that are not included on the list in Box 2-5, including various aspects on environment, energy and climate change. And certainly, it might be expected that green economic growth would be an important component for consideration.

The *Five Changes* pollutant emissions reduction recommendation from the CCICED 11th Five-Year Plan Task Force has not been fully implemented and remains highly relevant for the 2011-2015 period. The Five Changes are: 1) change from sole emphasis on reduction of total amount of emissions to a combination of total emissions reduction and environment quality improvement; 2) change from priority of key industries to comprehensive reduction; 3) change from control over total emissions of single pollutants to synergic control over multiple pollutants; 4) change from emphasis on capacity to implement reduction programs to emphasis on the quality and actual effects of the programs; and 5) change from reliance on administrative methods to market-based economic instruments.

There are a number of key needs for improvement and updating of environmental laws and regulations in order to address the more complex environmental protection situation that exists within China today, and to address the greater use of economic incentives. To complement an enhanced regulatory framework, there is a need to build and to enforce an indicator system that emphasizes both total emissions control and environment quality improvement. There are many specific needs to be met in relation to expanding the range of pollutants to be controlled and to o enhance local implementation of total emissions control. Examples include: boiler emissions reduction for coal-burning industries and to transform approaches to SO_2 emissions reduction; steps to carry out total emissions control of nitrogen oxides for the thermal power generation industry; choose key river systems and lakes for ammonia nitrogen control; choose some sensitive lake reservoirs for pilot total nitrogen and phosphorus control; provide pilot total non-point source pollution control in some areas. There is a need to create active prevention and control of such newly emerging environment problems as POPs, mercury pollution and VOCs; and to develop and implement pilot programs such as restoration of pollution sites, polluted soil and neutralization of electronic wastes.

Box 2-5 Tendering Guidelines for Initial Research Projects on National Environmental Protection for the 12th Five-Year Plan

(Issued in 2009 by the Department of Planning and Financing, National Environmental Protection Ministry and the China Environment Planning Institute)

(1) The national environmental protection objectives of the 12th Five-Year Plan are to be regarded as phase requirements for realizing an all-round welfare society by 2020, featuring fundamental improvements in environment quality.

(2) Methods to control the total amount of pollutant emissions are to be improved and optimized, issues such as control of total N, P, nitrogen oxide and other new pollutants to be studied, and practices for total amount control to be furthered.

(3) Control of water pollution is to be furthered by applying systematic management of pollution in key waters such as changing from target total amount control to volume total amount control.

(4) Total amount control of air pollutants, especially prevention and control of nitric oxides and regional joint prevention and management of air pollution, is to be the leading direction.

(5) Eco-environmental protection and soil pollution prevention and management is to be one of the key tasks for the 12th Five-Year Plan.

(6) Integrated utilization of solid wastes such as domestic, hazardous, medical and industrial wastes and the relevant key projects are to become important work during the 12th Five-Year Plan, requiring innovative technologies and techniques, improved support policies and laws, and strengthened social administration.

(7) Support from public financing for environmental protection is to continue to grow as the Chinese economy keeps growing rapidly, and a designated financial funding assurance mechanism, which is stable, well-oriented and specifically targeted in spending, is to be built up.

Five very important items on energy and environment include:

(1) Strategy for sustainable use of coal.

(2) Immediate and longer-term steps towards Low Carbon Economy and Development, including implementation in both urban and rural settings, in various industrial sectors, and shifts towards green growth for both domestic and export products.

(3) An energy productivity strategy, including a progressive, predictable approach to energy pricing and the use of an improved mix of regulatory and economic incentives.

(4) Carbon pricing, which may be based on carbon tax, cap and trade, or other

arrangements.

(5) Targets for energy efficiency and energy-related environmental con-cerns, with some based on absolute amounts rather than intensity.

In summary, there are many specific drivers that should be taken into consideration in the design of the 12th Five-Year Plan goals for energy and environment. Among them are the followings:

(1) Energy conservation and energy efficiency needs in a variety of sectors to bring energy intensity in line with or better than existing international norms.

(2) Reduction in energy intensity for urban buildings, infrastructure construction and operations, and urban transportation.

(3) Continued efforts to expand as rapidly as possible the use of renewable energy sources in China, focusing particularly on wind, solar, marsh gas (methane), and small-scale hydro.

(4) Specific actions related to international arrangements on energy, environment and climate change, including carbon pricing and possible trading, CDM, bilateral and multilateral agreements on technology transfer and partnerships, IPR, and investment arrangements.

(5) Adaptation needs concerning climate change.

(6) Mandatory targets for reduction in GHG emissions and carbon intensity of development.

(7) Continued improvement in environmental quality through more stringent reductions in pollutants covered under the 11th Five-Year Plan mandatory targets, plus a broader range of pollution control (e.g. mercury from coal burning, NO_x).

(8) A system for reduction in total pollution load for some sectors and regions.

(9) Improved protection for ecological services, and ecocompen-sa-tion.

(10) Environment and health targets designed to reduce or eliminate mortality and cases related to specific causes, and improvement in environmental safety associated with key sectors such as coal mining and various types of industrial sectors.

(11) Full achievement of the MDGs within China, including those related to environmental sustain-ability.

(12) Strengthening frameworks to improve green growth opportunities, including scientific R&D, innovation technology investment, institutional strengthening and capacity building related to advanced efforts that will provide China with new economic growth opportunities and export potential related to meeting international demand especially those related to environment and energy.

(13) Improvement to the statistical information base for both energy and for environmental performance.

According to some views, the Low Carbon Economy could characterize a new approach to implementation of scientific development and harmonious society for the 12th Five-Year Plan, since it represents not only such a major turning point in sustainable development, but also because it will open great new opportunities for China’s future economic growth and development.

2.6 Conclusion—Prospects for a Green Prosperity Future

This Issues Paper has taken on an almost impossible task of trying to examine the implications of several major global shifts of historical dimension taking place virtually simultaneously. A year ago it appeared that they were on a track of imminent collision, perhaps even leading to global collapse. The issue of financial meltdown and economic recession has been turned into a series of hopefully manageable problems—mainly for the major economies of the world to resolve. China has been vaulted into a role of greater international responsibility and consequences due to its favourable path of economic recovery. Certainly the problems with the global economy China and others will face in the coming five years are massive: restructuring the world’s financial system, including the problems of moving away from high levels of deficit spending in some countries; ensuring adequate safeguards on trade and investment; and other issues highlighted during the recent G20 Leaders Summit in Pittsburgh. Yet there is a sense of optimism gradually emerging, in part due to the rapid action by political leaders to avert worst-case scenarios. It also is clear that without a credible and stable global financial system in place, sustainable development goals will be very difficult or impossible to achieve globally and therefore within countries as well.

The second great shift has been the depth of dialogue on the issue of climate change in this year of lead-up to the Copenhagen climate change meeting that will take place in December 2009. There is now a reasonably well-entrenched view that climate change—along with poverty elimination—are defining problems for our common future and security during this century. Unless they are addressed well and soon, the costs will be perhaps unbearably high. Unfortunately getting a solid agreement about the best approach, with high levels of immediate action, is proving to be extremely difficult in the lead-up to Copenhagen. This problem has implications for green growth, for development of international markets for new technologies, and, very importantly for domestic consumption patterns in both industrialized and rapidly developing countries in particular. The Copenhagen climate change meeting is of historic significance to be sure—a beacon that will send its beam far into the future. But whatever the outcome, it is the start of a new way of thinking about our planet, and particularly about developing the Low Carbon Economies needed for the future.

The third shift is international cooperation concerning poverty reduction, and global capacity to address this serious problem. China's strides towards meeting its Millennium Development Goals present a remarkable success story, but one that is tempered by growing inequalities in wealth, and the realization that a fair part of China's population remains far too close to the poverty line. Yet China also can contribute much through expanded international cooperation throughout the developing world. The technologies that China is diffusing in its rural areas, its experience with renewable energy, and the advantages it brings in driving down the costs of production of many products are examples of unique contributions China can bring to many others in the world. The multiple crises that have emerged in recent times, including high prices for natural resource and energy commodities, the high price and scarcity of food, threat of pandemics and, in many parts of the world, natural disasters of increasing intensity and frequency. These problems will need to be dealt with in more systemic ways and with fresh visions and solutions. Poverty is interlocked with climate change impacts and adaptation, especially for water issues, and with improving environment and development relationships.

The fourth and hopefully very enduring shift is towards societies based on innovation that can more rapidly address the changing circumstances and demands on productive forces within national economies and globally. Green growth involves new forms of both production and consumption. It should influence all sectors of economic productivity, ranging from primary and secondary industries to the commercial, tourism, telecommunications and other aspects of modern tertiary activities. It is understandable that much of the focus on green growth currently centres around energy, environment, and climate change, but ultimately it is transformation of lifestyle, infrastructure design, and the way business is carried out that will determine better outcomes— a future of Green Prosperity.

Will China be the global leader in developing this new future? It is difficult to answer this question because it depends upon China's own willingness to take on this role as part of its rise in the world. And in part it depends upon the wealthier countries undertaking their own transformations. China's potential is great because: 1) it has the means to address key challenges and opportunities precisely at the point in time when it is building the infrastructure to house, transport, meet energy and water supply needs of its people at a better level; and 2) it is prepared to invest in social improvements, especially for health and education. China also has demonstrated its tremendous capacity to succeed in the global marketplace. Whether it is LED lighting, wind turbines, advanced coal plants, or a myriad of other advanced green technologies, perhaps including electrical vehicles, through the great size of its domestic markets, its export marketing skills, and its ability to be adaptive, smart and fast, China has advantages that will be put to good use in coming years.

Green Prosperity also depends upon expanded international cooperation. This will involve a greater degree of sharing, and not only of wealth, knowledge and experience. The power sharing that is taking place in the restructuring of global institutions, and in the decision-making among the world's major economies is an outcome that would have hardly been believed possible only a year ago. China has strengthened its potential for international cooperation as a result. This is seen in the case of environment and energy where there has been a rush of many countries to engage with China on matters of energy, environment and climate change. This new engagement is often on the basis of solving problems of mutual interests. Ultimately many of the results will be helpful not only to China but to the other countries involved. This is a pattern that should be encouraged.

It is well to seriously consider the meaning of Ecological Civilization, a phrase used mainly in China. If nations can prosper at low levels of ecological damage—with a deeply felt respect for nature and the ecological services provided by the global commons and by the rich resources of the planet—then we might achieve an Ecological Civilization globally. China's leadership has called for this state of harmony between people and the planet, and we must presume that it will become a central part of China's on-going development philosophy. Other countries will have much to learn, and hopefully much to contribute, during this common journey towards a prosperous future.

Chapter 3 China's Pathway Towards a Low Carbon Economy

3.1 Preface

Today, it is widely accepted that global climate change presents one of the biggest challenges for human development. At the global level, the scientific consensus is driving global action towards emission reduction and the transition to a low carbon economy. Some developed countries have substantially adjusted and continue to change their socio-economic policies in a move towards low carbon development. Trade-related greenhouse gas (GHG) emissions are also likely to come under increasing scrutiny in the coming decades. This is especially acute for emerging economies dependent on export-led growth. These concerns bring structural changes to the global economy and trade patterns that imply a new paradigm for economic development.

Already frequently stricken by natural disasters, a further increase in the number of climate-related natural disasters would incur not only ecological and economic losses to China, but also threaten domestic social stability. Growing industrialization and urbanization together with China's continuing coal-based energy structure (at least in the short-run) imposes tremendous pressure on China's resources and environment. Increasing dependency on imports of oil not only raises uncertainties for economic development but also worsens energy security. With global economic imbalances causing financial crises, the pattern of economic growth in China is facing unprecedented challenges.

Against this backdrop, the move towards a low carbon economy is an inevitable path for China if it is to realize its development goals. Developing a low carbon economy is of critical strategic importance for China as the country evolves its economic development model, adjusts its economic structure, enhances its technological innovation capacity, and strengthens the sustainability of its economy. In recent years, China has already adopted rigorous energy conservation and emission reduction policies that are important to kick-start a low carbon economy. Looking ahead, China stands to benefit significantly from a transformation of its pattern of economic growth. Such a transformation will allow China to capitalize on new growth opportunities as a supplier to satisfy increasing global demand for low carbon technologies.

3.2 Global Shift to a Low Ca-rbon Economy

In this report, a Low Carbon Economy (LCE) is defined as a new economic, technological and social system of production and consumption to conserve energy and reduce greenhouse gas emissions compared with the traditional economic system, whilst maintaining momentum towards economic and social development.

This definition is underpinned by three principles:

(1) A LCE would eventually decouple economic growth from greenhouse gas and other polluting emissions, through technological and other innovations and changes in infrastructure and behavioural changes.

(2) At China's current stage of development, still undergoing industrialization and urbanization, "Low Carbon[1]" is a relative rather than an absolute concept. Emissions per unit of economic output are reduced more rapidly under a LCE than would be the case with a continuation of the status quo.

(3) A Low Carbon Economy achieves many key development objectives including long term economic growth, creation of jobs and economic opportunities, reduction of resource consumption, and enhancement of technological innovation.

To avoid dangerous levels of climate change, global temperature rises need to be restricted to no more than 2˚C above pre-industrial level. To realize this goal, global emissions will need to peak within the next ten years; they will need to be halved or more by 2050. In order to achieve this, energy systems that are close to zero emissions will need to be developed. Eventually these will need to be implemented globally. Different development situations will mean countries have different pathways to a low carbon economy. Consequently this report does not make specific recommendations on absolute emissions targets for China, focusing instead on relative measures of carbon intensity and energy consumption.

The cost of low carbon transition is a critical issue for policymakers today. In practice, the overall costs of CO_2 reduction are likely to be lower than expected. In many sectors clean technologies already exist and reduction measures are low cost or even profitable, for example in energy conservation, efficiency and renewable energy production. However, cost estimates vary quite widely. This is partly because

[1] "Low Carbon" is shorthand for "low greenhouse gas" – while CO_2 is the main contributor to global warming, the role other greenhouse gases must not be overlooked.

technology costs are uncertain, and are dependent on the global price of oil, which can fluctuate significantly. McKinsey's CO_2 abatement cost curve[1] suggests that approximately one third of the 36 Gt CO_2 affordable global abatement opportunities in 2030 are achievable at negative cost (i.e. representing a net economic benefit even without considering reduced climate damages). McKinsey also estimate that the total costs of mitigation will be on the order of 0.6%-1.4% of global GDP by 2050.[2] The negative cost options are mostly associated with energy efficiency improvements. The Stern Review indicated that the total global costs of meeting a stabilization target sufficient to avoid the worst effects of climate change could range from －3.9% of world GDP (i.e. a net benefit) to +3.4% of world GDP in 2030[3].

Central to the vision for a low carbon economic future is increasing appreciation of the potential economic, social and political benefits – rather than the costs – of the transition. A recent study estimates that China alone will need $25 billion per year for investment in low carbon technologies.[4] Globally, the value of low carbon energy products are estimated by the Stern Review[5] to be worth at least $500 billion per year by 2050, and perhaps much more. According to the International Energy Agency (IEA) meeting a 450 ppm CO_2e concentration limit would require an increase in investment of 18%, averaging an additional $1 trillion per year up to 2050 compared to the Business-as-usual (BAU) requireme-nts.[6]

At the global level, the transition to a low carbon economy is no longer a choice but a necessity. Fluctuating prices and supply volatility are motivating the more efficient use of resources. The tightening global supply of oil and natural gas (as well as the imperative of climate mitigation) is fuelling the development of new technologies.

With deeper acceptance of the findings of climate-related science, the question today is less about whether low carbon transition is needed but how fast can it be implemented and at what scale. The low carbon economy can not only be a useful way through the current economic crisis but is the most viable means to ensure sustained growth in the medium and long term. Investment opportunities in low carbon goods and services may become increa-

[1] McKinsey & Co "Pathways to a Low Carbon Economy: Version 2 of the Global GHG Abatement Cost Curve".
[2] McKinsey Global Institute, 2008. The Carbon Productivity Challenge: Curbing Climate Change and Sustaining Economic Growth.
[3] Stern Review "The Economics of Climate Change" .
[4] Guiyang Zhuang, *Low Carbon Economy: No Alternatives Left for China*, Chinese Academy of Social Science, May, 2007.
[5] HM Treasury, *Stern Review: The Economics of Climate Change*, Executive Summary, 2006.
[6] IEA (2008), *Energy Technology Perspectives 2008*, International Energy Agency.

singly appealing compared to risks associated with investing in traditional sectors. A global assessment undertaken by Greenpeace International and the European Renewable Energy Council pointed to a net increase of nearly 2 million jobs in the power sector as a result of increased use of renewable energy by 2030[1].

As the case of Sweden demonstrates in Figure 3-1, it is possible to achieve GDP growth while emissions fall, although not many developed countries have so far been able to emulate Sweden's example.

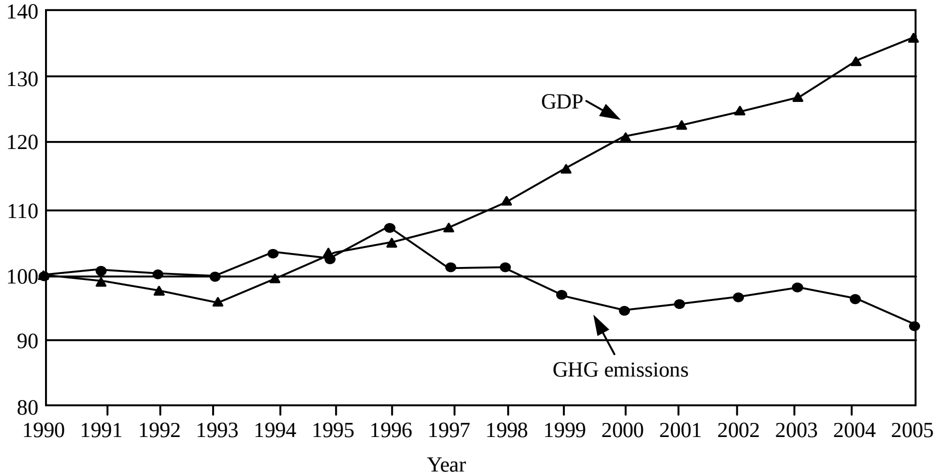

Figure 3-1 Sweden: Growing GDP with Emissions Reductions

Source: Swedish Energy Agency, 2008.

(1) Avoiding high future costs. The economic case for immediate transition to low carbon economy is compelling. The macroeconomic cost of transition is likely to be manageable. On the other hand, the Stern Review puts the costs of inaction on climate change at between 5% and 20% of GDP: the combined cost of both World Wars and the Great Depression. One needs look no further than losses associated with extreme weather-related events to comprehend the potential scale of impacts. Global economic loss attributed to climate related disasters reached an unprecedented 185 billion dollars in 2005. The United Nations projects that weather disasters could cost a trillion dollars (or 3% of current global GDP) per year by 2040.[2] In just one exam-

[1] European Renewable Energy Council, Greenpeace International, Working for the Climate, Renewables Energy and the Green Job Revolution, August 2009.

[2] Daniel Wallis, Disasters losses may top $1 trillion/yr by 2040-UN, *Reuters*, 14 November 2006.

ple in China, the 2005 drought in Ningxia Hui Autonomous Region cost an estimated 1.27 billion RMB – 2% of its GDP – damaging 289,000 hectares of crops.[1]

(2) Avoiding dangerous carbon lock-in. Carbon 'lock-in'[2] describes a situation whereby due to economies of scale, a country's technological and institutional infrastructures coevolve towards dependency on fossil-fuel-based systems. Work undertaken for the Dutch Environmental Assessment Agency suggests that delaying the peaking of global emissions by 10 years doubles the maximum emission reduction rates needed from 2.5% to over 5% per year, when compared to immediate action. This leads to far higher costs as high-carbon infrastructure and equipment installed over the next decade would subsequently need to be scrapped before the end of its economic lifetime.[3]

Our decisions in the next 10-15 years will determine whether or not a climate-safe future will be possible. Lock-in is equally important for decisions on public transport, urban design, construction standards and major industrial investments. Lock-in will also blunt attempts to capitalise on the competitiveness possibilities. It will be enormously expensive to correct poor decisions post hoc.

(3) Ensuring energy security. Achieving energy security is a major driver for China's low carbon development. Policies such as diversifying energy sources and improving end-use efficiency – both necessary to ensure energy security – are contributing to the shift into low carbon options. The Chinese economy is over four times less energy efficient than that of the EU measured in terms of consumption per unit of GDP at current prices. To respond to climate change and achieve energy security together, China can continue to place great emphasis on energy efficiency whilst investing in low carbon options in the power and transport sector to reduce dependence on fossil fuels.

(4) Trade in a carbon-constrained world. Trade and investment can facilitate the worldwide transition to a low carbon economy through the creation of new market incentives. Trade and investment also enhances access to countries' comparative advantages, leading to cheaper inputs and prices. Despite the benefits brought by global trade, trade-related CO_2 emissions are likely to come under increasing scrutiny in the coming months. This is especially problematic for emerging economies dependent on export-led growth. Many US

[1] Ministry of Civil Affairs in Ningxia. See: Li Yue, Wu Yanjuan, Conway, D., Preston, F., Lin Erda, Zhang Jisheng, Wang Taoming, Jia Yi, Gao Qingzhu, Shifeng, Ju Hui (2008) Climate and Livelihoods in Rural Ningxia: Final Report. AEA Group. p.26. http://www.china-climate-adapt.org.

[2] Unruh, G.C. 2000 "Understanding carbon lock-in" *Energy Policy 28 pp.817-830*.

[3] MNP (2005) *Meeting the EU 2 ^{0}C climate target: global and regional emissions implications*: M.G.J. den Elzen, M. einshausen, Netherlands Environmental Assessment Agency, 2005.

legislators have championed proposals to impose border tariffs on exports from developing countries not taking 'comparable actions' to limit GHG emissions. These ideas are also favoured by a number of European governments and legislators.

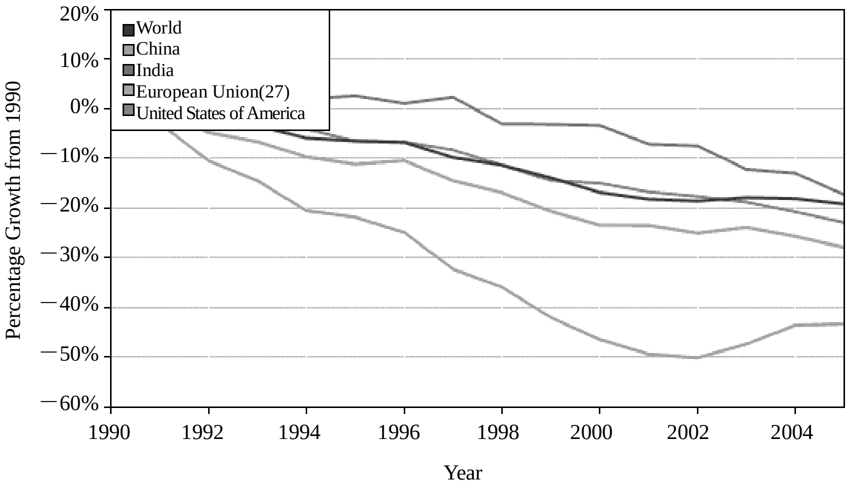

Figure 3-2 Global Carbon Intensity Trends

Source: WRI 2009.

Table 3-1 below indicates a range of actions by both developed and developing countries either to achieve a particular level of abatement or to cap national emissions. All these policy developments and the abatement initiatives taken to meet them—whether from governments, businesses or consum-ers—are redefining the calculus for exp-orting countries. To ensure long term survival, it is becoming critical for exporters to understand and adapt to the dynamics of an increasingly carbon-constrained world.

Table 3-1 Strategic Action for A Low Carbon Economy - Selected Countries

Country	Action
Australia	Cap and trade 'Carbon Pollution Reduction Scheme' to be phased in from 1 July 2011 and a commitment to reduce carbon emissions by 25 percent below 2000 levels by 2020 (pending UNFCCC post-Kyoto agreement).
Brazil	Implementation of a "National Policy for Energy Efficiency" that will result in a gradual energy saving up to 10^6 TWh/year to be reached by 2030, a reduction of emissions of around 30 Mt of carbon in that year.
Costa Rica	Pledged to be carbon neutral by 2021.

Country	Action
France	Emission reductions of the order of 75%-80% before 2050 if other countries do the same (a conditional target).
UK	2008 Climate Change requires legally binding 5 year carbon budgets to be set by an independent expert committee. The Act requires emission reductions through action in the UK and abroad of at least 80% by 2050. The carbon budget for 2020 is set at 34% reduction compared to 1990, increasing to 42% following a global deal on climate change. Pledge to build no new coal-fired power stations without CCS to capture at least 25% of carbon emissions and 100% of emissions by 2025.
Mexico	Planning a domestic cap-and-trade system by 2012 to cut emissions from certain sectors (cement, oil refining etc.). The government has pledged to halve carbon emissions by 2050 on 2002 levels.
Norway	Aim of being carbon neutral by 2030. Has committed 140 million Euros over 5 years CCS projects in selected EU member states.
South Africa	A plan to halt its growth of greenhouse gas emissions at the latest by 2020-2025 and to adopt various economic and policy measures so that emissions will eventually stabilise and decline.
Sweden	In 2000 Sweden discussed a target of reducing own emissions by 50 % from 1990 level before year 2050. The government has said that Sweden should work internationally for stabilising the concentration of greenhouse gases at a level below 550 ppm CO_2-equivalents. Swedish per capita emissions should be below 4.5 tons CO_2-equivalents before 2050. This represents a reduction of just over 40 % compared to today's level. The 2008 budget included 7 billion Krona for climate and energy initiatives between 2009-2011.
United States	The government has suggested a 14%-15% reduction in carbon emissions from 2005 levels by 2020. The Waxman-Markey Bill (recently passed US House of Representatives, now facing the Senate) calls for an absolute cap covering 85% of the US economy, resulting in a 17% reduction by 2020 and over 80% reduction by 2050 compared to 2005 levels. The Bill requires electric utilities to meet 15% of their electricity demand through renewable energy sources and energy efficiency by 2020 and outlines US$90 billion in new investments in clean energy technologies and energy efficiency by 2025.
Japan	The incoming Prime Minister has stated that Japan would seek to reduce CO_2 emissions by 25% below 1990 levels by 2020. This target would be contingent on a deal involving all major emitters in Copenhagen in December 2009.
EU	Committed to cutting carbon emissions by 30% of 1990 levels by 2020 (pending UNFCCC post-Kyoto agreement). The 2007 EU climate and energy package has set 3 additional targets to be met by 2020: a 20% reduction in energy consumption compared with projected trends; an increase to 20% in renewable energies' share of total energy consumption; and an increase to 10% in the share of petrol and diesel consumption from sustainably-produced biofuels.

3.3 Necessity and Urgency of Developing a Low Carbon Economy in China

3.3.1 Low carbon economy is consistent with the strategic goal of scientific development

A low carbon development pathway is the best way for China to achieve a resilient and prosperous society, while building on and enhancing China's priorities such as the Scientific Outlook on Development, the construction of a resource-saving, environment-friendly society, and the development of a circular economy. Efforts to maintain a safe climate is in line with the Chinese priority of developing a harmonious society, and is fully consistent with existing Chinese efforts on energy saving and environmental protection. The low carbon economy provides a pathway to the new industrial and economic growth model that China urgently seeks.

China has experienced a remarkable economic expansion over the past three decades, triggered by domestic reform targeted at rapid industrialisation and urbanisation, coupled with opening its economy to international trade. Today, China is the third largest economy and the third largest exporter in the world. Its economic status is likely to grow in the next 20 years, together with corresponding expansion in scale of industrialisation and urbanisation. However, the Chinese economy also faces immense challenges. First, the current trends are not sustainable, with high resource pressures on the environment. China also needs to tackle the threat of climate change, including adapting to its impacts. Its industrial structure remains sub-optimal, with weak innovative capacities. Its comparative advantage in low value addition production has also been weakened especially following the global financial and economic crisis. Export-oriented economies like China face great pressures in an increasingly uncertain global economic setting.

China's existing model of development is therefore not sustainable. Current growth rates in energy consumption will lead China to be increasingly dependent on imports of coal, as well as increasingly dependent on imports of oil and gas with higher world prices. In 2006, China's GDP accounted for 5.5% of the world total; its energy, steel and cement consumption respectively accounted for 15%, 30% and 54%. Climate change already threatens to reduce crop yields through water-stress and extreme weather, and if it goes unmitigated climate change will severely impede China's development.

Globalization has not only led to an international redistribution of industrial production; it has also meant a redistribution of energy and resource consumption, and hence, emissions. According to the

World Energy Outlook 2007: China and India Insights, the amount of energy 're-exported' by China in 2004 was 400 Mt of oil equivalent (Mtoe), amounting to 25% of the country's energy consumption. The amount of energy embodied in the commodities China imported that year was 171 Mtoe, amounting to 10% of energy demand. The proportion of energy embodied in the commodities China exports is much higher than that for other countries (for the US, the EU and Japan, the figures are 6%, 7% and 10% respectively). This high proportion exacerbates the rise of China's carbon dioxide emissions.

International economic structures and trade rules are changing in response to energy and resource constraints, as well as in response to financial instability caused by unsustainable trade flow imbalances. While a global move to a low carbon economy places pressures on China's development, it also rings great opportunities for future growth. A move towards a low carbon economy can address the challenges outlined above, and realise the long term goal of sustainable growth.

Developing a low carbon economy presents China with an opportunity to leapfrog the process of resource-intensive, highly polluting growth experienced by Western countries. There are additional incentives for China to move towards more efficient manufacturing processes and towards a lower-carbon industrial structure in order to stay at the forefront of international trade.

In short, China's move towards a low carbon economy is inevitable, necessary and urgent. There are considerable benefits to China of taking early action. China needs to avoid lock-in to energy-intensive urban and industrial infrastructure. Investments made now and over the next decade will determine China's exposure to energy security and climate change risks for decades to come. By acting now on R&D and commercialization activities, China can take a leading role as a supplier of equipment and know-how to rapidly growing international markets for low carbon technologies, goods and services. These changes will re-enforce China's domestic aims of becoming less dependent on exports of heavy energy-intensive goods, and becoming a market leader in higher value-added technology- and information-based goods and services.

The country is already a world leader on critical low carbon technologies such solar power, heat and wind turbines and is rapidly developing key technologies for electric vehicles. Choices made in China will shape the global markets for such goods.

3.3.2 China is Already Shifting Towards a Low Carbon Economy

Existing programmes provide a strong foundation for China to move along a low carbon economic pathway China's scientific

Outlook on Development' concept provides essential guidance for economic and social development. It emphasizes people-oriented development, which must be comprehensive, balanced and sustainable. This overall strategic approach sets the framework for more specific policies and actions.

The 11th Five-Year Plan sets specific goals for a decrease in energy and resource intensity. It identifies "substantially improving the efficiency of resource utilization" as one of the main goals of economic growth and social development during the period of the Plan, and sets the following targets:

(1) energy consumption per unit of GDP will be cut by around 20%;

(2) water consumed per unit of industry value added will be reduced by 30%;

(3) effective utilization coefficient of field irrigation water will be lifted to 0.5;

(4) rate of industrial solid wastes utilized will be lifted to 60%.

China's National Climate Change Programme (CNCCP) outlines objectives, basic principles, key areas of actions, as well as policies and measures to address climate change for the period up to 2010. Guided by the Scientific Outlook on Development, China will carry out all the tasks in the CNCCP, strive to build a resource conservative and environment-friendly society, enhance national capacity to mitigate and adapt to climate change, and make a further contribution to the protection of the global climate system.

According to the State Renewable Energy Medium- and Long-term Development Program, renewable energy is expected to account for 15% of China's total energy supply by 2020, up from 7% at present, with the capital support of around 1.5 trillion RMB (200 billion USD) from the government. (The Program is being further revised, and the renewable target may be adjusted upwards.) Nearly 40 million households will use biogas around the country by 2010 under the State Rural Biogas Development Programme (2006-2010), and annual biogas production will reach 15.4 billion cubic meters, which equals to energy consumption of 24.20 Mt of standard coal and 140 million *mu* (approximately 9.3 million hectares) of annual forest stock. Progress is on track: 31 million homes were using biogas sources for cooking and heating by the end of 2008, an increase of 5 million on the previous year. The use of wind power is also expected to increase significantly, with plans for up to 100 GW of installed capacity by 2020, up from around 12 GW in 2008.

3.3.3 Benefits for China are Significant

China's move towards a low carbon economy will not just be a reactive response to external forces arising from shifts in global economic structure and pressure to reduce climate impacts. There are also very significant positive benefits to be gained for China as it moves to tackle its own internal energy resource and environmental constraints. It will alleviate resource and energy pressures; improve the structure of energy consumption; and safe-guard energy security.

Now is the time for China to make a decisive shift from its previous energy- and carbon-intensive development patterns to a more sustainable path. By acting now, China stands to gain by avoiding lock-in to inappropriate capital stock, positioning itself as a global leader and provider of low carbon technology, and making use of emerging carbon markets and other international financing mechanisms.

As a result of China's rapid industrialization and urbanization, massive amounts of infrastructure and equipment are set to be put into operation over the next 2 decades. Furthermore, in response to the global economic crisis, the Chinese government has launched a 4 trillion RMB direct fiscal stimulus plan. Together, this provides China with an extraordinary window of opportunity for reconstructing and upgrading domestic industries in China.

If this wave of investment fails to use advanced technologies, equipment, and infrastructure, China will lock in high energy consumption, high pollution and high emissions for their entire life-cycle — possibly for decades. China will therefore live with the decisions it is making during this decade for many decades to come.

At present, China is a global leader in terms of R&D and commercialisation for some low carbon technologies. However, public and private sectors from developed countries are also injecting large amounts of capital into low carbon R&D. Competition to develop and commercialize new technologies is fierce, and China must keep up. Once low carbon technologies go into in the stage of wide commercialization elsewhere, China would simply replicate its traditional pattern of becoming a home for low-cost competition, instead of establishing new international competitive advantages based on home-grown innovation.

China's 2006 *National Medium- and Long-term Science and Technology Development Planning Framework* spelled out specific targets for energy technology development. By 2020, Chinese researchers are anticipated to achieve breakthroughs in energy development and conservation technologies, clean energy technologies, as well as on the optimisation of the energy mix. Over the same period, major manufacturing industries are expected to reach or approach the energy efficiency level of advanced countries. The Ministry of Science and Technology (MOST) draws up the technology R&D plans and provides funding for the national programs.

One possible model that China is considering for incubating these developments builds on the experiences in the early 1980s when China embarked on an extraordinary journey towards greater economic openness. Special Economic Zones (SEZs) — geo-graphical regions with more liberal econo-mic laws than the rest of the country —played a vital role. Building on this successful model, a consortium of European and Chinese research institutes developed the concept of "low carbon zones" (LCZs), and are currently engaged in piloting and developing the methodology for LCZs in Jilin City Municipal Area.

3.4 Understanding Challenges and Opportunities

China faces challenges in the transition to a low carbon economy. It remains a developing economy, with low GDP per capita income. Capacities and income levels also vary across different regions. It is therefore critical to understand current constraints and to overcome a range of technological and institutional barriers.

Industrial structure. A major factor is China's industrial structure. A large share of China's economy is in a stage of industrialization marked by heavy chemical industries, the development of iron and steel, vehicle and ship manufacturing, and mechanical engineering industries, all of which require a large volume of materials and energy. The development of tertiary industry, with lower energy intensity, lags significantly behind the world average. In addition, there is a dramatic variation among regions in China in terms of economic development level and industrialization stage.

China's energy-intensive industries are the pillars of the national economy. Employment pressures make it harder to speed up structural adjustment in the short term and close inefficient production capacity. Compounding this is China's natural endowment in terms of energy: huge reserves of coal, which encourages over-reliance on this carbon intensive source. Another obstacle relates to the shift in China's policy toolbox for promoting energy saving: from the current, largely administrative tools such as centrally-determined targets for local governments and enterprises, to a market-oriented approach. Inevitably there will be a time lag between the introduction of market mechanism and its implementation. There will also be a time lag before the benefits from investment in energy efficiency and emission reduction measures materialise.

Building sector. China's building sector currently accounts for about 28% of the country's total energy consumption. China also has plans for major expansion of the housing sector, estimated to 20 billion m^2 by 2020, this equates to all the current housing stock in the EU 15. Part of the solution is to expand long-term fiscal and tax incentives for energy-saving in the construction sector, which are currently lacking.

Institutional barriers are a challenge. Currently, charges for central heating and cooling are based on floor-space, giving users no incentive to save energy. Many cities in China have introduced time-of-use (TOU) power policies, but many buildings are not installed with a TOU meter. Where mandatory building energy-saving standards exist, surveys show that only a small proportion of new residential buildings in large Chinese cities adhere to the standards: 50% for northern areas, 14% for areas with hot summer and cold winter, and only 11% or so for areas with hot summer and warm winter. China's policy on energy auditing for new buildings is yet to be effectively implemented. Because issues like energy-saving policy, energy price, fiscal and tax policy, and environmental protection cut across several government departments, an appropriate authority should be introduced to promote coherence.

Transport sector. Globally the transport sector is the largest and fastest-growing emitter of CO_2. In China, the sector's energy consumption and emissions are likely to increase significantly in the coming years. A policy priority should be to decrease the rate of emission growth in the short term, and to develop alternative new technologies and mode of transport in the meantime. The introduction of stricter standards on vehicles (grams of CO_2/km) has been shown to significantly increase average efficiency. Technological changes are not the only mechanism to lead to efficiency improvements. Behavioural changes could also bring considerable gains, such as altering driving habits, driving more slowly and evenly, car-pooling, and a switch to public transport for those who can afford cars. Some of these measures require relatively simple measures, such as changing speed limits or greater public awareness.

Innovation and R&D. China must attach great importance to R&D, focusing on medium and long-term strategic technologies. It needs to support the rapid diffusion and use of existing commercial low carbon technologies, rationalize venture investment and financing to encourage companies to develop new low carbon technologies, and enhance international cooperation to promote technology transfer from developed countries to China.

Insufficient technological innovation capacity is a weakness of China's economy. The country is a large resource consumer, but its average economic output per unit of resource consumed is less than 10% of that of developed countries. China is the third largest trader, but only a tenth of its exports are accounted for by homegrown brands and intellectual property. China is a big manufacturer, but it needs to import major technical equipment. China's exports of high-tech products are growing, but it relies heavily on importing key components for those products, and has to pay the foreign companies large fees for software technology standards. Many enterprises spend much more on technology imports than on technology absorption and assimilation. On average, the proportion of investment on imports to that for absorption is 6.5:1; in Japan after World War II, it was 1:7 – more than reversed, although this partly reflects the much greater level of globalization today, with imports and exports of goods and services typically being a much greater part of many international companies' business models. "Strengthening capacities of independent innovation of information technology" is a major goal of China's State Informatization Development Strategy (2006-2020).

The deployment of low carbon technology. Many (though not all) of the technologies that will enable a rapid, transformative change in the way energy is produced are already available, but not adequately deployed. Energy efficiency gains will only be achieved by a concerted effort across all sectors of society. The general public and other energy consumers will have to be engaged to ensure purchasing and investment decisions on the entire operational life of appliances, not only on upfront costs.

Lower- and zero-carbon supply options require market stability. Since in most cases, fossil fuel-based energy sources are currently cheaper than the low carbon alternatives, investors need both short term incentives and confidence in a longer term policy framework. For example, if the environmental costs can be internalized into product prices, on-shore wind power prices are already competitive. However, barriers such as access to the grid and planning regulations often inhibit new investment. Relatively simple measures could be introduced to prioritize these technologies, enabling their wider diffusion in existing markets. The removal of other barriers, such as prohibitive financing, overly burdensome regulations and difficult access to energy networks will also have to be addressed if rapid diffusion is to be achieved.

Supply chain bottle-necks. Changing engineering standards and the materials used in the manufacture and use of goods can have widespread implications for supply chains. In particular, higher efficiency standards for buildings have been known to result in bottlenecks due to the shortages of specific energy-efficient materials, e.g. high spec windows. On paper, overcoming these potential blockages in the supply chain is simple: increase production. However, in practice it is more complicated, and may require a number of measures including clear medium and long term targets that facilitate R&D and investment; financial incentives for new production investment; increased co-operation and patent sharing to enable leapfrogging to the best available technology; and stricter penalties and regulation to avoid production based on redundant or soon to be redundant technologies.

Table 3-2 Barriers to the Deployment of Energy Efficient Technologies and Practices

Barrier	Why	How to overcome the barriers?
Low energy prices	-Subsidies -Prices do not include environmental costs	- Eliminate perverse subsidies - Provide aid to those who need them most through alternative mechanism - Put a price on carbon
High upfront costs and long pay back periods	-Most consumers value the present cost of consumption	-Fiscal incentives (e.g. tax reductions) to decrease upfront cost -Encourage financial institution participation
Slow diffusion of technologies	-Lack of skills, knowledge and support on the use of technologies -Fragmented and non integrated industry structures (e.g. building sector)	-Technology standards
Entrenched business models	-Lack of incentives for energy companies to reduce customer demand	-Internalize carbon prices in energy services -Financially reward end-user EE measures -Promote ESCOs -Encourage and incentives energy companies to promote cleaner energy, technologies and energy efficiencies
Diversity of consumers and energy needs	-No single solution fits all	-Promote voluntary sectoral initiatives and negotiated agreements
Information failures	-Lack of product performance information and EE alternatives -Uncertain future energy prices and development	-More effective technology standards (e.g. building codes) -Product energy labeling -Products energy performance information and labeling - International EE standards benchmark and local standards enforcement -Encourage the "smart meter" development
Split incentives (principal agent problem)	-Those making decisions on EE do not benefit (e.g. building owners and tenants)	-Provide clear information and incentives (e.g. tax rebates, mortgage discounts, rebates, preferential loans)
Uncertainties on investment and risks	-Uncertainties add a premium to investments	-Economic incentives that cover those risks -Develop robust energy and carbon markets
Consumer behavior	-Low priority of EE investments -Lack of awareness and information on energy consumption and costs	-Develop carbon markets -Incentives to remove and replace old equipment -Raise education and awareness on EE (for example through community-based initiatives)
Investment costs higher than expected	-Don't include all transaction costs	-Boost best practice sharing and EE education

Source: Developed by WBCSD and its member companies (2009).

3.5 Scenarios for Low Carbon Economy up to 2050

Four scenarios are developed for this study, which look at the implications of introducing low carbon technologies and practices at different rates on levels of energy use and the relative and absolute levels of CO_2 emissions.

BaU under high growth rate (BaU). Annual average growth rate between 2005 and 2050 is set to be 6.4%, representing the high economic growth prospect obtained in previous analyses. Characterized by high consumption mode and global investment, local pollution control, pollute first then mitigate, huge investment in technology and rapid technology improvement.

Low Carbon Scenario under high growth rate (HLC). This scenario **c**onsiders factors such as sustainable development, energy security, and economic competitiveness. High energy saving standards, renewable energy and nuclear power generation developments, and carbon capture and storage (CCS) technology applied to a certain degree. Medium investment in low-carbon economy under the condition of full development of the Chinese economy.

Enhanced Low Carbon Scenario under high growth rate (HELC). Global mitigation of GHG emissions realizing a low GHG stabilization target. Main mitigation technologies are further developed, and have a faster decrease in cost. High investment in low-carbon technologies. CCS used to a much larger scale.

Low Carbon Scenario under low growth rate (LLC). The low carbon emission path that China can achieve, considering the requirements for low carbon development from China and the demand for global emission reduction.

Figure 3-3 below shows the implications of climate change and energy security under different scenarios. Compared to the BAU scenario, Low Carbon under high growth (HLC) has positive benefits on not only climate and energy security.

As can be seen in Figure 3-4 below energy demand is expected to increase in all scenarios, due to the growth in the economy. However, there is a significant difference of about 25% between the low growth low carbon and BAU scenarios. Changing the energy mix can have a significant impact on the emission profiles, with the enhanced low carbon scenario leading to missions about 50% lower than BAU. Importantly, the HELC scenario, with high levels of economic growth achieves the same levels of emissions cuts as the low economic growth model. This is because the higher economic growth enables low carbon technologies to be introduced at a faster pace.

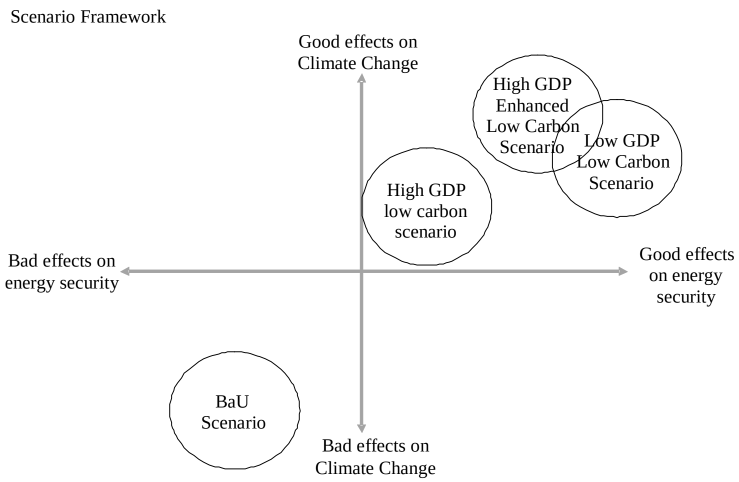

Figure 3-3 Implications of climate change and energy security under different scenarios

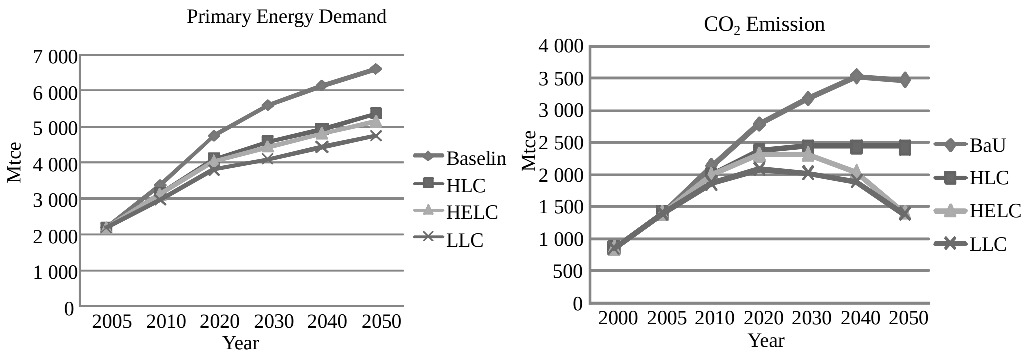

Figure 3-4 Energy consumption and carbon emission under different scenarios

Table 3-3 Energy consumption and CO_2 emission of different scenarios

	energy consumption/Mtce			CO_2 emission/Mt		
	BAU	Low carbon	Enhanced low carbon	BAU	Low carbon	Enhanced low carbon
2020	4 820	4 000	3 920	10 190	8 290	8 040
2030	5 530	4 470	4 280	11 660	8 600	8 170
2050	6 660	5 250	5 010	12 710	8 820	5 120

Table 3-4 Energy intensities of different scenarios

	2005—2020	2020—2030	2030—2040	2040—2050
BAU	3.5%	4.7%	3.2%	2.6%
Low carbon	4.2%	5.0%	3.6%	2.5%
Enhanced low carbon	4.4%	5.2%	3.5%	2.5%

In terms of the incremental investment (Figure 3-5), compared to the BaU scenario, more advanced technologies would be deployed in the low carbon scenario, with higher unit cost of investment in production capacity. But energy savings would more than offset this additional cost. This means that the total investment required is lower in the low carbon scenario than the reference scenario. In the enhanced low carbon scenario, with earlier large-scale deployment of advance technologies, the investment cost would be higher than the other two scenarios.

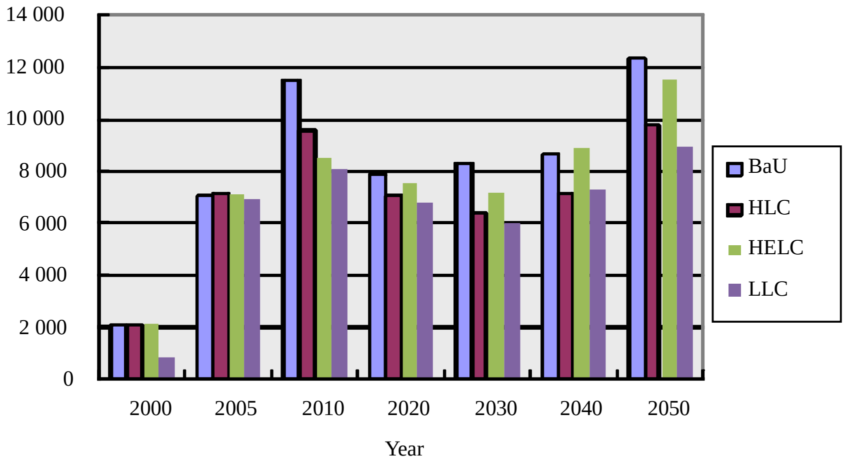

Figure 3-5 Investment needs in energy sector (billion RMB)

3.6 Roadmap for China's Low Carbon Development — Based on Five Pillars and Three Bases

Based on the scenario analysis, this report outlines the roadmap for China's low carbon development. Figure 3-6 describes the basic framework, with five key pillars. These include: low carbon industrialisation; low carbon urbanization; sustainable consumption; low carbon energy and sustainable land use. These pillars are underpinned by three cross-cutting foundations, including technology and innovation; markets and pricing reforms; as well as institutional change.

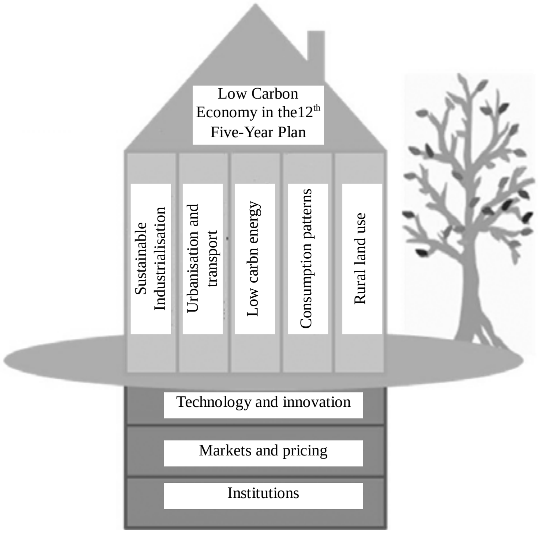

Figure 3-6 Roadmap of China's Low Carbon Development

3.6.1 A Major Strategic Choice and A Low Carbon Vision for China

Scenario analysis shows that if China does not change its economic growth pattern, by the year 2030 its per capita CO_2 emissions will reach 8 tons per capita, while more than 80% of petroleum will be imported from foreign countries. But by taking a low carbon development pathway, China can reduce energy consumption in 2030 by 20% to 4.47 billion tons coal equivalent, and carbon dioxide per capita to 5.9 tons - based on domestic efforts to develop a low carbon economy. After 2030 the growth of GHG emissions slows down and remains broadly stable or even goes down.

Compared to the reference scenario, emissions reduction in the low carbon scenario will be driven by: 1) industrial re-structuring; 2) efficiency gains in industrial end-use, transport, building and electrical efficiency; 3) life-style change, including transport modal shift; 4) improvements in energy sector, including higher efficiency of fossil fuel use and low carbon energy development; 5) use of CCS. As seen in Figure 7 industrial restructuring, efficiency gains as well as lifestyle changes will significantly contribute to carbon emissions reductions – 60% by 2020, 62%

by 2030 and 57% by 2050. The development of new energy sources also makes a great impact – from 16% by 2020 to 24% by 2030 and 30% by 2050. Contributions from CCS will begin from 2030.

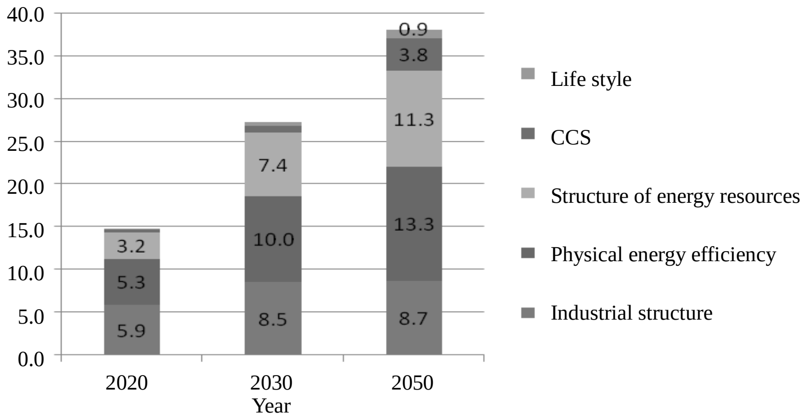

Figure 3-7 Contribution to emissions reduction under low carbon scenario

(Unit: 100 Mt CO_2)

The global shared desire to slow down climate change could have the effect of further strengthening technological advances and reducing the cost of key low carbon technologies more rapidly. Under these conditions, China could even further reduce energy consumption and GHG emissions. By 2050 carbon dioxide emissions decrease to 5.12 billion tons, lower than emissions in 2005.

If China achieves low carbon development in the process of industrialization and urbanization, its economic and social development would have the following characteristics:

(1) Industrial production is highly efficient, which means low emissions per unit of output.

(2) Energy conversion is highly efficient, which means low emissions per unit of electricity and distance travelled.

(3) Renewable energy sources and clean energy take a larger proportion of energy supply.

(4) High energy efficiency and low emissions in transportation.

(5) Domestic and commercial buil-dings are energy efficient.

(6) Reduced export of products with high energy consumption and/or emissions.

(7) Public transport replaces private transport; people use bicycles and feet more frequently.

(8) Industrial structure is optimized; low carbon industry has become a new focus of economic growth.

(9) Agriculture, forestry and other land uses are managed to encourage carbon sequestration.

3.6.2 Strategic Objectives for China's Development of Low Carbon Economy

To realize the vision, four dimensions should be considered. Firstly, energy saving and energy efficiency enhancement should be vigorously promoted, in order to significantly reduce energy consumption per unit of GDP. Secondly, the energy structure should be optimized, so that the carbon emissions per unit of energy consumption will drop remarkably. Thirdly, carbon productivity can be substantially improved. In addition to energy efficiency and adjustments to the energy structure, optimizing land use management and increasing rural carbon sinks will make an important contribution here. Finally, China can lead the R&D and commercial applications of the world's low carbon technology, making low carbon industry a new source of economic growth and a new edge in national competitiveness.

According to analysis undertaken by the Task Force, these strategic goals can be quantified as follows:

(1) On energy intensity, the goal is to reduce energy consumption per unit of GDP by 75%-85% by the year 2050, which means an annual drop of 3%-4%. The proportion of secondary industry should decline from the current nearly 50% to about 30% in 2050. China will strive to reach an internationally advanced level of physical energy efficiency by 2015 and reach an internationally leading level by 2030. Low carbon cities can be developed through a new model for urbanization and by establishing low carbon consumption patterns.

(2) Regarding energy structure optimization, China will strive to reduce carbon emissions factor per unit of energy consumption by 35%-50% by 2050. By 2030, more than half of the newly increased energy demand will be met by low carbon energies; by 2050, the main increased energy demand will be met by clean energy. CCS will be gradually promoted and used since 2030.

(3) On carbon intensity, the goal is to reduce carbon emissions per unit of GDP by 85%-90%. In other words, China's carbon productivity shall rise by 10 times, while carbon emissions per unit of GDP shall decrease by 4%-5% annually.

(4) On improving carbon sinks, China will add 500-600 Mt of CO_2 to carbon sinks each year via afforestation, land management and other measures.

3.6.3 Five Pillars for China's Low Carbon Development

3.6.3.1 *Pillar 1: Low Carbon Industrialization*

Optimizing and upgrading China's industrial structure. China will strive to increase the proportion of tertiary industry to make the modern service industry of knowledge, technology and management intensity. At the same time, across the industrial sectors, China will cultivate and develop emerging high-tech and energy-saving environmental industries. These will become two key drivers of economic growth.

In the medium and long term, the development and application of new technologies becomes the main focus of energy saving and emissions reduction efforts. The aim is to realize localized, independent innovation in key low carbon technologies.

Table 3-5 Projection of China's industrial structures (%) from scenario analysis

	2005	2010	2020	2030	2040	2050
Primary industry	12.4%	10.0%	6.7%	4.7%	3.6%	3.0%
Secondary industry	47.8%	49.0%	46.6%	42.9%	37.6%	33.4%
Tertiary industry	39.8%	40.9%	46.7%	52.5%	58.8%	63.7%

Table 3-6 Industrial efficiency standard - comparison to international level

	2000		2005		2007	
	China	BAT Int	China	BAT Int	China	BAT Int
Coal consumption for Power supply/gce/kWh	392	316	370	314	356	312
Steel /kgce/t	784	646	714	610	668	610
Aluminium/kWh	15 480	14 600	14 680	14 100	14 488	14 100
Cement /kgce/t	181	126	167	127	158	127
Ethylene/kgce/t	1 125	714	1 073	629	984	629

Source: Wang Qingyi, 2008 China Energy Data.

Developing a circular economy with a high level of resource utilization, low energy consumption and emissions. In the near term China should: vigorously conduct resource-saving actions, in particular for construction materials like steel and cement; promote advanced and applicable technologies, process engineering and equipment to improve the recycling rate of mining, ore dressing and smelting; enhance the management of energy, raw materials, water and other resources in key industries; for waste generation, strengthen pollution prevention and control of the whole process to realize "zero emission" of waste; on renewable resource generation, vigorously reclaim and recycle various waste resources to support the re-manufacture of obsolete machinery and electronic products, and establish trash collection and sorting systems; establish systems and approaches towards a comprehensive, integrated product policy; and establish solid waste collection and classification systems.

Promoting more application of advanced and proven technology, and improving energy efficiency. The current efficiency of physical energy in China is 20%-40% lower than that in developed countries. From a policy point of view, China must strengthen the monitoring of new projects and products, strictly implement and gradually improve energy efficiency standards; close down backward production facilities and encourage people to trade-in old low efficiency products for new ones; introduce advanced, efficient technology from foreign countries and proactively assimilate and adapt the introduced technologies. China should arrange R&D and demonstration of new generation of low carbon technology as soon as possible. Table 3-7 below is the blueprint for technological development in China.

Table 3-7 Blueprint of low carbon technology innovation and application

	Phase I (12th Five-Year Plan)	Phase II (2010-2030)	Phase III (2030-2050)
Large-scale application	Current, proven, and advanced energy efficiency technology, energy saving building, solar thermal applications, combined heat and power generation, heat pump, ultra-supercritical boiler, wind power, second generation nuclear power, hybrid electric vehicles	Third nuclear power, wind power, next generation solar PV and concentrated Solar Po-wer, electric vehicle, IGCC	Fourth nuclear power, CCS, solar electrical energy generation, second generation bio-fuel
R & D and promote commercialization	Third generation nuclear power, wind power advanced components, electric vehicle, IGCC, solar photovoltaic	Fourth generation nuclear power, CCS, second bio-fuel	Nucleosynthesis, third bio-fuel, advanced ma-terials
Basic research	Fourth generation nuclear power, CCS, solar thermal generating, second generation bio-fuel, advanced materials	Nucleosynthesis, third bio-fuel, advanced ma-terials	

Building a support system for low carbon technology innovation and strengthening the policy environment. Specific measures include: setting up the special institute for promoting low carbon technology innovation; building a common platform of technology innovation or establishing a new alliance for technology innovation; promoting group development of universities, R&D institutes and enterprise R&D, promoting information exchange. Furthermore, policy development for technology innovation should be sped up, including accelerating financial support for basic R & D; supporting demonstration by providing government funding, tax reduction, preferential loans and temporary prices; and to encourage commercialization, setting a price for carbon, solving the imbalance of new technology information, granting franchise rights, government procurement and improving regulatory standards and implementation.

3.6.3.2 *Pillar 2 : Building Low Carbon Cities-A New Approach to Urbanization in China*

According to the experiences of OECD and EU countries, the energy utilized in urban buildings and transport accounts for two thirds of final energy consumption. The share also grew rapidly in China from 35.9% in 2000 to 41.9% in 2007. Given the pace of urbanization, avoiding building sector lock-in is critical for China's low carbon development. China should optimize the spatial arrangement and improve the energy efficiency of basic infrastructure to develop a low carbon city as soon as possible. Specifically, it should:

Advocate compact urbanization. Research shows a negative correlation between the urban population density and urban energy consumption per capita. China should draw lessons from urbanization models from other countries and develop a compact urbanization pathway that is applicable to China's predicament, This could be achieved through keeping to a certain level of urban density; developing city groups and belts based on mega-cities and city centres; and identifying an urbanization strategy based on large-scale cities and the concept of compact cities.

Vigorously develop public transport system and optimize urban transportation structure. Specific policies include: 1) Promote urban public transport to increase the modal share of public transport and curb the growth rate of private cars. 2) Accelerate the development of intra-city railways and inter-city expressways to form three-dimensional transport systems; cities of population 2 million and above may consider intra-city railway transport. 3) Continuously elevate mandatory fuel efficiency standards of motor vehicles, and vigorously develop low carbon vehicles such as hybrid and electric vehicles.

Strengthen the promotion of energy-saving building technology and standards and develop low carbon urban buildings. Specific policies include: 1) Introduce building energy efficiency standards and labeling systems, improve building energy saving standards, and improve enforcement and monitoring; 2) Strengthen energy conservation initiatives for existing energy inefficient buildings, encourage energy service companies to improve existing public buildings; 3) Support R&D of important energy saving building materials and commercialization; 4) Pro-vide incentives to developers and consumers to invest in and purchase energy-conserving, low-carbon buildings, provide tax breaks to buyers of energy-conserving, low-carbon homes; 5) Demonstration of energy-conserving, low-carbon buildings.

Improve urban energy supply modes and increase the utilization of new energies. First, encourage the development of distributed energy sources such as combined heat and power (CHP) generation, which has an integrated energy efficiency of 70%-80%. CHP has been an important measure for the Nordic countries to improve energy efficiency. However, in northern cities of China, CHP generation accounts only about 20% among urban heating. Combined heat, power, and cooling (CHPC) should be vigorously promoted in northern China to increase the urban energy supply efficiency. Second, advance the reform in district heating system, implement household based heating metering to provide incentives for personal energy saving. Third, improve the rate of electrification and the rate of urban gas utilization to increase the proportion of high quality clean energies.

Strengthen urban energy management and carry out energy saving product certification. The electric power consumption of large scale public buildings is equal to the total electric power consumption of urban residential buildings, but is only 5% of the total building area; if the refrigerating appliances, electric machines and electric equipment in those large scale public buildings are revamped, 30%-50% energy can be saved. There should be a supervisory system for energy consumption of large commercial buildings, energy auditing and reform demonstration and energy saving operation management demonstration. China can enlarge the range of certified energy saving products, and explore the establishment of an internationally recognized system for certified products as well as improving consumer awareness of certified products.

3.6.3.3 *Pillar 3: Optimizing China's Energy Structure, and Developing More Low Carbon Energy*

About 90% of greenhouse gas emissions in China come from the burning of fossil fuels. Therefore, optimizing the energy structure and developing more low carbon energy are highly important - helping to reduce the GHG emissions per unit of energy consumption. Under the low carbon scenario, the energy sector will reduce CO_2 emissions by in 2020, 2030 and 2050 by 380 Mt, 830 Mt and 1.59 Gt respectively, contributing a share of 20.3%, 27.3% and 40.9% in terms of total reductions. With the deployment of CCS, further reductions from the energy can be achieved: an additional 100 and 380 Mt of CO_2 reduction in 2030 and 2050 respectively.

To realize this potential, it is critical to gradually reduce the share of coal in energy consumption, speed up the development of natural gas and guarantee the security of oil supplies, and to actively develop the utilization of hydropower, nuclear power and renewable energy sources. By 2020, these alternative energy sources will be increased significantly. By 2030, clean energy can meet more than half requirements of new added energy. In 2050, clean energy can meet most of requirements of new added energy. At the same time, an infrastructure system suited to the development of renewable energy sources such as a smart electric grid will be built. The specific approaches are as follows:

Intensive and effective use of coal. The first step is to control the rate of growth of coal. By 2020, coal growth will have reached its peak and the share of coal in energy consumption will be reduced from about 70% at present to about 55%, then to below 50% in 2030, and to about 33% in 2050. Secondly, advanced coal-fired power generation technology will increase efficiency. In 2020, the aim should be to reduce coal consumption in power generation to 320 g/kWh; new thermal power units will mainly adopt ultra-supercritical generating technology and IGCC. By 2030, with a reduction of coal consumption of power generation to 290 g/kWh, the proportion of IGCC plant in additional plant will increase to 50%. By 2050, coal consumption in power generation will be reduced to 270 g/kWh. Thirdly, poly-generation technology such as combined heat and power and cold cogeneration will be vigorously promoted to increase comprehensive utility efficiency. In 2020 and after 2030, the goal is to increase the efficiency of transforming coal to electricity from the current level of 55% to 65% and 80% respectively.

Switching to lower carbon fuels. Great efforts should be made to develop energy-saving and low carbon transport such as electric vehicles; sustainable bio-fuels and the development of public transport. China should strive to limit the amount of petroleum consumption to within 550 Mt in 2020 and within 700 Mt in 2030. By expanding the development and use of domestic natural resources and by importing natural gas and LNG from surrounding countries, natural gas can replace a significant amount of coal and petroleum in China. By 2020, 2030 and 2050, the goal is for the proportion of natural gas consumption in primary energy consumption to reach about 8%, 12% and 14% respectively.

Large-scale deployment of low carbon energy. China should speed up the construction of hydropower, nuclear power, and wind-power and promote commercialization of solar power by 2020. Low carbon power generation capacity will reach about 550 million kW, accounting for 35% of total installed capacity. Low carbon energy utilization will reach 800-900 Mt standard coal equivalent, equivalent to 20% of energy consumption. 50% of installed capacity will be low carbon by 2030 and, by 2050, all new installed capacity will be low carbon. Globally, the proportion of low carbon energy supplies will exceed one third by this time and China's energy will be cleaner and more diverse: coal 33%, oil/gas 33% and low carbon energy sources 33%.

Table 3-8 International comparison of China's low carbon energy targets for 2020

	Proportion of low carbon energy in energy consumption 2020	Proportion of low carbon power generation in total installed capacity
China	20%	35%
America	20% renewable energy plus approximately 15% nuclear	N/A
United Kingdom	15% renewable energy plus approximately 5%-10% nuclear electricity	30-50 GW of renewables, 1-5 GW of nuclear from a total installed capacity of 100-120 GW
European Union	20% renewable energy and approximately 30% nuclear electricity	Approximately 350-400 GW of renewables, 100 GW of nuclear from a total installed capacity of 1000 GW

* In North America and Europe, there are no targets for the use of energy, therefore the figures are based on trend analyses.

Building a strong, smart grid. As the proportion of low carbon energy grows, additional demands will be placed on infrastructure and grid management. In response, China should construct a strong grid framework and enable transmission of electricity from new sources such as wind and nuclear power. Secondly, the ability of the distribution network to manage variability of supply and demand should be improved, and supported with demand side management, including in future from electric vehicles. Local renewable energy should be promoted.

Implementing carbon capture and storage in stages and in a focused manner. Before 2020, China should focus on research and development and experiment and demonstration, and can also undertake some low cost carbon capture and storage by integrating with petroleum exploitation. Later, China's IGCC plant and some industrial processes are expected to employ CCS.

3.6.3.4 *Pillar 4: Sustainable Consumption Patterns*

Low carbon consumption is an important part of the low carbon economic system. Japan and the United States are broadly at the same level of development, yet Japanese energy demand is 4 tons of standard oil equivalent per capita, while the US is 10 tons per capita. Analysis shows that 70% of the Japan-USA energy consumption gap lies in different patterns of consumption. Low carbon consumption—an extension of the sustainable consumption concept—is described in China by the "6R" principles:

(1) Reduce: save resources, reduce pollution;

(2) Re-evaluate: green consumption, environmental protection;

(3) Reuse: reuse, multiple use;

(4) Recycle: garbage classification, recycling;

(5) Rescue: rescue species, protect nature;

(6) Re-calculate: consumers consider the "carbon footprint".

Consumers should be encouraged to choose products and lifestyles with small carbon footprints. To build a low carbon consumption pattern, several aspects should be promoted—including through culture, policy, concept, principle, habit, behavior and evaluation. The details are as follows:

Strengthening institutional framework: The "Sustainable Consumption Act" and "Green Procurement Act" should be enacted in the near term. Accelerate research on carbon emission standards on the consumption side. In the medium and long term, "Solid Waste Disposal Act" should be stipulated and consumption side carbon emission standard should be enacted and improved.

Increasing tax and fiscal stimuli: Fiscal support for consumers of green products will be increased in the short term. Subsidies will be provided for products that use electricity efficiently, new energy automobiles, etc. Green consumption credit will be studied. In the medium and medium to long term, carbon emission tax and environmental tax will be designed and implemented, and the proportion of green consumption credit will be increased. In the long term, combination with wider tax reform is necessary to realize transition to a nationwide green tax system.

Intensifying public education: A national public awareness plan and education activities will be explored in the near term, which includes community and company awareness raising and school education. Family based education will be encouraged, and citizen awareness of green consumption will be improved. In the medium and long term, a national Merit Award Scheme will be implemented (awards such as "Green Enterprise", "Green Community", "Green Household" and "Green School"). The publicity should cover both urban and rural areas, reaching all citizens. China will develop a social norm of low carbon consumption behavior.

Establishing a system for green information sharing and monitoring mechanism: in the near term China will establish a publicity information system related to law, standards, administrative proceedings, technology and products. In the medium and long term, it should promote a "carbon footprint" calculating formula for the whole society, designed and suited to China's conditions. In the long term, using information technology, we will build real time information and monitoring mechanisms to reveal carbon emissions.

3.6.3.5 *Pillar 5: Land Use Management and Carbon Sinks*

In recent years, the amount of carbon stored in China's terrestrial ecosystems has increased by 190-260 Mt annually. This is equivalent to around 28%-37% of the total amount of carbon dioxide emitted by industry in China. Carbon sequestration is therefore an important dimension to the low carbon economy. Three key land use types are forests, arable land and grassland. In each case, three dimensions should be considered: increasing the amount of carbon stored, protecting existing carbon storage; and offsetting emissions from other sectors.

Increasing carbon sequestration in forests. Forests are an important store of carbon in China. In recent years the amount has grown by 150 Mt of carbon annually. In order to increase sequestration in forests, China should take the following measures: recovery of degraded ecosystems, establishing an agriculture-forestry system, strengthening forest management to improve the production of forest, prolonging rotation time; reducing deforestation, improving logging regulations, improving logging utilization efficiency, effectively controlling forest disasters (forest fires, plant diseases and insect pests); using marsh gas instead of fuel wood and durable lignin products instead of energy intensive materials, recycling logging residue and further processing of wood products via recycling.

Increasing carbon sequestration in arable land. Arable soil makes an important contribution to the total carbon sequestration in terrestrial ecosystems as well as the most active sink. The organic carbon content of China's arable land is relatively low in general, about 0.8%-1.2% in South, 0.5%-0.8% in North China, 1.0%-1.5% in northeast and below 0.5% in most areas of the northwest. The organic carbon content of most European arable lands exceeds 1.5% and in the US it reaches 2.5% to 4%. Therefore, China has a great potential to increase the carbon storage of arable land.

Retaining and increasing carbon sequestration in grassland. The key to retaining and increasing carbon sequestration in grassland lies in preventing degeneration and exploitation. Specific measures include reducing grazing density, enclosing grassland, planting new areas and restoration of degraded grassland. In addition, grassland sequestration can be improved by animal husbandry management approaches such as fence breeding, rotational grazing and by introducing different grass varieties.

Table 3-9 Main measures to increase carbon sequestration

Land type	Carbon sequestration	Retaining carbon stocks	Substitution
Forest	Forestation and reforestation Forest fertilizer Prolong rotation time	Reduce cutting Prevent intensive agriculture and grazing and disforestation Fire management Plant diseases and insect pests management	Other biological energy source instead of fuel wood further processing of wood products Prolong useful time of wood product Recycling of wood product and paper Develop replacement industry
Arable land	Returning strew to arable land Fertilizer management Zero tillage Returning land for farming to forestry and grassland Recovery of degenerated soil Using organic fertilizer	Prevention soil degradation Fertilizing management Water management Vegetation conservation	Develop bio-fuel Develop replacement industry
Grassland	Artificial forest, plant grass Recovery of grassland Fertilizing and irrigating gra-ssland	Prevention overgrazing Closing grassland	Taking reasonable animal husbandry management measures Develop replacement industry

3.7 Policy Recommendations

This report offers eight specific recommendations:

(1) Start the development of a low carbon economy as early as possible, incorporate the concept into the 12th Five-Year Plan, and introduce CO_2 emission intensity as a binding target in the Plan.

(2) Reform energy pricing to reflect market demand and supply, resource shortages and environmental costs.

(3) Build a green tax system and increase fiscal expenditure for the development of the low carbon economy.

(4) Using market mechanisms to promote low carbon development.

(5) Aggressive support for technological innovation, diffusion and international cooperation.

(6) Improve legislation and regulations, and strengthen enforcement of laws and standards.

(7) Improving the quality of energy and carbon statistics and measurement.

(8) Include the requirements of the

low carbon economy in urban planning, and run demonstration projects.

3.7.1 Start the Development of A Low Carbon Economy as Early as Possible, Incorporate the Concept Into the 12th Five-Year Plan, and Introduce CO_2 Emission Intensity as A Binding Target in the Plan

Earlier transition to a low carbon economy is better than a later transition. Strategic deployment of low carbon development should be launched as soon as possible. The first recommendation of the Task Force is the inclusion of Low Carbon Economy as a key principal in the 12th Five-Year Socio-Economic Development Plan.

(1) In the 12th Five-Year Plan, set targets for reduction of carbon emissions per GDP unit. According to preliminary calculations, during the 12th Five-Year Plan period energy consumption per unit of GDP could be reduced by about 15%-17% through energy saving measures, while the development of new energy sources could reduce carbon emissions per unit of GDP by 5%-6%; thus energy-saving measures and new energy sources combined could reduce carbon emissions per unit of GDP by 20%-23% or greater. Therefore we suggest that a 20% reduction in carbon emissions per unit of GDP is set as one of the binding targets of the 12th Five-Year Plan.

(2) In the 12th Five-Year Plan or its programmes for implementation, identify the main methods and sectors through which the low carbon economy will be developed. At the same time, disaggregate low carbon economy targets and tasks to regional and sectoral level, and increase enthusiasm for development of new energy.

(3) Include low carbon industrial development and technological innovation as important parts of the 12th Five-Year Plan's programme for structural adjustments and technological innovation. Promote low carbon innovation and industrial innovation via project construction, industrial development, technological innovation and systems and mechanisms.

3.7.2 Reform Energy Pricing to Reflect Market Demand and Supply, Resource Shortages and Environmental Costs

Reform of energy pricing is a key lever for meeting low carbon objectives. Three areas have been identified: First, gradually realise competitive price setting in the energy sector, with clear supervision of natural monopolies. Second, reflect the external costs and resource consumption of energy development, processing and use in the price of energy products. Third, cross-subsidies should be made transparent and later be eliminated, with any subsidies for energy consumption being provided from public finances.

Specifically:

Coal: The cost calculation policy should be reformed, with fees for use of coal reserves, safe production, environmental restoration, transfer of coal mines and employee health costs fed into the cost of coal, thus internalizing external costs and gradually realizing coal pricing which reflects total costs.

Electricity: The price of conventionally generated electricity (such as from coal) at the point of supply to the grid should be gradually allowed to be set by the market. The cost of distributed electricity should gradually become independent. The issue of cross-subsidy of retail electricity costs should be gradually resolved, in order to provide a foundation for bilateral electricity trading. In the near future the extra costs associated with renewable and clean energy will need to be promptly apportioned as these sources expand.

Oil and natural gas: Further reform the pricing of oil products. Recently the government has set retail costs in accordance with international prices. In the mid- to long-term, the wholesale markets should be liberalised in order to create a competitively priced market. The factory-gate cost of natural gas should gradually shift from government-set to market-set, while ach-ieving a more rational price via adjustment of resource taxes.

District heating: Centralised heating provision and more efficient combined heating-cooling projects should be promoted and encouraged. Heating and cooling use should be measured by household, and pricing reformed. Reform of heating subsidies should take place as soon as possible, with hidden subsidies becoming visible, and a “pay for what you use” system implemented. Heating should become a monetised commodity, with a rational price setting mechanism.

3.7.3 Build a Green tax System and Increase Fiscal Expenditure for the Development of the Low Carbon Economy

Incorporate costs of environmental damage and resources depletion in energy pricing through adjusting taxes and fees during early resource exploration. This includes: raising fees made for release of pollution; increasing the scope of collection of fees; gradually replacing pollution fees with pollution taxes; and ensuring the “polluter pays”. Resource taxes should be collected as a percentage of the market price—not as a fixed amount for a given quantity of the resource. Export tax rebates for energy-intensive products should be reduced, or extra tariffs could even be imposed, in order to reduce the export of energy in this form.

Guide consumption and behavior through an energy tax to increase costs. In China, petrol and diesel already incur taxes of 1 RMB and 0.8 RMB per litre respectively. We suggest that at an appropriate time this is increased, and other energy taxes introduced.

Preparations for a carbon tax should start soon in order to send a stable price signal for low carbon innovation and large-scale commercialisation. It should not be set too high at the onset, but as the economy further develops and societal acceptance deepens it should be adjusted upwards.

Strengthen fiscal support for energy saving, renewable energy and low carbon technological innovation, including:

(1) Energy-saving: Regular budgets should include an outlay for energy-saving; energy-saving products and companies should receive tax breaks and direct subsidies; and energy-saving should be given greater weight in government procurement.

(2) Promotion of renewable energy: Further reduce value-added tax for renewable energy; implement business tax reductions for the sector; reduce import tariffs and value-added taxes on renewable energy equipment; offer subsidies for households purchasing solar roofing or small wind power generators.

(3) Promote technological innovation: Increase investment in low carbon research and development; provide tax breaks for enterprises carrying out low carbon research-and-development and technological innovation.

(4) Increase funding channels: In the near future, existing government funds should be reorganized and standardised, with orientation shifting from construction funds to funds for sustainable development of energy, focusing on energy-saving, renewable energy development and technological innovation. In the mid-to long-term, part of the revenue from additional fuel, energy and carbon taxes can be allocated to sustainable development funds.

3.7.4 Using Market Mechanisms to Promote Low Carbon Development

In addition to using carbon tax to determine the price for carbon, China should use market mechanisms to encourage low cost carbon abatement.

In the long term China should establish a carbon trading scheme. In the near term, a voluntary carbon trading scheme would help build capacity and accounting systems. Appropriate subsidies or loan support should be used to encourage firms to carry out voluntary emissions reductions, with participating firms proposing emissions reduction against their baseline emissions, with the government organising emissions trading among the companies. Companies could register at the existing environmental asset exchanges, allowing the trading, settlement and auditing platforms there to be used, establishing emissions auditing, reporting and operating methods. At the same time, third-party certification agencies would confirm emissions baselines and reductions, with confirmed surplus emissions rights and those already confirmed by international authorities traded at the exchange.

Within a global framework to reduce carbon emissions, China should make use of international financing mechanisms. This is not only about attracting carbon finance but making use of the mechanisms like the Clean Development Mechanism (CDM) to encourage the deployment of energy savings technologies. In addition, China can gradually introduce a carbon banking system, establishing carbon accounts for regional and major enterprises.

3.7.5 Aggressive Support for Technological Innovation, Diffusion and International Cooperation

(1) Strengthen the construction of public research-and-development institutions and testing platforms. These will have a hugely important role in systems supporting technological innovation. They will be particularly crucial in the research and development of framework and common technology, promoting commercialisation and carrying out major government research programs. We propose establishing a new, open national energy research institution. This will have not just the ability and facilities to carry out research; it will also be able to carry out pilot projects, hence covering basic research, development, trials and testing and certification. The institution will be open to businesses, universities and other research institutions, and will carry out research and development of basic and common technology, experiments, testing and certification. This will resolve the lack of adequate common technology in the new energy sector.

(2) Further improve policies encouraging technological innovation. First, continue to implement the extremely important policies on self-reliance programs and requirements for equipment in major projects to be sourced domestically, to promote localisation. Second, as soon as possible, implement detailed rules for implementation of the plans for adjustment and reinvigoration of the equipment manufacturing industry, establish and use risk compensation mechanisms for new domestically produced equipment, and encourage insurance companies to insure these projects. Implement preferential tax policies for technological innovation. Also, fund and encourage firms to form alliances to research common technologies and the domestic production of key components.

(3) Seek technology cooperation opportunities along the innovation chain from research to piloting and finally large scale commercialization. This includes support for large-scale demonstration, as well as tax incentives and subsidies for purchases of low carbon products.

3.7.6 Improve Legislation and Regulations, and Strengthen Enforcement of

Laws and Standards

(1) Improve legislation of energy production and transfer, energy-saving, solid waste and forestry sectors to help reduce carbon emissions. Specifically: As quickly as possible produce and implement the *Energy Law*, and make revisions to the *Coal Law, Electricity Law, Energy Saving Law* and *Renewable Energy Law* that will further encourage the development and use of clean, low carbon energy sources. Produce and improve regulations on implementation of the *Law on Promotion of the Circular Economy*. Establish systems of regulations based on the *Agriculture Law*, *Forestry Law*, *Grasslands Law* and *Land Management Law* that will improve agricultural and forestry production, and increase the carbon storage of their ecosystems. Revise regulations on protection of forests, farmland and grasslands, and strictly control development in environmentally vulnerable regions. Strengthen policies to prevent the destruction of natural forest, grasslands and farmland.

(2) Draft and improve energy standards. Improve design norms for energy-saving in the main energy-consuming industries and building energy saving standards, and improve standards for controlling heating and cooling of buildings. Draft energy-efficiency standards for energy-consuming industrial equipment such as fans, pumps, transformers and engines; as well as for domestic appliances, lighting, office equipment and vehicles. China could also consider adopting a system like Japan's Top Runner programme – using the most efficient model on the market and then stipulating that the efficiency of this top runner model should become the standard within a certain number of years.

(3) Strengthen enforcement of energy-efficiency standards. Energy-efficiency standards should be included in the evaluation and auditing of industrial projects. New or expanded fixed-assets projects should be subject to carbon-emission reduction evaluations and auditing, with approval refused for those that do not carry out, or fail, evaluations—thus reducing emissions at source. Energy efficiency tests should be carried out for all major public buildings and commercial residential housing, with completion procedures denied to those failing to pass.

(4) Improve "carbon footprint" labeling and certification. Gradually implement a "carbon footprint" labeling system, and steadily expand the scope of the scheme. Increase public awareness to shift consumption to low carbon products and therefore encourage firms to develop those products.

3.7.7 Improving the Quality of Energy and Carbon Statistics and Measurement

(1) Improve energy statistics and systems. Improve energy survey and auditing methods to increase the scientific nature of statistics gathered. Strengthen and standardise energy statistics activity at the grassroots level, to increase accuracy. Also, establish statistics agencies below the city level to strengthen the foundation of statistics gathering.

(2) Establish a carbon footprint measuring system. The first step is, on the foundation of energy-saving and emissions-reduction work, verify the emissions of energy and emission intensive products and equipment in key industries. Encourage other businesses to calculate their greenhouse-gas emissions according to international standards—either doing so themselves, or employing a third party to do so. This information will inform clear carbon emissions standards and carbon emissions reduction targets for both industries and products. At the same time, the authorities should organize experts to research methods of calculating carbon footprints and labeling standards. A supervision and certification authority should be formed. The measuring of carbon footprints should be included in the Statistics Law. Appropriate monitoring and certification bodies should be set up to determine the criteria as well as to encourage the acquisition of metering equipment, training of personnel, and monitoring mechanisms. In future, the Statistics Bureau should begin to collect carbon emissions data and make relevant data publicly available on a regular basis. In addition, industrial associations should be encouraged to monitor the rate of technology innovation, and use of lower carbon technologies.

3.7.8 Include the Requirements of the Low Carbon Economy in Urban Planning, and Run Demonstration Projects

(1) Include requirements for “low emissions, high efficiency” in urban planning and rural development planning. Propose and improve low carbon urban planning strategy, exploring low carbon urban planning in terms of urban zoning, industrial structure, public transport and land use.

(2) Start a batch of low carbon urban development projects in suitable cities in the near future. Survey and analyse energy use of aspects such as transport and buildings; then use economic incentives, policy and systems, technological innovation and application, and public funding to achieve energy-savings, ultimately reducing urban carbon emissions. In the near term, new cities should include low or zero-carbon communities, industrial zones or ecological cities. Common standards for measuring low carbon development should be developed and agreed, reflecting the diversity of development characteristics

(3) Low carbon development should

be taken into consideration when choosing winners of national ecological, environmental and liveable city competitions. Change the current situation in which environmental cities are environment-friendly in some aspects, but overall still have high carbon emissions.

(4) The rural dimensions of China's future low carbon economy should not be overlooked. Land use management and change has a significant effect on the amount of carbon stored in terrestrial ecosystems. Sustainable approaches to agriculture, forestry and bioenergy can make a significant impact on greenhouse gas emissions, creating important opportunities for carbon finance in rural areas. Urban-rural economic and transport linkages affect the pattern of energy and greenhouse gas emissions, and many industries are located in rural areas. China is already seeking to achieve balanced urban-rural development. The low carbon economy can make a major contribution to this objective.

Chapter 4 Economic Instruments for Energy Efficiency and the Environment

4.1 Preface

4.1.1 Interaction between Energy and Environment in China

While the fast economic growth over the past 30 years in China has significantly increased living standards, this has also brought huge pressures on the environment. Despite improvements in the environmental conditions of many cities and regions across the country, the deteriorating trends in the nation's environmental quality has not yet been curbed, and many citizens are subject to poor quality water, air, and soil as well as a more fragile ecological system. Risks of environmental accidents are mounting due to a range of environmental problems, including accumulated pollution from industrial and civil sources as well as emerging new problems and pressing global environmental challenges. Such risks have become a bottleneck on China's sustainable economic growth and social progress. The causes for China's environmental problems are complicated, relating to fragile natural conditions, the boom of heavy and chemical industry, extensive economic growth, energy consumption patterns, and poor environmental management. Among these causes, the rapid growth of total energy consumption, coal-centered energy structures, and low energy-efficiency largely leads to China's serious environmental pollution. (Figure 4-1)

Total energy consumption amounted to 2.85 billion tons of coal equivalent (tce) in 2008, while primary energy production was 2.6 billion tons—both doubled of the year 2000 figures. The explosive growth of total energy production and consumption directly caused massive emission of pollutants, such as SO_2, smog, dust, NO_x and CO_2.

In terms of energy structure, coal remains China's main component of energy supply and consumption, accounting for 70% of total primary energy, which is 40% higher than the global average. 80% of the country's electricity is generated by thermal power. Coal is by far the most popular fuel in use. Such a coal-based energy structure has resulted in SO_2-centered pollution in China.

In terms of energy efficiency, although remarkable progress has been achieved over the past 20 years-with a 4% average annual rate of energy conservation, the comprehensive efficiency of energy consumption in China is a mere 30%-about 10% lower than in the developed world. Moreover, China's economic growth has been increasingly relying on the volume of energy consumption since 2002. In 2002, 2003, and 2004, the elasticity of energy consumption in China was 0.66, 1.53 and 1.59 respectively. Fortunately, the figure had dropped to 0.97 in 2005 and 0.7 in 2007, but is still 7 times that of Japan. While the energy intensity of China has decreased from 11.9 tce for 10 000 US Dollars of GDP in 2005 to 10.48 tce in 2007, it is still 5-7 times that of the developed world. Needless to say, China's low energy efficiency is a major feature of its extensive economic growth pattern, and results in intensive pollution. It is estimated that China's SO_2 and NO_x emission per unit of GDP is 8-9 times that of OECD countries.

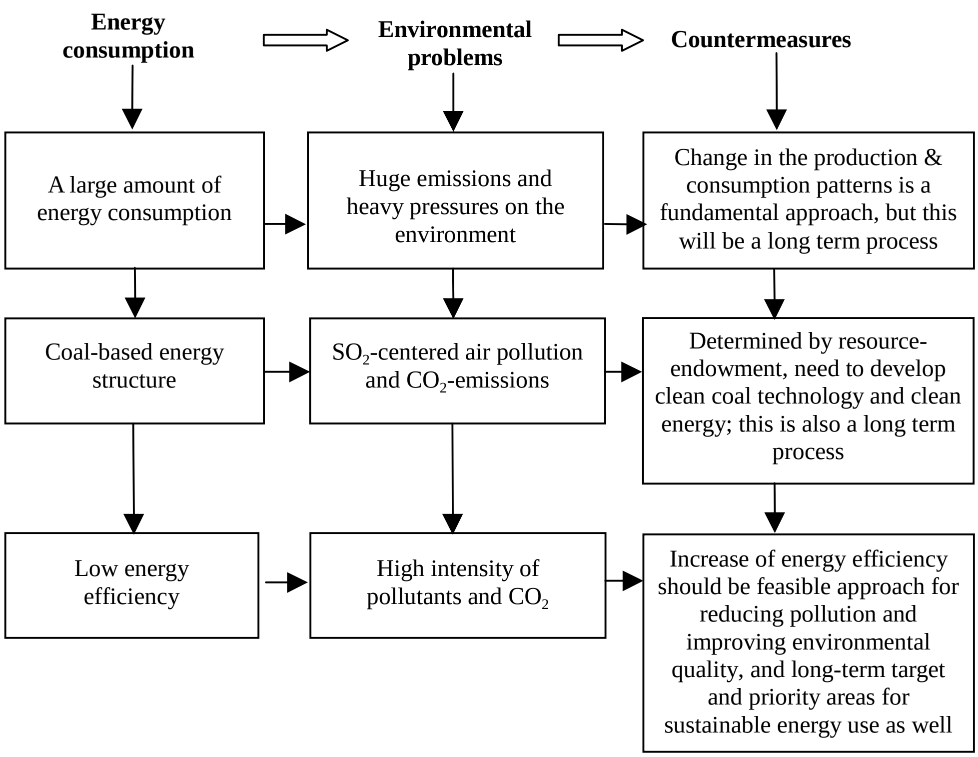

Figure 4-1 Interaction between energy and environment

Reducing total energy consumption, improving energy structure, and raising energy efficiency are three approaches that can help resolve China's environmental problems and balance economic growth and environmental impact. But China is currently at the middle stage of industrialization, with a relatively low level of economic development and rapid urbanization. Energy demand will undoubtedly continue to grow for a very long period of time still to come. A fundamental change in the country's economic development pattern is a prerequisite for decoupling energy demand and economic growth. Since China's natural endowment has resulted in a coal-based energy structure, improving such a structure requires clean coal technology and the development of renewable energy, such as wind energy, hydropower, solar energy, and bio-energy. Obviously, changing the country's economic development pattern or energy restructuring will take a long time. Raising energy efficiency is, comparatively, the most feasible solution to reduce the intensity of pollution, and should therefore be the long-term target and a priority area for sustainable energy use.

4.1.2 Challenges in Energy and Environment Management and New Initiatives in Economic Instruments

China has long relied on a command-and-control approach for managing energy and the environment. However, such an approach is confronted with many challenges as a market economy takes roots and keeps developing in China, bringing with it high administrative costs, non-lasting effects, ineffective implementation, and impaired social justice. To meet these challenges, the Chinese government has explicitly voiced the need to establish a system of economic instruments. During the 6th National Conference on Environmental Protection in 2006, Premier Wen Jiabao pointed out that China should no longer only rely on the command-and-control approach but rather, take an integrated approach including legal, economic, technical, and necessary administrative measures to protect the environment and improve environmental management by following economic and natural rules. The report of the 17th Party Congress of the Communist Party of China (CPC) in 2007 stated that reform of fiscal and taxation policies should help to promote sustainable development by incorporating environmental considerations. The Comprehensive Work Plan on Energy Conservation and Pollution Abatement issued by the State Council in 2007 has as well detailed the requirements for market-based instruments (MBI). Raising energy efficiency and developing economic instruments constitute pressing objective demands and a strong desire on the part of the Chinese government.

Drawing upon the practices and experiences over the past decade, since 2005, the Chinese government has made great efforts in developing environmentally-sound economic instruments, which target different stages of the whole spectrum of economic activities (Figure 4-2).

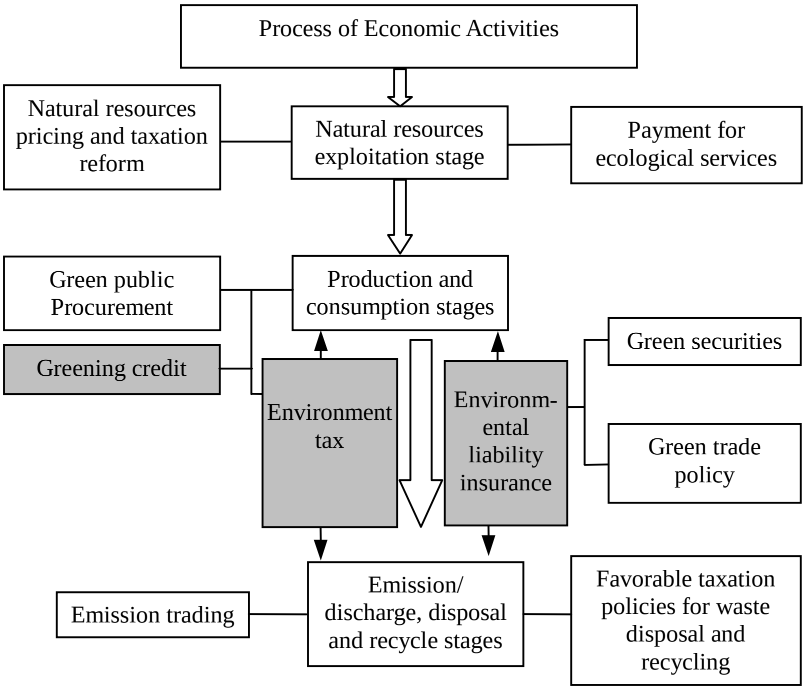

Figure 4-2 The system of environmental economic instruments in China

As shown in Figure 4-2, China has developed a clear structure of environmental economic instruments. Resources and energy pricing and taxation policies are following a fast track of reform with more relevant support from available research work. Discharge/emission fees and preferential taxation policies for waste recycling have been in place for many years and are being continuously improved. Other new instruments, such as ecological compensation (payment for ecological services), emission trading, green trade policies, green public procurement, environmental performance evaluation and information disclosure of stock market listed companies, have started pilot programs or even nationwide implementation. In contrast, instruments such as environmental taxation, greening credit and environmental liability insurance, are in the early stages of policymaking and implementation and relevant studies are too weak to provide support for policymaking.

4.1.3 Research Targets and Methodologies

In the light of the above-mentioned situation, CCICED set up the Task Force on Economic Instruments for Energy Efficiency and the Environment in 2008. The overall goal of the Task Force is to make strategic and policy recommendations to the Chinese government on specific economic instruments based on the research, with the target of raising energy efficiency and improving environmental management. The Task Force is comprised of two research groups. The first task of Research Group 1 was to study the system of environmental and energy-related taxation and develop a roadmap for strengthening the environmental taxation system that includes taxation system, which is an effective measure to increase energy prices, and provide incentives to raise energy productivity and reduce pollution intensity. Considering the pressing needs for raising energy efficiency, responding to climate change, reducing pollution and developing a low carbon economy, the second task of Research Group 1 is to design a scheme for a carbon tax in China. Bearing in mind the need to improve China's environmental management and existing economic instruments, the scope of Research Group 2 focuses on a green credit policy and on an environmental pollution liability insurance system. Green credit policy reforms traditional credit policy by incorporating environmental considerations so that, on the one hand, restrictions may be imposed upon the financing of companies who are non-compliant with environmental requirements as well as energy inefficient, energy-and-pollution intensive and natural resource-based industrial sectors. On the other hand, companies with desirable environmental performance and environment-friendly industries may enjoy preferential financing policies. Such incentives will help regulate the environmental behavior of enterprises and reduce credit risks for financial institutions. China is currently faced with frequent environmental pollution accidents, while the necessary liability and compensation schemes are not in place. Therefore it is a significant step to carry out studies on the environmental pollution liability insurance system (Figure 4-3).

The Task Force has made great efforts to achieve the set targets, such as: conducting desk studies on the relevant current situation in and challenges to China and on international experiences and the implications within the context of economic instruments for environmental and energy efficiency management; organizing a study tour in Germany, Sweden and localities within China on environmental and energy taxation, green credit, and environmental liability insurance; holding various meetings like a kick-off workshop, four Task Force working meetings and more than ten internal seminars. Based on the results of these efforts, the Task Force has reached significant conclusions and has formulated policy recommendations to the Chinese Government in areas of energy productivity, environmental taxation, green credit policy, and environmental liability insurance (Figure 4-4).

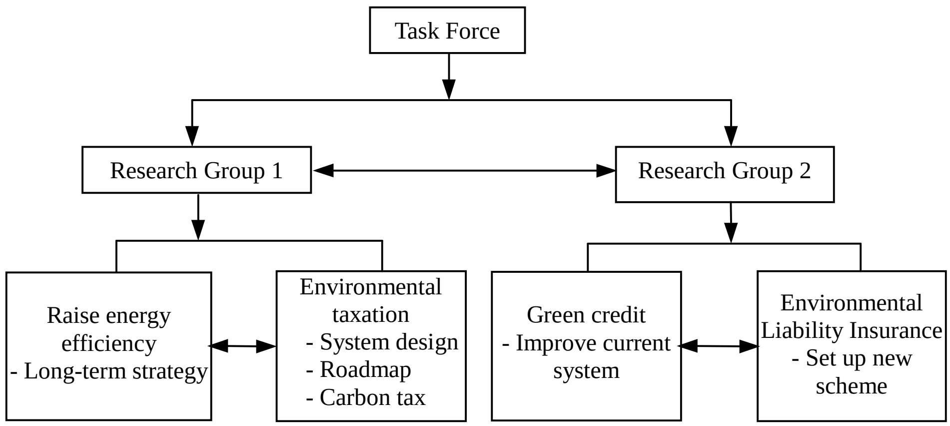

Figure 4-3 Scope and research tasks of the Task Force

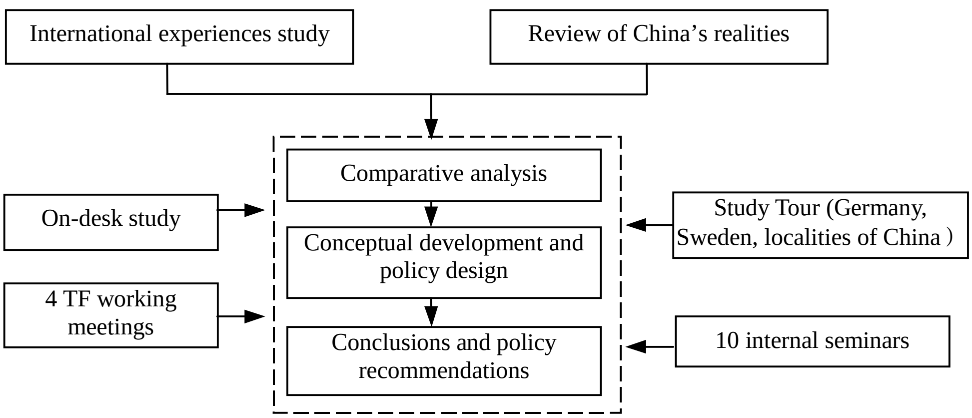

Figure 4-4 Methodology of the Task Force study

4.2 Environmental Taxation and Energy Efficiency

4.2.1 Current Situation and Challenges in China

As explained earlier, improved energy efficiency is the most feasible solution to the problems of intensive pollution, environmental degradation and the negative impacts of climate change, as well as the long-term target and priority area for sustainable energy use. In fact, the Chinese government has attached great importance to raising energy efficiency and has set detailed and stringent targets in this regard. According to the 11th Five-Year Plan, China should reduce its energy intensity per 10,000 RMB of GDP from 1.22 tce in 2005 to lower than 1 tce by 2010, or a 20% drop; and decrease water consumption per unit of industrial added value by 30% and SO_2-emission and COD-discharge by 10%.

Taking a holistic view of energy and economic systems, the core objective of higher energy efficiency is to increase energy productivity. Energy productivity can be defined as the quantity and quality of goods and services produced by input of a given composition of energy; this is relevant not only to the energy efficiency of one of the links, but also to the whole chain of economic activities. In other words, the concept of energy productivity has the connotation of energy optimization and high level of efficiency of the economic system, and thus may help gain a complete picture of the relationship between energy consumption and economic expansion. There are two ways to demonstrate an increase in energy productivity; providing the same quantity and quality of goods and services with less energy consumption, or generating more and better economic output with unchanged energy inputs. Therefore the key to raising energy productivity is to increase efficiency and optimize the entire energy and economic system.

As proven by international experiences, energy and environment related taxes serve as an effective tool for inducing higher energy prices, which further help raise energy productivity. Therefore such taxes may serve as a long-term incentive that helps curb energy demand, promote technological innovation and raise energy efficiency. The present reality in China is that the dominant policy and related measures targeting the raising of energy productivity remain administrative regulations, such as energy development plans, energy sector planning and policies, catalogues for industrial restructuring, laws and regulations on energy efficiency and pollution reduction, etc. Remarkable progress has been made in pricing reform for electricity, coal, natural gas, crude oil, refined oil and renewable energy, as well as resource taxes, preferential policies for energy conservation and pollution reductions. However, such measures could not serve as long-term incentives and there is much room for improvement. In particular, the most effective tools, namely energy and environment related taxes are still in the pipeline or even non-existent.

In light of the direction for fiscal and taxation reform in China, it may be an irreversible trend to introduce environmental tax. The “Circular of Comprehensive Work Plan on Energy Efficiency and Pollution Reduction of the State Council” issued in June 2007 stated that taxation policies that help promote energy efficiency and pollution reduction, including the levying of environmental tax, should be introduced and improved. The opinions on deepening economic institutional reform by the central government in 2008 and 2009 also pointed out that studies on environmental taxes should be carried out.

China has not yet introduced environment-targeted taxes such as an energy tax, sulphur tax or carbon tax. Therefore the pricing leverage is not effective in improving energy efficiency and pollution treatment. Current environment related taxes in China, such as consumption tax and resource tax, were not specifically geared to meet environmental challenges, but rather to regulate consumption behavior and resource use. One can tell that there is not a complete environment-related tax framework in place in China, and this partly accounts for the impotency of the current tax system to address energy and environmental issues. In addition, the fiscal difficulties in the localities of China are partially attributed to the tax sharing system, which somewhat leads to local protectionism of polluting companies and environmental non-compliance.

Therefore China has an urgent task to develop a roadmap for the introduction of a comprehensive environmental tax system, so as to establish long-term incentives for raising energy efficiency and improving the environment.

4.2.2 International Experiences and Implications for China

In the early 1990s, some OECD and EU countries started comprehensive green tax reforms in a phased manner. These policies comprised three complementary approaches: 1) streamlining or abolition of environmentally harmful subsidies, including direct public expenditure, “market price support” and/or environmental tax reductions and exemptions; 2) restructuring of existing relevant taxes by taking into account of environmental standards, and 3) the introduction of new environmental taxes.

Revenue neutrality has been an overarching principle of environmental tax reforms (ETR) in EU countries, e.g. the introduction of an energy or carbon tax was offset by reducing, the rates of other taxes, such as social security contributions and personal income tax, in order to keep a constant tax burden. Such tax optimization could generate a “double dividend”: the tax system would be green and effectively protecting the environment, while helping to minimize other distorting taxes, cut the welfare cost of taxation and increase employment (by reducing the tax wedge on labour). This double dividend and revenue neutrality approach reduced resistance and facilitated smooth tax reform.

Two decades of experiences in OECD and EU countries proved that environmental taxes are an effective tool. In 2006, 375 kinds of energy and environmentally related taxes were applied in OECD countries, including 150 energy related taxes, 125 transportation related taxes, some water and air pollution targeted taxes and a few other taxes on certain products like packaging, batteries, pesticides, chemical fertilizers, lubricants and household appliances. Most of these taxes played a significant role in raising energy efficiency and reducing pollution.

International experiences also show that, as part of the environmental tax system, carbon taxes are an effective tool to reduce pollutants and CO_2 emission and to improve energy efficiency. The countries that applied carbon tax witnessed large scale expansion of bio-fuel and a remarkable drop of fossil fuel consumption, which significantly adjusted their energy supply structures. In the meantime, carbon taxes also helped reduce CO_2 emissions. During 1990 and 2006, the CO_2 emission of Sweden dropped by 9% while its GDP grew by 44%. Research shows that if the Swedish tax system in 1990 had remained unchanged, Sweden would have produced 20% more CO_2 than the current level. Similar proof can be found in Germany, whose ecological tax reform helped reduce its CO_2-emission by 2%-3% from 1999 to 2003. Thanks to environmental tax reform, the demand for oil in some European countries showed signs of decline. The demand dropped by 1.5%-5% on the basis of figures available in 2004. The scale of falling demand is attributable to the tax rate as well as the magnitude of its subsequent secondary effect.

The sulphur tax of Sweden introduced in 1991 resulted in a significant drop of sulphur content in oil-based fuel, or at least 50% lower than the mandatory standard. The sulphur tax also helped to reduce SO_2, NO_x and CO_2 emissions by 94%, 20% and 54% respectively, compared with the year 1970. The sulphur tax of Belgium led to a considerable fall of high-sulphur-content fuel consumption from 20% of the market share in 1994 to less than 1% in 1998. Sulphur tax helped Denmark achieve an 84% decrease of sulphur emissions within a ten year period from 1995 to 2004.

Environmental tax reform is a win-win strategy for both the environment and the economy. Not only did such tax reforms in OECD countries not bring about negative impacts on economic growth (GDP), but in some cases, even positive effects were measured. In addition, the introduction of environmental taxes helped create considerable job opportunities. For instance in Germany, 250 000 more jobs were created during 1999-2003, representing an increase of 0.5%. The tax did not negatively affect the international competitiveness of industries, either. In OECD countries, the revenue of environmental tax accounts for 6%-7% of the total, or 2%-2.5% of GDP.

It should be noted that the economic and social backdrop of OECD countries and EU states were different when they carried out their respective environmental tax reforms, their policy targets also varied. For example, when Sweden introduced a carbon tax in 1991, environmental pollution was no longer a big problem in that country, and the main purpose was rather to further reduce fossil fuel consumption, improve energy efficiency, and decrease greenhouse gas (GHG) emissions. While, when Germany introduced ecological taxes, it had multiple goals: to cut labor cost, raise energy efficiency, reduce the social welfare burden and promote economic growth. These environmental taxes were designed according to the realities of different countries and did not exert negative impact on GDP growth, but rather contributed to strengthening economic development.

The experiences of OECD and EU countries demonstrate that, firstly, as long as the energy price rise keeps pace with increased average energy productivity, on average, environmental/energy taxes will neither bring about negative impact on social welfare nor result in economic losses for citizens and industries. The precondition is that the additional revenue of environmental/energy taxes can offset the losses caused by distorting taxes or the abolition of such taxes. Secondly, both theory and practical experience show that higher energy prices, even simply the announcement of the introduction and increase of such environmental taxation, can send a strong signal to consumers and companies, and help curb their energy demand, propel technological innovation and in the end improve energy productivity. Thirdly, the introduction of environmental/energy taxes such as fuel tax, carbon tax or pollutant tax is a valid approach to help establish a long-term escalator mechanism for energy prices, while environmentally harmful subsidies and tax policies should first be eliminated.

4.2.3 Main Conclusions and Policy Recommendations

4.2.3.1 Main Conclusions

Drawing upon international experiences on environmental tax reform and taking into account the current challenges China is facing in the field of environment and development, the realities and trends for energy consumption and tax reform as well as the result of carbon tax simulation studies, the Task Force reached the following conclusions on how China could raise energy efficiency and improve environmental quality through environmental tax reform.

(1) Raising energy prices is an effective long-term incentive to improve energy productivity.

In light of the current economic development trends and mounting energy and environmental pressures, China should set higher long-term energy productivity as a national target. Attention should be paid not only to the production/supply links of energy systems, but also to energy demand/consumption. Raising energy prices is the most appropriate pathway to curb energy demand, to encourage technological innovation and in the end to optimize energy use and to improve energy productivity. Considering the complexity of energy pricing issues, China may consider adopting a long-term "escalator strategy", namely to raise energy prices progressively by small increments over a fairly long period of time. Meanwhile, the public should be informed of such price rises, in advance, so as to avoid social and economic turbulence.

(2) Environmental taxation is a key tool to help set up a long-term "escalator" energy price mechanism.

The essence of environmental taxation is to raise the cost of the environmental and resources. OECD and EU experiences demonstrate that environmental taxes such as energy tax, carbon tax, and sulphur tax are effective economic tools to help improving energy efficiency, reducing pollution and cutting CO_2-emission. By removing environmentally harmful subsidies and tax policies, an environmental tax reform could help establish a long-term "escalator" pricing mechanism.

(3) Environmental taxation will not bring about negative impact on economic growth but rather may even favor economic development.

The main target of launching environmental tax reforms is to improve energy efficiency and thereby reduce environmental impact by raising the cost of energy, natural resources and pollution. OECD and EU experiences show that as an important cost factor, if the energy price rise keeps pace with average energy productivity improvement, environmental/energy tax will, on average, neither give rise to negative implications on social welfare nor bring about economic losses for people and industries. According to the carbon tax simulation studies of the Task Force, the short-term negative impacts will soon be offset by the long-term positive effects of the carbon tax, including a boost in economic output and corporate investment, higher employment, an increase in exports and imports, growth in fiscal revenues and so on. A carbon tax will help to promote effective regulation of energy-intensive sectors, improve energy efficiency, reduce environmental pollution, and maintain stable and rapid economic growth.

(4) The environment for introducing environmental taxation is maturing in China and a relevant tax reform should be carried out at the appropriate time.

Firstly, academics and relevant government agencies have carried out theoretical studies on environmental taxes for a long while. Such research provides solid foundations for environmental tax reform. Secondly, as China has gained very positive experience in developing energy and resource pricing mechanisms and fuel tax reform, psychologically, the general public will be in a favorable position to accept environmental taxes. Thirdly, the environmental tax will serve as an important green incentive to improve environmental quality, and help to build a resource-efficient and environment-friendly society. Therefore the introduction of environmental taxation is in accordance with the political will of China. What is more, relevant ministries have also completed a large amount of research and policy studies on environmental taxes. In this way China is a mature environment for the introduction of environmental taxes. However, given the more general context of increasing pressure from the current financial, energy and food crises around the world, it may not be the best time to introduce environmental taxes right now; that said, China should remain well prepared to launch reform in its taxation system at a more appropriate right time in the future.

4.2.3.2 Policy Recommendations

Based on the above conclusions, the Task Force puts forward the following policy recommendations on China’s environmental tax reform, including the roadmap and action plan for carbon tax reform.

(1) Introducing environmental taxes is an important component of China’s tax reform.

There are some major problems in China’s existing environmental taxes. For instance, the proportion of environmentally-related taxes compared to total tax revenue and to GDP remains relatively low compared to developed countries; China has not levied any pollution targeted tax yet and there is no complete or effective environmental tax system. At the same time, the rates of pollutant emission/discharge fees remain low and regulators lack mandatory power when collecting such fees. Among these problems, lack of pollution targeted taxes and a complete and effective system of environmental taxes comes to the fore. What’s more, the tax sharing system has resulted in fiscal difficulties in Governments at the sub-provincial level, and this has somewhat given rise to a “protectionism” of polluting companies upon which local government has relied for revenue.

Environmental policies will understandably not be implemented effectively in such circumstances.

Environmental taxes are a significant economic tool and long-term incentive to protect the environment. Therefore, laun-ching an environmental tax oriented reform at the current stage will not only help to meet the daunting environmental challenges but also help to better cope with climate change, to develop a low carbon economy, and to improve the quality of China's economic growth.

(2) An environmental taxation system in China should be established step by step, by announcing and subsequently introducing new environmental taxes, restructuring existing taxation with environmental consideration and improving related environmental tax policies.

Taking into account international experiences and China's realities, the main approaches for establishing and improving an environmental tax system in China are: 1) introduce new taxes; 2) restructure existing taxes; 3) improve existing environment-related tax policies. Therefore, China's environmental tax system should be composed of three parts: environmental tax, other environment related taxes, and environmental tax policies. The three parts are inter-connected and complementary to one another and, as a complete system, play a role in environmental protection (Figure 4-5).

According to China's priorities for environmental protection, namely water, air, prevention and treatment of solid waste pollution as well as the need for CO_2-reduction, China's environmental tax system may initially cover these items. With regard to carbon tax, which has become a hot issue lately, it can be introduced as one variety of environmental tax.

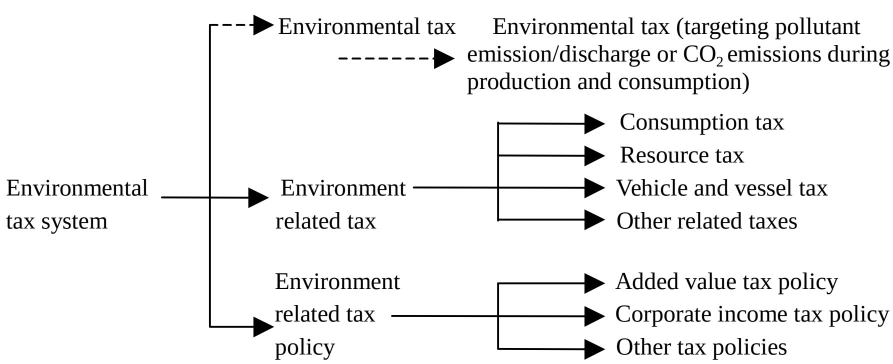

Figure 4-5 Composition of environmental tax system

Table 4-1 Scope of environmental tax

Scope and object		Content
Pollution emission/discharge	Waste gases	Including SO_2, NO_x etc.
	Waste water	Including industrial waste water, etc.
	Solid waste	Including coal ash, metallurgical and chemical waste, construction waste, etc.
CO_2-emission	CO_2	Including CO_2 produced by the burning of coal, natural gas, oil and other fossil fuels.

(3) Environmental tax reform should take into consideration the realities of China's economic and social development levels, and adopt a gradualist and "easy ones first, hard nuts last" approach.

Despite the maturing environment for environmental tax reform in China, the Government should nevertheless take a gradualist and "easy ones first, hard nuts last" approach. The reform may be carried out in three phases: phase 1, improve existing environment related taxes such as resource tax, consumption tax, vehicle and vessel tax etc., and introduce stand-alone environmental taxes as soon as possible; phase 2, further improve environmentally-related taxes and relevant tax policies, and expand the scope of environmental taxes; phase 3, further expand the scope of environmental taxes and optimize the overall environmental tax system.

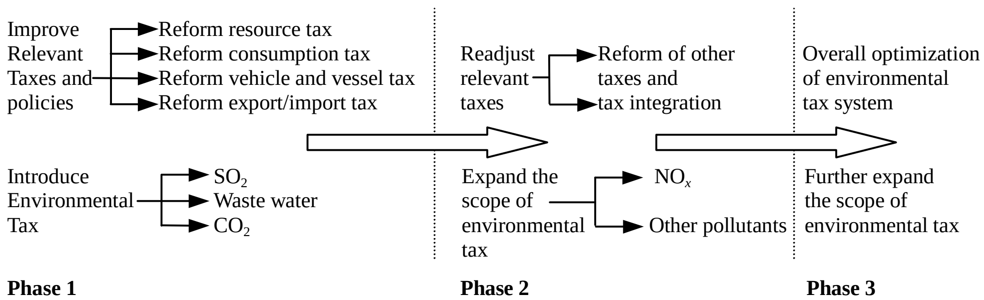

Figure 4-6 Roadmap of environmental tax reform

(4) A carbon tax is an important option for China to cope with climate change, promote energy efficiency and pollution reduction, and develop a low carbon economy as well.

The experiences of developed countries have proved that carbon tax/energy tax is an effective economic tool that helped considerably to cut CO_2-emissions, reduced environmental pollution and improved energy efficiency. Countries that imposed carbon taxes witnessed a significant drop of fossil fuel consumption and an optimized energy structure. Therefore, a carbon tax may also be an effective economic tool for China.

To introduce carbon taxation in China can be a good choice, since it's in line with the trends of tackling climate change and developing a low carbon economy; it has a low levying threshold and encounters no legal or administrative hurdles. Yet, there are also certain obstacles and challenges, such as the relationship between carbon, resource and consumption taxes, the effect on energy price and energy demand/supply, and the negative impact on economic growth and sector competitiveness in the short run.

(5) Develop a suitable carbon tax scheme for China based on international experiences.

According to the experiences of developed countries, careful analysis should be carried out before the introduction and designing of carbon taxation so as to minimize resistance. During the designing period, various factors should be considered, including coordination between the carbon tax and other taxes, as well as other economic tools, and international taxation coordination and collaboration, etc. The suggested factors of China's carbon tax are listed in Table 4-2.

Table 4-2 Carbon tax factors

Tax factors	Terms
Tax payers	The entities and individuals consuming fossil fuels and directly emitting CO_2 into the natural environment are obliged to pay carbon tax.
Tax scope	Carbon tax shall be levied upon CO_2 that is directly emitted into the natural environment from fossil fuel consumption during production, operation and consumption activities.
Tax calculation	Emission amount is calculated by the fossil fuel consumption amount of taxpayers. CO_2 emission amount = fossil fuel consumption amount × CO_2 emission coefficient. Fossil fuel consumption amount refers to the total amount of fossil fuel that enterprises consume during production and operation activities producing CO_2; fossil fuel includes coal, crude oil, gasoline, diesel oil and natural gas, etc.
Tax rate	Carbon tax shall be levied at norm quota tax rate and calculated in accordance with different emission quantities.
Preferential tax policies	A. tax reduction for certain energy intensive sectors according to the needs for economic and social development; B. tax reduction or exemption for enterprises that reduce and recycle CO_2 through advanced technology and meet certain standards; C. exemption for individuals whose CO_2 emissions result from coal and natural gas consumption that are meeting the needs of their daily lives.
Others	Collection mode, payment deadline, payment location, etc.

(6) Choose the right timing for introducing the carbon tax and the reasonable tax rate based on the impact analysis of carbon taxation on the environment, the economy and the social situation.

The design of a carbon tax rate shall take into account the following important factors: 1) marginal cost of CO_2 reduction; 2) impact on macro-economic development and industrial competitiveness; 3) differences among various fuels and industries; 4) gradual rise of tax rate; 5) balance between carbon tax and other fossil fuel targeted taxes. Considering the economic and social realities of China, the carbon tax rate should be low in the short term and gradually rise to higher levels. By taking these factors into account, carbon tax can be effective in regulating human behaviour resulting in CO_2 emissions, while avoiding negative effects on the international competitiveness of Chinese industry and on the daily lives of low-income groups.

Based on estimations using carbon tax modelling, it is suggested that a lower rate be chosen when initially implementing a carbon tax, in order to alleviate the negative influence of the tax on the economy and the resistance of the relevant stakeholders. For instance, the maximum rate of the carbon tax rate might not be more than RMB 15 per ton CO_2 in the beginning and this will still allow for different options and designs there under. Meanwhile, the dynamic adjustment mechanism of the carbon tax rate should be established, and the tax rate could be changed according to the fluctuation of the social and economic situation.

The timing for introducing a carbon tax is subject to having a favourable external environment, including a sound domestic and global economy, and a moderate tax burden. With the Chinese economy still recovering from the repercussions of the global financial crisis and resource tax reform in the pipeline, the best time might be to introduce the carbon tax when the Chinese economy has fully recovered and resource taxes are well established. However, such an environmental tax reform can already contribute to the recovery process: it spurs innovation and triggers cost reduction. The development of international climate negotiations and domestic priorities for environmental protection/climate change should also be seriously taken into account for the decision as to when to introduce a carbon tax. A suggested timetable for the introduction of a carbon tax is as follows (Table 4-3).

(7) Improve supporting systems and create a favorable external environment for the carbon tax.

It is suggested that the carbon tax should be a central tax and aimed at supporting the development of energy efficiency and new and renewable energy. The carbon tax revenue should be incorporated into the regular Government budgets and be managed together with other taxes while maintaining an emphasis on energy efficiency and environmental protection.

Table 4-3 Suggested timetable for the introduction of a carbon tax

	Timing	Remarks
The first best case: “fast scenario”	The 12th Five-Year Plan period (2011-2015)	On the basis of resource tax reform, to find the right timing to introduce a carbon tax as a part of environmental taxation.
The second best case: “slow scenario”	The 13th Five-Year Plan period (2016-2020)	China cannot effectively reach its domestic target of coping with climate change if carbon tax has not been introduced by 2020.

It is also important to promote the publicity of the carbon tax, establish a regular rate adjustment and notification mechanisms, strengthen the supporting capacity of the carbon tax collection and management, and coordinate the relationship between the carbon tax and other energy related policy measures on energy efficiency, renewable energy and efficiency standards.

4.3 Green Credit

4.3.1 Current Situation and Challenges in China

4.3.1.1 *Background*

Achievements in social and economic development over the past three decades, since the country’s reform and opening-up, have made China the most exciting story in the world. China’s global GDP ranking has risen from 15th in 1978 to 4th in 2008. Per-capita GDP grew by an average of 9.1% every year, from USD 190 in 1978 to USD 2,360 in 2008[1]. Rapid economic growth and urbanization have put the environment under tremendous pressure. Environmental issues and pollution problems pose serious challenges. As such, despite a host of state-driven initiatives, China has missed its environmental goals set in the 10th Five-Year Plan.

The Chinese Government has attached great importance to challenges in environment and resources and has adopted a series of policies and taken respective actions. In the 17th CPC National Congress Report, President Hu Jintao pointed out, “The cost of resources and environment brought by economic growth is too great.” Meanwhile, Premier Wen Jiabao stressed many times that the objective of energy saving and emission reduction as specified in the 11th Five-Year Plan is obligatory. Furthermore, the State Council promulgated Opinions on

[1] National Statistics Bureau of China, 2008. “Part 16 of the Series of Report on Achievements in China’s Economic and Social Development During the 30 Years since Reform and Opening-up”. http://www.stats.gov.cn/tjfx/ztfx/jnggkf30n/t20081117_402517351.htm (accessed on April 6, 2009).

Strengthening Environmental Protection by Implementing Scientific Outlook on Development in 2005 and issued the Comprehensive Work Plan for Energy Saving and Emission Reduction in 2007. Both are the programmatic documents by which the Chinese government has carried out environmental protection and promoted energy saving and emission reduction in recent years. In these documents, an overall plan has been made for the implementation of environmental protection and energy efficiency.

According to statistics, the energy consumed and pollutants discharged in the so-called "double-high" industries (petroleum processing, coking and nuclear fuel processing, manufacturing of raw materials and chemicals, manufacturing of nonmetallic mineral products, ferrous metal smelting and rolling, non-ferrous metal smelting and rolling as well as the production and supply of electricity and heat)[1] account for approximately 70 percent of total generated across all industrial activities. In non-industrial activities, construction and road traffic are recognized as the two major sectors with respect to energy consumption and pollutant emission. While people's living standards are improving, domestic refuse and sewage discharge are increasingly becoming the leading sources of pollution.

Due to the underdevelopment of China's capital market, banks have always been the most dominant institutions for enterprises, governmental agencies and individuals to acquire external financing. On average, about 80 percent of external financing for these said entities is provided through banks. According to statistics, as of the end of 2008, the outstanding medium- & long-term loan from banks stood at RMB 2.6226 trillion in "double-high" industries, RMB 1.5843 trillion in water conservancy, environment and public utilities management, and RMB 2.3594 trillion in traffic and transportation, warehouse and postal service, while the outstanding loan in real property was RMB 5.2818 trillion and RMB 114.8 billion in automobile consumption. The sum of these balances amounted to 39.8 percent of GDP. Financing activities conducted by the banking sector have an extremely significant impact on the development of these industries and departments.

Therefore, the banking sector plays an irreplaceable role in effectively implementing environmental protection and energy efficiency, and striking a balance among economic growth, investment return and environmental protection. By incorporating "green" factors such as environment protection and energy efficiency into the banks' financing activities (namely, implementation of green credit), the environment protection

[1] These six industries are referred to as "high energy-consuming and high polluting" industries or, in short, "double-high" industries.

sector may obtain effective support to solve environmental problems of environmental pollution and ecology degradation caused by “double-high” industries, traffic and transportation, real estate construction and consumption as well as people’s daily life.

Meanwhile, the Chinese government has stepped up efforts for energy efficiency and pollution reduction in recent years, including stricter environmental regulation. Numerous seriously polluting factories were closed down or ordered to restrict production, resulting in increasing bad loans for banks. Such negative impact propelled financial institutions including banks to seriously consider environment-induced financial risks and adopted relevant preventative measures. According to the statistics of the China Banking Regulatory Commission, by the end of March 2007, the total non-performing loans of the five major banks in energy intensive and heavily polluting industries stood at 43.709 billion RMB, representing a bad loan ratio of 3.28%. The calcium carbide, iron alloy and cement industries topped the list with a bad loan ratio of 28.8%, 27.6% and 20% respectively.

In order to exert efficiently the function of banking sector in facilitating environment protection and energy efficiency and to reduce the credit risks caused by environmental and social risks practically, the banking regulatory authorities, environment protection authorities and other relevant departments have consolidated their cooperation to promote banks and other financial institutions in implementing the scientific outlook on development and have issued Green Credit-oriented documents such as Opinions on Implementing Environmental Protection Policies and Regulations and Preventing Credit Risks and the Guiding Opinions on Credit Granting for Promoting Energy Efficiency and Pollution Reduction, which put forward an overall requirement for implementation of green credit in the banking sector. The banking sector is thus eager to cooperate with the environmental authority and competent departments to gain a better understanding of environmental policies development and get access to corporate environmental information, both of which can play an important role in better controlling credit risks, ensuring banking assets safety and reducing non performing loans.

Against such a political, economic, and environmental background, amid close collaboration between the Ministry of Environmental Protection and China Banking Regulatory Commission, the country witnessed a rapid development of green credit policy and its far-reaching implications.

4.3.1.2 *Policy Implementation Content*

Green credit is an economic tool that has been implemented with distinct Chinese characteristics, including a set of financial credit-centered policies and mechanisms and practices for promoting energy efficiency and pollution reduction.

China’s green credit policy has four aspects. First, green projects or companies are supported by appropriate credit policies and measures (related to loan term, interest rate, and loan limit). Second, non-compliant projects or companies are discouraged by punitive credit measures, such as loan suspension and withdrawal. Third, banks are able to reduce their credit risk in lending activities by supervising and urging their customers to strengthen management of environmental risks and improve resource efficiency. Forth, banks are required to seek new business opportunities for advancing environmental protection and energy efficiency and to develop new financial products to expand credit and related services. Through green credit activities, banks can facilitate sustainable development and achieve a win-win for themselves, their customers, and the whole society through collaboration with enterprises and other stakeholders.

China has a long history of green credit policy. In 1995, the People’s Bank of China issued the Circular on Implementing Credit Policy and Strengthening Environmental Protection, which required banks to consider resource protection and pollution control in lending policies. In 2004, the National Development and Reform Commission, People’s Bank of China and China Banking Regulatory Commission jointly issued the Circular on Strengthening Coordination between Industrial and Credit Policies and Controlling Credit Risks, which denied credit support for all new projects related to restricted or obsolete industries.

Since 2006, China’s green credit policy has advanced even further. The former State Environmental Protection Administration, China Banking Regulatory Commission, and the People’s Bank of China carried out consultations and joint studies as the basis for issuing a variety of documents around 2007 to enhance green credit policies. These documents include: The Guiding Opinions on Improving and Strengthening Financial Services for Energy Efficiency and Environmental Protection by PBOC, Opinions on Implementing Environmental Regulations and Policies and Preventing Credit Risks by SEPA, CBRC and PBOC, Circular on Preventing and Controlling Credit Risks of Energy Intensive and Heavily Polluting Industries and The Guiding Opinions on Credit Granting for Promoting Energy Efficiency and Pollution Reduction by CBRC, and so on. In addition, SEPA, CBRC and PBOC signed a working agreement to incorporate environmental information into the credit reporting system and strengthen information-sharing and exchange. Amongst the above-mentioned documents, the Opinions on Implementing Environmental Regulations and Policies and Preventing Credit Risks and The Guiding Opinions on Credit Granting for Promoting Energy Efficiency and Pollution Reduction comprise the core of China's green credit policy.

According to the Opinions on Implementing Environmental Regulations and Policies and Preventing Credit Risks, financial institutions and environmental regulators should abide by the requirement of environmental laws and regulations and impose stricter environmental supervision and credit management on new projects. Financial institutions should implement more stringent loan review, granting, and management policies. On the one hand, no additional loans should be approved for projects that seriously breach environmental laws and regulations while on the other hand, preferential lending policies should be applied to green projects. The Guiding Opinions on Credit Granting for Promoting Energy Efficiency and Pollution Reduction requires banks to adopt the principle of "differentiated treatment, supporting some sectors while restraining others" and to strengthen management with respect to due diligence, examination on lending, post-lending supervision, compliance, loan contract, authority of credit granting, policies of industrial credit granting, process of risk management, risk pricing, internal audit control, personnel assignment and training, information disclosure, and stakeholders with the aims of promoting the sustainable development of the banking business, China's economy and society while also efficiently preventing various risks incurred by the banks' customers due to high energy consumption, high emissions and heavy pollution.

4.3.1.3 *Progress to Date*

In the wake of the introduction of China's national green credit policies, the subordinate environmental and banking authorities at all levels have put forward local policies. According to incomplete statistics, more than 20 localities, including Fujian Province, have developed local policies. Recently, Hebei Province has developed a performance evaluation system for green credit implementation.

In the meantime, green credit policies were also well-received by commercial banks. According to the requirement of The Guiding Opinions on Credit Granting for Promoting Energy Efficiency and Pollution Reduction, commercial banks have developed internal management systems for controlling environmental risk within the credit system. Many banks, such as Industrial and Commercial Bank of China, China Construction Bank and China Development Bank, not only introduced a strict environmental review mechanism, but have also implemented an "environmental veto" mechanism within the credit approval process. The active involvement of banks has been critical to ensuring the effectiveness of green credit policies and making this a high-profile economic tool that attracts substantial popular attention. In China, green credit is an important and successful measure for promoting energy efficiency and pollution reduction.

By June 2008, the five major commercial banks, namely Industrial and Commercial Bank of China, Agricultural Bank of China, Bank of China, China Construction Bank and Bank of Communications, had lent a total of 377.952 billion RMB to support 595 key green projects and 110.529 billion to 1619 projects related to green technology and product dissemination. This represents an increase of 50.694 billion and 15.965 billion, respectively, since January 2008. Policy banks (non-commercial banks) loaned 224.058 billion RMB to support green projects including clean energy, waste water treatment, and so on. The National Development Bank lent 30 billion RMB through the Special Fund for Energy Efficiency and Pollution Reduction, of which, 4.5 billion RMB was invested in Taihu Lake treatment. Over the same period, the five commercial banks approved facility and loans of 14.905 billion RMB and 12.767 billion RMB, respectively, for the restricted industries. This was 1.022 billion RMB and 0.508 billion RMB less, respectively, compared to the beginning of the year, and 364 million RMB and 358 million, respectively, for industries that will be gradually phased out (this represents a 141 million RMB and 124 million RMB drop, respectively, for such industries).

4.3.1.4 *Problems and Challenges*

Despite the early progress that has been achieved, China needs to be clear that the development of green credit policy is still in the initial stage, there is much room for improvement in terms of policy content and technical support. China is faced with quite a few problems and challenges in this regard.

The main problems are: First, an incomplete policy system and inefficient implementation; second, lack of diversity and effectiveness of available tools for implementation; third, insufficient information exchange; fourth, lack of supervision, evaluation, and regulation of banks and their reluctance for voluntary action; and fifth, the low capacity of banks and financial institutions for policy implementation.

China is also confronted with many challenges. First, due to fierce competition among commercial banks the implementation of the green credit policy is facing a great challenge; second, protectionism in the localities obstructs the implementation of green credit policy; third, private capital is not well regulated and non-compliant small and medium sized enterprises may still get funding support through this channel; fourth, small and medium sized banks and financial institutions are both most affected by environmental regulations and most resistant to green credit policy.

4.3.2 International Experiences and Implications to China

4.3.2.1 *Relevant Exercises and Main Practices*

There is no explicit “green credit policy” in other countries, though similar sustainable banking concepts and initiatives are plenty in the international community, such as the principle of self-discipline in environmental governance, and state promoted green financial products. These practices can be classified in four categories.

(1) Green financial initiatives of the international community and multinational organizations.

The UN Conference on Environment and Development, in 1992, put forward the Declaration on Environment and Sustainable Development of the Banking Sector, which was a great contribution of the banking sector in the area of environmental protection. So far, 272 institutions and organizations around the world have signed the declaration. Bank of Shanghai was the first Chinese bank that signed on the document; it demonstrated that Chinese banks were trying to become greener by doing their part in promoting environmental protection and sustainable development.

OECD countries have agreed on a Revised Recommendation on Common Approaches to the Environment and Officially Supported Export Credits, which sets out strengthened environment-related requirements for export deals to qualify for support from OECD Members' Export Credit Agencies. The Revised Recommendation calls on the OECD Members to evaluate carefully any export credit applications with a loan period over two years that are officially supported and make sure their potential environmental impact meets the standards of relevant international organizations, in particular the World Bank and the IFC.

(2) Self-disciplinary principles of green financing.

Faced with widespread criticism for their poor environmental, social and human rights performance, a number of international banks have initiated and advocated the Equator Principles, which helped internalize environmental, social and human rights risks, and improve the image of the banks. The Equator Principles are a set of self-disciplinary benchmarks for the banking sector to shoulder more social and environmental responsibilities. They include 10 basic principles, 8 environmental and social performance standards of the IFC, and 62 Environmental, Health and Safety Guidelines of the World Bank and the IFC, which should be complied with during financing activities. The Equator Principles enjoy growing influence with more than 60 international banks which have signed up to them, including a few from developing countries like Brazil and China. The capital raised by these banks accounts for about 90% of the global total.

(3) State-promoted subsidies to green credit.

In order to support green projects, which often show low returns and are of a public and long-term nature, it is a common practice for many countries to grant low rate loans to these projects through policy banks or commercial banks. The experience of the UK, Japan and Germany are of particular interest to China.

The Household Energy Efficiency Law of the UK in 1995 required a 30% drop of household energy consumption within 10 years on the basis of 1996 or 1997 figures. In order to achieve this goal, the UK government introduced a set of policies and measures to improve energy efficiency, including discount loans, low rate loans or interest free loans for equipment investment and technological development projects to improve energy efficiency. Within the 200 million pound Energy Efficiency Fund in 2002, 25% was used for discount loans, of which 10 million pounds were granted as interest free loans.

In order to propel enterprises to maintain a balance between environmental and economic interests during production activities, the Development Bank of Japan put forward a financing policy based on an "environmental rating". The rating result would determine who could access loans and at what rate. Driven by the need for tackling climate change and CO_2 reduction, the Bank again introduced an environmental-rating-based discounted loan in 2007. Those rated companies who commit to reduce CO_2 emission per unit of production by more than 5% in 5 years will enjoy an additional rate discount of 1% when applying for CO_2 treatment loans.

In Germany, the policy bank KFW Bankengruppe raises money in the capital market while financial subsidy policies for environmental projects are channeled through commercial banks. In this way, government subsidies can be exploited to their fullest extent. This is how Germany does it: First, the KFW Bankengruppe raises money in the capital market with the support of a government subsidy, and then the KFW Bankengruppe will use the capital raised to develop long-term and low-rate financial products and sell them to commercial banks, finally, after adjusting the rate, the commercial banks will sell the green financial products and services to end clients with very preferential rates and loan periods. This practice can also contribute to energy efficiency improvement and GHG emission reduction.

(4) Innovation on green financial products.

The international obligation for GHG emission reduction has not only created an active carbon trading market, but has also impelled financial institutions, including banks, to innovate on new green financial products, such as carbon financing and energy efficiency financing. Many banks have started to develop products that are oriented to a low carbon economy and CO_2 emission reduction. Green financial products and services for individuals and small and medium sized enterprises have covered such business as loan, deposit, credit card and lease.

4.3.2.2 *Experiences and Implications to China*

Comparing Chinese and international policies and green credit practices, one can discover that China has some successful experience and some shortcomings as well. The banking regulatory authorities, environment protection authorities the other competent departments have done a good job in taking joint actions and working out relevant policies, thereby providing a good platform for fair competition among banks. Meanwhile, banking regulatory authorities and environment protection authorities have provided the banking sector with a relatively complete and timely service of environmental information via regulatory information sharing, thus facilitating the banks' capacity to manage environmental risks, and materialize the joint oversight on enterprises with high environmental risks. However, one can also identify several shortcomings. Firstly, the green credit policy is largely government-led in China, while international practice emphasizes joint promotion by government, market, and the banking sector. Secondly, China's green credit policy system is incomplete and less practicable compared with those in foreign countries. Thirdly, policy tools and insufficiently diversified and innovation in green financial products is lacking. Fourthly, Chinese banks are required to promote energy efficiency and pollution reduction, and shoulder more social and environmental responsibilities, potentially neglecting their legitimate need for reasonable profit in implementing green credit policy.

Developed countries, including the US, Japan, and European nations, have actively promoted the development of diversified green financial products, such as green credit and financial subsidies, which play a positive role in environmental protection and GHG emission reduction. China could learn a lot from the experiences of these countries.

First, the role of the market should be stressed in promoting green credit policy. Green credit policy contains two core aspects: preferential credit policy for green projects, and restricting or denying lending support for projects with negative environmental and social impacts. International experience, particularly the German experience, shows that the market plays an essential role in both aspects. State support for the policy banks may be channeled through the capital market and the direct involvement of commercial banks can help move the green credit policy closer to end clients in order to maximize efficiency. Ultimately, the green credit policy should not only bring about more environmental and social responsibilities for banks but new business and profit opportunities as well.

Second, green credit benchmarks are widely accepted and advocated by the international community and the banking sector. However, there is much room for improvement in terms of policy completeness and practicability in China. The 8 Social and Environmental Performance Standards of the IFC and the EHS Guidelines referenced in the Equator Principles may serve as effective tools that help the banks to accurately rate the risk of a project and assist the client to improve project design for reduced operational risks.

Third, clearly defined environmental liability is the basis for implementing green credit policy. Only by clearly stipulating environmental liability, rights and obligations in the law, can the government, enterprises and the banks be propelled to protect the environment and reduce pollution.

Fourth, environmental review is critical for promoting green credit policy. Due to the complexity of environmental issues and diversity of technological processes, it is often difficult for banks alone to identify the environmental implications of a certain project, and the support of the environmental agencies in terms of environmental assessment is particularly necessary. The Japanese and German experiences show that environmental review is not only beneficial for the banks but can also help reward the green companies and punish the dirty ones.

4.3.3 Conclusions and Policy Recommendations

4.3.3.1 *Main Conclusions*

(1) A green credit policy with Chinese characteristics has been well-established.

A Green credit policy with Chinese characteristics is well established. The core content of the policy is preferential lending support for green projects, and strict review and loan restrictions for energy intensive and heavily polluting projects. The close collaboration between environmental agencies and the banking sector, in policy development, information sharing and personnel training, has pushed forward the development of green credit policy in China. Under government regulation and the guidance of a scientific approach to development, more and more banks have set up internal mechanisms and procedures for green credit and voluntarily shoulder more social and environmental responsibilities. A top-down system of green credit policy has been well established in China. With expanding content, the green credit policy has become an important and successful economic tool for promoting energy efficiency and pollution reduction.

(2) There is much room for improvement in China’s green credit policy.

Compared with advanced international

practices, there is still much room for improvement in China's green credit policy. Only by resolving the problems can the policy better meet the domestic need. The most prominent problem of China's green credit policy is reliance on administrative measures and not market mechanisms, which has so far resulted in inefficiency. In the future, China should strengthen the role of market forces in developing more green financial products. Sector-oriented green credit policies also need to be developed so as to ensure efficient implementation.

(3) The green credit policy is an important tool for modulating and regulating macro-economic activities.

Against the background of financial crisis, lending support is often the decisive factor for the subsistence and development of enterprises. As China introduced its economic stimulus package, a large amount of capital is pouring into the market and the lending scale is sharply expanding. In the first half of this year alone, the total loans granted exceeded 7 trillion RMB. This has given rise to concerns over lax implementation of the green credit policy, repetitive construction, excessive production capacity and new bad loans. As a matter of fact, the green credit policy should play an important role in encouraging lending support for projects with attractive economic, social and environmental returns while discouraging credit loans for projects that seriously pollute and damage the environment. It should thereby help achieve the overall goal of "sustained economic growth, improved industrial structure and better development". In the recently introduced set of policies for regulating industries with excessive production capacities, including iron, steel, cement etc., the State Council has clearly identified strengthened environmental supervision and stricter credit management as macro regulatory measures. Therefore it can be said that the green credit policy not only helps promote energy efficiency and pollution reduction, but also serves as an important tool to achieve macro regulatory goals.

4.3.3.2 ***Policy Recommendations***

(1) Clarify and stress the supportive aspects of the green credit policy.

There is currently a misconception that the green credit policy is basically a punitive tool. But, in fact, the green credit policy includes not only punitive and restrictive measures, but also positive measures, such as subsidies and loan preferences for green projects by means of credit instruments. Such supportive measures are also very important for achieving the goal of improved energy efficiency and pollution reduction. Because of the misconception, the supportive side of the green credit policy has not been stressed. The policy has centered upon the punitive aspect while very few supportive tools were developed. This has resulted in a lack of innovation and a weak structure of the green credit policy, which hampers the effectiveness of the policy in supporting the energy efficiency and pollution reduction program.

Therefore China should put more weight on the supportive and regulatory aspect of the green credit policy. It remains important to further strengthen the social and environmental responsibility of banks, and curb the development of energy intensive and heavily polluting industries by credit restrictions. However, it is also essential to encourage the innovation of supportive green policies and credit products, such as loan preferences and subsidies. Meanwhile, it is necessary to reform existing financial and taxation policies for energy efficiency improvement and pollution reduction so as to raise capital efficiency and ensure the policies are fair and widely applicable.

(2) Improve the enabling policies for energy efficiency and pollution reduction through market-based reform in the financing area.

The Chinese government has attached great importance to the energy efficiency and pollution reduction program. China has not only established the Special Fund for Energy Efficiency and Pollution Reduction, but also provided capital support for green projects through the National Development Reform Commission and China Development Bank. Within the 4 trillion RMB stimulus package, a considerable sum of 400 billion will be used to support green projects. The absence of a market-based mechanism has resulted in low capital efficiency, and the administrative approval procedures will also easily breed corruption.

In order to make the use of capital more effective, transparent and fair, market-based reform shall be introduced, mainly through the leverage exerted by financial institutions to expand the effect of energy efficiency and environmental protection.

1) Establish a national guarantee fund for energy efficiency and emission reduction, and offer credit guarantees for eligible credit capital by sharing risks with financial institutions in the banking sector.

2) Offer interest subsidies to key energy efficiency and emission reduction projects. The government may confirm the range of subsidies for loan interest through invitation to bidding and tender towards financial institutions and the banking sector.

(3) Improve the existing green credit policy and strengthen its practicability and effectiveness.

1) Accelerate the introduction of industrial policies related to green credit; require banks to clarify the policy boundary and scope in reviewing the credit grant; restrict higher energy consumption and pollution projects in order to adjust the industrial structure and promote sustainable development.

2) The collaboration among environmental agencies, competent industrial authorities and banks, should be further strengthened. The environmental agencies

should establish close collaboration with competent industrial authorities, provide timely corporate environmental information by developing sector guidelines for implementation of green credit policy, carry out “green project” verification, and establish an integrated environmental risk rating system for enterprises and projects. These measures will help improve the practicability and effectiveness of the green credit policy. The banks should create more green financial products, conduct strict credit management and review, acquire timely green credit information, and provide green loans for green projects. By doing this, the banks and environmental agencies can together support the work of energy efficiency and environmental protection projects, and further facilitate sustainable development.

3) A supervision and information disclosure mechanism for green credit implementation should be established as soon as possible. Disclosure of information about non-compliant companies, as well as the banks’ implementation of green credit policy will help the banks to shoulder their social and environmental responsibilities.

(4) Guide and regulate overseas investment by Chinese financing institutions and strengthen their social and environmental responsibilities.

China should also strengthen its regulation and management of its overseas investment and develop relevant policies in this area. Large companies and banks should be encouraged to manage their investment or credit granting process by adopting international benchmarks. Additionally, with regard to the large amount of private investment by small and medium sized enterprises, targeted polices are also needed for greening such investment.

(5) Develop a special green credit policy to support the healthy development of small and medium sized enterprises (SMEs) .

Affected by the financial crisis, access to loans has become difficult for SMEs which is a prominent problem for their development. The situation of SMEs needing renovation or development of environmental facilities is particularly severe.

Therefore, when developing financial policies for supporting SMEs, the Chinese government should work on the introduction of a special policy and develop special green financial products for SMEs. Loans should be provided to support the development of green SMEs that enjoy healthy prospects and are in compliance with national industrial policies and the policy of energy saving and pollution reduction. At the same time, the Chinese government should impose on SMEs a strict review of energy saving, pollution reduction and credit granting processes, and reject lending support for heavily polluting and high energy consuming SMEs.

(6) Strengthen supervision and education, and better regulate private capital

flow.

The lack of effective regulation on private capital has incapacitated China's macro-regulatory policies, while the expansion of the sector and its neglect of social and environmental interests continued. Therefore, in addition to introducing green credit within public financial institutions, it is also important to strengthen the supervision and regulation of the private capital lending sector.

Supervision should be strengthened on heavily polluting and energy intensive companies, and severe punitive measures should be imposed on non-compliant activities. Thus, the investor will learn a lesson from the punishment and realize the high financial and environmental costs if social and environmental interests are neglected. What's more, the government should strengthen education on financial and environmental issues and the related costs of irrational investment. Such education will help investors to develop awareness of the risks involved in funding industries with high energy consumption and pollution.

4.4 Environmental Pollution Liability Insurance

4.4.1 Current Situation and Challenges in China

Over the past 30 years, China has achieved amazing economic success but at the same time, large-scale environmental problems and conflicts have accelerated due to a tremendous expansion of economic aggregates, irrational industrial structure, and poor factory location. China has hence entered an era characterized by frequent environmental accidents. According to statistics, from 1998 to 2005, the annual direct loss caused by pollution accidents in China reached 140 million RMB, on average. Between 2003 and 2006, there were a total of 5,532 environmental pollution/destru-ction accidents, resulting in a direct economic loss of 637.267 million RMB and a total compensation/fines of 178.534 million RMB, while seriously impairing the health, life, and property of local residents. An environmental risk survey of China's petro-chemical industry carried out by the former State Environmental Protection Administration in 2006 showed that 81% of the 7,555 surveyed petro-chemical projects are located in environmentally-sensitive areas, such as river valleys and highly populated regions. 45% of these projects are associated with high environmental risk and those located in major river basins pose threats to the local environment, with no preventive mechanism in place.

Against this background, administrative regulation alone is not enough to prevent environmental emergencies. Therefore, it is absolutely imperative to establish a long-term mechanism for environmental risk management, especially environmental pollution liability insurance. Environmental pollution liability insurance requires the insurer to bear the responsibility of economic compensation and pollution treatment in case the insured party accidentally causes environmental pollution so that any victims are compensated on a timely basis, even if the insured is not solvent. Environmental pollution liability insurance has only been developed over a few decades in some developed countries. Such insurance has become the main financial instrument to prevent environmental risk and resolve the problem of environmental damage compensation. For this reason, many companies have used environmental pollution liability insurance to better manage their environmental risks. The introduction of environmental pollution liability insurance in China will help improve pollution compensation mechanisms, strengthen preventive management of environmental accidents, reduce the cost for the government in the wake of environmental emergencies, safeguard the legitimate rights of the victims, maintain social stability, reduce bankruptcy cases, and ensure sustained corporate development.

In recent years, China has made some progress with respect to environmental pollution liability insurance. In 2007, the former State Environmental Protection Administration and China Insurance Regulatory Commission jointly issued the Regulatory Opinions on Environmental Pollution Liability Insurance. The Regulatory Opinions state the principle, target, implementation, and supporting mechanisms of environmental pollution liability insurance and serve as the most important guideline at the national level. In the meantime, some provinces, like Jiangsu and Liaoning, have already initiated legislation in this field.

Since the promulgation of the Regulatory Opinions in 2007, many insurance companies (including PICC, Ping An Insurance, and Pacific Insurance) have developed environmental pollution liability insurance products and gained approval from the China Insurance Regulatory Commission. In 2008, the Ministry of Environmental Protection and the China Insurance Regulatory Commission co-hosted the National Working Meeting on Environmental Pollution Liability Insurance Pilot Programs, marking the formal launch of pilot programs across the country. Provinces and municipalities, including Jiangsu, Chong-qing, Hubei, Hunan, Henan, Ningbo, Shenyang, Shenzhen and Suzhou, were identified as regions where pilot programs could be carried out with enterprises that produce, operate, store, transport, and/or consume hazardous chemicals, and specifically with the petro-chemical industry, which is prone to pollution accidents and with hazardous waste disposal enterprises, waste landfills, waste water treatment plants, and industrial parks. In July 2008, the Hunan branch of Ping An Insurance Company compensated the victims of pollution accidents caused by Hao Hua Chemical Company. This was the first case of environmental pollution liability insurance reimbursement in China, signaling a new age for environmental pollution liability insurance.

Generally speaking, environmental pollution liability insurance is still in an initial stage of development in China, and there are many problems that need to be addressed: First, due to cost considerations and lack of awareness, few companies are interested in buying environmental pollution liability insurance. Second, the underwriting ability of Chinese insurance companies needs to be improved to manage profitability uncertainty and the higher operational risk of environmental pollution liability insurance. Third, too much government intervention will not help to establish a long-term mechanism for pollution compensation and may, in fact, undermine the credibility of environmental pollution liability insurance. Fourth, because the environmental pollution liability insurance is a new development in China, many people are not yet aware of its role, nor the needed policies, operation, and management of such insurance. Fifth, the current global financial crisis exerts considerable negative impact on the popularization of environmental pollution liability insurance in China.

Additional factors constrain the pu-larity of environmental pollution liability insurance in China. First, legal support is lacking. No national law or regulation on environmental pollution liability insurance currently exists in China. Second, liabilities can be obscure and there is a lack of internal push for environmental pollution liability insurance. Third, standards for insurance product pricing and reimbursement are lacking. China has neither developed an environmental risk assessment methodology nor pollution damage verifications and compensation standards. These technical obstacles need to be resolved to facilitate a broader acceptance of environmental pollution liability insurance. Fourth, incentives are lacking for both the insured and insurer, and there is a high operational risk for insurance companies. Fifth, there is a lack of policy and financial support from the central government to the pilot regions. As no special funds have been provided at the national level, the programs are currently mainly supported by local governments.

4.4.2 International Experiences and Implications to China

At present, there are two advanced models of environmental pollution liability insurance in foreign countries: namely, *mandatory* environmental pollution liability insurance (which has been adopted by the US, Germany, Russia, and Argentina) and *voluntary* environmental pollution liability insurance (which has been adopted by France and the UK). Mandatory environmental pollution liability insurance focuses on mandatory insurance complemented by voluntary insurance. In this model, mandatory environmental pollution liability insurance is imposed on risky firms while most others can buy the insurance on a voluntary basis. The mandatory model involves insurance as well as other financial guarantees by law (e.g. financial guarantees and fund). Such financial guarantees make the insurance more flexible.

Countries that have adopted the voluntary model differ in their approaches, priority areas, operational models, and insurance products, but there are also some similarities amongst them with respect to the overall trends of Environmental Pollution Liability Insurance. First, legislation serves as the basis and a precondition for introducing Environmental Pollution Liability Insurance. In this respect, laws set the legal status and provide for an operation model, an underwriting approach, managing institutions, compensation liabilities, and priority areas. The law endows the insurance with more mandatory power. Legislation is also a benchmark of the development level of environmental pollution liability insurance. Second, mandatory insurance is a general trend of environmental pollution liability insurance development. All countries with the mandatory approach have developed catalogues to better manage environmental pollution liability insurance. The catalogues are developed in accordance with the management needs of different countries and normally include an equipment catalogue, a product catalogue, and a risk assessment based catalogue. Third, compensation liability for pollution damage is specified and increasing weight is given to environmental restoration. There are clear provisions in the laws of these countries regarding the compensation liability of pollution damage. Such provisions play a vital role in regulating insurance policies and pay-outs. The insurer must bear compensation liability as stipulated by law and pay more attention to its responsibility for environmental restoration. Relevant provisions can be found in the laws of the US and Germany, and the environmental pollution liability insurance of Argentina is even purely restoration-oriented. Fourth, the establishment of an environmental aid fund is an important supplement to the compensation mechanism. When pollution damage exceeds the cap of insurance reimbursement and the insurer is insolvent for extra loss, some countries have established environmental aid funds to help control operational risks of insurance companies. Every environmental pollution liability insurance policy sets a cap on single reimbursement and total pay-out within certain insurance periods; in other words, insurance companies underwrite a limited liability. The environmental aid fund therefore plays a very important supplementary role to improve the environmental pollution liability insurance, preventing possible social conflicts and safeguarding the environmental rights of the people.

In the long run, the environmental pollution liability insurance products of different countries are becoming increasingly less profit-centered. The following are some prominent features: First, the scope of coverage is gradually expanding. Initially environmental pollution liability insurance only covered environmental emergencies and incidental accidents, but the scope of coverage has gradually expanded to environmental damage caused by accumulative pollution. Second, a pay-out cap was set to reduce the operational risk of insurers. Third, the time limit of claims was extended. Because of the invisibility of damage caused by environmental pollution, people began to pay attention to the accumulative and long-term nature of such damage, and the time limit for claims was extended. The US applies the "sunset clause" for environmental pollution liability insurance where both parties of the insurance contract agree that the insured may make a claim against the insurer up to 30 years after the insurance's expiry date. The Environmental Liability Insurance Law of Germany sets the time limit for a claim at 10 years, there have been several developments with respect to product diversification. In addition to environmental damage liability insurance, in the US, many other products can be found, including Underwriter Environmental Damage Liability Insurance, Errors and Omissions Insurance of Professional Environmental Risks, and Asbestos and Lead Abatement Contractors General Liability Insurance, etc. Fifth, there has been a professionalization in the way such insurance is managed. Considering the complexity of environmental issues, many countries have set up specialized agencies to manage relevant business. For instance, Argentina established an Advisory Committee on Environmental Risk Assessment and Fiscal Guarantee, whose responsibility covers environmental standards and guidelines, and general regulations on contract clauses of Environmental Damage Risk Insurance. India has also set up an Environmental Court and an Advisory Committee on Public Liability Insurance, which are mainly responsible for dispute settlements relating to public liability insurances.

4.4.3 Conclusions and Policy Recommendations

4.4.3.1 Main Conclusions

(1) Environmental pollution liability insurance has been widely-adopted as an advanced market-based instrument.

Environmental pollution liability insurance is a widely-adopted management tool for environment protection in the world. As currently a prominent way for enterprises to fulfill their environmental responsibility, environmental pollution liability insurance has a good performance in terms of preventing environment risk and compensating pollution damage. After several decades of development, many counties have already built relatively complete systems for environmental pollution liability insurance (including the refinement of legal and regulatory systems, diversified insurance products, etc.), and enterprises recognize its value in fulfilling environmental responsibility. With such a market operation, government help with no longer be required. In these countries, Environmental pollution liability insurance is on a positive trend and can play an important role in enhancing enterprises' environment protection and safeguarding victims' rights. According to international experiences, it is necessary and feasible to promote environmental pollution liability insurance in China, and the experiences relating to laws and market run are particularly worth further study.

(2) Environmental pollution liability insurance is a challenge to implement in China and there are opportunities for improvement; it is critical to respond to the challenge and take the opportunities to improve relevant laws, regulations, policies, and standards.

With both increasing environmental requirements and more frequent environmental accidents, there is great market potential for environmental pollution liability insurance. Still, considering the imperfection of the socialist market economic system of China at the current stage, the inadequate incorporation of environmental cost into products and services as well as the severe lack of experience with employing market-based approaches to resolve environmental problems, the wider uptake of environmental pollution liability insurance confronts strong challenges. In general, Environmental Pollution Liability Insurance is at an early stage in China, and the market remains rather small. Compared with the US and Germany, supporting laws, regulations, policies and standard are still very weak, and the necessary guidance to spur further development of Environmental Pollution Liability Insurance is weak. Therefore, establishing and improving relevant laws, policies, and standards are key for the development of environmental pollution liability insurance in China.

(3) Duly adjust the strategy for environmental pollution liability insurance to reflect the realities of the current financial crisis.

The influence of the financial crisis on the national macro-economy has not yet come to an end, and it does not favor the promotion of environmental pollution liability insurance. Hence, appropriate adjustment to the development strategy for environmental pollution liability insurance is needed to respond to changes in the economic situation and in the priority of the nation's economic development. While the scale of existing experiments with environmental pollution liability insurance can be maintained, the pilot exploration should focus more on certain areas and industries with high environmental risks and high frequency of accidents. More efforts in the form of pilots to solve technical problems, enhance the technical properties, and gradually improve the related mechanisms and policies, while accumulating experiences and lessons with an aim to lay a foundation for a more comprehensive implementation of environmental pollution liability insurance in the future.

4.4.3.2 *Policy Recommendations*

(1) Establish a legal and regulatory framework to enable environmental po-llution liability insurance.

1) To improve related laws and regulations for the identification and division of responsibility for environmental damage, strengthen environmental responsibility and accountability, implement the "responsible-party pays" principle to create a real binding force for environmental liability on enterprises that can generate market demand and create the motivation for enabling effective environmental pollution liability insurance. First, it is necessary to improve the content of the identification and division of responsibility for environmental damage, enshrine in relevant laws the liability of those who create environmental accidents makers to provide compensation. In international practice, compensation relates to casualties, property damage, and ecological environment recovery (or remediation) expenses. The liability provisions can be specified in one special law or within a number of laws. Second, efforts are needed to strengthen investigation of criminal and civil liability of those who create environmental incidents, and various approaches should be explored to reduce reliance on the current method of mainly administrative punishment. Finally, efforts are needed to enhance and implement liability investigation, so that those who create environmental incidents will conscientiously realize the serious legal implications regarding compensation and the significance of environmental risk prevention, which is of great importance to promoting environmental po-llution liability insurance.

2) Legislation is the primary tool for building an environmental pollution liability insurance system in China, at the current stage. It is extremely difficult to promote environmental pollution liability insurance without a legal basis. Efforts should be made to expedite the legal construction of environmental pollution liability insurance, and to establish a legal system that favors the promotion of such insurance. First, it is necessary to implement legislation primarily at the national level. The contents of pollution liability insurance should be ap-

pended into the special laws concerning environmental protection during their amendment, such as Environmental Protection Law of PRC, or Law of PRC on Prevention and Control of Water Pollution, Law of PRC on Prevention and Control of Atmospheric Pollution, Law of PRC on Prevention of Environmental Pollution Caused by Solid Waste, and so forth. Second, efforts should be made to work out detailed rules or administration measures for the implementation of the environmental pollution liability insurance, which explicitly stipulate the relation between environmental pollution liability insurance and the civil liability system, the scope of application of liability insurance and the limits to the subject matter, the status of a third party under the liability insurance, liability for payment by the liable insurer, the plea and reconciliation on a claim of a third party under the liability insurance, and other issues. In addition, it is necessary to encourage the regions with legislative rights to take the initiative to carry out the legislation work of environmental pollution liability insurance, map out supporting regulations, policies, and measures, and launch experiments in order to accumulate experience for the formulation of relevant national laws.

3) Thirdly, clear channels for third party compensation must be made available for those who have been damaged by environmental pollution. At present, third parties have an arduous task to receive compensation, even if liability is clear.

(2) Establish a policy framework to enforce environmental pollution liability insurance.

1) The MEP should work to develop the standards and guidelines for environmental pollution liability insurance. This includes developing a compensation standard for pollution damage, environmental risk assessment standard, clean-up standards for contaminated sites, and so on so that the relevant activities can be implemented in accordance with certain criteria with the aim of regulating related market subjects' behavior vis-à-vis environmental pollution liability insurance and ensuring that environmental pollution liability insurance functions according to policy objectives.

2) By combining international development trends regarding environmental pollution liability insurance with the actual situation in China, it is necessary to adopt a model in which both mandatory and voluntary insurance are combined, and encourage the majority of enterprises to purchase environmental pollution liability insurance on a voluntary basis. First, efforts should be made to fully analyze the economic contribution, pollution discharge, frequency of pollution accidents, technological progress, social influence and other factors of industries with high pollution and high environmental risks. This involves studying and

proposing a directory of industrial technology for mandatory environmental pollution liability insurance, and determining the methods for industries that need to purchase mandatory environmental pollution liability insurance. According to China's industrial environmental risks and the conditions of accidents, enterprises that produce, transport, store, and use dangerous chemicals and petrochemicals, those that carry out hazardous waste disposal, and other industries should be included within the scope of management under the mandatory environmental pollution liability insurance. Second, it is necessary to study and propose technical guidelines on the establishment of the directory. In this respect, the basic requirements for methods under the mandatory insurance must be specified, and indicators and parameters regarding procedures to establishment the directory and perform technical selection should be standardized. In addition, the directory of industrial techniques under the mandatory environmental pollution liability insurance should be subject to dynamic and timely adjustment; techniques included in the directory should reflect actual management needs, with the aim of deliberately including techniques with higher environmental risks and greater harms within the scope of management under the mandatory environmental pollution liability insurance.

3) Environmental pollution liability insurance is in the public interest. Policy support from the central government is needed for the initial implementation of such insurance. Internationally, the provision of proper tax abatement and exemption is a common practice. The launch of appropriate preferential policies at the initial stage in China's implementation of environmental pollution liability insurance will not only encourage a greater number of pollution-discharging enterprises to purchase the insurance, but it will also diminish the operating risks of insurance companies. Thus, the benefits of both insurers and insured enterprises are guaranteed, which complies with the State's policy orientation of energy conservation and emission reduction. Therefore, MEP should join hands actively with financial, taxation, and banking management authorities to speed up the favorable and incentive policies which support the environmental pollution liability insurance, such as reimbursing companies with a certain proportion of their discharge fees as their premium paid to the insurers, connecting the insurance with the green credit system, tax reduction and exemption for insurances companies and so forth. In addition, it is recommended to establish a special fiscal fund to subsidize insurers and insurants in pilot areas to put forward the environmental pollution liability insurance on a voluntary basis.

4) It is necessary for the country to establish an environmental relief fund as

early as possible, which can be used for compensation where indemnity exceeds the limit of the environmental liability insurance and policy holders are unable to bear indemnity liability, in order to alleviate the financial impact of major environmental accidents and even environmental disasters. The environmental relief fund is chiefly aimed at safeguarding the rights and interests of victims and dissolving social contradictions caused by accidents. As a result, society assumes part of victims' losses. Such funding is a major supplement to the environmental pollution liability insurance, and an important part of the national compensation and relief mechanism. The environmental relief fund can be established by referring to overseas countries' experience, with a wide variety of fund sources, including: part of the funds transferred by the government through national finance appropriation, pollution discharge fees, funds raised through social organizations, and private donations, etc.

(3) Improve the supervision and management mechanism and establish an environmental pollution liability insurance guidance center.

1) It is important to strengthen collaboration between environmental and insurance authorities, with clear-cut distribution of labor to establish jointly the mechanism for investigation, loss adjustment, claims auditing and liability verification of environmental pollution accidents. It will be necessary to strengthen routine supervision and administration, conduct information exchange and communication in a timely manner, and establish an approval and solicitation system for environmental pollution liability insurance products to tackle problems arising from implementation of the insurance, and ensure the development of environmental pollution liability insurance in conformity with the established policy objectives.

2) Establish an Environmental Pollution Liability Insurance Guidance Center under the administration of the MEP. The major responsibilities of this center would be to formulate industrial environmental risk assessment guidelines and compensation standards for damages from pollution, to develop and refine an industrial process directory for compulsory environmental pollution liability insurance, to conduct studies on financial and taxation policies conducive to environmental pollution liability insurance, etc.

(4) Strengthening efforts in relevant education and capacity building.

1) The MEP and CIRC should actively carry out nationwide training on the subject of environmental pollution liability insurance for relevant personnel to improve their understanding of its importance so as to gain in-depth understanding of the requirements, goals, and methods of environmental pollution liability insurance and grasp the basic management skills and

technical approaches.

2) It is necessary to strengthen actively the fundamental research on environmental pollution liability insurance, which includes the accumulation of relevant data, research on environmental standards and so forth. It is also necessary to increase investment in the study gradually, to enhance the R&D of relevant insurance products, and to promote the technical support system of the environmental pollution liability insurance.

Chapter 5 Energy Efficiency and Urban Development —the building sector and the transport sector

5.1 Introduction

Controlling energy consumption related to the daily activities of people in cities, hereafter referred to as “urban-life energy” use, is integral to mitigating the threats posed by hydrocarbon scarcity and climate change to China’s development in the coming decades. Speaking before the United Nations (UN) in New York in September 2009, President Hu stressed China’s determination to comprehensively tackle the challenge of carbon dioxide (CO_2) emissions and, consequently, climate change. Controlling urban-life energy use, with its dual goal of achieving high quality of life in urban areas in ways that also minimise energy demand and carbon emissions, is fully consistent with China’s commitment and has the potential to make a significant contribution. While improvements in the performance of technical systems and supply side management are necessary components of this urban-life energy use goal, they alone will not be enough. Demand side management will prove equally, if not even more, critical, most notably through:

(1) advocacy and adoption of energy and carbon efficient lifestyles;

(2) development of cities with an urban morphology that limit needs for mobility;

(3) discouraging energy intensive consumption patterns through appropriate energy pricing and taxation.

With this in mind, the mandate of the Task Force was to investigate issues and formulate policy recommendations related to the potential for energy efficiency associated with various aspects of urban planning. The primary mission of the Task Force was to explore energy consumption associated with daily life in urban areas, hereafter referred to as “urban-life energy consumption”. This term embodies four essential components of energy use:

(1) energy use in residential buildings, such as for lighting, cooking, hot water, heating, cooling, and domestic appliances;

(2) energy use in office buildings and

other non-residential and non-industrial buildings, such as energy use for lighting, heating, cooling, office work and auxiliary appliances;

(3) energy use in buildings used for leisure and entertainment, such as theatres, shopping malls, gym centres;

(4) energy use for urban passenger transport, including both public transportation systems and private vehicles.

Since the whole urban system includes, but also extends beyond, the four urban-life energy use components listed above, a number of issues relating to data availability and quality surfaced as a result. Existing consumption data and statistics were predominantly sector-based, and did not include separate statistics on urban-life energy consumption. To solve this problem, two approaches were adopted:

(1) For international comparisons, we used a proxy for urban-life energy consumption: a country's total commercial energy consumption which is comprised of the residential, tertiary and road transport sectors, sourced from Enerdata's Globalstat database.[1]

(2) For detailed city analyses, we used data based on surveys carried out in China, as well as data from international city comparisons carried out by the Task Force during the project.[2]

This report presents an exploratory undertaking by the Task Force that investigates possibilities for controlling the evolution of total urban-life energy consumption and related greenhouse gas (GHG) emissions in China. Part 1 of this report discusses why controlling urban-life energy consumption should be a priority for policy makers. Part 2 considers the critical policy issues needing to be addressed in relation to the urban-life energy use objective. Part 3 provides an overview of policy recommendations based on primary findings of the report.

5.2 Controlling Urban-life Energy Consumption: a Priority

This report's focus on urban-life energy consumption does not negate the importance of industry and agriculture-related energy consumption. On the contrary; in China, these two sectors account for approximately 70% of conventional energy use. Urban-life energy use, which accounts for a much smaller proportion of conventional energy use in the country, is currently lower on the priority lists of policymakers. Rapid growth at 7.4% per year over the last decade, however, means that the urban-life energy use will be responsible for increasingly greater propor-

[1] Enerdata's GlobalStat database includes enhanced IEA statistics up to 2006, and data derived from various national, international and industry sources for 2007 and 2008 (http://www.enerdata.eu).

[2] Details on surveys and data sources for cities can be found in the main report.

tions of China's total conventional energy use over the next two decades.

5.2.1 Why Urban-Life Energy Consumption Is Important

In 2008, energy use from building and road transportation sectors contributed only 27% to total commercial energy use in China. This figure is comparable to energy use in other emerging economies of the world, such as India and Brazil (Figure 5-1 over leaf). Yet the experiences of developed countries show that once industrialization is fairly advanced, the contribution to energy use from buildings and road transport tends to progressively increase alongside economic growth and changes to industrial structure fostered by such growth. For example, in OECD and EU member countries, energy use from buildings and road transportation accounted for 60% of total commercial energy use in 2008. In European countries where more detailed data are available (France, Germany, and the UK), actual energy consumption for urban passenger transport plus households and services accounted for more than half of total commercial energy consumption (Figure 5-1).

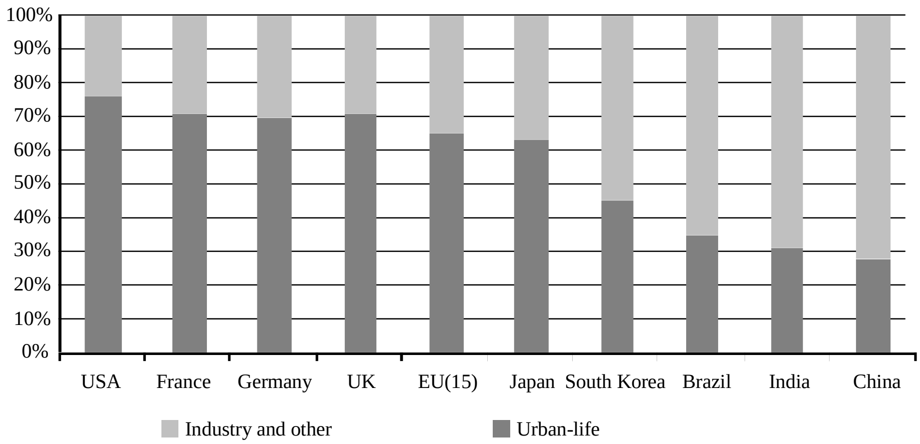

Figure 5-1 Share of urban-life energy consumption compared with total commercial energy consumption, by country (2008)

Source: Enerdata's GlobalStat database.

OECD countries are home to one sixth of the world's population, yet they are responsible for approximately half of total global conventional energy consumption, 58% of which is used for building and road transport. Furthermore, OECD countries account for 75% of global Gross Domestic Product (GDP). By contrast, the remaining half of global conventional energy consumption is accounted for by developing countries that are home to the remaining five sixths of the world population. Only 36% of this total conventional energy is ultimately consumed for use in buildings and road transport. In addition, developing countries account for only 25% of the world's GDP. The per capita energy consumption in buildings and road transport in OECD countries is therefore nine times higher than the average level in the rest of the world, and four times higher than the average level for urban populations in non-OECD countries.[1]

Per capita urban-life energy consumption for buildings and road transport in China is comparable to US levels in the mid 1950s, and Japanese levels in the late 1960s. Since then, urban-life energy consumption in the US has multiplied by a factor of three, and in Japan by a factor of two. If China follows urban consumption trends similar to those of OECD countries over the last century, dramatic increases in energy consumption can be predicted as the country develops through a rapidly emerging economy and enhancing living standards. Baseline scenarios for China run with the POLES model for the World Energy Council and the European Union indicate that urban-life final energy consumption has the capacity to increase by more than 300 Mtoe between 2008 and 2020, and by another 350 Mtoe between 2020 and 2030.[2]

If the per capita urban-life energy consumption levels of the four fast growing developing economies (Brazil, Russia, India and China, or BRIC nations) were to equal those of OECD 2008 levels, the world would need twice as much energy as it does today. Such a scenario implies an almost unimaginable strain on resources, taking into consideration presently available energy sources and environmental threshold capacities. The critical challenge, therefore, is to meet human development and welfare requirements while simultaneously keeping energy consumption and CO_2 emissions within sustainable limits. If this delicate balance is not maintained, ramifications on the world economy could be deep and long lasting, with drawbacks for all nations, including China and other fast growing developing economies.[3]

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[1] Statistics show that annual per capita urban-life energy consumption of Chinese urban citizens is about 0.54 toe, while the average level of American citizens is as high as 3.27 toe (Enerdata's GlobalStat, 2008).

[2] EU World Energy Technology Outlook 2050 (2006); WEC's "Deciding the Future: Energy Policy Scenarios to 2050" (2008).

[3] The Stern Report evaluated the consequence of climate change on global and regional economies which appear to be far more important than the costs of mitigating CO_2 emissions (Stern Review on the Economics of Climate Change, 2006).

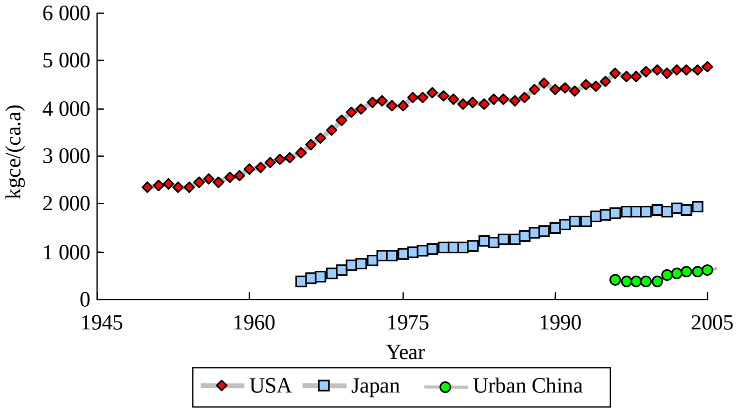


Figure 5-2 Trends for building energy consumption per capita for some typical countries

Sources: US Census bureau, http://www.census.gov/popest/states/tables/NST-EST2008-01.xls; The Energy Data and Modeling Center. Handbook of Energy & Economic Statistics in Japan. Japan: The Energy Conservation Centre, 2008; Building energy research centre of Tsinghua University. 2009 annual report on China building energy efficiency. Beijing: China building industry press. 2009.

There is a marked difference between the goods production sector and other economic sectors (mostly building and transportation) on issues concerning energy conservation and efficiency. For urban-life energy use, which is strongly linked to the activities of daily life, energy conservation and efficiency solutions will not be entirely determined by technological breakthroughs. Better organization and management, energy prices, lifestyle choices and other non-technical factors all hold much greater potential for impacting energy demand and mitigating related GHG emissions, compared to similar efforts in the goods production sectors. In other words, whereas energy consumption and efficiency in the goods production sectors are highly constrained by the technical environment, for urban-life energy consumption, individual choices and decisions are key factors.

5.2.2 The Critical Issue: Decoupling Urban-Life Energy Use from GDP

Unlike energy consumption in the goods production sectors, urban-life energy consumption is not directly driven by the production of goods, and therefore by the related generation of GDP. It is mostly driven by energy services provided to the people, which only partially contribute to the generation of GDP. When GDP rises, people accumulate more money, as more goods and services are made available to them, and as living standards increase. This is usually followed by increases in energy use, as demonstrated by the experiences of industrialized countries.

Although higher levels of per capita GDP are generally associated with higher levels of energy use, the correlation is not straightforward. Experiences from OECD countries at the individual country level have shown large differences among countries, not only with how urban-life energy consumption has been linked with GDP in the past, but in the present day as well. Figure 5-3 below shows that similar levels of GDP per capita can yield very different levels of per capita urban-life energy consumption.

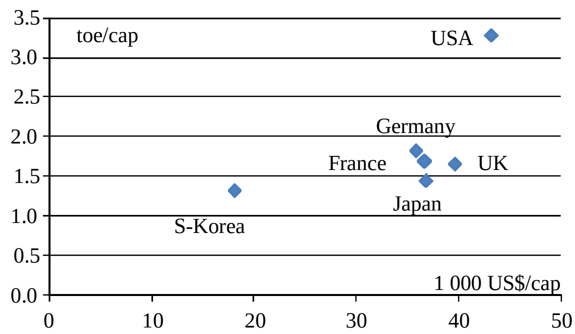


Figure 5-3 Per capita urban-life energy consumption and GDP in industrialized countries

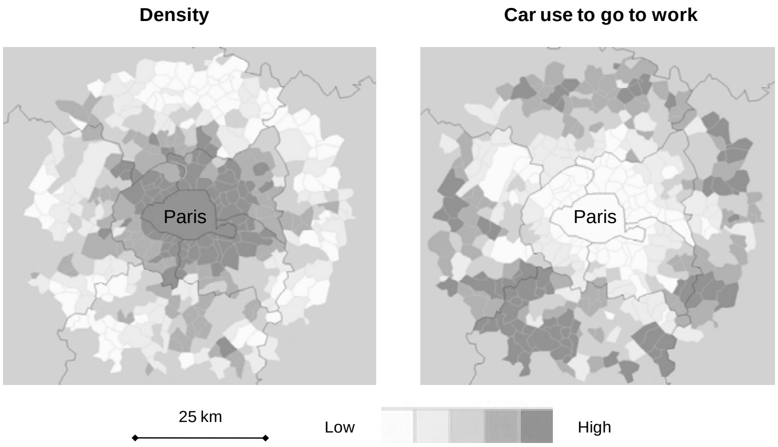
Differences in per capita consumption between the selected countries cannot be solely accounted for by climate, as shown by the comparison among European countries and between the USA, South Korea and Japan. The real reasons behind these differences have more to do with land use and urbanization patterns than with climate. To provide an example, let us consider the case of the US and Japan. They share similar levels of GDP per capita, but Japan's per capita urban-life energy consumption is considerably lower, at just under half that of the US level. This is to be expected: Japan has high population densities with people living in closer proximity to one another, whereas US populations tend to be geographically spread out with large distances between people and amenities. In addition, very low energy taxation in the US means that energy prices on the whole are much lower than those in Japan, with higher energy consumption in the US as a result.

The case of the US suggests that the lower the energy prices and the more space available, the more extensive the urban sprawl, and the higher the per capita urban-life energy consumption, regardless of GDP per capita. Table 5-1 below compares road transportation patterns in the US and Japan. It shows that the per capita energy consumption for transport in the US is three times that of Japan, for a similar level of GDP per capita. Indeed, the US is a much larger country, requiring more intercity road transportation, but in both countries the vast majority of road travel is for urban and local distance purposes only.

Table 5-1 Road transportation and energy consumption in the US and Japan

	US	Japan
GDP per capita	43.000	37.000
Average density	31 people/km^2	350 people/km^2
Number of cars per household	2,4 cars	1,2 car
Energy consumption of road transport per capita and year	1.820 koe	600 koe

Detailed comparisons between cities in Europe, Japan and the US were carried out by the Task Force to see if the above diagnosis could be strengthened, particularly with regards to the relationship between urban-life energy consumption and urbanization patterns.[1] The case of greater Paris highlights the issues. Figure 5-4 below compares the extent to which personal car use is determined by housing density, and examines associated energy consumption patterns as a consequence of daily activities.



Energy used in toe per year	Paris (2.1 M inhab.)	1st suburb (3.2 M inhab.)	2nd suburb (4.1 M inhab.)

Figure 5-4 Density, car use and daily energy consumption levels in greater Paris

Source: Task Force study on international cities comparison.

[1] The detailed results of this research are available in the final report.

There are some well-known reasons as to why urbanization patterns play such a key role in the link between urban-life energy consumption and GDP:

(1) Daily travel distances to amenities and the work place are mostly determined by the size and layout of the city;

(2) Density of daily trips on main axial routes and the density of heat demand are mostly determined by a city's population, compactness and spatial layout;

(3) Building floor area is a driver of total building energy consumption. For example, over the last ten years China's per capita urban building floor area has doubled. As a result, building energy use has also doubled;

(4) Features such as building type, glazing, and natural ventilation are mostly determined by urban design and layout.

Another point that can be deduced from figure 5-3 is that OECD countries may have similar GDP per capita with strong differences in urbanization patterns, which means that both features are not very strongly correlated. Conversely, the manner in which GDP is used depends upon the specific urbanization pattern of a municipality. The higher the per capita energy consumption, the higher the share of the income necessary to purchase energy and related equipment (a car for instance), and the lower the available income for purchasing more welfare oriented goods and services.[1] Hence, the claim that more energy intensive urbanization leads to more welfare per unit of GDP does not always hold true; increasingly, research is showing the opposite.[2]

In summary, the collective experiences of OECD countries, in particular Japan and selected European countries, have demonstrated that urban-life energy use can be decoupled from GDP to a certain extent, with urbanization patterns and energy prices playing a much larger role. The Task Force believes that China may be able to go even further in decoupling its urban-life energy consumption from its GDP. First, it can benefit and learn from previous experiences of OECD countries. And secondly, with issues such as climate change and oil scarcity rising higher on the agenda, conditions will be more conducive to decoupling over the next two decades than in the 20th century.

5.2.3 Lifestyles: a key target for controlling urban-life energy consumption in China

At its core, urban-life energy consumption is strongly influenced by lifestyles and related consumption patterns. To further reduce urban-life energy in cities, greater emphasis will be placed on domi-

[1] JP Orfeuil's "Mobility, Poverty and Exclusion in France" (2003).

[2] On this question, see the recent report by the Stiglitz Commission to French President Sarkozy: "Report by the Commission on the Measurement of Economic Performance and Social Progress" (2009).

nating social culture and values (for instance, one would feel, for those newly-built high-rise double skin commercial buildings, glorified due to their fashion, or humiliated due to their high energy cost and uncomfortable environment, etc.), individual choices and behaviours. Of course, income levels matter, but they do not solely define consumption patterns: these are largely defined by the type of urban environment, amenities and physical organization of space in which people live, service price and availability, and the nature of value-driven criteria used for making personal decisions and choices.

The lifestyle policy challenge can be approached in terms of four 'pillars' that have the capacity to transform the Chinese urban landscape, as described below.

5.2.3.1 ***Pillar 1: Creating genuine Chinese patterns of urbanization***

China is set to face a huge increase in the size of its urban population over the next 30 years, with 300 million new urban citizens being added during this time.[1] Despite presenting the country with enormous challenges, this situation could also create significant opportunities for policies aimed at controlling urban-life energy consumption. The challenge for policymakers is to accommodate this new urban population with much higher material expectations than populations in rural areas, without creating major drawbacks for the economy and the environment. Opportunities exist for designing genuine Chinese urbanization patterns in which the demand for energy services is maintained at lower levels (for example, through good accessibility with short distances), and good economic conditions allow the development of comprehensive energy efficient services (for example, public transport on dedicated lanes, efficient district heating etc.).

5.2.3.2 ***Pillar 2: Low energy intensity services that are available and appealing***

Well-planned urbanization patterns are a pre-condition for decoupling urban-life energy consumption from GDP, but they are not enough. People can and will adopt low energy consumption patterns only if low energy intensity services for mobility and for heating and cooling and corresponding facilities are available and appealing. This is particularly important in supporting decoupling in the medium and long term. The majority of such services have to be planned in the early stages of urban settlements; service implementation costs rise with later stages of urban development.

5.2.3.3 ***Pillar 3: Selection of technical systems***

Technical systems performance is determined truly very much by level of service provided, or demand of services in our urban-life. Most advanced energy carriers, de-

[1] Source: China Population and Family Planning Commission.

signed for lifestyles of high energy consumption, are proved to be inefficient when operated in a saving mode of lifestyle. It indicates that innovations of technical devices and systems are necessary to fulfill requirements of sustainable green lifestyles, which uses less energy but with higher efficiency and helps maintain comfortable and healthy living of people. For instance, public transport systems cost much more energy than private vehicles, due to high no-load rate when there is strict time limitation of waiting for buses, but become appealing when prolonged waiting time is allowed to certain extent. The same thing occurs to centralized air-conditioning systems in buildings. They are proved to be efficient while there are needs of "full-time and all-space" cooling with requirements of constant temperature and humidity. However, housewives of those who prefer "part-time and part-space" cooling would choose split-type air-conditioners instead, since the electricity bill would be much less. Since there is no consistent set of technologies in China that could fully fulfill lifestyles of high energy consumption, significant chance emerges for China to develop suitable building and transport systems for green lifestyles.

5.2.3.4 *Pillar 4: Promoting values which shape personal choices*

To decoupling increase of urban-life energy use from GDP growth, corresponding social culture and values are needed, which impacts subtly people's decisions to be healthy, nature-resource saving and environment-friendly ones. Admittedly, economic issues play significant role in decision making, yet proper pricing and taxing of energies could mitigate, to considerable extent, the impact of economic growth, while enhance considerations for other issues.

And it features significantly the fast developing cities that the culture, concept and values of citizens keep changing with expanding modernization and urbanization in China. It is high time to cultivate new social and cultural values which are dominated by concepts of saving and the concrete base of green lifestyles. Then it becomes possible to achieve sustainable development with different urbanization modes from developed ones.

5.3 Decoupling urban-life energy use from income level increases in China

The drivers of urban-life energy consumption fall into one of two categories: 1) de-mand of energy services, and 2) energy efficiency of energy carriers. Controlling total urban-life energy consumption therefore requires control and appropriate reduction of the demand for services as well as the development of energy efficient technologies and systems to supply these services. Demand for services is mainly determined by urbanization patterns and related local lifestyles, cultural values and social organization, while the energy efficiency of energy carriers is more a function of available technologies. Both drivers will be further analyzed in the following subsections in relation to the urbanization process in China, along with a discussion of issues and challenges related to the decoupling of urban-life energy consumption from income level increases.

5.3.1 Growth trends of building floor space, urbanization and urban transport patterns

Thirty years have passed since the beginning of China's economic reform. During this time, China's urbanization rate has been increasing at a much faster pace compared with historic urbanization rates of already industrialized countries (Table 5-2). The urbanization ratio for China was 17.9% in 1978, but reached 45.7% in 2008, with an annual increment of more than 0.9%. If the rate of urbanization increase remains stable, the urbanization level in China is expected to reach 47% in 2010, and 60% around 2030, the world average.

Table 5-2 When the urbanization ratio of some typical countries grows from 20% to 40%

Country	Britain	France	Germany	USA	Former U.S.S.R.	Japan	China
Year	1720-1840	1800-1900	1785-1865	1860-1900	1920-1950	1925-1955	1981-2003
Period	120 Years	100 Years	80 Years	40 Years	30 Years	30 Years	22 Years

Source: China's Urbanization Process and Space Expansion.

In line with the fast pace of urbanization, per capita building area in China is increasing. Statistical data for China show that the current per capita urban floor area for residential and commercial buildings is nearly 30 m^2. This exceeds the corresponding index for Hong Kong, and brings the country closer to the average per capita urban floor area values of Japan and Singapore, currently about 36 m^2. In some instances, indices for certain Chinese provinces and cities exceed the average value of Japan and Singapore. Overall, however, China's per capita floor area is far lower than that of the US and Europe. Despite this, the last 15 years have seen a doubling of urban building floor area every 7 years, with more than 1 billion m^2 of buildings being constructed every year. If this trend continues, with 1 billion m^2 of buildings constructed each year, alongside urban population increases of 15 million a year, China's per capita urban floor area will reach 42 m^2 within 20 years, bringing it much closer to today's European levels. Total building energy consumption is almost certain to grow alongside increases in the building stock. If the urban building stock doubles, corresponding building energy consumption may undergo a two-fold increase, potentially even higher. Surveys and analyses carried out by the Task Force indicate that, the peaking building stock is not in line with the real needs of increasing population. The driving forces hidden behind would only be clarified by further investigations and researches. If irrational motivations overwhelm other driving forces and yield up the building stock to an unnecessary and improper scale, a control mechanism for scales of urban construction and urban buildings may need to be established, to effectively restrain the unnecessary urban sprawling.

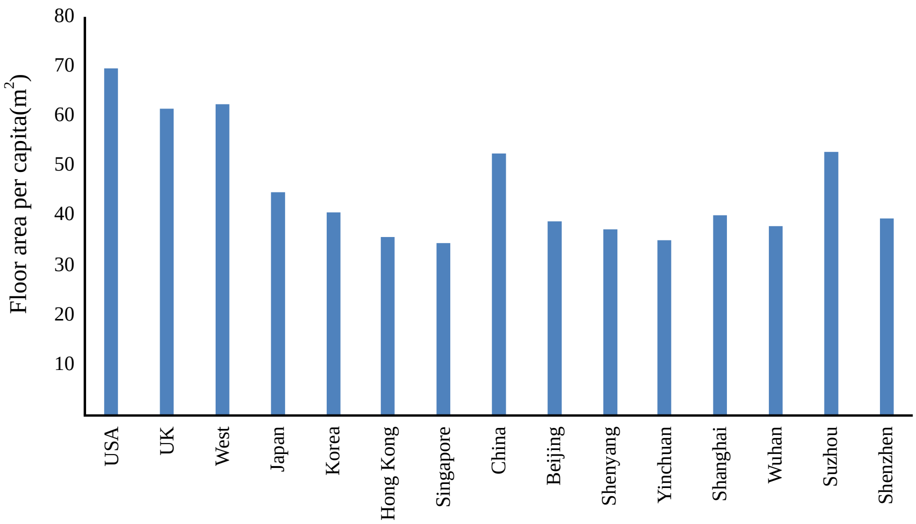


Figure 5-5 Per capita floor area comparisons between cities in China and selected countries of the world

Sources: IEA, AEI, Tonooka, Korean statistics, China Statistical yearbook.

At the end of 2007, there are 655 cities in China, and their total built-up urban area was 35,470 square kilometers with 340 million residents, and the average population density is 10,294 per square kilometers; the actual building floor area in cities was 18.79 billion square meters, including 11.97 billion square meters of residential buildings. According to these data, the calculated per capita floor area of Chinese citizen, both residential and non-residential buildings included, reaches as high as 53 m^2/ca., exceeding levels of Japan, Hong Kong and Korea by far (Figure 5-5). Yet it is notable that there are considerable numbers of buildings are serving immigrant workers in Chinese cities, so the real value would not be so much. However, it should be fully stressed.

Meanwhile, the proportion of so-called high-grade buildings, which are actually with high energy consumption, hikes in the newly-built buildings. Some high-grade residential buildings consumes more than twice of energy, in terms of unit area, as normal ones do, some glorifying office buildings more than quadruple. As is advertised, these buildings, truly, attained the developed level, but much more of energy use than of other bling-bling things in their posters. It seems in China that things are deviating from decoupling energy use from GDP growth by providing technical devices and systems suit for green lifestyles, but to, unwittingly, copying urbanizing routines of developed countries, and energy use.

The consequence has been a sharp rise in urban passenger transport volume and oil consumption. Since 1980, the year when urban residents' demands for transport started what has since been a continuous increase, passenger volume of urban public transport (including public buses, trams, and subways) has been growing steadily. In 2005, passenger volume reached 48.4 billions passengers-trips, which is 2.6 times greater than the level in 1980.

Generally, with the rapid development of urbanization and motorization, the basic problems of urban public transport in China have not fundamentally changed. There is still a conflict between road infrastructure development and efficient mobility services, and problems of traffic congestion in large cities have increased dramatically, resulting in shrinking quality and attractiveness of public transport. Though the modal share of public transport has risen from 10% to 35%, which is much higher than it ever was before, it is still lower in comparison to other cities of a similar nature in developed countries, where the average share of public transport is between 50% and 70%.

At the same time, physical space for non-motorized transport (NMT) modes has been dramatically compressed by the rapid development of cars. Overall, the share of public transport and NMT modes such as bicycles in Chinese cities has been gradually shrinking each year (Figure 5-6).

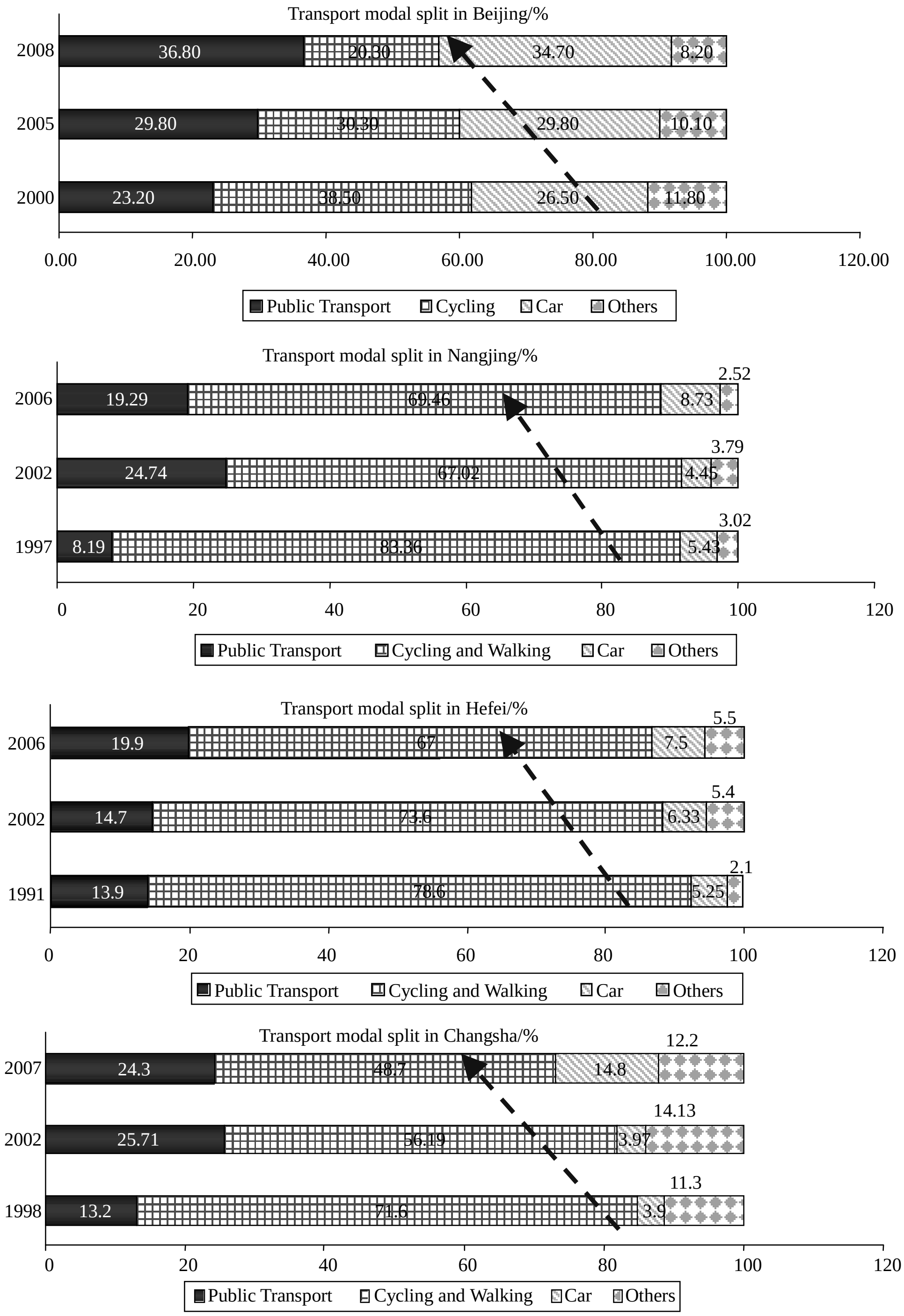


Figure 5-6 Modal Splits for Transport in Selected Cities, China

5.3.2 Following the OECD: Trends in China's Energy Consumption for Buildings and Transport

China's urban-life energy consumption constitutes a mere third of the country's final conventional energy use today, a figure similar to EU levels in the 1960s. However, over the last ten years, urban-life energy consumption has been increasing by 7.4% a year, in comparison to final energy consumption, which has been increasing at 5.9% annually.[1] In global comparisons, China, as the largest developing country in the world, is still experiencing a relatively low level of urbanization, and the per capita urban-life energy consumption for the country is not high.

In 2008, China's total per capita commercial energy consumption levels for buildings were 10% of those in the US, and 17% of those in the EU and Japan.[2] For urban areas only, the per capita commercial energy consumption of buildings in China rose to 23% of levels in the US, and almost 40% of levels in Europe and Japan. For residential buildings, China's energy consumption levels per m^2 represented one third of consumption levels in the US and one half of those in Europe.[3] With a growing economy, improvements in living standards and under the influence of ideas of "a joint track with international standards" and "30 years of no backwardness", energy consumption levels for many high standard buildings in China have already reached industrialized country levels.

For the road transport sector, China's per capita fuel consumption has been increasing rapidly from 1990 to 2008, with an annual average increase of almost 9%. In absolute terms, however, China's per capita consumption is still minute compared to those of other industrialized nations. China's per capita road transport energy consumption is less than 15% of levels in Japan and Korea, 10% of those in the EU, and 4% of those in the US. However, narrowing the comparison down to urban populations only, the results for China become much more comparable to those for industrialized countries, with per capita consumption representing more than 30% of consumption levels in Korea and Japan, 25% of levels in Europe, but only 10% of levels in the US. Beijing, where the motor fuel consumption level is already three times higher than the national average, currently represents half the current average motor fuel consumption levels of Japan and Korea[4] (Figure 5-7).

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[1] Enerdata's GlobalStat database.

[2] Enerdata's GlobalStat database.

[3] Source: Building energy research centre of Tsinghua University. 2009 annual report on China building energy efficiency. Beijing: China building industry press; 2009.

[4] Source: CATS.

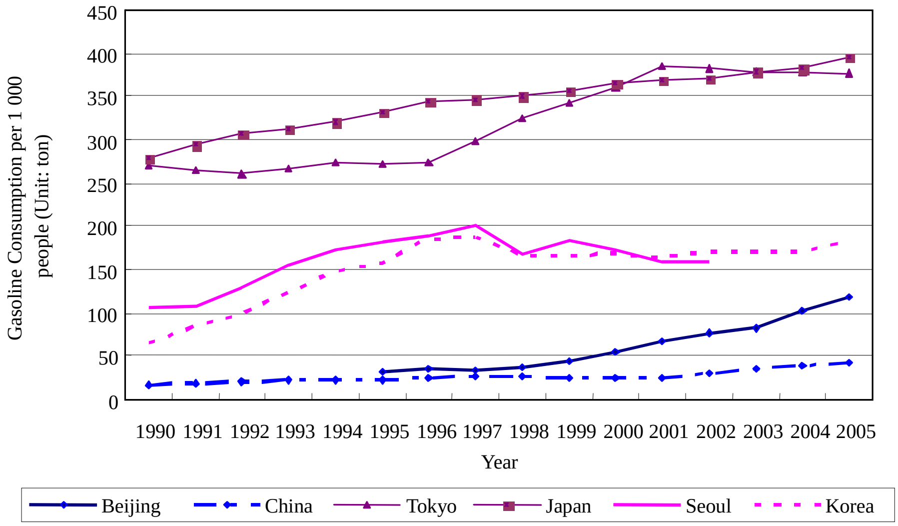


Figure 5-7 Per capita gasoline consumption in China, Japan and South Korea

Surveys carried out by the Task Force showed that although the average per capita energy consumption value for Chinese citizens is still far from those of developed countries, the average per capita consumption level for the highest 10% of consumers in China is almost identical to the average for developed countries (Figure 5-8).

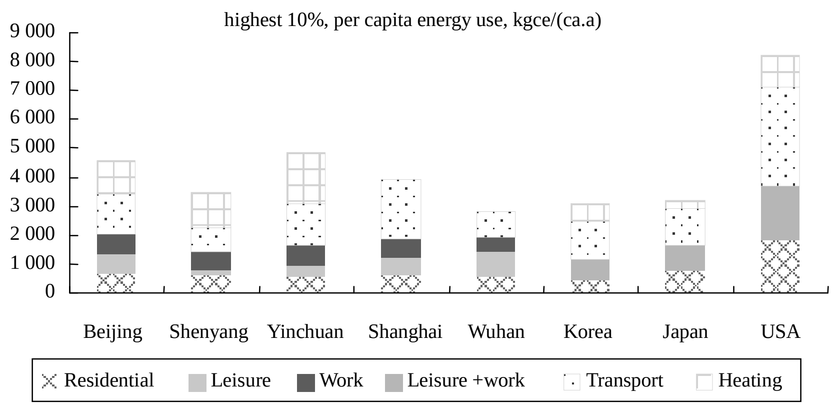


Figure 5-8 Urban-life energy consumption per capita in Chinese cities and foreign countries

The findings from the review of current trends in energy consumption in bui-ldings and road transport in China confirm initial concerns expressed at the beginning of this report. Should China continue down the same pathway of economic and urban progress that has characterized its development over the last few decades, it will come closer and closer to per capita urban-life energy consumption levels similar to those of developed countries today.

5.3.3 Discrepancies in per capita energy consumption among and within Chinese cities

A large-scale survey was carried out by the Task Force in six Chinese cities (Beijing, Suzhou, Shenyang, Yinchuan, Wuhan and Shanghai)[1] as well as several cities in selected developed countries. The aim of the survey was to compare and understand per capita energy use across different municipalities, both within and outside China, in a developing and developed country context.

Figure 5-9 below shows the distribution of the urban-life energy consumption (excluding space heating in Northern China cities) per household, according to consumption deciles (from the 10% households with the lowest consumption up to the 10% with the highest energy consumption), in five surveyed cities.

It is clearly that:

(1) There are huge difference in energy uses in the consumption sector between the highest and the lowest groups. 20% people in the city from the highest consume same amount of energy as the 80% of the rest. However, no obvious correlations between energy use and income are observed (it will be discussed hereinafter).

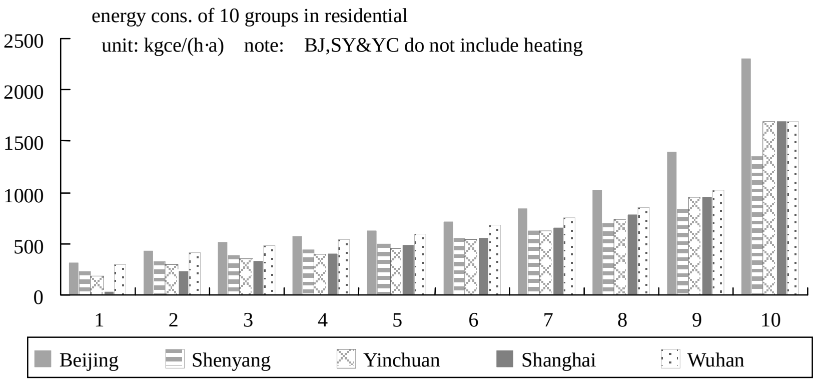
(2) Although the shapes of the distribution of energy use for different cities in China are very similar, the mean value for each city is quite different. It seems some correlation with the economic level of the city. And it could be further attributing to the cultural differences and corresponding habits of consuming and lifestyles, etc.

(3) Although the average value for Chinese citizens is still far from the developed countries (5%-20%), the average of the highest 10% is almost in the same level as the developed countries. This means it would not be very far future the Chinese energy use in consumption sector reach to the same level of developed countries if they follow the same trace of economic and urban development.

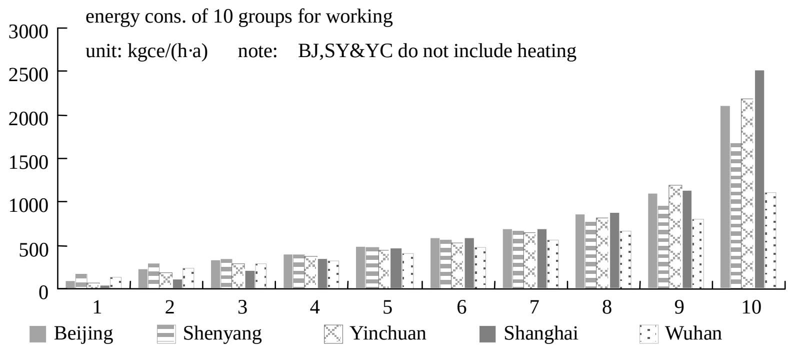
(4) Distribution of heating energy consumption among different groups of people in Beijing, Shenyang and Yinchuan are quite even, which is quite different with other energy end-usages in consumption sector. It is observed that per capita energy use for heating in China is around developed level, yet the energy use for

[1] For more details, please refer to the final report.

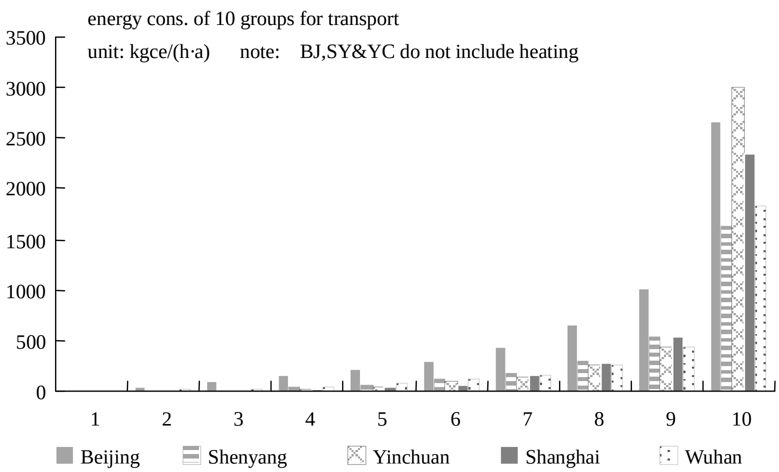
other



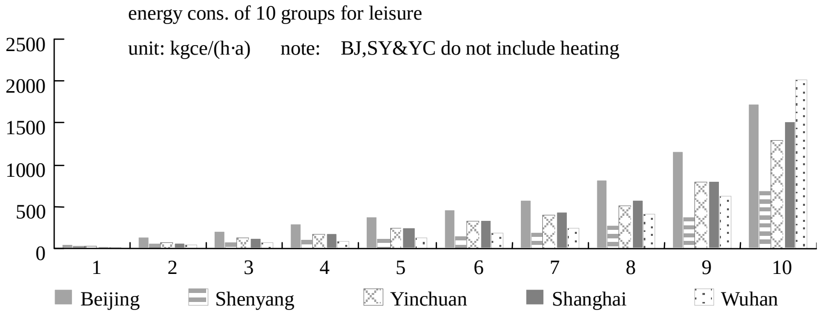
(a) energy use in households



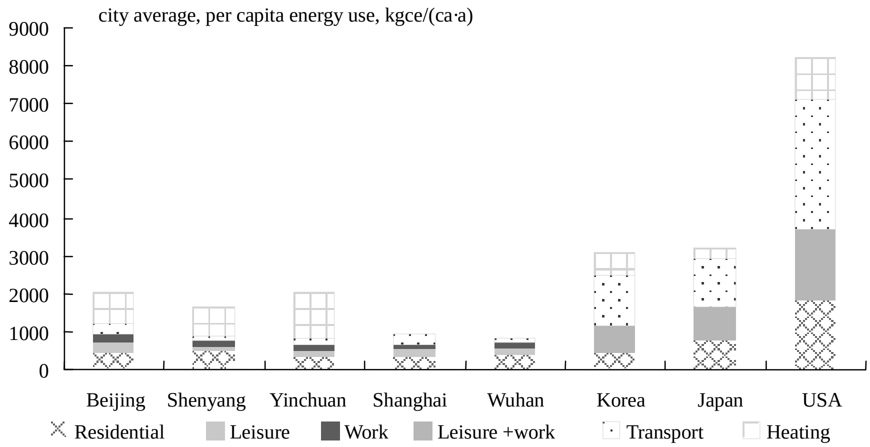
(b) energy uses for working



(c) energy use for transport



(d) energy use for leisure time



(e) average per capita energy use of each city

Figure 5-9 Distribution for urban-life energy consumption per household for survey cities (district heating energy not included for cities at northern China) [1]

end-usages in consumption sector is much lower. The difference reflects well that the impacts of market and social welfare upon energy use in consumption sector are of

[1] Energy use for heating in Beijing, Shenyang and Yinchuan are not included in above results. The energy bill for district heating is charged according to served floor area, yet the heating fee of considerable number of residential buildings is paid by residents' employee. It is quite common in China that householders even do not know how much he has paid for heating. In general, district heating in China is kind of social welfare, which is not as in the market mechanism. As a result, the features of energy use of it are much different from others in consumption sector. So it accounts for the energy use in market separately, as (a)-(e) in Figure 5-9, in convenience of analysis. Yet the data of developed countries are national average ones. For instance, the area that needs heating in winter in USA covers only 40%-50% of the total area of the country. While the domestic data are average ones within a city. As a result, the heating energy use of Beijing, Shenyang and Yinchuan are higher than that of developed countries.

great difference. This report will discuss possible policies to achieve energy conservation for heating through mechanism reform. So, the energy use discussed in following paragraphs does not include energy use for district heating system in northern China.

Following will be discussion on reasons for observed differences of each energy group.

5.3.3.1 *Floor area per capita*

Figure 5-10 below shows total building floor area in terms of m^2 per capita and per capita urban-life energy consumption for cities in China and abroad. The building floor area includes mostly residential and service buildings. One of reasons for the difference in energy use across the surveyed cities can be attributed to differences in the total building floor area. The greater the floor area, the greater the energy use.

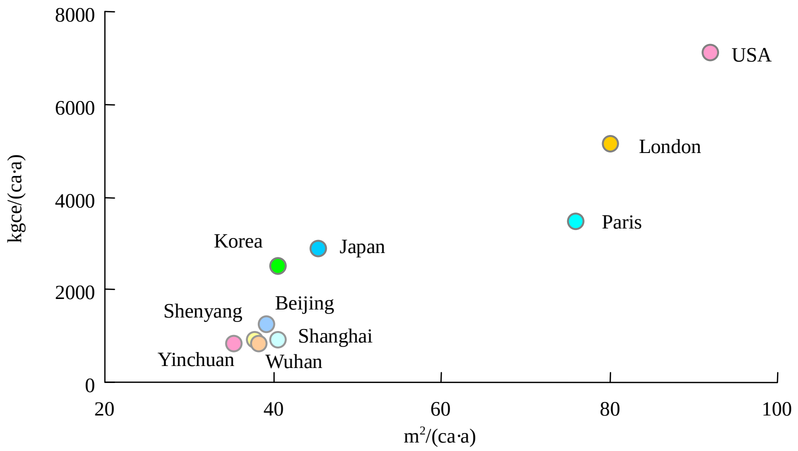


Figure 5-10 Per capita urban-life energy use and floor area (residential and commercial)[1]

5.3.3.2 *Income*

Figure 5-11 below compares the distribution of the urban-life energy consumption per household according to two series of deciles: one based on energy consumption (pale), the second based on income (dark). The purpose of this comparison is to show how far differences in consumption levels are

[1] Data sources: Chinese cities - 2008 statistic year book for each city, along with investigations; Paris and London - see final report on international cities comparison; Korea - Korean Energy Economics Institute (2005), Energy Use Survey (2005); Seoul - Ministry of Commerce, Industry and Energy (2005); Japan - The Energy Data and Modelling Center, Handbook of Energy & Economic Statistics in Japan, The Energy Conservation Centre (2008); US - The United States Department of Energy (2008), Buildings Energy Data Book, US: D&R International, Ltd. (2008).

explained by differences in income, and how far they are due to other factors, mostly related to lifestyles and consumption pattern. The bigger the angle between the dark and pale lines is, the weaker the relationship between energy and income.

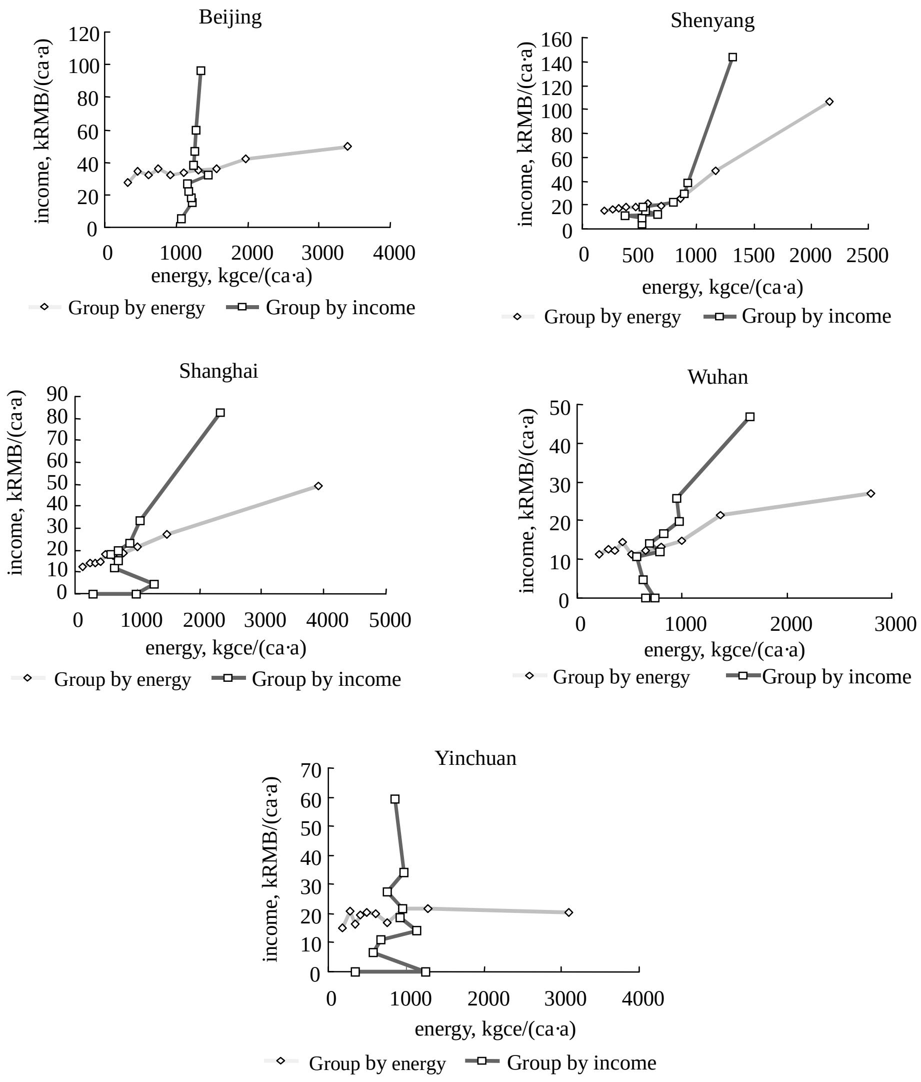


Figure 5-11 Distribution of urban-life energy consumption levels in Chinese cities

Note: there are some groups whose incomes are 0 in the figures, due to they are supported by other members of their family. Since those supported do not have as much transport and work energy use as other members do, all members of a family are categorized into different groups according to individual income level.

This figure clearly shows that the relationship between income levels and energy consumption levels is rather weak everywhere, and almost not significant in some cities (Beijing, Yinchuan). Although the Task Force did not have enough time to comprehensively investigate the differences among cities, helpful material to understand the reasons behind these differences has been provided by the survey and used by the Task Force. This is reviewed below.

5.3.3.3 ***Consumption patterns***

Survey data for four of the six Chinese cities (Shanghai, Wuhan, Shenyang, and Yinchuan) were analysed by the Task Force sociologists at Tsinghua University in an attempt to further explore the underlying drivers of 1) observed differences in energy consumption per capita, and 2) personal attitudes towards ideal lifestyles. Four main drivers were explored: age, income, education and occupation. Detailed results and findings are featured in the in the final report; the main conclusions are as follows:

(1) In each city, more than half of all respondents' attitudes to energy use in their daily lives were to maintain a certain degree of comfort while still attempting to save energy, with about 20%-35% of respondents prepared to forego comfort in order to save more energy.

(2) Respondents identified comfort and health as two of the most important characteristics of an ideal lifestyle. This has important implications for priority setting. Energy techniques need to be improved in order to meet people's demands for comfort which are as low in energy-intensity as possible. The relationship between health and behavior that promotes low energy consumption (for instance, cycling) should also be publicly promoted, in order to encourage healthy lifestyles and simultaneously discourage unnecessary energy use.

(3) Of the four drivers (age, income, education, and occupation), age was the greatest determinant of attitudes towards energy use and lifestyles. It was observed that younger people tended to use more energy in order to maintain a more comfortable life, whereas older people tended to be thriftier with their energy use. In addition, the general focus towards personal healthiness was more prevalent in older people than in younger ones. Finally, younger people have more varied views on ideal life style than older people.

(4) Explicit correlations between the other three drivers (income, education, and occupation) and respondents' attitudes were not identified in the analyses.

(5) The answer to the question of why age influences attitudes towards ideal lifestyles and energy use lies in the rapid socioeconomic and cultural changes that have been transforming China over the last few decades. This has resulted a younger generation with greater and more complex lifestyle expectations, and has led to an aban-

donment of traditional customs emphasizing thrift and restraint.

(6) Given that age was the greatest determinant of people's attitudes towards energy use and ideal lifestyles, China's future energy strategy should incorporate greater educational and awareness initiatives, as well as a reconsideration of the role of traditional cultural values in the context of energy use.

Another question needing to be answered for consumption patterns was "to what extent do social differences account for variations in energy consumption?" Figure 5-12 below shows electricity consumption of split air-conditioning units for 25 families in a residential building for employees of a design consultancy company. Every family unit was installed with two to four split air-conditioning units, and air conditioning electricity use per household was defined as the measured electricity consumption of each family unit divided by the building floor area of each unit. The primary reason for variations in energy consumption among different families is the air conditioning unit operation hours: the value ranged from 50 to 2,000 hours per year. Some families use an approach to air conditioning of "part time and part space", while other families have adopted a continuous air conditioning approach, "full time and full space". According to the survey, the operating hours, and consequently, the electricity consumption are not related to the income levels of each family, nor to the professions of the householders. The only correlation found was in the ages of each family. The data showed that the older the family the shorter the operation hours, and the younger the family the longer the operating hours. As mentioned previously, this is mainly a reflection of changing cultural and lifestyle norms.

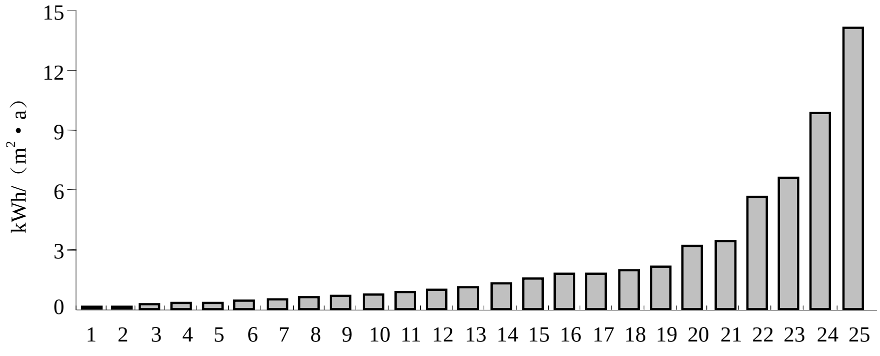


Figure 5-12 Measured air-conditioning electricity consumption per household for certain residential buildings in Beijing

To provide a comparison with the previous example, a so-called "high energy performance" residential building in Beijing was installed with a high energy efficiency central air-conditioning system. The electricity consumption for the air conditioning system the same year that it was installed was 19.5 kWh/m^2. This is almost eight times higher than the average electricity consumption for the multifamily residential building in the previous example, running with split unit air conditioning systems. Although the "high energy performance" building did feature state-of-the-art technologies both in terms of building fabric and the air conditioning system, its overall electricity consumption was still considerably higher. This is attributed to the building's "full time and full space" approach, which contrasts with the multifamily residential building's general "part time and part space" approach.

5.3.3.4 *Building working conditions*

Details of energy consumption, including space heating, space cooling, electricity for chillers, pumps, fans, lighting and appliances, in surveyed office buildings in campus of Tsinghua University (TH), downtown Beijing(BJ), Shanghai(SH), Lyon(FR) and Philadelphia(US) are illustrated in Figure 5-13. It is very interesting that the overall energy consumption intensity per floor area varies from 34 to 330 kWh/m^2, although the function and climate are similar.

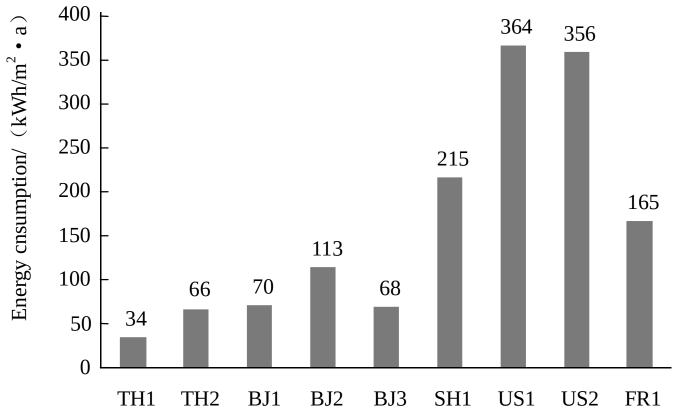


Figure 5-13 Comparison for office building energy consumption in different countries

Note: TH represents campus buildings in Beijing, BJ represents a building in Beijing, SH in Shanghai, US in USA and FR in France.

One potential explanation is that the difference comes from the different service quality provided, consequently the working efficiency in those high service quality office buildings may be higher than the lower ones. However in-situ questionnaires showed that almost no complaints in the lowest energy office buildings such as TH1 and TH2, but a high frequency of complaints in the high energy intensity buildings. A question emerges from the survey as to why people need to pay huge energy bills to run the "high standard" buildings.

Table 5-3 Travel distance and modal shares for various Chinese cities

City	Average travel distance（km）	Travel modal split (%)[1]	
		Public transport	NMT(Cycling+Walking)
Yinchuan	8.4	20.7	64.2
Beijing	11.0	38.3	27.7
Shenyang	9.5	18.8	68.1
Suzhou	11.5	10.4	44.4
Wuhan	9.8	23.4	61.0

5.3.3.5 *Urban trip distances and modal splits*

Table 5-3 shows the average daily travel distance and modal shares for five of the six Chinese cities surveyed (long distance travel for office and holiday trips are not included). Travel demand and share of public transport and NMT play a role in the determination of urban-life energy consumption (this is analyzed in details in the final report of the task force). Does longer per capita travel distance indicate a better life quality? Or is this a reflection of city size and urban lay-out? For any given travel distance, travel by car will be more costly than public transportation and than non-motorized transport. However, the greater the distance needing to be traveled, the more appealing the car is due to its advantage of speed, despite the downsides of cost and energy intensity. Rational use of private vehicles whilst creating an urban environment favorable to the development of public transport and NMT modes is a key component of urban energy saving.

The reasons behind these low levels of modal shares for public transport are investigated below:

(1) Urban public transport legislation

Currently, unified regulation making public transport a priority does not exist, for various reasons. The "Regulation for Urban Public Transport" is still in the consultation stages, which means that there is no strong legal framework for planning, constructing, operation and management of

[1] Source: Survey data from CATS.

public transport developments. Therefore, requirements for land, funding, development rights and operational subsidies for urban public transport cannot be effectively implemented, construction is insufficient, and land for stations is not always available.

(2) Urban public transport financing

Financing mechanisms need to be improved, as only limited subsidies are available from the central government. Management of public transport subsidies is carried out by local governments, which individually determine how subsidies are to be managed within the particular municipality. In the low public fares system, many public transport enterprises face operating difficulties. According to 2005 survey data, 80% of key public transport enterprises were running under deficit at the time, 12% were breaking even, and only 8% were receiving a surplus. In 2005, subsidies from local governments for 23 out of 36 cities amounted to 2 160 million RMB. A more recent survey in nine cities showed that public transport enterprises in eight of the cities were still running at a deficit. Furthermore, the survey showed that deficits can lead to instances of employee overtime (being employed for more than 10 hours per day) as well as generally low salaries for employees in public transport enterprises. This in turn threatens the solidarity of the employee team and the public transport enterprise operation as a whole.[1]

(3) Allocation of urban space

Weak coordination between urban planning, road construction and transport planning results in the shrinkage of public land specifically designated for non-motorized transport, and creates difficulties in the management of public transport, as emphasized above.

5.3.4 Findings of researches and surveys

Research findings have raised the following points:

(1) Urban-life energy use is not determined by technological capacities alone; it is a reflection of societal lifestyles, cultural values, and associated habits. These qualities in turn are a function of the urban landscape, which plays an important role in determining demand for energy services. At the same time, total energy use is driven by total demand of services, with technology determining the energy use per unit of service demand.

(2) Differences in per capita urban-life energy consumption may be related to differences in life quality levels. However, the relationship between energy consumption (which is related to the services used) and quality of life is far from linear. A small change in lifestyle may cause a huge in-

[1] For more detailed information, please refer to the full report.

crease in energy consumption, if it leads to a switch from a low energy intensity service to a high intensity one without significantly improving living conditions (switching from the metro to a car to go to work, for instance). In many cases, high demand of energy intensive services does not necessarily provide significantly better living conditions (such as those relating to health, working efficiency, and commuting time). Sometimes, the reverse may occur, with high demand for energy intensive services resulting in worse living conditions.[1]

(3) Unlike the industry sector, where the predominant pathway towards reducing energy consumption is through increases in energy efficiency by way of technical improvements and innovations, reduction of urban-life energy consumption needs to focus on service demand control. Because the relationship between living conditions and demand for energy services is non-linear, controlling the increase and structure of demand for energy services may be the most effective measure. This is partly achievable through adequate urban planning.

(4) Improving the quality of life for people should, of course, be the ultimate goal. The challenge therefore, is to encourage sustainable social models and structures which provide a quality of life that citizens like and make them happy, with the lowest levels of energy consumption possible. The current Western model cannot meet this goal sustainably. The Chinese government has expressed its willingness to "establish a society that could save resources and be harmonious with the environment", which is in line with a new model of consumption. What is needed is the adoption of an inclusive, modern development model, which not only addresses the specific development concerns of China, but draws from development models from other emerging economies such as India, Brazil, Mexico and countries in Southeast Asia.

(5) China's low per capita energy consumption for buildings and road transportation can in large part be attributed to lifestyle differences, which can only partially be explained by differences in income. Therefore, the technologies needing to be implemented in Chinese buildings and transport systems, and the energy services required to control energy consumption should acknowledge such lifestyle differences rather than simply copying or imitating so-called energy efficient technologies from the West. The latter have been designed to accommodate for different lifestyle patterns which are inappropriate for China on a large scale. In addition, many

[1] Orfeuil (op cit) has shown that in greater Paris, people living far from the inner part of the city have no choice other than very intensive use of cars, which is very costly, and in turn results in a relative poverty phenomenon.

energy services adopted from the West have resulted in increases, as opposed to decreases, in real energy consumption. In particular, support for the automobile industry as a pillar of economic growth has conflicted with the need to develop low energy consumption transport systems which minimize car use. Rebalancing support towards the development of "green" and innovative equipment and services, and improving the public transport industry may help China address this conflict.

(6) Urban transport development provides vast opportunities for electric bicycle (e-bicycle) development. Public transport development in most Chinese cities is currently lagging, both in terms of incomplete infrastructure and poor quality of service. Statistics show that travel by public transport in cities with 500,000 residents represents approximately 10% of total travel, with only a few cities rising to 20%. In cities with less than 50,000 residents, public transport accounts for less than 5% of all travel.[1] This is not helped by the fact that the average speed of public transportation in China is only 10 km/h[2]. These percentage figures for Chinese cities are far lower than those for cities in Europe, Japan and South America. E-bicycle travel can save 50% of time used on public transportation, and 30% of time used by standard bicycle travel. Integration of e-bicycles in cities could simultaneously meet residents' demands for mobility in transport, and supplement the shortages in travel services arising from less advanced public transport systems. In 18 Chinese cities which permit the use of e-bicycles, e-bicycle travel generally surpasses that of all other forms of transport for a variety of travel purposes, such as to/from work and school, entertainment, family and friend visits, and suburb touring.

5.3.5 Controlling urban energy consumption in China:reformulating policy objectives

As is known, reduction of energy use for unit output of goods and materials plays the dominating role in achieving energy conservation in manufacturing and industry sectors. The more one reduced it, the more one would be efficient, even the total amount of energy use increases. It is reasonable since one would argue that more goods be produced. But for urban-life sector, the total amount of energy use is the ultimate goal. Services are goods and materials produced in urban-life sectors. If we merely focus on energy use of unit output, as is in industry sectors, total amount of provided services will inevitably hike in order to maintain a lower energy use of unit

[1] Ma Lin, Speech, Launch Meeting of the Transport Committee of China Urban Public Transport Association Application Forum (October 2006).
[2] Qiu Baoxing, Speech, National Conference of Prior Development of Urban Public Transport (December 2006).

output. However, the ultimate outcome is that, on the contrary, the total amount of energy use increases. As a result, considering present conditions in China, the ultimate goal for policies on energy use in urban-life sector could be: to further enhance quality of provided services in building and transport and standards of people's living, within current total amount of energy use, or even lower, and through technological breakthrough and innovations. Or policy objectives could hardly be achieved. The following section discusses a set of six mechanisms commonly employed, to var-ying degrees of success.

(1) Using percentage of reduction as a key target for energy efficiency. It is widely used in current policies, in ways of, for instance, encouragingly, energy reduction of 50%, 65% and 70% in buildings, etc. These standards are evolutions of standards on heating in cold climate zone in northern China where there needs heating. Normally, if the U-value of envelopes reduces to 50% of current value, the heating demand would reduce accordingly to 50%, too. As a result, it is used as reference index to evaluate how energy efficient a building is. Yet in areas where the dominating energy demand are with cooling, appliances rather than heating, the energy use in buildings do not so much related with insulation, but much more with applied devices and systems, and demanded services of residents. If we simply look into insulation of envelopes in these areas, the course of energy conservation in China buildings sector would probably be misled. On the contrary, due to neglect of great impacts of lifestyles on energy use, buildings in name of 50% or 60% energy efficient but in real of more energy use than current level, would emerge.

(2) Using actual penetration rates of specific technologies to evaluate energy efficiency achievements. For instance, insulations of external walls, low-radiant glasses and ventilating double skin façade, water or ground sourced heat pumps, etc. However due to climate, function and use of buildings (for instance, the interior heat sources, etc.), there are divergent requirements on buildings and systems, and further requires different technologies and devices for energy reduction. As a result, there is no such a technology that could meet requirement of energy reduction in buildings under all circumstances. On the contrary, blind use of some "energy efficient" technologies, without careful consideration of local requirement, would not only increase the investment, but also rise energy use in buildings. Blind use of technologies, in most cases, would force people to turn passively to a way of life with much higher energy demand, and consequently cause much more energy use in real conditions.

(3) Using percentages of renewable energy in the total energy demand of buildings or transport as key targets for

commercial energy reduction. This mechanism does not always successfully result in meaningful energy reduction and efficiency. Consider the following example: there are two similar buildings, Building A and Building B (with identical area coverage), but the energy consumption of Building A is 50% higher than that of Building B. Even if 20% of Building A's energy is supplied with renewable energy and 0% of Building B's energy is, the actual commercial energy consumption of Building A is still 20% higher than that of B. It is therefore misleading to label Building A as an "energy efficient building" merely because it employs renewable energy. In fact, when we mention energy efficient solutions, encourage of green lifestyles, or expanding use of renewable energies, etc., we are ultimately in the aim of reducing use of fossil fuels. So it should be prerequisite that the use of fossil fuels is less than normal ones when we are encouraging use of certain renewable technologies.

(4) Using energy efficiency standards as key indicators of energy savings. Again, this may be insufficient if the policy objective is to control the total urban-life consumption level. For example, Mercedes-Benz car engines might be much more energy efficient than QQ cars (a low-cost Chinese brand of car), and therefore benefit from a much higher efficiency standard than the QQ. But if we consider actual energy consumption per km, QQ cars consume much less. Which car, then, should receive policy incentives in the form of subsidies? The same problem occurs when deciding on financial subsidies for public transport versus private cars, and technologies in buildings. Consider the following example. There is a residential estate in Beijing that uses radiant heating and an individual air conditioning system to maintain room temperature. In order for indoor temperature to be maintained at 24℃, 14W/m^2 of radiant heating needs to be used, as well as 11W/m^2 of the air conditioning system. The total actual energy consumption is higher than the reference value, which is 21 W/m^2 by local standards. However, building energy efficiency standards are evaluated under specific theoretical standard conditions: the working condition of applied radiant heating (24℃real) should be the standard condition, which is 18℃ (then the theoretical energy consumption appears to be 10.5W/m^2), and the energy use of air conditioning system is not taken into account because it is an added service. Evaluation of the energy consumption of this building in terms of efficiency standards yields a total value of only 10.5W/m^2, which appears to be half of the reference value. But in reality, the building uses 25W/m^2. Does it make sense to say that it is more energy efficient than the standard requirement? As can be seen, energy efficiency standards by themselves do not represent a credible mechanism for

the controlling of urban-life energy consumption. Actual energy consumption should be the criterion of evaluation for energy efficiency.

(5) Using vehicle flow as the main indicator of urban transport planning efficiency. To some extent, this may go against the objective and means of a policy aimed at controlling urban-life energy consumption. Indeed, what is really needed in urban transport planning is an improvement in the accessibility and travelling conditions for people. Up until now, the traditional urban traffic planning guiding ideology has been more aimed at to satisfying a car-oriented urban traffic system, which runs against the urban transportation energy and CO_2 emissions saving targets. In the practical process of planning and formulation, policymakers one-sidedly consider solving the problem of traffic congestion, which is thought to be the same as solving the problem of motor vehicle mobility. Therefore in urban planning, attention has been disproportionately biased towards car-oriented road construction. It is well known that the most energy efficient and environment-friendly transport modes are first NMT modes and second, public transportation. However, the infrastructure required for successful implementation of NMT is being widely misappropriated, resulting in a worsening NMT environment. In fact, car-oriented urban traffic planning results in numerous restrictions on a whole range of activities, as well as accessibility, thereby seriously hindering the improvement of urban traffic operation efficiency and related energy efficiency.

(6) Using private car ownership levels as a key indicator for living standards. This obviously challenges the objectives of a policy aimed at controlling urban-life energy consumption. As providers of mobility services, cars have much higher energy intensity than other methods of transportation such as NMT and public transportation. The use of private car ownership as an indicator for living standards enhances the status symbol of the private vehicle, leading to sharp increases in private car fleets. The idea that an individual car user should be completely accountable for his or her consumption of energy, use of road infrastructure, public space, and environment externalities, has yet to gain popular support. Neglecting the full social and environmental costs of private car ownership in turn reinforces car use and increases problems of urban congestion and environment pollution. Promotion of cars as status symbols results in decreasing recognition and acceptance of NMT and public transport as desirable providers of mobility services. Luxury, business and official cars are at the forefront of the status symbol phenomenon, and are increasingly becoming responsible for larger and larger shares of energy con-

sumption and CO_2 emissions related to urban transport.

5.4 Policy Recommendations

5.4.1 Preamble

Energy demand of China in future is largely dependent on the goal of development and relevant policies. However, it is impossible for China to take the traditional routine of energy strategies, which is to first predict demands in markets, and then research the side of energy supply, and then balance between demand and supply. It is required to take fully into account the possible development of real economy and society, as well as the limitations of energies and resources, and optimize selection of strategic policies and tasks, to achieve an energy efficient society as a whole. Now the surplus production capacity due to over fast development is challenging China. It is urgent to take measures to restrain fast increase of energy use in building and transport sector. The answer for China would not be those for developed countries in the history, but be to achieve sustainable development with higher living standards and lower energy consumption and to construct energy efficient cities with Chinese characteristics.

Surveys, and notably the original surveys conducted in six Chinese cities for the preparation of this report, show the co-existence of multiple lifestyle and consumption models, with very different consequences regarding energy consumption levels. On one hand, one can still detect the strong influence of a "historic" model, rooted in Chinese cultural values and habits, that is associated with a fairly low level of per capita energy consumption; on the other side, one sees the rapid adoption of lifestyle and consumption models that are "imitative" of the OECD countries model and that lead to a high level of per capita energy consumption and greenhouse gas emissions. Undoubtedly, the rapid increase in household income in China is currently associated with the adoption of the "imitative" model by a part of the population. While currently this concerns only a limited part of the Chinese population the adoption of this imitative model is spreading rapidly in urban areas, in particular in the eastern provinces. This leads to growing social inequity as the majority of the population is faced with rapid deterioration in its environment and is not offered with models that it can afford to adopt to escape poverty. The spread of the "imitative" model would create very serious problems for the further development of China in the near future. The development of a harmonious society and the implementation of the policy directions set by President Hu in his September 2009 UN speech require that China limits the spread of this "imitative" model and develops a modern consumption model inspired from Chinese traditions. In addition to being sober in energy consumption and respectful of the environment, this model can make a powerful contribution to the achievement of a high quality of life by the majority of the Chinese population as China further urbanizes and develops.

Indeed, the original surveys conducted as part of this work programme have shown very clearly that, far from being synonymous with reduced social welfare, the lower energy use and carbon emissions associated with modern consumption models based on Chinese traditions can go together with high levels of satisfaction regarding the way people meet their building and transportation needs. This provides strong factual evidence that policies to “control urban-life energy” use can, simultaneously, promote patterns of urban-life energy consumption and related GHGs emissions that are sustainable and meet the needs and aspirations of the majority of the urban population. If accompanied with the right policies and the provision of appropriate services and infrastructure, lower energy use does not mean lower welfare and lower quality of life; on the contrary, it implies the opposite.

Currently, considerable amount of research institutes and individuals are focusing on energy, environment, economy and social development of China in 2020, 2030 and 2050. And many of them are taking GDP as decisive parameter to predict social and economic situations in future society, according to growth rate of current industries. Such forecasts and researches would definitely indicate very much energy demand in future and thus support to the export-oriented economy of China in future. However, considering the huge population of China, in order to maintain energy and resource-saving and environment-friendly economic and social development, it is needed, from now on, to carry out urban construction and guide economic development under instructions of energy efficient mode, which is scientifically developed under considerations of consumption demand, city organization and social modes in future, and could afford all people with life of good quality within limited energy and environment capacity and further achieve high civilization of Chinese nationality. The project has find some certain examples of low energy use and high satisfaction in building and transportation sectors. This issue can’t give the total path of the ideal city in the future. Further study on modes of resource-saving and environment-friendly urban society, is necessary and TF suggested CCICED to carry out a continued project at next stage.

The policy recommendations put forward hereafter address the pre-requisites and present the measures needed to implement such a policy to control urban-life energy consumption and related GHGs emissions. These recommendations stress the systemic character of this energy and carbon issue, and its strong relationship with lifestyles.

5.4.2 Set up a Technical and Economic Framework for an Urban-life Energy Use Control Strategy

Controlling energy consumption involves maintaining the path of energy consumption development on a pre-defined (low growth profile) trajectory, and controlling total consumption. For urban-life energy use, this applies to consumption at the individual city level. As pointed out earlier, statistics are not available which describe the complete characteristics of urban-life energy consumption, neither at the city level, nor the national level. Therefore, the development of such a statistical system is critical for the implementation and monitoring of an urban-life energy control strategy, and constitutes the first priority.

Attaining a desirable level of control over the total of urban-life energy consumption and of associated greenhouse gas emissions requires a set of mutually supportive, evidence-based policy measures. An evidence-based approach implies that policy measures be based on actual energy consumption of all types of building and transport activities, rather than on theoretical efficiency standards presently being measured in a fragmented, non-systemic manner. Similarly, policy achievements should be assessed on the basis of actual energy consumption data following policy implementation, and not on the theoretical efficiency gains claimed by equipment manufacturers or building constructors independent of actual usage figures. Adopting an evidence-based approach will enable the capture of the full effects of changes in lifestyles associated with the technical systems, as opposed to focusing on theoretical performances that ignore these effects. In this respect, financial subsidies that are based on theoretical efficiency standards rather than on actual energy consumption run the risk of being financially wasteful, as well as a source of energy waste and carbon emissions which could have been avoided. In parallel, pricing strategies need to significantly penalize consumers who consume more than a certain level, per m^2 or per person for example.

Proposals for action:

(1) Set up a national database for urban-life energy consumption and GHG emissions covering urban transport and buildings at the city level. The purpose of the national database is to provide basic data for management, monitoring, evaluation and research purposes, as well as to inform scientific decisions and evaluations. Issues to consider include: 1) the role of various institutions in data collection, at city and national levels; 2) linkage with the national statistics system; 3) format and functionalities of the database; and 4) content and capacity building; 5) financial support.

(2) Use actual consumption levels (at individual and city levels) to design policy instruments for controlling urban-life energy

consumption. More specifically: 1) set up actual consumption standards for buildings, as well as urban-life energy consumption objectives for individual cities, according to location; 2) define the basis for standards and objectives, and elaborate the methodology for evaluating appropriate standards and objectives; and 3) Define push-pull policy instruments (subsidizing, pricing, etc.) based on standards and objectives.

(3) Create a National Institute for Monitoring and Evaluation (M&E) to monitor urban-life energy consumption at the national and municipal level, and to evaluate performance against set objectives.

5.4.3 Promote Healthy Urbanization Through Urban Scale, Density and Morphology

Urban planning rules and allocation of construction rights should be consistent with the goal of controlling the energy demand of urban systems. If urbanization maintains its present pace, and total building floor area in cities doubles by 2030, then total urban-life energy use is also projected to double, at least. The rate of urban construction needs to slow down to avoid over-supply. Urban development should insist on the principle of quality first, and a rational approach to total building area should be adopted in order to ensure that per capita urban-life building area (including residential and non-residential civic buildings) is smaller than those in Europe.

Some policies are already in place which addresses this question; however implementation is yet to come to fruition. The implementation of a property tax would play an important role in reducing oversized urban buildings. This would have additional municipal benefits, since local governments would not have to rely on selling land to ensure an annual stable fiscal income, and they could control more easily the speculative investment in house buying. Local fiscal income could then contribute directly to more sustainable development and improved housing situations of lower income groups in society.

Land use allocation is another critical issue for urban energy consumption. Urban morphology should be optimized in order to ensure shorter travel distances for residents. Public transportation networks need to form the backbone of infrastructure to serve future dense population distributions. A combination of mixed land use developments, services which are accessible and within walking distance (for example, shops, schools, health and fitness buildings, sports and entertainment centres, cultural centres, and green spaces) and high population density is required.

Proposals for action:

(1) To accelerate the compilation and implementation process of the national urban system planning and land use planning, through the balance of national spatial planning to guide the scale, speed and

rhythm of urbanization.

(2) To combine the urban planning making and planning environment impact evaluation, to carry out a special research on urban transport demand and building energy demand, to reduce urban transportation and building's energy consumption. It includes: to guide urban development scale by phase, to optimize the urban structure and function layout, to search a compact development mode, as well as reasonable urban density and intensity, to enhance the mixed use of urban construction land, and to improve the urban comprehensive capacity.

(3) Urban planning should insist the principle of quality first, and the total building area should be design rationally to make sure the urban-life building area per capita is not larger than 40 m^2 (including the residential building and non-residential civic buildings), which should be smaller than that in Europe. In order to reach the goal, to control the yearly increased building floor area to about 700 million m^2, which is far smaller than the present actual fact of 1.2-1.5 billion m^2.

(4) Implementing Property Tax would be an effective measure to control the over-sized urban construction and contribute lots for energy saving in near future. If taking the major part of the property tax to local government for infrastructure construction and solve housing problem of the lower class, the effect that the local government will not rely on the selling of the ground to ensure the stable fiscal income and control the demand of house buyers whose aim is investment and also the luxurious expense in some interpreters will be realized. The local fiscal income will be directly related with the municipal infrastructure construction, environment construction and the "livable cities", and thus improve the construction of the sustainable development, and also is the most effective way to restrain the overdevelopment of the construction of the cities.

5.4.4 Make Mass Transportation and Non-Motorized Transport (NMT) a National Strategic Priority

China is experiencing a declining trend in mass transportation and non-motorized transport, a trend which needs to be reversed quickly in order to facilitate low energy and low carbon urban development. In the context of urban transport, public transport and NMT are key mechanisms for energy savings in residents' daily lives. Public transport needs to be established as a priority by legislation, as does the establishment of a financing mechanism. Current management of public transport is not coordinated due to the lack of legislation. Stronger implementation of the National Development Strategy of Public Transport, therefore, is a top priority.

The attractiveness of public transport and NMT is determined by the speed, reliability, security and comfort these modes of transport can offer. Dedicated lanes for the exclusive use of public transport increase speed and reliability. Dedicated lanes for NMT ensure security and reliability. Allocating more public space for dedicated public transport and NMT lanes, and less space for personal cars, will drive up the quality of public transport and NMT services upwards and make the use of cars less attractive in mega cities. For new cities, and city extensions, this is a matter of securing space for public tranpsort and NMT in an integrated urban and transport planning context. For existing urban areas, it is a matter of space reallocation in existing streets and roads, which requires strong cooperation between transportation and public police authorities.

Public transport suffers from insu-fficient funding in many cities. Many public transport enterprises are currently running under deficit, and employee salary levels are below average. This results in decreasing service quality, which, in add-ition to congestion, increases people's relu-ctance to use public transport. Therefore, running alongside the priorities of app-ropriate public space allocation and the efficiency of public transport and NMT services, is the fundamental need for adequate funding for public transport and NMT services.

Building sustainable cities requires strong coordination between public authorities at the local, regional and national levels, and between different administrative departments within each level. Land use, construction, transport, energy and the environment are intricately related issues, with strong interactions needing to be addressed through integrated planning at both central and local levels. The integration of urban land use planning with urban transport planning needs to be strengthened through administrative reforms.

Proposals for action:

(1) Set up a special fund for development of public transport, regulation of public fares, and a subsidies compensation mechanism at the central level, to be funded from private car use taxation (fuel tax, taxation of car purchase, possible congestion charges, etc.).

(2) Formulate the 12th Five-Year National Plan and a 3 Year National Action Plan for Urban Public Transport Priorities, along with annual action plans for public transport and NMT priorities in land use planning, construction investment, subsidies for public transport, road rights allocation, and policy support.

(3) Launch the "Legislation for Urban Public Transport" as soon as possible, including the explicit requirement for establishment of an Integrated Urban Transport Authority (IUTA), at the level of each city to govern public transport networks, and plan and control operational services. Allow the local government to implement measures that discourage the use of personal cars and encourage the use of public

transport and NMT.

(4) Require urban master plans to guarantee the prioritization of public transport and non-motorized transport in the allocation of public space in new development zones and existing built areas (including parking places for cycles near bus stations, subway stations and other interchange transportation hubs and cycling lanes connected with public transport stations).

5.4.5 Deepen the Reform of Heat Networks and Systems in North China through Institutional Reform

It is widely recognized that large-scale district heating networks powered by high efficiency combined heat and power (CHP) plants present one of the best solutions for meeting the heating needs of urban buildings in northern China. CHP systems offer the potential for additional energy savings of 30% to 50%, compared to current energy consumption levels. However, despite the energy saving advantages offered by CHP, current trends indicate that district heating by CHP is being gradually replaced by heat pump and other individual heating systems. The reasons behind this are numerous:

(1) no market mechanism exists in the district heating field;

(2) district heating companies have the responsibility of providing basic living conditions in order to maintain social stability; and

(3) under the current system, district heating companies receive the majority of their income from initial installation fees, rather than from the operation of their services.

The ideal solution would be to measure and bill heat at the end-user level, and this is something which has been advocated for ten years now; however, it remains very difficult to implement. Therefore, we propose the implementation an alternative solution based on Nordic management modes for district heating.

Proposals for pilot action and experimentation:

(1) Separate the management of the primary network from the existing district heating company, attaching it to the primary network of the company in charge of the CHP and peak shaving plants. Under this scenario, the district heat company retains management of the secondary network and takes charge of end-use services. District heating companies pay for the amount of heat delivered from the primary network at heat exchange stations.

(2) Pricing Connection fees should be waived in order to incentivize district heating companies to provide good services that minimize heat consumption as opposed to merely expanding the number of connections.

5.4.6 Promote "Green Lifestyles" and Encourage Corresponding Technologies

Lifestyles are a key target for strategies aimed at controlling urban-life energy consumption. This involves convincing citizens that "energy conservation starts with me" and creating a social atmosphere that collectively feels proud of energy saving, and ashamed of energy waste. It concerns itself with criteria that people use in their choices in everyday life—beyond the purely economic rationale.

The higher the energy prices, the more likely it is that these other criteria will influence decisions and choices of people towards lower energy use. Optimal energy pricing should therefore constitute an additional policy objective in the sense that taxation levels should fully reflect the negative externalities of energy use (CO_2 emissions, exposure to hydrocarbon scarcity) that the urban-life energy use strategy is attempting to reduce.

To an extent, people's lifestyles can only become less energy intensive if the available technologies allow them. Therefore, technical systems which encourage highly consumptive energy behaviour should be progressively discouraged or limited through policy regulation.

Proposals for action:

(1) Request educational NGOs to advise schools on education materials, such as applicable textbooks and relevant activities and competitions, at the primary, secondary and tertiary levels. Also, to relay the importance of energy saving in daily life and teach educational institutions how to cultivate energy saving habits in younger generations.

(2) The various levels of Government should all lead by example and incorporate energy efficiency measures into government buildings and related transportation, which should be included as a significant indicator in government performance assessment. There should be public disclosure of energy use in large government buildings and fuel use of government cars.

(3) Communicate a "green lifestyle" message through mass media such as logos at big events (for example, Olympics and Expo.) and on major landmarks. These should encourage energy saving or "green" lifestyles.

(4) Central Government should establish legislation that identifies wasteful energy systems, as a function of location, which should be progressively prohibited or limited.

Chapter 6 Rural Development and its Energy, Environment and Climate Change Adaptation

6.1 Preface

China is a huge agricultural country, with a rural population of over 700 million. The challenges entailed in ensuring the well-being of agriculture, countryside, and farmers—the "three rural issues"—have always been critical to the healthy development of the nation's economy and society. A stable and sustainable rural energy supply, in turn, is a prerequisite for ensuring rural economic development, raising farmers' living standards, and preserving the rural environment. That is, a sound rural energy supply is an essential foundation for both achieving sustainable development in China's countryside and building a well-off society in an all-around way.

With the continuous development of the rural economy, ecological and environmental problems are becoming more obvious. In fact, China is entering an important historical period, facing the dual challenge of building an ecologically friendly new socialist countryside amid a global financial crisis while also tackling climate change. Research on rural energy, environment, and adaptation to climate change has therefore become vitally important. That research shows that a stable and sustainable energy supply can raise farmers' living standards while also enabling rural areas to both mitigate and adapt to climate change.

6.2 An Overview of Rural Energy, Environment, and Ada-ptation to Climate Change

As an inextricable part of the national energy system, rural energy can be defined in two ways: narrow and broad (Luo Guoliang et al. 2008). In its narrow sense, rural energy refers to commercial energy transported from other places and used in rural areas, as well as local forms of energy, usually renewable. In its broad sense, it refers to the notion that rural areas of many developing countries must rely on local sources of renewable energy because commercial supplies are limited at their current state of development. In its essence, rural energy refers to the overall challenge of providing energy to rural areas (Wang Xiaohua et al. 2003).

The rural energy supply includes all commercial and noncommercial sources, both renewable and nonrenewable. Rural energy demand refers to energy used by both households and producers. Household energy consumption includes energy used for cooking, heating, cooling, hot water, lighting, and home appliances. Energy consumed for production includes that used for agriculture, forestry, husbandry, fishing, and the transport and initial processing of the resulting goods, as well as for farmer-owned township enterprises.

Aspects of rural energy explored in this report include supply and demand, energy management in rural areas, and the development and use of renewable energy resources.

6.2.1 The Environmental Impact of Rural Energy Use

China's rural energy and environmental issues have always been closely linked. On the one hand, energy use puts great pressure on the rural environment and ecology (Chen Jiabin 2003). On the other hand, the development of new and renewable energy sources in rural regions could promote more effective use of agricultural wastes, such as livestock manure and crop straw, play a pivotal role in improving the rural environment, and ensure rural sustainable development.

Chinese farmers have long relied on traditional cookers with a thermal efficiency of less than 10 percent, wasting a great deal of straw, wood, and coal. The traditional use of these energy sources—which entails direct burning—has also brought energy shortages and greenhouse gas (GHG) emissions in rural areas (Wang Gehua et al. 2002).

The transformation of rural society and higher living standards will spur much higher rural energy use, and thus even more GHG emissions (Zhao Xingshu 2005, 2006). Fortunately, new and renewable energy resources that replace conventional sources can improve the efficiency of rural energy use while reducing GHG emissions.

6.2.2 Controlling GHG Emissions and Adapting to Climate Change

Nearly every country has resolved to take active steps to reduce GHG emissions while strengthening the ability of social and economic systems to adapt to climate change. China has long been an active participant in formulating and executing international policies related to global climate change. In 2007 the Chinese government issued a national action plan to respond to global warming. This plan proposed that, by 2010: 1) Energy consumption per unit of GDP will fall by 20 percent from 2005 levels. 2)The discharge of major pollutant will decline by 10 percent. 3) Renewable energy, including large hydropower, will account for more than 10 percent of the nation's primary energy supply. 4) Forests will cover 20 percent of the nation's area, storing some 50 million additional tons of carbon-dioxide.

To achieve those goals, the nation must pursue large-scale changes in its economic structure, energy system, and consumption patterns. Those shifts, in turn, will create opportunities for rural economic development and revolutionize agricultural production, the development and use of rural energy, waste disposal, and rural environmental protection. To achieve those goals, the nation will need to vigorously develop renewable energy, strengthen the comprehensive processing and use of agricultural and other rural waste, and continue to pursue carbon sequestration, such as by planting forests.

Of course, global climate change means that extreme weather events such as floods and droughts are becoming more frequent and ferocious, undermining the stability of agricultural production and threatening rural sustainable development. China must therefore strengthen the ability of its agriculture and countryside to adapt to climate change, to ensure steady development of agricultural production and a sound rural ecology. Toward that end, the nation must provide economic rewards to encourage farmers to adopt agricultural practices and technologies that can both mitigate and withstand climate change.

6.2.3 Tackling the Global Financial Crisis while Building a New Socialist Countryside

The global financial crisis directly affects China's countryside and farmers. Because of a sharp drop in exports, some domestic industries have too much capacity, and some enterprises have had trouble remaining in operation. As a result, millions of migrant workers have flocked back to rural regions, undermining farmers' income and rural stability.

In 2008, under dual pressure from the global financial crisis and serious natural disasters at home, the Chinese government adopted positive coping strategies, such as expanding investment in "agriculture, countryside, and farmers" and constructing an ecological civilization. For example, in the Report of the 17th National Party Congress, President Hu Jintao pointed out that one way to realize the goal of constructing a well-off society in an all-around way by 2020 is by building an ecological civilization.

That goal is spawning new development ideas. These emphasize the use of market pricing and regulatory structures to comprehensively address energy construction and environmental protection, and to build the capacity of the Chinese countryside to mitigate and adapt to climate change.

These policies have proven effective in stimulating domestic demand and sustaining economic development. However, the financial crisis may slow the growth of government revenues at all levels and curb agriculture-related expenditures, rural infrastructure construction, and supplies of rural public goods.

6.3 Trends and Challenges in Rural Energy Use

Since the reform and opening-up, under the nation's diversified development policy and in light of local conditions, China has begun to develop renewable rural energy resources. These include biogas systems, which rely on anaerobic digestion of animal and human waste to produce methane; straw briquettes, produced by compressing straw; small hydropower stations; wind energy; and solar energy.

For example, from 1990 to 2000, China promoted the development and use of more than 10 renewable energy technologies in rural areas, including biogas and wind. The use of these technologies prevented the release of 159 Mt of carbon dioxide (CO_2) and 231,000 tons of methane (CH_4) emissions (Wang Gehua et al. 2002). The nation has also reformed rural power grids, brought power to 30 million people in far-flung areas, and improved the energy efficiency of rural production and everyday life (Luo Guoliang 2008).

However, overall planning and investment in the rural energy system continue to lag behind those efforts in urbanized regions. These longstanding problems also mean that energy demand will grow more strongly in rural areas than in urban regions for quite some time, and that relying on conventional sources to supply enough energy for rural economic and social development will be difficult. The rural energy deficit will become more and more obvious.

6.3.1 The Current Situation

In 2007, rural energy consumption totaled 727 Mt of coal equivalent (Mtce), with commercial and non-commercial supplies accounting for 58.7 percent (427 Mtce) and 41.3 percent (300 Mtce) of that amount, respectively.

6.3.1.1 *Rural Energy Consumption for Household Needs*

Energy end-use by rural households totaled almost 346 Mtce in 2007, with commercial supplies accounting for 23.2 percent and non-commercial supplies providing 76.8 percent of that amount. Straw and firewood are the main non-commercial energy sources, accounting for 60 percent and 35 percent, respectively. Coal and electricity are the main commercial energy sources, accounting for 62.6 percent and 22.4 percent, respectively (Table 6-1).

Table 6-1 Energy end-use by rural households, 2007

Type	Amount		Reference quantity (10,000 tce)	Per capita consumption		Percent
Commercial energy sources			8 015	110	kg ce	23.2
Coal	7 173	10 000 tons	5 014	69	kg	14.5
Electricity	1 459	100 million kWh	1 793	201	kWh	5.2
Petroleum products	363	10 000 tons	533	5.0	kg	1.5
LPG	379	10 000 tons	649	5.2	kg	1.9
Natural gas	1.61	100 million cubic meters	21.57	0.2	cubic meter	0.1
Coal gas	1.73	100 million cubic meters	4.98	0.2	cubic meter	0.0
Non-commercial energy sources			26 561	365	kg ce	76.8
Straw	33 998	10 000 tons	15 979	467	kg	46.2
Firewood	18 217	10 000 tons	9 291	250	kg	26.9
Methane	1 023 963	10 000 cubic meters	731	14.1	cubic meter	2.1
Solar energy	5 810	10 000 cubic meters	560	0.08	cubic meter	1.6
Total			34 576	475	kg ce	100

Source: Department of Science and Technology Education of the Ministry of Agriculture.

Note: tce = tons of coal equivalent. “Other” includes liquid petroleum gas, coal gas, and other sources such as solar water heaters. ce = coal equivalent.

In 2007, per capita rural household energy use reached 475 kilograms of coal equivalent—1.7 times that in urban areas. Rural energy use is inefficient because rural residents rely on few high-quality energy sources. For example, per capita household use of non-commercial energy totaled 365 kilograms of coal equivalent, while per capita household use of commercial energy totaled just 110 kilograms of coal equivalent—less than 40 percent that in urban areas. Per capita household use of electricity, natural gas, coal gas, and liquefied petroleum gas (LPG) is also lower than national levels. This suggests that demand for high-quality energy sources has great potential for growth in the countryside.

The level and structure of rural household energy use vary regionally. Both total household consumption and per capita household consumption are higher in western areas of China, for example, than in central and eastern areas.

Household energy use has become more diversified and commercialized in more developed rural areas. The use of straw and firewood is higher—and the use of electricity, petroleum products, and liquefied petroleum gas far lower—in the West than in central and eastern areas, and domestic biogas is relatively well-developed in the West (Figure 6-1). In eastern areas, in contrast, higher-quality energy sources such as electricity and LPG account for a larger proportion of household energy use, dramatically improving energy efficiency (Figure 6-1).

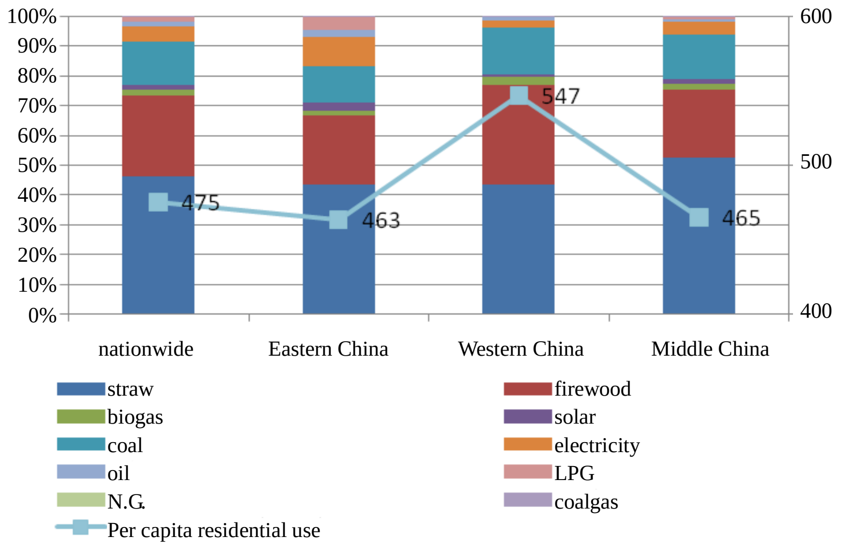


Figure 6-1 Per capita consumption of various types of energy for household use, by region, 2007

6.3.1.2 *Rural Energy Consumption for Production*

End-use energy consumption for rural production reached 380 Mtce in 2007. Commercial sources provided most of this energy, including coal (62.4 percent), petroleum products (17.3 percent), coke (5.9 percent), and electricity (5.4 percent). Firewood is the main non-commercial energy source, contributing 9.1 percent of all energy used for production (Table 6-2).

Township enterprises are major energy users, accounting for 84.5 percent of total energy used for rural production in 2007, while agriculture, forestry, animal husbandry, and fisheries accounted for only 15.5 percent.

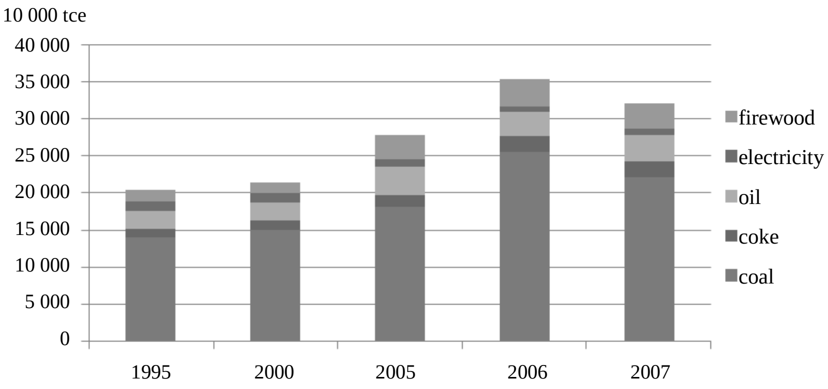
Commercial sources supply most of the energy used by township enterprises, with coal providing 68.8 percent, and petroleum products supplying 11.0 percent. Agriculture, forestry, animal husbandry, and fisheries rely completely on commercial energy sources, including petroleum products (51.1 percent), coal (27.8 percent), and electricity (19.8 percent).

Table 6-2 Energy used for rural production, 2007

	Total energy used for production (in 10 000 tce)	Percent of total	Amount used by agriculture, forestry, animal husbandry, and fisheries (in 10 000 tce)	Percent	Amount used by township enterprises (in 10 000 tce)	Percent of total
Coal	23 788	62.4	1 688	27.8	22 145	68.8
Coke	2 230	5.9	79.4	1.3	2 153	6.7
Petroleum products	6 581	17.3	3 109	51.1	3 555	11.0
Electricity	2 047	5.4	1 203	19.8	876	2.7
Straw	3 452	9.1		0	3 452	10.7
Total	38 098	100	6 080	100	32 181	100

Source: Calculated by the authors from National Rural Renewable Energy Statistics, 2008, and China Energy Statistics Yearbook, 2008.

Note: tce = tons of coal equivalent.



Note: tce = tons of coal equivalent.

Figure 6-2 End-use energy consumption by township enterprises, 1995–2007

Although township enterprises are considered an integral part of rural economies, the nation does not collect or report information on their energy use—particularly of enterprises in suburban areas—as energy used for rural production. Information on end-use energy consumption by township enterprises are therefore probably greatly underestimated (Figure 6-2). For example, current statistics show that from 1995 to 2007, township enterprises accounted for only 12.7 percent of the nation's energy use, even though they contributed about 30 percent of GDP.

6.3.2 Problems with Rural Energy Consumption

As rural energy use has risen and its structure has changed, problems have become more evident.

First, a great deal of rural energy ends up as waste, because the traditional use of biomass—direct burning—is very inefficient. Second, the use of commercial energy sources, especially coal, has caused severe environmental problems. Burning coal produces huge amounts of waste, and most residents simply discard coal residues along with household garbage in open inner yards or nearby areas, without any treatment. And rural residents usually burn coal indoors, so they face serious indoor air problems from total suspended particles (TSP), sulfur dioxide (SO_2), carbon monoxide (CO), and other pollutants (Li Zhiwen et al. 2006).

The development of cleaner sources of rural energy has suffered from a dearth of long-term financial support. Development of renewable energy sources for the countryside, in particular, relies heavily on government funding. The gap between government funding and the need for new sources of rural energy is widening day by day.

Farmers' difficulty in obtaining loans is another significant brake on the construction of rural renewable energy supplies. Under collective land ownership, peasants cannot get adequate credit, because they cannot put land or homes into market circulation or pledge them as collateral assets. Because peasants cannot find a guarantor or have no proper mortgage, most cannot get financial support for expanding their supply of clean energy.

6.3.3 Future Rural Energy Demand

As China's rural economy continues to grow, a rapid increase in rural energy consumption seems inevitable over the next 10 years (Zhao Xingshu 2003).

Rural energy demand reflects the size of the rural population, the level of a region's economic development, income levels and living standards, the price of energy, and levels of energy efficiency. China's current economic development strategies and rural energy policies suggest that these factors will undergo significant changes.

6.3.3.1 *Rural Population*

The major contributors to the size of the rural population are its natural growth rate and the rate of urbanization. In China, urbanization occurs at a higher rate than natural population growth. That means the rural population is shrinking. In 2010, China expects to have a rural population of 700 million, accounting for 51 percent of the total population. By 2020, those numbers will fall to 610 million and 42 percent, respectively. By 2030, the rural population will decline by another 5.3 million, while still accounting for 36 percent of the total.

6.3.3.2 *Income Levels and Living Standards*

Energy consumption interacts closely with income levels. The higher rural residents' incomes, the higher their requirements for energy that provides "comfort, convenience, and cleanliness" (Lu Hui et al. 2006). Under the national goal of building a well-off society in an all-around way, per capita net income of China's farmers will keep growing at an annual rate of 5–6 percent over the next two decades. A moderately prosperous society in all respects means not only higher living standards but could also lead to a potentially cleaner environment, because these changes will spur demand for high-quality commercialized energy.

6.3.3.3 *Changes in Rural Energy Demand*

The Task Force analyzed China's rural energy demand and carbon emissions for 2010, 2020, and 2030, taking 2005 as the base year. In so doing, we relied on a qualitative and quantitative analysis of historical trends in population, income levels, grain yields, and the added value of agriculture, forestry, animal husbandry, and fisheries.

In our analysis, we considered industry restructuring and energy technology that may emerge in the next two or three decades, based on China's Long-Term Energy Alternative Plan (LEAP), as well as the impact of social, economic, and environmental uncertainties on rural energy demand and greenhouse gas emissions.

Our research revealed that end-use energy consumption by agriculture, forestry, husbandry and fishery production will reach 120 Mtce in 2030. As rural production modernizes and industrializes, the use of petroleum products and electricity will grow rapidly, while the proportion of coal in the consumption mix will drop to about 10 percent.

With new rural construction and rising living standards, farmers will gradually increase their demand for energy for heating, cooling, boiling water, electrical appliances, and transportation, even while the number of people per rural household drops.

To understand the impact of those changes on energy use, we examined two scenarios. In the conventional scenario, both the absolute use of traditional biomass resources and their proportion in the household energy mix continue to decline over the next 20 years. Households rely on modern technologies for using straw and wood resources to obtain clean energy. By 2030, the ratio of modern to traditional use of straw will reach 1:1, in this scenario.

The proportion of other modern renewable energy sources such as small hydro, small wind, methane, and solar energy in the rural energy mix will also expand gradually. Rural household demand for high-quality commercial energy—particularly electricity, oil products, and LPG—will also rise. The household use of coal will continue to decline slowly, as it has over the past three years.

In the intensive renewable energy scenario, rural areas develop small hydro, small wind, marsh gas, and solar power resources more quickly than in the conventional scenario. As the government accelerates the modern use of biomass, the ratio of modern to traditional use of straw will reach 2:1 in 2030, reducing not only direct combustion of those resources but also coal consumption.

In this scenario, per capita household energy use continues to increase in the next 20 years, and reaches 0.7 tons of coal equivalent by 2030. However, because of the declining rural population, total household energy use then begins to fall. Commercial energy supplies from other regions meet most of the incremental rural demand for household energy, but non-commercial supplies remain the major sources. By 2030, the ratio of commercial to non-commercial energy sources for household use reaches 1:2.

6.3.4 Renewable Energy Resources in Rural Areas

Fortunately, renewable energy resources—such as biomass, hydropower, wind power, solar power, and geothermal—are widely available in China's countryside.

Annual gains in grain yields and grain-to-straw ratios suggest that annual crop straw resources can total 600 Mt. If half of those resources are used as soil fertilizer, livestock feed, and raw materials for making paper, the remaining 300 Mt can be used to produce 150 Mtce of energy each year.

Twigs and other waste from the lumber industry can total 900 Mt annually. Transforming just 300 Mt of that waste into energy would yield about 200 Mtce. The yield of biogas produced through anaerobic digestion of animal waste, meanwhile, could be 70 billion cubic meters. And farmers could plant energy crops on over 20 million hectares, which could provide 50 Mt of organic liquid fuel equivalent to 70 Mtce. Together these annual biomass resources total about 600 Mtce.

The economically exploitable installed capacity of small hydropower resources—single stations with 100 to 50,000 kW of capacity—is about 128 million kW. Some 90 percent of these resources occur in Hubei, Hunan, Guangdong, Guangxi, Henan, Zhejiang, Fujian, Jiangxi, Yunnan, Sichuan, Xinjiang, and Tibet.

China also has considerable wind energy resources, as it is favored by prevailing monsoons. In particular, Southeastern coast and islands, Inner Mongolia, the Northwest, and some areas in the Northeast have abundant wind resources, with wind speeds above 3 meters per second for as many as 5 000 hours each year.

Finally, most of China lies below north latitude 45°, so the nation enjoys abundant solar resources. Sunshine tops 2200 hours annually in Xinjiang, Tibet, Qinghai, Gansu, Inner Mongolia, Shanxi, and Hebei. In fact, solar energy is already reasonably well-developed in those areas especially for solar water heating, especially in the Northwest and Qinghai-Tibet.

6.3.5 The Evolution of Policies on Rural Energy Use

Since 2000, given continuous econ-omic growth and the accumulation of national wealth, China has underwritten the construction and management of the energy industry. The national government has also emphasized the exploration of renewable resources to supply rural energy, especially biomass and small hydropower plants. Efforts such as renovating the electricity grid in rural areas, constructing new electricity facilities, and exploring new forms of energy such as biogas systems have boosted the rural energy industry.

Under the goal of balancing urban and rural development and constructing a new socialist countryside, the rural energy system can finally become an integral part of the national energy system, and rural areas will have equal opportunities to enjoy commercial energy services. Making good use of their natural renewable energy resources, in turn, will help rural areas ensure food security, protect the environment, and mitigate global climate change. New energy and environmental pricing policies that encourage the development of clean renewable energy and reward cuts in pollutants, including greenhouse gas emissions, are essential to achieving these results.

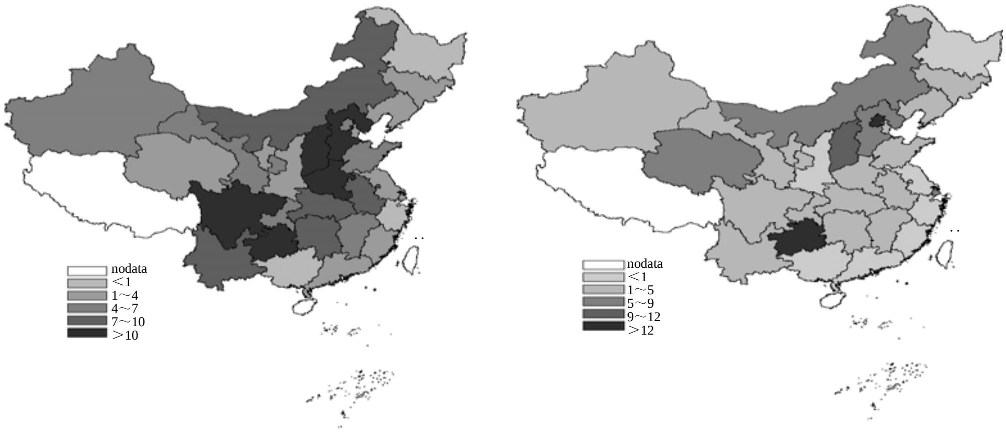
6.4 The Environmental Effects of Rural Energy Use

6.4.1 The Impact of Rural Coal Combustion

Unlike traditional biomass resources, waste from the large-scale rural use of commercial energy—mainly fossil fuels, including coal and petroleum products—cannot be readily recycled.

Since the reform and opening-up, coal has become the primary commercial energy source in rural China. The pollutants emitted from coal combustion include sulfur dioxide (SO_2), nitrous oxide (NO_x), and solid waste. The volume of these wastes is large because rural areas have not implemented the needed control technology, especially compared with urban areas.

SO_2 emissions from rural coal use have grown 7.3 percent annually, from 2.01 Mt in 1980 to 10.91 Mt in 2004. These emissions vary by region. The highest total emissions occur in Hebei, Shanxi, Henan, Sichuan, and Guizhou provinces, while the highest per capita emissions occur in Beijing, Shanxi, and Guizhou (Figure 6-3).



(a) SO_2 emissions per province (10,000 tons) (b) SO_2 emissions per capita (kg)

Figure 6-3 SO_2 emissions from rural coal consumption, 2004

Like SO_2 emissions, NO_x and TSP emissions from rural coal consumption are rising, with emissions from agricultural use of coal growing more quickly than those from household use of coal.

The amount of solid waste from household use of coal is also growing. Rural residents rely on honeycomb briquettes and coal balls, which produce much more waste than the direct use of coal.

Coal combustion also emits pollutants such as carbon monoxide (CO) and benzopyrene (BaP). People exposed to these substances for long periods may suffer from respiratory diseases and cancer, and their children often have birth defects. Coal combustion also causes fluorosis, a disease affecting teeth and bones, in many areas, especially Southwest China.

6.4.2 The Environmental Impact of Traditional Energy Use

Traditional non-commercial energy sources consist mainly of straw and firewood, which can be burned directly. The pollutants from such energy sources include TSP, SO_2, methane (CH_4), and NO_x (Yu Jiangping el al. 2008; Wang Xiaohua el al. 2004; Cao Guoliang el al. 2005).

Straw and firewood contribute 98 percent of all emissions from biomass burning (Table 6-3). Other sources, such as forest fires and grassland fires, contribute a tiny share.

Table 6-3 Pollutants from Biomass (percent)

Pollutants	Straw	Firewood	Forest fire	Grassland fire
SO_2	97.98	0.78	1.08	0.16
NO_x	75.29	23.65	0.86	0.19
NH_3	75.20	24.08	0.61	0.11
CH_4	84.78	14.62	0.47	0.12
EC	83.21	15.00	1.53	0.25
OC	91.18	6.67	1.76	0.39
VOC	46.93	51.66	1.31	0.11
CO	76.08	23.10	0.65	0.17

Source: Cao Guoliang el al. 2005.

6.4.3 The Environmental Impact of Renewable Energy

As noted, China is developing renewable energy sources as an important approach to meeting rural energy needs, reducing pollution, and promoting economic development. If the nation reaches its goal for 2010, the use of renewable energy could reduce annual SO_2 emissions by 4 Mt, NO_x emissions by 1.5 Mt, dust emissions by 2 Mt, and CO_2 emissions by 600 Mt, while also saving 1 500 Mt of water and protecting 150 million mu of woodland.

If the nation reaches its 2020 goal, the use of renewable energy could reduce annual SO_2 emissions by 8 Mt, NO_x emissions 3 Mt, dust emissions by 4 Mt, and CO_2 emissions by 1 200 Mt, while saving 2,000 cubic meters of water and protecting 300 million mu of woodland.

6.4.4 Rural Energy Use and Climate Change

The rapid development of the rural economy and swift rise in the quality of rural life are bringing continuous changes to rural energy use. These changes are clarifying the relationship between the development and use of rural energy, reductions in GHG emissions, and global climate change.

6.4.4.1 *Rural Energy Use and Greenhouse Gas Emissions*

Rural coal combustion is the main source of CO_2 from energy use in the Chinese countryside. CO_2 emissions from rural coal consumption have been rising. In 1980, those emissions totaled 190.96 Mt, but by 2004 that figure had quintupled, with an average annual increase of 7.3 percent.

According to the LEAP model, direct rural CO_2 emissions from both production and household energy use will rise in the coming 20 years—whether or not the nation expands its reliance on renewable energy sources. Under normal circumstances, China's carbon emissions in rural areas will total 78.7 Mt, 91.56 Mt, and 103.31 Mt in 2010, 2020 and 2030, respectively, representing an increase of 8.1 percent, 25.7 percent, and 41.9 percent over 2005 levels. Greater reliance on renewable energy sources will reduce those emissions (Table 6-4).

Table 6-4 Direct Carbon Emissions from Rural Production and Household Energy Use under Two Scenarios (in 10,000 tons)

Year	2005	2010	2020	2030
Normal circumstances	7,283	7,870	9,156	10,331
Mid-level household energy use under normal circumstances	4,289	4,572	4,777	4,722
Strengthened reliance on renewable energy	7,283	7,695	8,739	9,272
Mid-level household use, given strengthened reliance on renewables	4,289	4,396	4,361	3,663

In fact, renewable energy sources can help China cope with climate change in three key ways. The first is by improving energy efficiency and controlling increases in energy use. The second is by replacing conventional energy sources while meeting rising energy demand. And the third is by relying on energy use to achieve multiple goals, including strengthening the rural economy and reducing rural GHG emissions and other pollution. Research has shown, for example, that biogas can reduce average net GHG emissions by 1.88 kilograms per cubic meter (with a range of 1.76–2.11 kilograms per cubic meter).

6.4.4.2 *Strengthening the Capacity of Rural Areas to Adapt to Climate Change*

Climate change has already adversely affected rural production in China, and that impact will continue and even worsen. In the past 100 years, the nation's average annual temperature has risen 1.1℃, with warmer temperatures especially obvious in the most recent 50 years. The location and timing of precipitation and extreme weather events have also changed, significantly affecting agriculture and the development of the rural economy.

According to Xiong Wei et al. (2007), the per-unit yield of the three main food crops could remain steady in the face of a 2.5–3° rise in average temperatures, if farmers adjust their planting structures (leaving out the fertilizer effect of CO_2 and adaptive measures). However, if average temperatures rise further, per-unit yields will fall.

Because of continuous climate change, droughts now common in northern China will occur more frequently, so crop yields will be more dependent on irrigation. Rising temperatures and accelerating decomposition of soil organic matter will shorten the release cycle of chemical fertilizers.

To safeguard its food supply, China may respond to these changes by increasing its energy consumption and use of chemical fertilizers. However, those responses will pose more obstacles to rural energy efficiency and managing GHGs and other emissions. Given this dilemma and uncertainty, China's food security will largely depend on the effectiveness of adaptive measures, such as low-carbon agriculture and progress in agricultural technology.

6.5 International Experiences in Rural Energy, Environment, and Adaptation to Climate Change

Many countries have sought to develop modern energy sources in rural areas to enhance productivity, improve farmers' living standards, and accelerate economic development. Their experiences can help China identify the obstacles and find the best solutions to establishing a new socialist countryside.

6.5.1 Lessons from Developing Countries

In many African and Asian countries, progress on rural electrification lags population growth because of limited resources. However, in Thailand, more than 80 percent of the rural population has access to electricity, while in Costa Rica, cooperatives provide electricity to almost 95 percent of the rural population, and in Tunisia, 75 percent of rural residents have access to electricity.

These experiences show that successful rural electrification programs must meet the following conditions:

(1) They must have effective institutional structures, such as rural electrification authorities and cooperatives.

(2) They must keep the arbitrary use of policies and funds to a minimum, to ensure fairness and transparency in all decisions.

(3) They must establish baseline criteria for rural electrification, as it can make a significant contribution to sustainable development only in areas with existing demand for services such as lighting, television, refrigeration, and transportation, and where farmers' income has reached a certain level.

(4) The price of rural electricity should be realistic. The initial connection charges demanded by a utility are often a far greater barrier to rural families than monthly electricity bills. Lowering the initial connection charges increases the number of users.

(5) Cost recovery is probably the single most important factor determining the long-term effectiveness of rural electrification programs. In most successful programs,

developers receive a substantial proportion of capital at concessionary rates or in the form of grants.

(6) The involvement of local communities in the development of rural electrification programs is essential.

(7) Optimized system design can reduce construction costs by up to 30 percent, and accelerate the pace and scope of the rural electrification program.

(8) Remote areas, where connections to the electricity grid would be prohibitively expensive, should consider alternatives such as photovoltaic systems.

6.5.2 Lessons from the United States

6.5.2.1 *Encouraging Rural Electrification*

Before World War II, U.S. President Franklin D. Roosevelt offered low-interest loans to utilities that would extend electricity lines into the countryside. However, because the number of farms was too small, utilities did not find it profitable to invest in rural transmission and distribution, even with the loans.

Farmers therefore set up cooperatives to purchase electricity in bulk and distribute the power. The cooperative movement became a key feature of the U.S. energy system, and cooperatives continue to provide farmers with relatively inexpensive power today.

6.5.2.2 *Encouraging Renewables*

The 2008 Farm Bill includes a number of provisions that encourage the development of renewable energy and empower rural communities to increase their energy self-sufficiency. For example, funds will help companies and rural regions build refineries to produce biofuels, pursue R&D on advanced biofuels, and improve the efficiency of hydropower.

6.5.2.3 *Paying Farmers to Reduce Greenhouse Gas Emissions*

Major opportunities for rural economies and land managers are emerging with the global effort to control atmospheric concentrations of carbon dioxide. That is because existing practices and technologies offer many ways to reduce GHG emissions—both directly, by cutting emissions at the source, and indirectly, by storing more carbon in soil and biomass. In the United States and other countries with mandatory and voluntary carbon markets, farmers and land managers can sell GHG reductions as GHG credits, or offsets, bringing them extra income.

Under business as usual, U.S. GHG emissions are expected to reach some 8,700 million metric tons of CO_2 equivalent by 2025. An often-suggested target is to lower U.S. emissions from today's levels by 15 percent by 2025, which would require a reduction of about 2 600 million metric tons of CO_2e per year. Research shows that land management practices and technologies could contribute significantly to reaching that target.

The price of carbon is a key factor in the amount of GHG reductions and credits farmers and land managers will supply by changing their land-use practices. The higher the price, the more GHG reductions farmers and land managers will produce. At a price of \$15 per ton of CO_2, land management projects could reduce GHG emissions by nearly 1,500 million metric tons of CO_2 per year by 2025—or around 60 percent of the reductions needed to meet the 15 percent target. At \$50 per ton, land managers could reduce their GHG emissions by almost 2,000 million metric tons of CO_2 per year—providing nearly all the cuts in emissions to meet this prospective target.

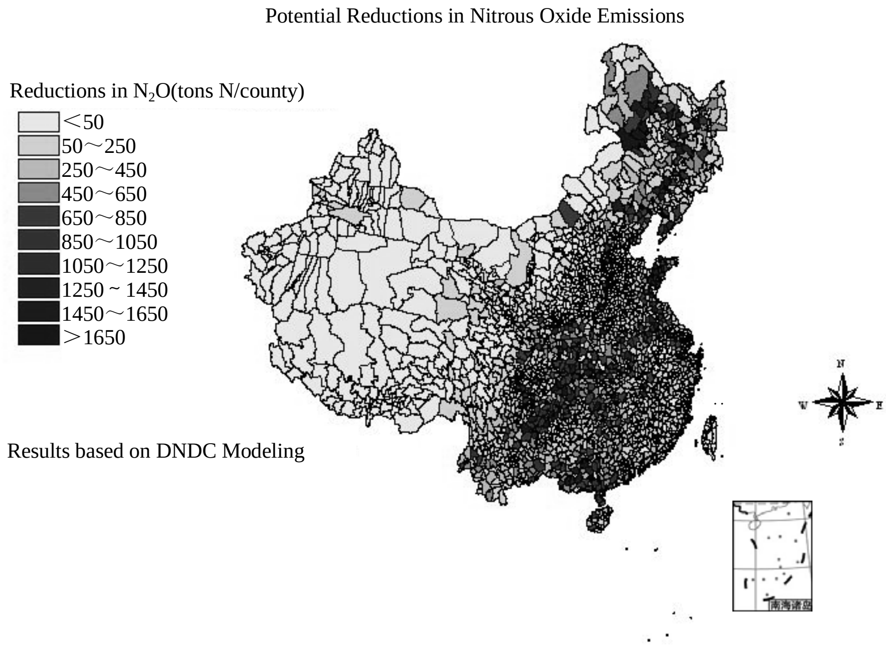


Figure 6-4 County based potential reduction in N_2O calculated based on difference between county based N_2O emissions from the baseline scenario and an optimal use scenario. Pattern of reduction opportunities reflect cropping intensity

The U.S. market for GHG credits is now based on voluntary transactions, so demand is relatively weak, resulting in prices of \$1–10 per ton of reductions in CO_2 emissions. In the European Union, which has adopted a mandatory cap on GHG emissions under the Kyoto Protocol, prices have risen well above \$35 per ton of GHG reductions in recent years. If the United States enacts a mandatory cap on

GHG emissions, as several bills now before Congress would do, the price of CO_2 will be high enough to spur the land sector to become a major producer of GHG offsets.

In a recent study of the potential GHG effect of improving nitrogen fertilizer management in China (Li and Salas, 2009), researchers found that applying nitrogen optimally to meet the needs of China's soils and crops would result in more than 300 million metric tons of CO_2e reductions annually.

6.6 Policy and Funding Options for Mitigating and Adapting to Climate Change in Rural Areas

6.6.1 Policies Promoting Energy-Efficient Rural Buildings

The Energy Saving Regulation for Civil Constructions, implemented in October 2008, stipulates that the state will encourage and support the use of solar, geothermal, and other forms of renewable energy in both new and existing buildings, and that local governments should allocate special funds to the initiative.

A team from the School of Architecture at Tsinghua University is pursuing the first large-scale domestic attempt to optimize and evaluate an integrated energy-saving system for rural buildings. The team has just completed a pilot project in a village in the Fangshan district of Beijing. The team has also cooperated with the Council for Promoting Sustainable Development in Beijing, and completed "green" renovation for more than 500 rural residences in Pinggu, Shijingshan, Huairou, and Miyun disfricts. If China's entire northern region adopted this approach, it could eliminate the need to burn about 5 Mt of coal equivalent (Mtce) for heat each year—worth about 50 billion RMB.

6.6.2 Policies Promoting Rural Renewable Energy

China's Energy Conservation Law stipulates that the government will encourage the development and use of new and renewable energy sources through various incentives, and allocate special funds to support that initiative. For example, regardless of their size, new power plants that rely on gasified straw can enjoy government subsidies of 0.25 RMB per kWh for 15 years. Operators of electricity grids must guarantee that they will buy all the power that such plants produce, and operators of the plants do not need to pay tariffs or value-added taxes on imported equipment.

6.6.3 Funding Mechanisms for Mitigating and Adapting to Climate Change

Ensuring that agricultural regions mitigate and adapt to climate change will require a large-scale national investment beyond that normally devoted to food production. About half of China's expected climate change mitigation costs and almost all its adaptation costs will occur in economic sectors related to rural poverty. The nation should use those funds to spur afforestation (the planting of trees on nonforested lands) and reforestation, improve forest management, and avoid deforestation. China also needs to invest funds in managing agricultural lands, grasslands, and rangelands to reduce nitrous oxide and methane emissions from fertilizer and livestock.

6.6.4 Funding for Large National Projects

Several key projects aim to protect and reconstruct the ecology of the upper reaches of the Yangtze River, and the upper and middle reaches of the Yellow River:

Rural biogas program. During the 11^{th} Five-Year Plan, the central government invested 3.4 billion RMB in marsh projects in these areas, benefiting 3.74 million rural households. Some 9,144 villages in 721 counties have also received government loans since 2003.

Rural irrigation program. The central government reformed the system for funding state-owned medium- and large-scale irrigation projects and pumping stations in 2002. Under the new policies, institutions managing medium- and large-scale state-owned irrigation areas and pumping stations are classified as public-welfare and quasi-public-welfare units, making them eligible for funds from local governments.

Returning Farmland to Forests Program. Under this program, which became fully operational in 2002, the central government established policies, funding mechanisms, and subsidies to encourage farmers to return farmland to forests. After their projects pass inspection, farmers can receive food subsidies and cash.

6.6.5 China's Clean Development Mechanism Fund

In November 2007, the State Council approved creation of the Clean Development Mechanism Fund, to be used to produce marketable credits for cuts in GHG emissions under the United Nations Clean Development Mechanism (CDM). This long-term, nonprofit state-owned fund will support efforts to mitigate climate change under the national strategy of sustainable development. The fund will encourage project construction, provide technical support, share and manage information, train personnel, and build institutional capacity and public awareness. This fund is an important innovation, because it will coordinate the efforts of domestic enterprises and governments and institutions abroad. It will also provide some of the experience and infrastructure necessary for full scale integration into the global carbon market.

6.6.6 Private Investment in New Energy Sources

China is actively building a sustainable energy system to spur the use of new and renewable energy sources. That effort will require investment from international financial institutions as well as domestic companies. In November 2008, the State Council unveiled 10 policies to encourage private capital to invest in research and development on new energy sources.

6.6.7 International Climate Change Funds

Several funds are investing in projects to produce marketable credits for reducing GHG emissions, with some specifically investing in China:

Global Environment Facility (GEF). By June 2002, China had received more than $300 million in grants from GEF—more than any other country. Those funds supported 55 projects targeting conservation of biodiversity, energy efficiency in industry, renewable energy, protection of international waters, control of land degradation, and related institutional capacity building.

The European Carbon Fund. A number of financial institutions in Europe created the European Carbon Fund (ECF) to invest in projects worldwide that reduce GHG emissions, and to market credits based on those reductions. According to a recent ECF study, the European Union's program for trading GHG emissions will create a market for reductions of some 2.2 billion tons of CO_2 emissions annually. The fund will try to find buyers for another 60 to 120 Mt of GHG reductions created through the Clean Development Mechanism.

The World Bank Fund. The World Bank manages nine carbon-related funds that use public and private financing to buy credits for cuts in GHG emissions from lower-income countries and communities. China's Umbrella Carbon Facility is one of the nine funds, which together handle more than $1.9 billion. The Umbrella Carbon Facility can produce double dividends, because the Chinese government has promised to invest 65 percent of the revenues from that facility in its Clean Development Mechanism Fund.

6.6.8 Voluntary Financial Mechanisms

In October 2007, American International Group announced that it would purchase GHG credits from projects in Xinjiang and Sichuan provinces that aim to conserve energy and provide more renewable energy. Transaction payments of roughly $2 million will help farmers obtain credits for about 310 000 tons of CO_2 reductions—offsetting half the GHG emissions from the company's global business segments in 2006.

These projects will reduce the use of water, fossil fuel, and nitrogen fertilizer in agriculture, and produce methane from anaerobic digestion of solid waste from human and animals for use for cooking and lighting. The projects will also plant trees in desert areas to conserve soil, block winds, fix sand, and reduce soil erosion.

6.7 Case Studies: How Rural China is Conserving Energy, Improving the Environment, and Tackling Climate Change while Addressing Rural Poverty

6.7.1 Cases on the Use of Biomass Energy

Rural sustainable development requires breakthroughs in the development and use of biomass energy. Fortunately, although this transformation is still in its early stages, the use of modern forms of biomass energy in rural China is growing rapidly.

6.7.1.1 *Biogas Projects in Xinjiang and Sichuan*

China has tried various methods of relieving energy shortages in rural areas, such as producing marsh gas, installing energy-saving stoves, and building small hydropower, solar energy, wind energy, and geothermal plants. Marsh gas has achieved the most widespread use.

For example, from 2004 to 2006 the government supported a marsh gas project in Xichong and Yilong counties in Sichuan province. According to information gathered during a door-to-door survey by researchers from Peking University, a minority of farm households had used government subsidies to build marsh gas tanks before the project began, with a few having installed the tanks as early as 1980.

Today nearly half of all peasant households in the project villages have now installed the tanks. Nearly a third of households have also updated their livestock facilities, and 14 percent have updated their toilets.

The government also promoted a family-use marsh gas project in a village in Manas County in Xinjiang prefecture from 2003 to 2005. The project was designed to integrate construction of the tanks with updated livestock beds, toilets, and kitchen stoves. Marsh gas generated through the project is mainly used for cooking and for heating water.

Several factors have affected the output of the tanks. The first is location: winter temperatures in North Xinjiang slow the production of the gas. Building the tank in a big-arch shelter or around warm livestock beds could raise gas production. Survey results show that only one-third of farm households chose to build their tank near warm pigsties or big-arch shelters, while the other two-thirds build the tanks in open courtyards.

The second factor is construction materials and quality: because marsh gas is produced under anaerobic conditions, the tank must be tightly sealed and well insulated. A survey revealed that 60 percent of marsh gas tanks in Manas County are made of brick and concrete, which are relatively low cost. Glass-reinforced plastics are good materials for such tanks, but only 11.43 percent of tanks in the project area are made of such materials because of high costs and low quality.

The third factor is capacity: family-use marsh gas tanks should not be too large, because the amount of material available for fermentation is limited. Most peasant households build 8–10-cubic-meter tanks, to ensure energy efficiency.

Because the tanks require a big up-front investment and pose other challenges, just 13 percent of households in Manas County are participating in the project. And even households that do participate often use marsh gas for cooking just two to three months a year.

However, despite these barriers, the marsh gas program has had a significant impact on coal consumption among peasant households in both Xinjiang and Sichuan. In Sichuan districts, for example, marsh gas now accounts for about 16 percent of household energy use, mainly replacing direct burning of straw and coal. Much of the straw formerly used as fuel is now returned to the soil, increasing its organic content and improving its quality. These benefits have reduced the cost of farming and improved farmers' net income.

6.7.1.2 *A Cost-Accounting for Electricity from Biomass*

The use of straw rather than coal to produce electricity could provide significant economic as well as environmental benefits. An analysis of the use of agricultural straw to produce electricity in Ningbo, in Zhejiang province, can shed light on the cost of biomass energy, and the income it could provide to rural communities.

Ningbo has abundant straw resources, with annual output averaging 1.85 Mt. The use of 50 percent of those resources to produce electricity could provide energy amounting to 462,500 tons of coal equivalent. The details follow:

Land: A 25,000-kW plant that can produce electricity from straw would require about 10 hectares of land to grow the straw. Buying enough wasteland for industrial purposes in Ningbo would cost 22.50 million RMB.

Fixed assets: Generating electricity from straw requires a place to store the biomass, factories, offices, subsidiary facilities, and equipment, which together cost 110.50 million RMB.

Raw materials: Dry straw purchased from peasants costs 100 Yuan per ton, and companies that buy and transport the raw material to the power plant charge 130 per ton. The 25,000 kW plant would need about 450,000 tons of straw each year. Thus the annual cost of raw materials would be 58.50 million RMB.

Salaries and other operating costs: Such a plant would require 150 employees. At an average salary of 3,500 RMB, annual employee costs would total 6.30 million Yuan. Other operating costs would total about 5 million RMB, and interest would cost 3 million RMB. Thus the plant would spend 14.30 million RMB on operating costs each year.

Income: If the 25,000 kW plant ran 8,000 hours a year, it would generate 200 million kWh. The plant would receive 0.35 RMB for each kWh it fed into the power grid for the first 15 years. The power plant itself would use 6 percent of the electricity it produced. Annual income from the sale of electricity would therefore total 112.80 million RMB.

Subsidies: Because electricity produced from straw provides social and environmental benefits, a plant can receive a one-time government subsidy of 8 million RMB, as well as tax relief for 15 years.

Bottom line: If the annual depreciation rate is 7 percent, yearly fixed costs of land, buildings, and equipment would total 8.75 million RMB, while variable costs such as materials, salaries, and operating costs would total 72.80 million RMB.

Pre-tax income would therefore total 31.25 million RMB, with a four-year payback on the initial investment. Thus rural communities could see substantial economic benefits from building such plants. Turning biomass into a high-value commodity, in turn, would raise peasants' incomes while producing clean energy, protecting the environment, and creating a recycling economy.

6.7.1.3 *Challenges to Producing More Electricity from Biomass*

Given the striking environmental advantages of producing electricity from biomass, national and local governments should create policies to encourage its development. Such policies are especially important because bottlenecks and unfavorable operating conditions are inhibiting its long-term development:

(1) An unstable supply of raw materials means higher costs.

(2) Collecting, storing, and processing biomass into solid fuel requires specialized agricultural machinery.

(3) The technology is immature: producing electricity from straw is still in the R&D stage.

(4) Costs are higher than those of producing power from coal and other fossil fuels, partly because biomass power plants themselves use a lot of energy.

6.7.1.4 *Recommendations on Expanding Rural Biomass-Based Electricity*

Government and power plant operators can take the following actions to expand rural biomass-based electricity:

(1) To help guarantee a stable supply of biomass resources, the government can help coordinate their production and use for

power plants.

(2) To stimulate the market for straw as an energy resource, the government needs to bring prices and costs in line with those of other fuels. Local governments can do that by setting the purchase price of biomass. This could also be accomplished by establishing a market price for GHG reductions through a trading system.

(3) Power plant operators, institutes of higher learning, and vocational schools need to cooperate on training, research, and technical support for the industry.

6.7.2 Cases on Using Energy Efficiency to Clean Up Pollution and Raise Income from Animal Husbandry

Since the reform and opening-up, animal husbandry in China has attracted global attention for its achievements. In 2007, national output of meat and poultry ranked first in the world, with an output of 69 Mt and 25 Mt, accounting for 25 percent and 38 percent of world output, respectively. China also ranked third worldwide in milk output in 2007, producing 36 Mt, or 5.4 percent of global output. Animal husbandry has become a pillar industry for China's rural development.

6.7.2.1 *The Impact of Animal Husbandry on Energy Use and the Environment*

China's expanding animal husbandry industry is raising peasants' income and improving the living standards of both urban and rural residents. However, the industry is also posing growing challenges to rural society.

In modern animal husbandry, farmers must provide daily ventilation for indoor areas, and cool them in summer and heat them in winter. The development of animal husbandry in China and a continuous increase in its scale has therefore meant growing energy demand. Global climate change and rising average temperatures will only make the situation worse.

Animal husbandry also accounts for a significant portion of agricultural GHG emissions. Livestock and poultry continuously discharge carbon dioxide created during metabolism, as well as methane produced by fermentation in their intestinal tracts. Ruminants such as cattle and sheep release methane at much higher rates than poultry and other animals. Animal waste also releases large amounts of methane and nitrous oxide during storage and treatment.

The huge volume of wastes from animal husbandry greatly pollutes the rural environment. In 2007, excrement from beasts and birds reached 2.7 billion tons, while cultivation sewage reached 11 billion tons. Because of the lack of waste treatment facilities, most of the wastes and sewage are discharged directly into the environment, seriously polluting the air, land, and underground water. Animal waste also contains numerous pathogenic microorganisms, parasitic ovum, and mosquito and fly larvae, which can harm both people and animals.

6.7.2.2 *Managing Animal Wastes More Effectively*

Two projects in rural China are aiming to raise the income of rural residents engaged in animal husbandry while reducing energy use, improving the local environment, and cutting greenhouse gas emissions.

(1) Oversize Marsh Gas Project of Shandong Minhe Animal Husbandry Co.

Shandong Minhe Animal Husbandry Co., Ltd., is Asia's biggest manufacturer of breeding chickens. The company uses an oversize marsh gas project, which costs over 60 million RMB, to produce combined heat and power. The project includes eight efficient, 3 000-cubic-meter anaerobic digesters, which produce 10.95 million cubic meters of biogas annually. The biogas is sent to a power plant with 3 megawatts of installed capacity. The power plant, connected to the grid, uses the biogas to produce 60,000 kWh of electricity daily, and 21,900 MWh annually. At a per-unit price of 0.35, the plant's annual income from the sale of electricity is about 7.60 million RMB.

After anaerobic fermentation, the digesters produce 47 tons of sludge each year (with a water ratio of 70 percent), which converts to 17.5 tons of organic fertilizer (with a water ratio of 20 percent), as well as about 850 tons of slurry (with a solid content of 1.3 percent). These substances retain most of the nutrient content of the chicken manure, including nitrogen, phosphate, and calcium, making them efficient green fertilizers.

The sludge is applied to crops and fruit trees and used in aquaculture and floriculture, while the slurries are used to irrigate neighboring farmland, replacing 310,000 cubic meters of fresh water every year. At a price of 500 RMB per ton, the sale of solid fertilizer brings in 3.20 million RMB each year, and annual income from the sale of both sludge and slurries totals 3.51 million RMB.

Total annual income from the project is therefore 11.11 million RMB, and net income is 5.61 million RMB, after operating costs. Given that the project required an investment of 60 million RMB, its static payback time is 10.7 years. However, because the project reduces GHG emissions by 86 000 tons of CO_2 equivalent, the company has agreed to transfer credits for those reductions to the World Bank—the first agricultural project approved under the United Nations Clean Development Mechanism (CDM). At $10 per ton of CO_2 equivalent, the company will receive nearly 58 million RMB for its GHG credits over a 10-year period.

That income, combined with revenue from the sale of fertilizer, brings the company's annual gross income from the biogas project to 16.91 million RMB. After deducting operating costs, the company will see total net earnings of 11.41 million RMB per year, enabling it to recover its investment in 5.3 years.

(2) Small Marsh Gas Project in Enshi Prefecture, Hubei Province.

In 2003, the Party Committee and government of Enshi proposed creating a model ecological prefecture and villages, with construction of marsh gas tanks as the core strategy. The government saw this approach as the key to resolving the “three rural issues” while also protecting the environment.

Local leaders planned to construct 700,000 marsh gas tanks in appropriate rural areas over five years. The cost of facilities was around 3,000–5,000 RMB each, of which 1,000 RMB was subsidized by the government. Farmers themselves paid the remaining 2,000–4,000 RMB. As of 2006, Enshi had built 410,000 marsh gas tanks for home use, accounting for 44 percent of farm households in the chosen areas.

On February 19, 2009, the project was approved by the CDM Executive Board and successfully registered as a CDM project. Around 33 000 farmers from eight counties and cities are involved in the project. By replacing coal use and the traditional approach to managing swine excrement, the project could reduce GHG emissions by 59 153 tons of CO_2 equivalent while providing income of 330 million RMB to local residents over 10 years.

6.7.3 Cases on Reducing Greenhouse Gas Emissions from Agriculture and Forestry

Rural China has huge potential to save energy and reduce GHG emissions. Annual straw output totals more than 600 Mt, and nearly 150 million households are suitable for producing marsh gas from animal and human excrement. Large areas of barren mountains and salt lick farmlands are suitable for growing energy crops.

Using these resources to reduce agricultural GHG emissions would help increase grain yield, improve the environment, and bring economic benefits, especially if farmers can receive payments for producing marketable GHG credits. Projects to reduce agricultural GHG emissions are therefore becoming very popular in rural areas.

6.7.3.1 *Xinjiang Chinese Tamarisk Greenhouse Gas Reduction Project*

The Chinese Tamarisk Forestation Project aims to reduce GHG emissions by growing more Chinese tamarisk trees, which store carbon as biomass while they grow, and also increase the amount of carbon stored in soil. The project is occurring mainly in Hotan prefecture, Xinjiang, a multiethnic region with 250 000 square kilometers of land and a population of 1.8 million. Hotan prefecture includes seven counties and one city—all of which are high-poverty areas, and thus receive key state support. Mountains cover 44 percent of the prefecture, deserts 42 percent, and oases 4 percent. Agriculture is the mainstay of the economy, so farmland accounts for 18 percent of the oasis area, where local peasants plant mainly cotton, wheat, and fruit trees.

The prefecture planted 100 000 mu with Chinese tamarisk and inoculated 60 000 mu with herba cistanche (a valuable traditional medicine) in 2008, and plans to expand reforestation by another 265 000 mu within 10 years. In addition, Manas, Hutubi, and Qitai counties would then have artificial Chinese tamarisk forests covering 365 000 mu, with a biologic carbon fixation of 288 000 tons of CO_2 equivalent. Carbon fixation includes the amount of carbon stored in biomass and soil, minus carbon dioxide and nitrous oxide emissions from the use of fossil fuel and any chemical fertilizers used to establish the trees.

Benefits of the Project

If artificial forestation of Chinese tamarisk carbon fixation at Manas, Hutubi and Qitai County reaches 365 000 mu and stores 288 000 tons of carbon dioxide equivalent by 2010, and credits for reducing GHG emissions earn $5 per ton of carbon dioxide emissions avoided, the project could earn a total of $1.44 million. If forestation in Hotan reaches 300 000 mu and biological carbon fixation reaches 400 000 tons of carbon dioxide equivalent, the project could earn $2 million.

Farmers could also earn $1.60–4 million annually from the sale of 20–40 tons of herba cistanches. If the area planted in Chinese tamarisk expands to 365 000 mu and the area inoculated with herba cistanches reaches 200 000 mu, total income from the project could reach $5.4–13.4 million.

The project is already providing more than economic benefits. The trees have clothed the bare desert in green, and form a windbreak and sand-fixing forest belt more than 300 kilometers long and 10–15 kilometers wide from the oasis margin in North Manas to the oasis margin of Hutubi County and Qitai County. Vegetation now covers 54 percent of this land, and the number of species of vegetation has increased from 4 to 46, because the forest allows a three-layer structure of trees, shrubs, and grass. These rising levels of biological diversity are expanding the area's productive potential, preventing the desert from encroaching on the oasis, and gradually improving the environment on which human survival depends.

6.7.3.2 *Soil Testing and Formulated Fertilization Project in Sichuan*

Jian'ge County is one of more than 200 counties that have encouraged farmers to test their soils and then apply fertilizer specially formulated to provide the precise amount of nitrogen, phosphate, calcium, and trace elements that the soil and crops need. The goal is to increase the percentage of the fertilizer that plants absorb while reducing the overall need for fertilizer.

Crops covered by the project include wheat, rice, corn, and rapeseed. A survey showed that crops absorb formulated fertilizer much more easily than regular fertilizer, so farmers can apply less. That helps reduce labor costs while increasing yield, with no significant change in unit cost. About 72.2 percent farmers in the demonstration villages therefore prefer to use formulated fertilizers, covering 77.3 percent of the demonstration farmland.

6.8 Policy Recommendations

China is an agricultural country, with rural residents accounting for 60 percent of the national population. The large, scattered rural population—and different natural conditions and level of economic development—make energy issues even more complicated in the countryside than in urban areas.

An accurate understanding of rural energy demand, supply, and use is important in tackling the "three rural issues—agriculture, countryside, and farmers—and in ensuring the effectiveness of national energy polices. Since the reform and opening-up, China's rural economy has been developing rapidly, and that development has brought significant changes in energy use. First, total rural energy use has nearly tripled, from 328 Mt of coal equivalent (Mtce) in 1980 to 956.5 Mtce in 2006.

Second, the use of noncommercial energy sources such as biomass has been relatively stable, fluctuating only slightly from year to year. The use of commercially produced energy, in contrast, has risen steadily—from 30 percent of all rural energy use in 1980 to 67.3 percent in 2006. That means that biomass no longer occupies a leading position in rural energy consumption. Although that energy source accounted for 70 percent of rural consumption in 1980, by 2006 it had dropped to about 30 percent.

Third, commercial supplies are becoming a major energy source for rural production, rising from 20.4 percent in 1980 to 47.6 percent in 2006. Coal, petroleum products, coke, and electric power are the main commercial energy sources, contributing 62.4 percent, 17.3 percent, 5.9 percent, and 5.4 percent, respectively.

Household users continue to rely mainly on noncommercial energy sources, which supply 76.8 percent of those needs, with straw and firewood contributing 60 percent and 35 percent, respectively. Coal is the largest source of commercial energy for rural residential use, contributing about 62.6 percent of the household commercial total, and electricity contributing 22.4 percent.

Our research shows that as farmers' income rises, they prefer high-quality, clean, commercial forms of energy for household use. We expect per capita energy use for rural household needs will rise to 0.7 tons of coal equivalent by 2030. With rural use of commercial energy growing at an annual rate of 8 percent, commercial sources will meet a growing share of rural energy demand, although traditional and modern noncommercial forms will remain basic energy sources. By 2030, the ratio of commercial to noncommercial energy sources for household use will be about 1:2.

To develop the rural economy and address the challenges of energy, environment, and climate change, the Task Force offers six policy recommendations to the government:

(1) Spur the rural use of biogas by integrating the construction of biogas facilities into efforts to rebuild the rural infrastructure.

The government should promote the development and use of clean, renewable, and low-carbon technologies to meet farmers' demand for high-quality energy for household use and production. However, today's rural energy policies—which rely on subsidies as a key tool—are no longer adequate to respond to changes in rural energy demand.

We suggest that the government build large and medium-sized biogas facilities as part of the national effort to rebuild the agricultural infrastructure, and set up market mechanisms to support that development. The government should also comprehensively address rural energy and environmental needs by fully enlisting government entities, enterprises, and farmers.

(2) Enhance the statistical analysis of rural energy use.

The Ministry of Agriculture has historically tracked and managed rural energy supply, demand, and use in China. The result is that information and action on rural energy use have remained separate from the national energy management system. However, this approach can no longer keep up with fast-growing and changing rural energy demand.

For example, data on rural energy now appear in the Energy Statistic Yearbook of China, produced by the State Statistics Bureau, and the Yearbook for Rural Energy of China and Statistics for National Rural Renewable Energy Sources, from the Ministry of Agriculture. These two sets of statistics rely on different measures, and data on energy use, structure, and efficiency among township enterprises are insufficient.

These statistics show that rural use of commercial energy accounted for 16.4 percent of the national total in 2007, and that use is rising steadily. If the nation included energy use by township enterprises in information on rural energy use, that proportion would be even higher. To ensure that rural energy becomes an integral part of

China's energy system, authorities need to strengthen their statistical analysis of rural energy end-use by both households and producers.

First, authorities need to unify the definition of rural production, to ensure that statistics reflect actual energy use of township enterprises. Second, national officials need to bolster the ability of county governments to organize and manage energy statistics. As our survey revealed, county-level accounting is a weak link in the creation of national energy statistics, as county statistical departments are unable to present systematic and accurate data on rural energy use.

Agricultural Bureaus, Forestry Bureaus, and other industry bureaus should then calculate and report statistics on local energy consumption under the guidance and organization of local statistics bureaus. The National Statistics Bureau can collect, check, and issue the overall results, to ensure the authority and authenticity of the nation's energy statistics.

(3) Adopt integrated measures to spur the development of clean and renewable energy sources.

Growing rural use of commercial energy sources such as coal, petroleum products, and electricity results in significant pollution and GHG emissions. Unlike urban regions, rural China lacks the infrastructure and technology to clean up these pollutants. For example, most pollutants from coal combustion are released directly into the environment, without any treatment.

Fossil fuels, especially coal, are the major source of CO_2 emissions from rural energy use. In 2004, rural coal burning poured some 1.04 billion tons of carbon dioxide into the air, of which 561.09 Mt came from agricultural use, and 477.63 Mt came from household use.

Rural CO_2 emissions have been rising continuously. In 1980, rural areas produced 191 Mt of carbon dioxide. By 2004, that amount had quintupled, after rising at an annual rate of 7.3 percent.

In 2004, the rural burning of coal also released 10.91 Mt of SO_2, of which 5.89 Mt stemmed from rural production and 5.02 Mt from household use. Rural coal burning further released 932 000 of NO_x and 644 500 of total suspended particles (TSP) that year, with agricultural production accounting for 503 400 of NO_x and 348 100 of TSP, and household use accounting for 428 600 and 296 300, respectively.

Rural coal use also produced 180 Mt of solid waste that year, with agricultural production contributing 100 Mt and everyday rural life contributing 80 Mt. The amounts of all these pollutants are rising rapidly.

Developing renewable energy sources could help relieve gaps between energy supply and demand, curb pollution, increase farmers' income, and control GHG emissions. Research has shown that the use of a cubic meter of biogas rather than coal reduces GHG emissions by 1.88 kilograms. From 1991 to 2005, biogas provided some 28.4 Mt of coal equivalent for heating. That energy source therefore reduced GHG emissions by about 73.16 Mt of CO_2 equivalent, with an average annual reduction of 4.88 Mt—or 0.07–0.16 percent of total national GHG emissions.

In 2005, China used some 166 MTCE of renewable energy (excluding traditional direct burning of straw and firewood)—accounting for about 7.5 percent of national primary energy use. The use of renewable sources reduced annual SO_2 emissions by 3 Mt.

Existing technologies provide several options for converting biomass into an efficient energy source: producing biogas (also known as marsh gas), solidifying or gasifying crop straw, and using biomass to generate electricity. Of those technologies, biogas is the most highly developed in China.

However, high up-front costs are restraining further development. The initial investment needed to build a straw gasification station averages 1.2 million RMB, for example. If each such station serves 200 rural households, each household must contribute 6,000 RMB in construction expenses. Stations that press straw into blocks are also difficult to organize and operate, and profits are limited, so private capital is not very interested in investing in the straw gasification industry.

The governments will therefore need to promote these technologies to bring them into widespread use. The government could do so by expanding its own investment in modern biomass facilities, and by providing subsidies and tax incentives to encourage private capital to invest in R&D on rural renewable energy technology. Only with government guidance can China fulfill the goal of fully commercializing its extensive renewable energy resources.

We recommend that the government also use favorable pricing to promote the use of clean commercial energy sources, particularly electricity, in rural regions. For example, a Rural Energy Construction Fund could promote sustainable energy development, while "transfer payments" could subsidize electricity use among farmers.

A rural renewable energy strategy and related laws and regulations are essential to both improving the rural environment and tackling climate change.

(4) Support the development of low-carbon, high-quality agriculture.

Rural regions suffer from extensive pollution from overuse of pesticides, fertilizers, and plastic sheeting; low energy efficiency and high emissions from agricultural machinery; air pollution from the direct burning of straw and firewood; and a lack of options for disposing of animal wastes.

Developing a low-carbon agricultural economy is the only way to fundamentally solve all those problems. A low-emission, high-efficiency, recycling agricultural industry will reduce both pollutants and rural GHG emissions. Recommended low-carbon practices include reducing the use of fertilizers, pesticides, and plastic sheeting; replacing fertilizers with farm manure; replacing chemical pesticides with biological pesticides; and replacing plastic sheeting with biodegradable sheeting. Other practices include phasing out old irrigation application technology while promoting more efficient irrigation methods, increasing the recycling of agricultural wastes, and promoting other technologies and practices that reduce energy use.

China should rely on a comprehensive, long-term strategy based on local circumstances to develop low-carbon agriculture, including long-term subsidies to encourage investment in new technology. National voluntary carbon-trading mechanisms, and payments to impoverished farmers for reducing pollutants and GHG emissions, are a cost-effective way to promote low-carbon practices while also contributing to the nation's goal of alleviating poverty.

(5) Spur the use of renewable energy sources to provide heat and electricity for rural buildings.

Rural buildings already account for a large proportion of energy use in China, and the amount of energy they consume is rising fast. Meanwhile fossil fuels such as coal are replacing the traditional direct burning of straw and firewood.

Greater reliance on renewable technologies to heat rural buildings can help conserve energy. To promote that goal, the central government has created programs demonstrating the use of solar and shallow geothermal technologies in rural buildings. These programs include a thorough assessment of the results, timely readjustment of policies based on those results, and replication of lessons learned on a wider scale. The programs also encourage researchers, manufacturers, designers, architects, and builders to learn from the problems encountered in the projects and improve their facilities and technologies before applying them nationwide.

(6) Improve the capacity of farmers and rural regions to adapt to climate change.

China's average temperature rose 1.1℃ in the past 100 years. The frequency and intensity of extreme events, such as high temperatures, drought, and rainstorms—the predicted result of climate change—are also rising. These changes have brought higher average precipitation levels in West and South China but lower levels in North and Northeast China in the past 50 years.

Research reveals a close relation between climate change and food security. If China's average temperature rises by

2.5–3℃, the per-unit yield of the nation's three major crops could either rise or fall depending upon assumptions about technical change and other climate-related yield impacts, and farmers can maintain total grain output by readjusting planting patterns. However, if the rise in the average temperature exceeds 2.5–3℃, the per-unit yield of all three major crops will decline continuously, inevitably affecting total output.

Given this uncertainty, and the growing incidence of extreme weather, enhancing farmers' ability to adapt to climate change is essential, to sustain the rural economy, improve rural living standards, and ensure food security. Toward that end, the nation needs to evaluate the speed and scale of disasters that climate change could cause. China also needs to develop systems for monitoring regional climate change, and providing early warning of disasters. And authorities at all levels need to consider adaptation to climate change when creating development strategies, and bolster community-based disaster prevention and training.

Both facts and models convince us that climate change will have a profound impact on China's food security. To respond to this threat, the government will need to adjust the structure of the nation's agricultural production and consumption. Funding and technology are the two pillars supporting the rural campaign against climate change. However, the nation should adopt flexible approaches that reflect the needs of each area.

China needs to introduce practices that sequester carbon in soil and biomass and reduce GHG emissions to a wider audience, including afforestation, low-till or no-till farming, better grassland management, alternative varieties of animals and fodder, and more efficient use of fertilizer. The government should establish consulting services at all levels to ensure that farmers have access to energy-saving technologies and information on low-carbon farming.

The government must provide subsidies, insurance, and credits to advance these goals, especially in areas with fragile ecosystems and large numbers of farmers. A program that enables farmers to obtain credits for reducing GHG emissions through changes in production practices, and that markets and trades those credits, could achieve the dual goal of removing CO_2 from the atmosphere and providing new income to farmers and land managers.

To ensure a self-sufficient food supply and relieve pressure on domestic resources and the environment, the government should import agricultural products with high resource costs, such as soybeans and corn. A map matching biodiversity with climate change patterns will also be a fundamental tool for planning to protect the nation's agriculture and food supply. China should also preserve information on biodiversity in national and international gene pools.

Chapter 7 Sustainable Use of Coal and Pollution Control Policy in China

7.1 Status and Prospects of the Development and Utilization of Coal Resources in China

7.1.1 Characteristics of Coal Resources and Distribution

7.1.1.1 ***Characteristics of Coal Resources***

Coal resources account for 94% of all fossil fuel endowments in China. The latest “Report on Energy Resource Survey” prepared by the World Energy Council (WEC) estimated that China’s gross coal resources and proven coal reserves rank No. 1 and 2 in the world, respectively. According to China Coal Resource Prediction and Evaluation 1999, China’s prospective coal reserves have reached 5,555.3 billion-ton (Gt), with cumulative proven reserves at 1,042.135 Gt. The prospective reserves and geologic gross reserves rank No. 1 in the world.

7.1.1.2 ***Characteristics of Coal Resources Distribution***

China’s coal resources cover an area of 600-thousand km^2. There are five major districts endowed with coal reserves: Northeast China, North China, South China, Northwest China, and Tibet and Yunnan, which are separated by Tianshan-Yinshan orogenic belt, Kunlunshan-Qinling-Dabieshan latitudinal orogenic belt, and Helanshan-Longmenshan longitudinal orogenic belt. The Daxinganling-Taihangshan-Xuefengshan fault belt carved up the three coal reserve districts of East China into six secondary coal reserve areas, i.e., Erlian - Hai'la'er, the Three Provincial Area of Northeast China, Huan-ghuaihai, Shanxi-Shaanxi-Inner-Mongolia- Ningxia, South China, and Southwest Ch-ina. (Figure 7-1)

A geographical characteristic of China’s coal resources distribution is its extensive coverage and relative concentration in the west and the north. Coal reserves amounting to 4.50 trillion-ton have been found in twelve provinces (municipalities and autonomous regions) including Shanxi, Shaanxi, Inner-Mongolia, Ningxia, Gansu, Qinghai, Xinjiang, Sichuan, Chongqing, Guizhou, Yunnan, and Tibet to the west line of Daxinganling-Taihangshan-Xuefengshan, accounting for 89% of gross coal resources. Twenty provinces (municipalities and autonomous regions) east of this line have coal reserves of 0.56-trillion-ton (without Taiwan), accounting for 11%. Eighteen provinces (municipalities and autonomous regions) including Beijing, Tianjin, Hebei, Liaoning, Jilin, Heilongjiang, Shandong, Jiangsu, Anhui, Shanghai, Henan, Shanxi, Shaanxi, Inner-Mongolia, Ningxia, Gansu, Qinghai, and Xinjiang north of the line of Kunlunshan-Qinling-Dabieshan have coal reserves of 4.74-trillion-ton, accounting for 93.6% of the gross coal reserve. Fourteen provinces (municipalities and autonomous regions) south of this line have coal reserves of 0.32-trillion-ton (without Taiwan), accounting for 6.4% of gross coal reserve. The unbalanced distribution dominated by geologic conditions determines the pattern of coal production and transportation from north to south, and from west to east.

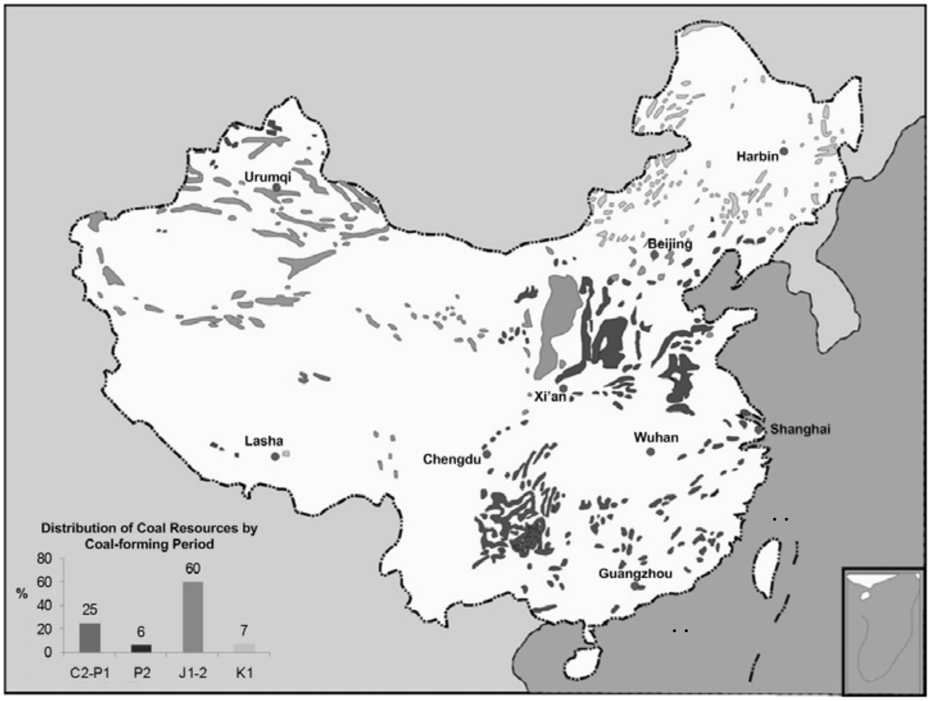


Figure 7-1 Chinese Coal Resource Distribution Map

Coal consumption is closely related to economic development due to the dominant role played by coal in China's energy sector. In China the reserve and supply-demand of coal resources are diversified in different places. The high coal demand in East China resource is met by coal resources transported from Shanxi, Shaanxi, Inner-Mongolia, and Ningxia (Jin-Shaan-Mongolia-Ning), where the coal reserves are the richest in China with output supplying the major parts of China. The four provinces and municipalities of Southwest China have relatively abundant coal reserves, and have the potential to be developed as one of the major coal suppliers in South China. In the broad area of Northwest China such as Xinjiang, where coal consumption is less demanded, and which is remote from the major coal consumers in the east, coal production and consumption is self-sufficient.

7.1.2 Position and Role of Coal in the Development of the Chinese Economy

Energy, especially coal which is dominant in China’s energy structure, constitutes the basis for the development of national economy. Even though the coal-dominating energy consumption structure has produced many environmental and social problems, it is still in wide use because China’s petroleum and natural gas reserve per capita is only 7.7% and 7.1% respectively of the world’s average. For many years coal occupied a ratio of 70% of the energy production and consumption structure in China. In 2007 its ratio in gross energy production reached 76.6% and that in gross consumption 69.5%. Energy consumption has been on rise with the development of the national economy, the process of urbanization, and the increase in the consumption of urban and rural residents. At the same time, China has actively developed hydropower, nuclear power, wind power and other new energy sources. In 1978, hydropower, nuclear power, wind power production accounted for 3.1% of the total energy production, and had increased to 8.2% in 2007. The proportion increased unceasingly in the energy production constitution. However, on the other hand, it is predictable that coal will remain the major energy resource in energy consumption structure in China for a long period in the future.

7.1.3 Status and Prospects of Coal Development in China

China’s coal industry, after 60 years' development, especially in the most recent 30 years of reform and opening up, has filled the gap in coal supply and demand that had existed for more than 30 years after the founding of PRC. This has contributed a huge part to the development of the energy industry and the security of national economic development. With a coal output of 1,397 Mt, China became the No.1 coal producer in the world in 1996, and has been since then. This represents 43 times the coal output of 32.43 Mt in 1949. In 2003, the raw coal output in China increased to 1,670 Mt, and to 2,793 Mt in 2008. The coal output has an increase of 1,416 Mt from 2000 to 2008.

Up to 2008, coal enterprises have gained a total annual sales profit of over 100-billion-RMB, an 86.496-billion-RMB increase, or 11 times more than the year of 2002. By 2007, there were 34 coal enterprises that have an annual output over 11 Mt accounting for 45% of national output, and 6 coal enterprises that have an annual output over 50 Mt accounting for 23% of national output. In 2006 major national coal mines have a mining mechanization proportion of 85.50%, with a mechanized mining proportion of 77.47%, an increase of 7.72% and 14.49% respectively from 2002. They also had a mechanized excavation degree of 28.44%, an increase of 12.56% from 2002. As for the death rate per one Mt, there has been a dramatic decline, see Figure 7-2 and Figure 7-3. In 2007, the death rate per one Mt for the leading state-owned coal mines was 0.383, a decrease from 0.575 or 60.0% less than 2005, or a decrease from 0.887, a decrease of 69.8% from 2002. In 2006, 219 safe and efficient coal mines produced 702 Mt of raw coal with an average output of 3.207 Mt per well, a death rate of 0.064 per one Mt, an average raw coal work efficiency of 18.8-ton/unit of labor and an average profit of 165-million-RMB per well. Thirty-five wells had a profit of over 100-million-RMB, with other economic and technical indexes approaching or attaining the level of the world's major coal producers.

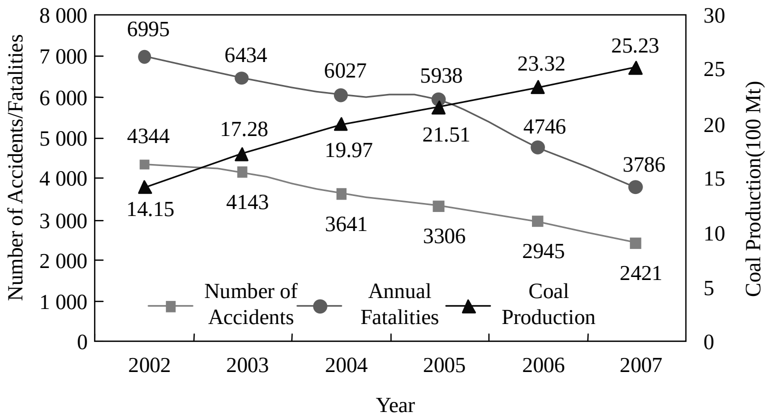


Figure 7-2 Coal Mining Accidents and Fatalities vs. Coal Outputs in China (2002-2007)

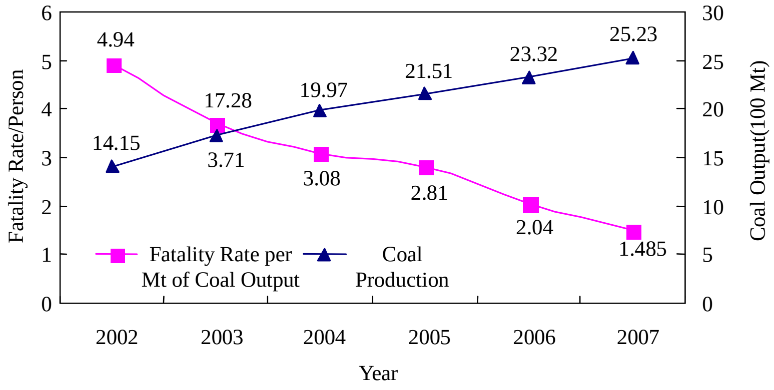


Figure 7-3 Fatality Rate per Mt of Coal Production vs. Coal Output in China (2002-2007)

7.1.4 Status and Prospects of Coal Utilization

In 2007 China's gross coal output is 2 513.77 Mt, with an import of 51.02 Mt, an export of 53.19 Mt, and a consumption of 2 586.41 Mt. Of this, the end-use is 24.03%, the intermediate consumption is 73.72%, and the washing loss is 2.25%. Sixty-seven percent of the intermediate consumption is for power generation, 21% for coking and 12% is for heat provision and coal gas production. Seventy-nine percent of the end-use is for industrial sectors, primarily consumed by industrial boilers and kilns, and the rest is for civil use or other sectors.

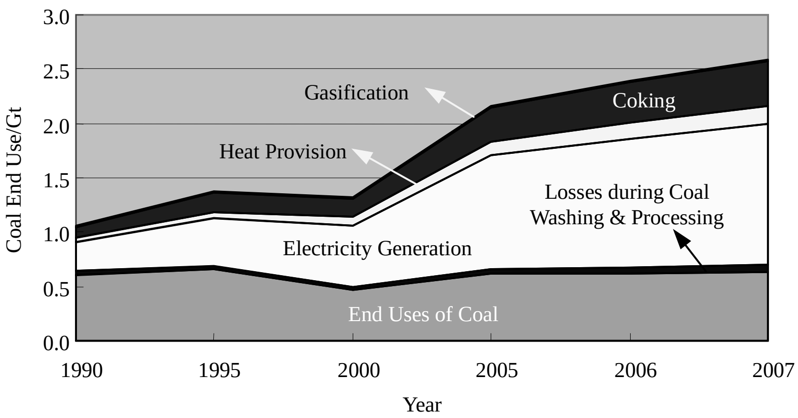


Figure 7-4 Coal Consumption by Sector in China (1990-2007)

Coal consumption in China has increased significantly and rapidly year by year from 1990 to 2007. See Figure 7-4. Generally, power generation is always the major consumer of coal production, the consuming ratio of which amounts to 25.78% in 1990 to 50.47% in 2007.

Energy consumption has been on a steady rise because of the economic development and the urbanization process in China. By taking into the consideration the economic structure adjustment, technical progress, and energy saving measures, the predicted domestic coal demand in year 2020, 2030, and 2050 will be 3.5 Gt, 4.0 Gt, and 4.2 Gt, with the ratios of coal in the primary energy consumption of 58%, 53%, and 43% respectively. In years to come, coal consumption demand for electric power will continue to rise, while demand for the building materials industry and steel industries will remain stable, and a new rise for the coal chemical industry is foreseen.

7.2 Strategic Targets and Constraints of Sustainable Use of Coal

7.2.1 Strategic Targets of Sustainable Use of Coal

Being a developing country, China has a huge demand for energy. For a long time coal will remain dominant in the primary energy structure in China because of the natural constraints of resources endowment. Safe, effective, environment-friendly mining and scientific, effective, and clean use of coal will be the theme in the sustainable development of the coal industry.

To realize this goal, coal enterprises have to undergo an intensive mechanization by developing supporting science and technology in the following 20 years (to 2030). These can address China's coal resource reality, which places a high demand for coal in the development of the national economy, while complicated geologic conditions in China's coal reserves makes mining difficult. As for safety, the annual number of deaths in mining accidents shall decrease from more than 3 000 to 300 with a death rate per one Mt decline from 1-person/Mt to 0.1-person/Mt. For effective mining, small mines with 60 to 150-thousand-ton of annual coal production shall be eliminated and closed. The number of coal mines shall decrease from more than 10-thousand to 2 000 or below. The mechanized mining proportion shall increase from 40% to 80%. A small ratio of mines (5%) shall have the mining process automated. The output of scientific mining shall reach 2.6 to 3.7 Gt. For clean mining, all the high gas coal seams will use gas drainage and utilization technology, and 80% of well water will be processed for re-use. Coal gangue piles are to be eliminated, and 80% of the subsided land to be reclaimed.

As for environment protection, pollutants from coal burning shall be strictly controlled, since over 80% of coal products are burned directly in the boilers of power stations, industrial boilers, industrial kilns and domestic cookers. By 2030, more than 80% of the residues of used coal and over 90% of waste water shall be processed. The emission of SO_2 and NO_x shall be controlled at 14.00-million-t/a and 15.00-million t/a respectively. On the basis of the estimated emission ratio of 85% and 65% of coal burning, the emission of SO_2 and NO_x from coal burning shall be controlled at 12.00 Mt/a and 10.00 Mt /a respectively. Meanwhile, with the application of energy saving and CCS techniques, CO_2 shall be controlled within 6.5 Gt/a by 2030.

7.2.2 Resource Constraints on Sustainable Development of Coal

Where there is much water, there are less coal resources and vice versa. Coal reserves in East China with a more developed economy only accounts for 7% of national coal reserves, while the water resources in East China accounts for 71.9% of the national total. Central China has coal reserves of 73.6% of the national total, while their water resource is 22.7% of national total. Specifically in Shanxi, Shaanxi, Inner-Mongolia and Ningxia, the proved coal reserve accounts for 64.4% of national gross, while the water resource only accounts for 2.6%. In the self-supply region of West China, coal reserves account for 11.6% of national gross, while the water resource only accounts for 4.6% of national gross. Shortage of water constrains severely the development of the coal resource.

What makes the case worse is that most coal-rich areas are suffering severe loss of water and soil. In these low vegetation coverage areas debris flow and landslides occur frequently, endangering the already fragile eco-environment. Severe environmental problems occur in the process of coal mining, such as land damage and occupation, water pollution and changes in hydro-geologic conditions, gas emission and spontaneous combustion of gangue, etc.

7.2.3 Constraints on Sustainable Use of Coal

7.2.3.1 *Energy Efficiency and Pollution Control in Coal-fired Power Generation*

Since the reforming and opening up in 1978, China has made a significant progress in energy efficiency and pollution control of the coal power industry. By the end of 2008, the total installed power capacity is 792 GW, of which 600 GW is coal power. The large-scale units (larger than 300MW) now occupy more than 50% of the total installed coal power capacity and the supercritical and ultra-supercritical technologies have become the main choices in newly built power capacity. At the same time, China implemented the policy of promoting the large-scale units and holding or closing down the small-scale ones. With all these efforts, the energy efficiency of coal power generation has been greatly improved. In 2008, the average coal consumption per unit electricity supply has been reduced to 349gce/kWh. In pollution control, more than 50% of coal power units have installed flue gas desulphurization (FGD) facilities, and the total emission of sulfur dioxide and dust by coal power generation has started to decrease.

As for NO_x control, more than 50 GW power units have either installed or planned to be equipped with de-NO_x facilities. It can be expected that, the new wave of installing de-NO_x facilities is coming and the uprising trend of NO_x emissions will be consequently reduced.

Nevertheless, the energy efficiency and pollution control of the coal power industry in China is still behind the most advanced level in the world. For example, the fraction of power capacity with unit scale smaller than 100MW is 24.8% in 2007 while it is only 7% in USA in 2007; the average coal consumption per unit coal powered electricity supply in China in 2008 is 11% higher than that of Japan in 2005 (313.3gce/kWh); and the emission of sulfur dioxide and nitrogen dioxide per unit electricity supply of coal power in China in 2007 is 30% and 150% higher than that in USA respectively in 2007.

In general, the constraints on China's coal power industry lie in three aspects:

(1) supply security, including insufficient production capacity meeting high efficiency and safety criteria and shortage in transportation capacity.

(2) pollution limitation, including conventional pollutants as SO_x, NO_x and dust in near term and mercury and respirable particulate matter emissions in long term.

(3) CO_2 emissions limitation.

Therefore, the strategic goals for the coal power industry can be summarized as: under the precondition of meeting electricity demand from social and economic development, the final electric coal demand should be reduced through all kinds of approaches; conventional air pollution should be reduced greatly in accordance with advanced international emission standards and the emission of mercury and respirable particulate matter should be regulated as soon as possible; and there should be early policy, regulation and technology preparations for carbon dioxide reduction. Besides, there is always the need for appropriate business environment and institutional mechanisms to ensure stable business development. The specific targets include the mechanisms for rational profit distribution between power and coal industries, reforming of the regulated electricity pricing mechanism and changing and normalizing of the business expansion model of the power industry.

7.2.3.2 ***Major Problems of Distributed Coal Combustion***

Low energy efficiency and huge waste of resources are still the two major problems in China, especially for industries that use coal as the fuel for boilers. Normally the thermal efficiency designed for boilers is between 72%-80%, which is close to the design level of developed countries. But in reality, most of the actual thermal efficiencies are between 60%-65%, 10%-15% lower than the identified thermal efficiency of boilers. Some boilers only have thermal efficiency of 30%-40% in actual application, 30%-50% lower than that of developed countries. For coal burning boilers, the longer they have been in use, the lower their actual thermal efficiency would be, which is the main cause for the gap compared to that of industrial boilers in application in developed countries.

7.2.3.3 ***Major Problems of Coal Conversion***

(1) Outdated techniques and low output, to certain degree, are still in existence. Resource waste and environment pollution are two major problems. Currently, China has hundreds of small mechanized coking installations to be closed or transformed. Their capacity is about 50 Mt, accounting for 15% or so of the gross capacity of mechanized coking installations in China. Moreover, in some places traditional coking and modified coking are still in production, in spite of the prohibition from the government, with more severe problems of resource waste and environment protection. Statistics show that in China, 55% of synthetic ammonia is produced by enterprises with outdated techniques, low energy efficiency, and environment pollution. The output of large-scale (⩾ 300-thousand-t/a) and high-tech enterprises only accounts for 25%. As for methanol production, enterprises with a capacity below 200-thousand-t/a account for 90% of the methanol producers in China, 58% of methanol capacity, and 56% of methanol output. These small-sized coke, fertilizer and methanol producers use outdated techniques and equipment for coal coking, gasification and synthesizing, such as discontinuous fixed-bed gasification techniques resulting in low energy efficiency and heavy pollution. In China today, nearly 50% of mechanized coking enterprises are in operation without dust collecting and processing equipment, or with equipment that fails to run effectively; half of small mechanized coking factories, and some medium coking factories, have incomplete coal gas purifiers (mainly desulphurization installations); a number of processes of mechanized coking have waste water drained directly without deni-

trification, all of which are far behind the advanced technology in developed countries.

(2) The solution to energy inefficiency in new coal-chemical technology is the recovery and utilization of low-quality heat energy. The data analysis on energy balance of new coal chemistry projects indicates that the efficiency of the conversion from coal to oil, chemical products or gas is between 30%-60%, relating closely to the key techniques, product quality, and production processes. The energy loss is concentrated in the reaction process, wherein a lot of heat energy is lost. For example, the reactor has a temperature of 250-260℃ during the process of methanol synthesis. Only medium pressure steam can be generated even if a water jacketed condenser is used. With such inefficient power generation, the output cannot be guaranteed. These old techniques reduce the effective use of the heat energy, and cause the low efficiency of comprehensive coal conversion.

(3) The new coal-chemical technology has to solve the problem of converting coal into other energy type in a more effective and cleaner way. In this regard, there still exist such problems in planning, technical development and demonstration, industrial policies, standard systems, and encouragement policies. For example, there is no long-term planning for the development of new coal-chemical industry, nor clear industrial policies to encourage the sealing up of CO_2.

7.2.4 Environmental and Climate Constraints in Coal Utilization

7.2.4.1 *Serious Air Pollution Caused by Coal Utilization*

The coal-based energy structure has caused severe environment pollution in China. In 2007, the total emissions of SO_2 has amounted to 24.681 Mt, NO_x to over 20 Mt, CO_2 to being the top 2 on the world list, for which coal use contributed to 80%, 70%, and 80% respectively.

(1) Since 2006, the emission of SO_2 is decreasing, while NO_x is increasing. In 2007 the emission of SO_2 was 24.681 Mt in China, a decrease of between 3.2%-4.7% lower than the previous two years (2005 and 2006). The environmental statistics of China includes the emission of NO_x from 2006. In 2007 the emission of NO_x was 16.434 Mt, an increase of 7.8% more than 2006 (15.238 Mt). The emission of soot and industrial powder and dust is decreasing from 2006.

(2) Electric power industry is a major producer of SO_2, NO_x and industrial soot and dust. In 2007, this industry took up a dominant position as an emitter of SO_2 and NO_x, emitting 58.2% and 64.3% respectively of total emissions of industrial SO_2 and NO_x.

(3) In some cities, ambient air quality

has not been in compliance. In 2007, some cities have seen an improvement in the overall quality of urban air. The number of cities with air quality lower than grade Ⅲ has decreased, the number of cities with grade Ⅲ air quality remains unchanged, and the number with air quality better than grade Ⅱ has increased. However, particulate matter is still the major pollutant in most cities. The proportion of tiny particles is increasing year by year. There are still 20.9% of cities with average SO_2 concentration failing to meet national standard of grade Ⅱ (0.06-mg/m^3). Cities violating grade Ⅲ (0.1-mg/ m^3) are 1.2% of all the cities involved according to the same statistics.

(4) The pollution of acid rain is mainly formed by soot. The electric power industry has caused much of the pollution of acid rain. In China the ratio of SO_4^{2-}/NO_3^- is between 5-3, indicating that SO_4^{2-} from soot is the dominant factor, and that China's acid rain is of the soot type. The main cause of acid rain is the emission of SO_2 from coal combustion. The electric power industry consumes 52.6% of the total consumed coal, and emits SO_2 and NO_x with a ratio of 58.2% and 64.3% respectively of total emissions of each. The electric power industry emits much of SO_2 and NO_x resulting in acid rain, and which has a great impact due to being transported long distances.

(5) In regions with a relatively developed economy in China, the regional structure of composite air pollution has been formed, especially in the city clusters of Beijing-Tianjin-Tanggu, Changjiang River Delta, and Pearl River Delta with emerging composite pollution structures and particular pollution features.

7.2.4.2 *Regional Environmental Constraints in Coal Use*

The coal consumption, pollutant emission, and pollution treatment level is unbalanced and diversified for regions with different economic development levels in China. Coal consumption per unit area and pollutant emission per unit area in East China are higher than Central China, and much higher than West China. The environmental constraints and development space are also diversified. China has four districts with different economic development levels. They are East China, Central China, Southwest China, and Northwest China. (the regional division is consistent with national Eleventh Five-Year allocation program of the total SO_2 emission reduction) Table 7-1 and Table 7-2 show the coal consumption and pollutant emission per unit area and rate of meeting pollutant control standards.

From the tables above, the features of East China, Central China, Southwest China, and Northwest China are analyzed as follows:

Table 7-1 Coal consumption and emissions of SO_2 and NO_x per acreage (2007)

Regions	Area (10,000 km^2)	Coal Consumption (10,000-ton)	SO_2 Emission (10,000-ton)	NO_x Emission (10,000-ton)	Coal Consumption Per Unit Area (t/km^2)	SO_2 Intensity (t/km^2)	NO_x Intensity (t/km^2)
East China	106.78	114 695.0	913.30	807.50	1 074.12	8.55	7.56
Central China	166.87	85 489.0	667.00	428.0	512.31	4.00	2.56
Southwest China	260.22	28 980.0	489.0	202.0	111.37	1.88	0.78
Northwest China	429.20	37 292.00	399.00	205.70	86.89	0.93	0.48
National Total	963.07	266 457	2 468.1	1 643.4	276.67	2.56	1.71

Table 7-2 Pollutant control standard compliance rate (2007)

Region	SO_2 Emission Standard Compliance Rate/%	Soot and Dust Standard Compliance Rate/%	Industrial Power Standard Compliance Rate/%	Industrial NO_x Emission Standard Compliance Rate/%
East China	91.63	95.51	95.57	89.68
Central China	87.01	90.68	86.68	80.26
Southwest China	79.10	70.33	67.83	72.82
Northwest China	68.23	68.93	66.02	70.53
National Total	86.3	88.2	88.1	77.5

(1) East China has the coal consumption per unit area and pollutant emissions of more than ten times that of West China, and it has less potential for improvement. Moreover, Pearl River Delta, Changjiang River Delta, and Beijing-Tianjin-Tanggu have city clusters featuring interacting pollutants between cities, which makes pollution even more serious. Regional photochemical pollution with photochemical smog and particulates, results in evident reduced visibility. Series of problems often occur during periods of continuous heavy pollution. Most of those regions have heavy acid rain pollution.

Emissions from East China are beyond the capacity of the environment. To increase the coal consumption, it needs to substantially reduce the existing emissions in order to create capacity, and use best practical technology to minimize pollutant emissions. Due to the limited environmental capacity, it is a challenging task to reduce pollutant emission while the coal industry is still to be developed in this region.

(2) Coal consumption and pollutant emission per unit area is lower in Central China than in East China, but higher than the national average. The emission standard-meeting rate is at the same level. As far as different regions are concerned, there is still some environmental capacity in the central region, but the distribution is not

even. Cities in the provinces of Shanxi, Henan, Hunan, Hebei and Anhui are severely stricken by SO_2 pollution. The condition for developing coal industry lies in the reduction of pollutant emission and technical progress, and in being away from cities with severe SO_2 pollution.

(3) Coal consumption and pollutant emission per unit area is far lower in southwest China and Northwest China than that of East and Central China, and the emission standard-meeting rate has the potential to increase. However, the coal reserves in Guizhou, Sichuan, Chongqing, and Guangxi of Southwest China contain high sulfur for creating acid rain. Northwest China has fragile eco-environment. Guizhou Province, Inner-Mongolia Autonomous Region, Yunnan Province, Chongqing City, Xinjiang Autonomous Region, Guangxi Autonomous Region, Gansu Province, and Shaanxi Province all have cities severely stricken by SO_2 pollution. All these environmental factors should be taken into consideration if coal industry is to be developed while other factors such as investment in technical progress and standard emission rate are also met.

7.2.4.3 *Needs of Carbon Emission Reductions for Coal Utilization*

Demands for more energy are on a rise for economic growth. Therefore, the pressure to reduce carbon emission in coal use is urgent. As predicted in the three scenarios of *World Energy Outlook 2007*, i.e., Reference Scenario, Alternative Policy Scenario, and High Growth Scenario, in 2015 and 2030 China's energy demand and CO_2 emission is shown in Figure 7-5 and Figure 7-6.

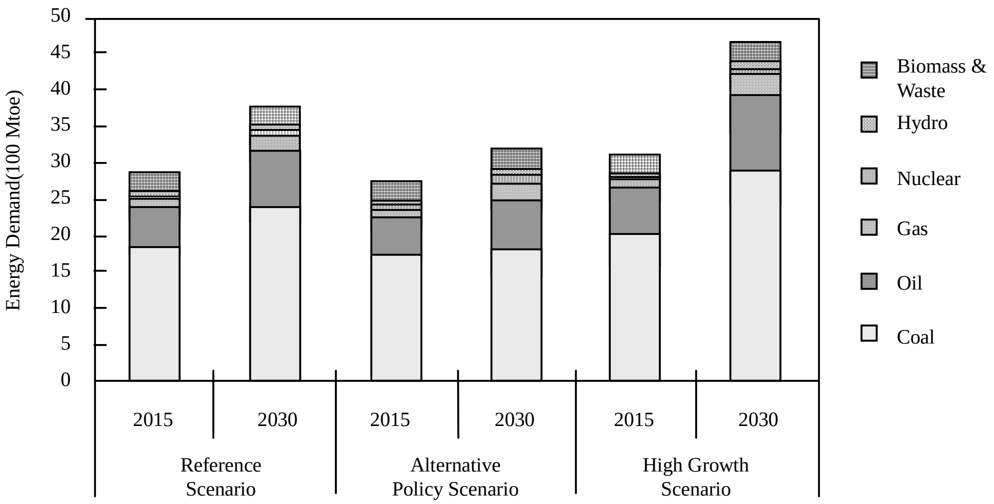


Figure 7-5 China's Energy Demand in Different Scenarios

(World Energy Outlook 2007)

As shown in Figure 7-5, in 2030 the dominant fuel to meet demand for energy is still coal. The increase of energy consumption and the coal-based energy structure means that CO_2 emission will increase accordingly.

In the Reference Scenario, the CO_2 emissions are 8.632 Gt in 2015 and 11.448 Gt in 2030. In the Alternative Policy Scenario, the CO_2 emissions are 8.092 Gt in 2015, and 8.877 Gt at the end of 2030. In the High Growth Scenario, the CO_2 emissions are 9.5 Gt in 2015 and 14.1 Gt in 2030. In each scenario, coal use is the largest producer of CO_2, more than 75% of the gross CO_2 emission in energy use. This is directly related to the energy consumption structure. CO_2 emissions come mainly from coal used in power generation, which accounts for over 60% of total CO_2 emissions from all coal uses.

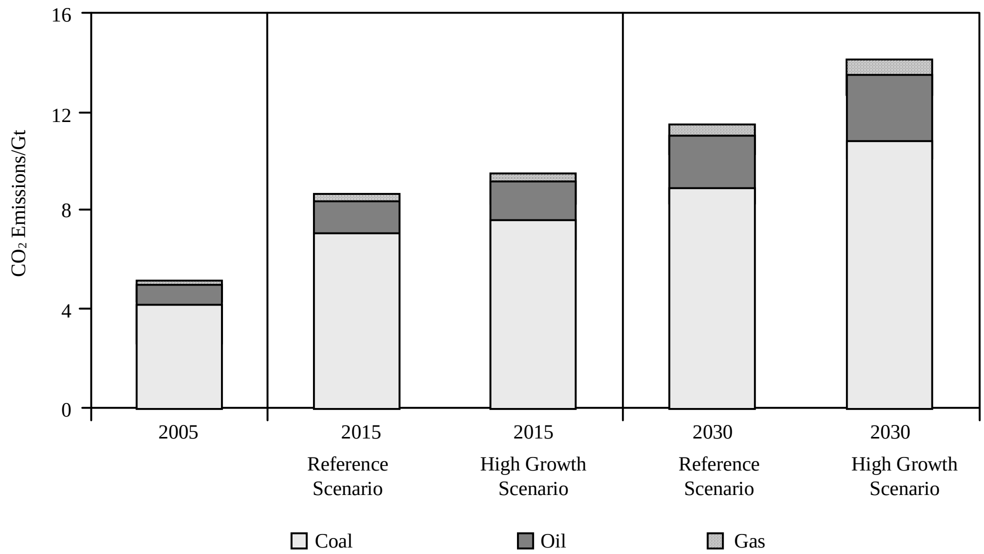


Figure 7-6 China's CO_2 Emissions in Different Scenarios (World Energy Outlook 2007)

In the Reference Scenario, CO_2 emissions from coal-burning power generation are expected to be 4.328 Gt in 2015, and 5.997 Gt in 2030. In the Alternative Policy Scenario, CO_2 emissions from coal-based power generation are expected to be 3.943 Gt in 2015, and 4.465 Gt in 2030. The increase of CO_2 emissions, as shown in the Reference Scenario, Alternative Policy Scenario, and High Growth Scenario, makes up 42%, 52% and 49% of the world's gross increase of CO_2 emissions respectively, from 2005 to 2030. This shows that CO_2 emissions in China are a major contributor to the increase of world CO_2 emissions. In the three scenarios, the CO_2 emission per capita is evidently higher than the world's average level in 2015, but lower than the level of OECD , as shown in Figure 7-7.

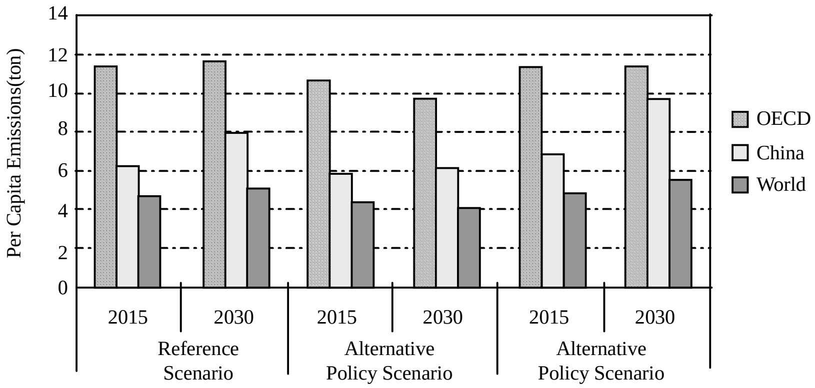


Figure 7-7 China's per Capita CO_2 Emissions in Different Scenarios

The rapid increase of CO_2 emission, especially the increase of CO_2 emissions per capita, greatly challenges China's coal-based energy consumption structure and extensive economic growth style. A huge international pressure for emission reduction is already felt in China's energy industry.

7.2.5 Ineffective Environmental Policies and Sustainable Coal Development

Currently in China, the laws related to coal industry for environmental protection include: Environmental Protection Law, Law on the Prevention and Control of Atmosphere Pollution, Environmental Impact Assessment Law, Energy Conservation Law, Circular Economy Promotion Law, Cleaner Production Promotion Law, Coal Law, Mineral Resources Law, Law on Water and Soil Conservation, and Land Administration Law; related regulations are: Decision of the State Council on Implementing Scientific Viewpoint of Development and Strengthening Environmental Protection, Some Opinions of the State Council on Promoting the Sound Development of the Coal Industry, Provisions for Land Reclamation. Related measures and standards are: Interim Measures for Environmental Protection in Coal Industry, Emission Standard for Pollutants from Coal Industry, Standard of Cleaner Production in Coal Industry, Emission Standard of Coalbed Methane/Coal Mine Gas (Trial), Technical Guidelines for Environmental Impact Assessment - Coal Mining Projects etc. Other environmental protection policies are: National 11th Five-Year Plan on Prevention and Control of Acid Rain and SO_2 Pollution, "11th Five-Year Plan" for the Development of Coal Industry, Coal Industry Policies, Notice on Issuing the Opinions of Energy Conservation and Emissions Reduction Work in Coal Industry, Notice on Issuing Suggestions on Coal Mine Gas Treatment and Utilization, Technical Policies for Prevention and Control of SO_2 Emission and Pollution from Coal Combustion, Opinions on Experimental Sustainable Development of Coal Industry in Shanxi Province, National 9th Five-Year Plan of Clean Coal Technology and 2010 Development Program in China, National Preferential Policies for Power Generation with Clean Coal Techniques, etc.

As can be seen from the laws, regulations, standards, and policies above, the environmental protection policies of coal industry in China have a wide coverage throughout the process of coal mining, processing and utilization, including the three fields of eco-environment protection, prevention and control of atmospheric and environmental pollution, and reduction of green house gas emissions, featuring "the involvement of many industrial phases and environmental issues". The key point is that although the environmental protection laws or policies in relation to the coal industry have an extensive coverage, they are difficult to apply either for lack of operationality or the absence of affiliated economic and technical stimulants. Specifically, the problems are: 1) The existing laws, regulations, and policies are insufficient, mostly stating principles without practical value; 2) The existing laws, regulations, and policies have too much focus on pollution control rather than on eco-environment, so it is hard for the eco-environment protection work to be carried out; 3) The existing laws, regulations, and policies tend to focus on administrative approaches rather than on effective measures for internalizing environmental protection cost; 4) The existing regulations and policies are issued by different government offices, resulting in ineffective supervision on environmental protection work; 5) The existing regulations and policies have no means of encouraging the widespread use of key techniques for sustainable development of the coal industry.

7.3 Resources and Environmental Protection Strategies for Sustainable Coal Development in China

7.3.1 Resources Guarantee Strategies for Sustainable Coal Development

7.3.1.1 *Analysis on Resources Guarantee Conditions for Sustainable Coal Development*

China is rich in coal reserves, however, a big part of it is in deep seams. Initial statistics show that of the available coal reserves, 36.1% are located in depths of less than 300 m, 44.6% between 300-600 m, and 19.3% between 600-1 000 m. The average mining depth is 400 m. Additionally the geologic structures of coalfields are relatively complicated. Only 9% of coal seams have approximately horizontal slope of less than 5°, 60% of coal seams have slopes between 5°-15°, 28% between 15°-45°, and about 2% coal seams have steep slopes of more than 45°. Only a small number of the existing coal mines have simple seam structure. Moreover, most coal-rich areas in China have fragile eco-environment prohibiting the large-scale increase of coal output. The depth of coal mines in East China is increasing 8-12 m every year. The problem of deep mining will become more severe in the future ten years.

7.3.1.2 *Gross Output Control of Coal Production*

The scale of coal production will be controlled within the allowable limits of environmental capacity, market demand, economic benefits, social benefits, and ecological benefits, and harm done to people's life and posterities, on the basis of well scheduled development by considering the diversified environmental tolerances of different areas. Energy security and safety shall not endanger food safety, ecological safety, social safety, and sustainable development of social economy. Coal mining shall be scheduled in a planned way in terms of resources saving, economical use of resources, the benefit of coal production and land reclamation.

7.3.1.3 *Relief of Eastern Coal Resources with Significant Water Hazards*

To solve the problem of the coal resources made unavailable due to water presence is an important measure to stabilize the coal output in the east. The coal-bearing carboniferous-permian in North China is one of the major coal-bearing formations in China. Many coal mines in the east are coal seams of carboniferous-permian. However, the middle-and-bottom layers of such coal seams are often made unavailable by Karst water at the bottom. Coal reserves of which amount to more than 20 Gt are affected. To make use of the coal resources disadvantaged by water present, measures will have to be adopted such as to enlarge the well drainage capability, shorten the length of coal pillar, and drain the water of the mining area after the survey of the hydro-geologic conditions.

7.3.1.4 *Planned Development and Utilization of Coal Resources in Western China*

The shift of coal resources development in China to Shanxi, Shaanxi, Inner-Mongolia, Xinjiang, Yunnan, and Guizhou is determined by China's coal resource conditions and required by the development of regional and social economy.

However, the coal resources in the west have to be developed in a well planned way: 1) Water use is to be planned in an integral way to meet the needs of coal resources development and local social and economic development. In so doing, it is critical to survey the hydro-geologic conditions and water resource of coalfields. 2) The quality of mine water is to be maintained to improve the comprehensive utilization ratio of the mine water. 3) Coal mining techniques for environment-friendly mining and development of western coal resources should be developed without delay.

7.3.2 Green Mining Strategies for Sustainable Coal Development

7.3.2.1 *Establishment of Clear Environmental Treatment Targets in Coal Mining*

By 2020, the subsided and damaged land from coal mining will be recovered up to 75%, and the gangue utilization and disposal proportion up to 95%, of which the utilization ratio will be up to over 85%. The utilization ratio of mining well water will be raised up to 70%, and the gas utilization ratio up to 60%. In 2030, the subsided and damaged land from coal mining will be recovered up to 80%, and gangue use and disposal ratio up to 100%, of which the utilization ratio will be up to over 90%. Hills of gangue shall be basically eliminated. The utilization ratio of mining well water will be raised up to 80%, and the gas utilization ratio up to 70%, basically realizing the full treatment of subsided land, full utilization and harmless disposal of "three wastes", and environment-friendly mining at coal mines.

Source control, prevention of process wastes, and after treatment are the three factors taken into account to realize the goal of environment-friendly mining.

7.3.2.2 *Wide Deployment of Green Coal Mining Techniques*

Green coal mining techniques are listed as follows: Water resources protection – "water conservation mining" technique; land and buildings protection – "filling mining" technique; gas extraction and emission – "co-mining of coal and gas" technique, etc. The application of these include: 1) To minimize environmental pollution in mining at the source, to promote gangue filling technique, and to build lanes and fill the mined-out area with gangue. 2) To use the pillar and strip mining method for shallow-layer coal seams production, and to use the interval mining and matched mining method for other coal seams to prevent ground subsidence. 3) Further research the technique for gas quality improvement, the technique for coal gas wells under mining and mine gas use.

7.3.2.3 *Reclamation of Subsided Land in Coal Mining Areas*

Today several modes for reclaiming subsided land are available. However, the land reclamation ratio is still low. Only

12% of subsided land in coal mines is reclaimed, far lower than the average 65% of foreign countries. Subsided land is still on a rise every year with both economic development and further coal mining. Therefore, land reclamation must be strengthened by both promoting and facilitating in order to solve the following problems and techniques: 1) To promote the public-par-ticipation mechanism and management for subsided land reclamation in accordance with the different types of subsidence. 2) To improve the precision in predicting the subsidence during coal mining, focusing on the prediction of subsided land when mining coal in complicated environmental conditions such as mountain area, alluvium, deep seam, and intensive mining. 3) To update the existing subsided land reclamation techniques with a focus on mining-farming combined areas, mountain areas, and areas with fragile eco-environment, together with the development of filling-type reclamation techniques and using equipment free of pollution. 4) To develop subsided land dynamic pre-reclamation techniques for land resources protection as well as land reclamation.

7.3.2.4 *Promotion of the Disposal and Synthesized Utilization of Coal Gangue*

An increasingly enlarged coal mining scale will bring about more solid wastes. Take the coal mining-and-washing industry for example. It produced 187.516 Mt of solid wastes in 2007, accounting for 11.4% of the solid wastes from all the industries. In recent years, the utilization ratio of solid wastes such as coal gangue is on the rise. In 1999 the utilization ratio of solid wastes from coal mining-and-washing was 24.70%, which was increased to 57.42% in 2003. In 2007, the synthesized utilization ratio of solid wastes was 63.64%, and the waste disposal ratio was 28.00%; the waste storage and emission ratios were 6.51% and 1.86% respectively.

China is far behind the developed countries in coal gangue utilization. On the one hand, western countries such as America and Britain have the total coal gangue utilization ratio of more than 90%; on the other hand, except for the coal gangue used as the matting material for road construction and filling material for subsided area, coal gangue is only used for making building materials such as bricks. Coal gangue and sludge for power generation gained little support in terms of policies at price, scale, and emission. In addition, distributed coal gangue sites and high cost of production and transport have greatly limited the large-scale development of power generation with coal gangue.

To deal with the above mentioned problems, countermeasures are given as follows: 1) Measures should be taken to promote synthesized utilization and industrialized production on the basis of different elements contained in the coal gangue.

No permanent coal gangue sites shall be constructed. Coal gangue is to be used mainly for power generation, new building materials, reclamation, road construction, and well filling. For those small coal mines which do not have the separate use conditions, should implement the regional concentration of use and centralized management. 2) Actions should be taken by the government to remove the existing hills of gangue, eliminating or lessening hazards from the gangue hills. The 3.55 Gt (Data from 2005) of existing coal gangue should be screened or washed for differentiated use, such as making coal gangue air brick, power generation, filling the mined-out area and subsided land of well mines, reclaiming farms and constructing roads. Coal gangue hills in undeveloped regions, or those unsuitable for other use should be managed to make them harmless and recoverable for eco-environment. 3) Coal gangue hills with spontaneous combustion hazard should be instantly treated to protect people's health, lives, and property loss from SO_2 pollution, gangue hill blasts, and slides.

7.3.2.5 *Utilization of Coal Mine Water Resources*

The major coal fields in China are severely short of water. 70% of coal fields, in terms of coal output, are stricken by severe water shortage for life. However, there is a tremendous use of well water drainage for coal mining. In 2007 6- billion-m^3 of mine water was drained, only 26% of which was reused. This means, to some extent, waste water from coal mining has been under control, but the gap in circular use of water is still large. Coal mine water use is unbalanced in different places. In 2005, East China has the highest utilization ratio (65.99%) of coal mine water, and Northwest China has the lowest utilization ratio of 26.93%.

To have coal mine water fully utilized, the following countermeasures are to be taken: 1) The utilization of all methods, utilization capability, and key problems must all be ensured. For coal fields with severe water shortages in North China and Northwest China, where most of the mine water is salt and bitter, water desalinization should be made to provide mine workers and neighboring residents with water. For coal fields with regional water shortages in Southwest China, mine water should be purified for production or domestic use. For coal fields in places with plenty of rainwater, the capability for mine water purifying and processing should be increased to upgrade the mine water utilization ratio in the sequence of industrial use first and domestic use second. 2) As for supporting policies, it is advised that in mining areas with plentiful water drainage (more than $3.5m^3/t$) but little ground water, mine water should be purified to the standard of drinking-water use and should be allowed to connect to the municipal water supply utility with a protected price from the government to secure its supply. The government should support the enterprises using purified mine water financially with subsidized loan. The purified mine water that has been certified for drinking use and is supplied to urban residents should be free of water resource fee.

7.3.2.6 ***Improvement in Coal Mine Gas Extraction and Utilization***

Related data show that China has a proved coal-mine-gas reserve of 3.5-trillion-m^3, and the anticipated gross reserve is 36.8-trillion-m^3. In 2008, about 5.8-billion-m^3 of gas has been extracted from coal mines, the utilization of which amounts to 1.7-billion-m^3, a utilization ratio of 29%. The gas is applied to 1,104 power generation installations with 920MW of capacity, and to 900-thousand homes. About 25-billion-m^3 of low-concentration gas is exhausted by ventilation.

At present, the coal bed gas is mainly applied to the following four directions: Chemical industry, civil use, power generation, and gas liquefying. The application in chemical industry is limited for its volatile source of gas. As for power generation, enterprises show little enthusiasm in the development and utilization of coal bed gas because of small power generation unit and low price of electricity. Gas liquefaction, cooling and separation results in liquefied natural gas (LNG). 1 000-m^3 of methane can be converted as one ton of LNG. Therefore, heat supply and power generation will be the major directions of coal bed gas utilization. In so doing, favorable policies would be: 1) To remove industrial protection and apply the same price policy for electricity from the same net so as to build a favorable environment for gas extraction and utilization. 2) To support coal bed gas production with favorable policies in terms of taxation, technological investment, and industrial coordination. As a matter of fact, coal bed gas and natural gas are basically the same in ingredients, application and the downstream market. As they may compensate each other in distribution, both should be planned to use the same net facilities.

7.3.2.7 ***Reinforcement of the Guarantee System in Coal Mine Environmental Treatment***

A special governmental organization is needed to integrate sectors of coal, land, environment, water conservation, electric power, and agriculture, and to supervise coal mining enterprises and local governments to carry out the work of land reclamation. Responsibility target should also be established to promote land reclamation and other environment treatment work.

Up to now, an efficient working mechanism for mine planning, opening and approval of mine closings has not yet been established; resulting in un-recovered mine waste sites and polluted eco-environment that impose long impact on local community. An increasing number of mines running out of coal will be closed in China. To accomplish this task, the following issues have to be taken into consideration: 1) To follow the idea of "Mining for Closure" to schedule the environment protection and recovery tasks throughout the life cycle of coal mines from survey, design, construction, mining, to closure so as not to leave harmful effect behind. 2) To include mine closure part of opening a mine throughout the life cycle of the coalmining project so as to form a complete mine opening-and-closing with publicized standards or criteria. 3) To improve the process of mine-closure planning to allow mine enterprises to bear in mind the duties of mine closing by following stipulated laws, regulations, policies, institutions, economic reward or punishment, and consensus. It should be made known that enterprises will be punished by confiscation of land reclamation security or by depriving their right of applying for new mining license, etc.

Other measures include, for example, amending the *Land Reclamation Law* to apply more strict land reclamation constraints. The reclaimed land ownership should be clearly stipulated and detailed rules and criteria easy for land reclamation operation are made.

What follows is the establishment of the land reclamation security fund system. 1) To clarify the contents and purpose of the land reclamation security fund, consolidating the name of it into "Land Reclamation Security Fund". 2) To improve the chaotic situations such as: more than one governmental office to charge the fee for environment protection and treatment, non-standardized management, poor efficiency of reclamation, loose supervision on reclamation, security pay-in form, payment and return style, and management mode etc. 3) To include "land reclamation security fund system" in national law so as to reinforce its application, which helps to form the security management and use system with clearly defined responsibilities, rights and duties of the government, the enterprise, banks, and the related people.

7.3.3 Environmental Protection Strategies for Coal Development in Western Regions

Water environment protection and water resources regeneration are the two key issues in protecting the eco-environment of the mining area in the west from the damages from coal mining. The coal mine development strategy in the west must be carried out with protecting water resources, which is critical to strengthen the land reclamation and eco-environment recovery of the mining area with fragile eco-environment.

7.3.3.1 *Water resources Conservancy Measures for Coal Development in Western Regions*

The application of water conservancy

mining technique by using the "three unders" mining[1] is to be promoted to minimize the damage to the roof of the coal seams and to prevent the water from flowing from fractured zone. In thin-layer coal seam mining, it is inevitable that the water-bearing stratum is affected. So, in order to realize the water conservancy mining, the water-bearing stratum should be altered to form manual water insulating layer to ensure that the underground water will not flood the well. The water conservancy coal mining techniques, even if extensively applied in "three unders" mining in East China, will still have some technical and economic problems to be solved compared with the same techniques used in western mining areas.

The second measure is to promote water resources recovery and integrated scheduling. Mining areas in the west have shallow coal seams with overlaid rock and soil layer of sandy type, featuring thin water insulating stratum and poor insulating performance that always results in difficult protection of the water-bearing stratum over the coal seam during mining process. In addition, they have a great number of gullies, watercourses, and lakes, which by themselves are good for the storage or transfer of underground water. Underground dams may be built to contain the water drained during mining process to form underground reservoirs, and certain grout curtains can be constructed to intersect water flow. Meanwhile manual transfer and storage of water can be carried out between underground water and ground water. For example, ground water from a wet period can be stored for future use underground, to maximize water conservancy in western mining area.

Thirdly, to improve the circular utilization level of mine water resources. Appropriate processing techniques and equipment are to be used to treat the waste water from mining process, such as depositing and filtering or using integrated techniques depending on the drainage direction and water quality, to remove contaminants or pollutants in mine water and turn it into usable water. The key point is the research and development is needed for new processing and re-generation techniques for highly mineralized mine water, since most mine water in mining areas in West China is highly mineralized.

7.3.3.2 *Land Reclamation and Eco-system Reconstruction*

The first measure taken is the integrated construction of coal mining and eco-system re-building. Coal mining shall be carried out in the integration of environment protection and eco-system re-building. This integration can turn the coal production process into environment

[1] A terminology widely used in the Chinese coal mining industry, which refers to coal mining under buildings, railways and water bodies.

treatment process. For example at the early stage of coal mining, water and soil conservancy preparations such as tree belt protection should be done. In the process of mining, the damaged land should be recovered by planting trees and grasses. After the mining is over, the work should be shifted to a comprehensive treatment of eco-system recovery to make it into grass land to eliminate the secondary impacts from land excavation.

The second measure is the promotion and application of the reclamation techniques for areas with fragile eco-environment. To develop chemical amendment techniques (developing specific chemical amendments, etc.), green fertilizer improvement techniques, and microbe amendment techniques (soil-free reclamation, etc.) to nourish the soil, improve the physical and chemical properties of soil, preventing slope slides and losses of water and soil. Economic crops and trees suitable for growing in eco-environment fragile areas in Northwest China should be developed and planted.

7.4 Strategies for Efficient and Cleaner Coal Utilization in China

The utilization of coal in China can be approximately divided into three major areas, i.e. power generation, direct combustion in industrial boilers and kilns, and chemical conversion. In 2007, coal consumption split in these three areas was: power generation 50.5%, industrial boilers (kiln) combustion 30%, and coal chemistry 18% in other purposes less than 2%.

7.4.1 Implementing of Highly Efficient and Cleaner Coal-fired Power Generation

7.4.1.1 *Scenario Forecast on Thermal Coal Demand and Associated Carbon Emissions*

The results of electric coal demand and CO_2 emission scenario analysis shows that, depending on the higher and lower social electricity demands due to different energy intensity and extra-high and high levels of lower carbon power installation that could be achieved by 2030, the electric coal demand in 2030 could vary between 1.177-2.143 billion tons, and the CO_2 emission could reach 2.892-5.215 billion tons. If the electric power industry is expected to reduce CO_2 emissions further by that time, carbon capture and storage (CCS) should be pursued.

The scenario study also revealed that if the current NO_x emissions standards for power plants can be effectively implemented, the NO_x emissions from coal power could be controlled to 6.27-8.47 Mt by 2030; if more strict emission standards similar to the current USA NO_x emission standard could be fully implemented, the total NO_x emission could be reduced to

2.09-2.82 Mt. As for SO_2, if China's emission standard, which will come into effect in 2010, could be effectively implemented, the SO_2 emissions could be controlled to 4.67-8.43 Mt by 2030. If even stricter environment policy can be conducted, which means mandatory installation of flue gas desulphurization facilities with de-SO_x efficiency of 95% and 98% or higher for all coal power units, the SO_2 emission by 2030 could be reduced to 3.3 Mt and 1.32 Mt respectively. So in a technical sense, the NO_x and SO_2 emissions of China's coal power could be well controlled by making stricter emission standards in cooperation with effective implementation. However, this will no doubt mean great economic cost and have serious impacts on the power industry. The difficulties in implementation should not be under - estimated.

7.4.1.2 *Policies for Highly Efficient and Cleaner Coal-fired Power Generation*

By scrutinizing the internal and external factors that influence the total electric coal demand, pollutant emissions, GHG emissions and the sustainable development of the power industry, the most important policy interrelations are concluded as follows:

(1) Less electricity demand and more low carbon power installation will help reducing electric coal demand, and then reducing coal electricity pollution emissions and CO_2 emissions.

(2) Coal power efficiency improvement will help reduce the electric coal demand, emissions of conventional pollutants and CO_2. Water resources availability will significantly influence the power generation efficiency, and CCS installation will greatly reduce power efficiency.

(3) The installation and operation of SOx and NO_x reduction facilities and the quality of coal for electricity will directly determine the overall scale of emissions.

(4) CCS installation will increase overall electric coal demand because of efficiency reduction, and will influence the future technology options.

(5) Rising coal prices in recent years were the primary reason why the Chinese power industry has run into deficit in the past. However, it must be recognized that the current unreasonable expansion strategy of power generation companies without due considerations of market principles and their gaming behaviors, have further weakened the electricity industry's ability for sustainable development.

Therefore, the following policies are suggested:

(1) In order to ensure a continuous efficiency improvement of whole power fleet from now up to 2030, it is necessary to optimize the unit size structure of installed capacity, mix continually and maximize the operating efficiency of existing units through all kinds of technical and administrative ways. It is also necessary to keep on developing more advanced next generation

technologies such as 700C unit, efficient air-cooling technology and low energy penalty CO_2 capture technologies.

(2) For the environment protection, it is necessary to strengthen the implementation of desulphurization standards, to, promote the application of de-NO_x technology and to further refine and improve the emission standards.

(3) For CO_2 mitigation, national strategy and policy for CCS development should be clarified as soon as possible. R&D and demonstration of CCS, IGCC and polygeneration should be promoted, and policy support should be given to promote coal/biomass co-firing power generation.

(4) For power industry development strategy, the coupling between coal and electricity prices should be built and promoted. National agencies should actively plan and invest coal production capacity expansion based on future electricity demand prediction.

7.4.2 Accelerated Implementation of Energy Conservation and Emission Reduction Measures for Industrial Boilers (Kilns)

7.4.2.1 *Promotion of Effective and Cleaner Distributed Coal Combustion Techniques*

The objective is to improve the thermal efficiency of coal boilers and kilns and control the emission of pollutants by constructing power coal blending factories, to stabilize and improve the quality of coal for combustion use, to strengthen studies on the performance of coal combustion, and develop advanced combustion techniques of high efficiency and low pollution, automatic control techniques, and advanced pollutant purifying techniques.

7.4.2.2 *Guarantee Policies for Effective and Cleaner Distributed Coal Combustion*

Accelerate the implementation of the upgraded technology for coal combustion industrial boilers; Select and optimize distribution of combined heat and power supply, central heating, fuel optimization, technical improvement of coal-burning industrial boilers (kilns); Make the "12th Five-Year Plan", work out complementary policies, organization and implement them as soon as possible.

For boilers with an actual thermal efficiency of less than 70%, they should be put into the schedule to be upgraded; For those with the thermal efficiency of less than 60%, a deadline should be set for mandatory upgrade; For those with the thermal efficiency transformation of less than 50% and which are already over their design life, they should be eliminated. The focus shall be put on upgrading chain boilers to increase their thermal efficiency up to 75% or more. The thermal efficiency of above 85% should be set for newly installed boilers. The application of highly efficient hop-pocket filter technology and the advanced desulphurization technology should be promoted to meet SO_2 emission standards. Certification should be made to promote the main boiler, auxiliary equipment, complete sets of technology and serial production, energy conservation, water conservation and environmental labeling. The monitoring system should be established to accelerate the construction of operational efficiency, and pollutant emissions.

Implementing the task of the technical upgrading of coal combustion industrial boilers (kilns) in needed. Increasing awareness is required of the urgent need for energy-saving and emission-reduction of the coal combustion industrial boilers (kilns). It is also needed to clarify regional implementation of technical indicators and time requirements and to sign responsibility objectives with enterprises. It is up to enterprises to lay out the coal combustion industrial boiler innovation plan, and organize their own implementation. The government's task is, accordingly, to inspect the progress and result made by enterprises through energy and cleaner production audit.

Upgrading the technology and equipment of coal combustion industrial boilers is required. Cement production enterprises should work out a plan to eliminate high energy consuming shaft kilns, wet process kilns, dry kilns, and any other kilns with coal consumption of more than 150 kilograms/ton by developing the decomposition technique of clinker dry process kilns with a daily chamotte production of over 4,000 tons, and by innovating the existing cement kilns so as to lower the energy consumption to 130 kilograms of standard coal / ton clinker or below.

The wall material production enterprises need to work out a plan to displace low-tech kilns with the application of such advanced techniques as high-efficiency coal combustion, waste heat recycling, efficient insulation and automatic detection. After the transformation, the energy consumption should reach 100 g of standard coal / block standard bricks or below. New techniques such as advanced coal combustion and waste heat utilization should be used in lime kiln furnaces so that the energy consumption can be reduced to 130 g of standard coal/kg lime or below. Systematic and synthesized transformation has to be made in fire-proof material kilns with the thermal efficiency of 35% or more. The application of advanced technology and supporting equipment, such as high efficiency dust removal, flue gas desulphurization and sulfur emissions and other real-time monitoring, must be made in newly established, revised and expanded coal combustion industrial boilers.

It is important to promote social benefits with the application of energy-saving techniques, green technology services, and market-oriented services. The responsibility for governments at various levels is to made preferential policies to support environmental protection enterprises and to strengthen the supervision.

Related standards and specifications should be made and revised. They include commodity coal quality standards, technical specifications for energy efficiency, and pollutant emission standards.

7.4.3 Strategies for the Promotion of Highly Efficient and Cleaner Coal Conversion

7.4.3.1 *Development of Highly Efficient and Cleaner Coal Conversion Techniques*

Objectives are: 1) To extend the application of large, advanced energy-saving and environment protection techniques and equipment in the coal coking industry. The focus is to extend the application of clean production techniques such as dry coke quenching and coal moisture control, and to use large coke ovens. 2) To greatly develop effective, low-carbon, clean coal conversion techniques such as coal hydrogenation liquefaction, coal gasification, coal-based Fischer-Tropsch synthesis, coal gas, and integrated gasification combined cycle (IGCC) poly-generation etc., (the modern coal conversion techniques). To develop and import techniques and equipment such as advanced gasification and large synthetic reactor to realize zero emission and clean conversion. 3) To probe into the integration of the effective, low-carbon, and clean coal conversion technique and the carbon sealing-up technique. Clean coal conversion will produce more than 50% of highly purified CO_2 of gross carbon emission that allows direct sealing-up of carbon. Promote the application of the integrated coal conversion technique, carbon capture and storage (CSS) techniques and technical experiments.

7.4.3.2 *Policies and Measures for Highly Efficient and Cleaner Coal Conversion*

1) Improve resources allocation, optimize resource utilization, and allocate the application of low-quality coal and coal with high sulfur in a rational and effective way by using the low-carbon, clean coal conversion technique. Encourage the development of new water-saving techniques of coal chemistry. 2) Actively use advanced and applicable techniques and improve the coal chemical industry with the emphasis on the cultivation of resource-saving and environment-friendly enterprises and industrial clusters. Eliminate enterprises with low capacity, and increase the admittance threshold of coal chemical industry. Encourage the use of advanced, clean coal chemical techniques. Reinforce the supervision and management on energy conversion efficiency and pollutant emission, and carry out examination on clean production. Intensify the independent development of the new coal chemical techniques including coal oil, coal-based methanol/ether, coal-based al-

kenes, coal-chemistry-power polygeneration and the large set of equipment needed to promote the experimenting and industrialized development. 3) Encourage enterprises to carry out CO_2 sealing up and utilization. Strengthen international communication and cooperation. Actively carry out geologic survey into oil fields and gas fields with potential of large CO_2 reserve to demonstrate the technical feasibility and economic rationale. Issue particular stimuli to encourage qualified coal chemical enterprises to carry out CO_2 sealing up and utilization. 4) Make and amend related standards of energy efficiency and pollutant emission for certain products. The standard making should follow the most advanced domestic or global techniques as the baseline to promote enterprises for continuous progress in energy-saving and environment protection.

7.5 Environmental Protection Strategies for Sustainable Coal Utilization in China

7.5.1 Implementation of National Coal Consumption Control Targets on the Basis of National Caps on Air Pollutant Emissions

Coal processing and utilization processes are the main emission source of atmosphere pollutants in China. The essential way to control atmosphere pollution is to reduce the coal consumption, which is also the most effective way to carry out multipollutants control strategy with least cost. The control on the emission of green house gases will be the main constraint on coal consumption, in the long and middle term, when the problems of acid rain and urban atmospheric pollution are basically solved and when SO_2 and NO_x treatment techniques have reached a certain level. But in the near future the main constraints on gross coal consumption are still the emissions caps for SO_2 and NO_x respectively.

7.5.1.1 *Medium- to Long- Term National Control Targets for Air Pollutant Emissions*

The target of emission cap for atmosphere pollutants is made on the basis of the following three factors: load of sulfur and nitrogen deposition, ambient atmosphere quality, and gradual reduction of total emissions.

(1) Target for SO_2 control. In China, the total SO_2 emissions in 2007 were 24.68 Mt. The 11th Five-Year Plan for National Economy and Social Development demands the reduction of total SO_2 emissions by 10% during that period. So the total SO_2 emissions in 2010 shall not exceed 22.95 Mt in China. The total SO_2 emissions in 2015, 2020, and 2030 shall not exceed 19 Mt, 17 Mt, and 14 Mt respectively. Further reduction measures will be carried out after 2030, if the actual

SO_2 emission does not meet the emissions cap, based on quality requirements of the urban environment.

(2) Target for NO_x Control. It is anticipated that in 2010 the NO_x emission will be 23 Mt. The total NO_x emission in 2015, 2020 and 2030 shall not exceed 21 Mt, 19 Mt and 15 Mt respectively.

7.5.1.2 *National Coal Consumption Cap on the Basis of Air Pollutant Emission Control*

Energy consumption structure, coal utilization style, coal quality, and pollution control level are the important factors that affect the emission of pollutants. Two scenarios ([0] and [1]) of coal consumption structure and two pollution control programs ([B] and [S]) are designed to analyze the coal use style and pollution treatment level in the future: [0] and [1] respectively represent the scenario of current coal consumption structure, and the scenario of and adjusted coal consumption structure. The benchmark program of pollution control [B] is to assume more strict control on the emissions from the electric power and transport sectors based on the current development tendency of pollution control policies; the denitrating of electric power plants are slow. [S] is the comprehensive, strengthened control program to take more strict control measures on coal-burning power plants, and industrial and transport sectors, especially to greatly promote the denitrating of power plants and the pollutant controls of coal-burning boilers and kilns.

(1) The Scenario and Program of Coal Consumption in 2030.

Coal consumption can be classified into three types: coal for power generation, coal for distributed energy supply, and coal for the coal chemical industry, of which the coal for power generation mainly refers to the coal for power generation by industrial boilers at 65 steam-ton/h or above. Coal for distributed energy supply mainly refers to the coal for industrial boilers and various industrial kilns below 65 steam-ton/h. Coal for coal chemical industry refers the traditional use in the coal chemical industry such as coking, synthetic ammonia, and calcium carbide, and the coal for new-type use such as coal oil, coal methanol, dimethyl ether, alkenes, and natural gas. At present these three types of coal consumption respectively account for 51%, 31%, and 18% of the gross consumed coal in China. In the future, the heat and power combined production style will gradually replace the distributed boilers for heat supply. The elimination and alteration of old industrial boilers and kilns will reduce the coal consumption of this type. With the increasing ratio of coal consumed by power generation and coal chemistry, the ratio of coal consumed by distributed heat supply and kilns, the intensity per ton of the pollutants emitted by coal will be decreased.

Therefore, the scenario of coal consumption structure is set in 2030 as: The coal consumed by power generation accounts for 70% of the gross consumed coal, and the coal consumed by distributed energy supply and coal chemistry each account for 15%. (Table 7-3)

Table 7-3 Scenarios of Coal Consumption by Sector in China

Scenario	Ratios of Coal Consumption		
	Power Plant	Distributed Heat Supply	Coal Chemistry
Coal Consumption Structure in 2007 [0]	51%	31%	18%
Adjusted Coal Consumption Structure in 2030 [1]	70%	15%	15%

(2) Maximum Coal Consumption Constrained by Upper Limit of Pollutants.

In the benchmark control scenario, the coal consumption structure stays the same as that of 2007. The electric power industry has intensified SO_2 treatment (Table 7-4 and Table 7-5). In 2015, 2020 and 2030 the average removal ratios of SO_2 are respectively 64%, 81% and 86% (42% in 2007). For coal-burning boilers and industrial kilns using washed clean coal or simple desulphurization facilities, the unit intensities of SO_2 emission will be reduced respectively to 5%, 15% and 30% of that in 2007. In 2015, 2020 and 2030 the gross emission of SO_2 will be controlled within the limit of 19 Mt, 17 Mt and 14 Mt. Then the maximum consumable coal will amount to 2.58 Gt, 2.97 Gt and 3.06 Gt respectively. In 2007 the gross coal consumption in China has been 2.586 Gt. In such a scenario, it is difficult to control the gross coal consumption within the limits. For NO_x emission control, if SCR denitrating installation is to equip the newly constructed units in developed eastern region after 2010 and LNB is used for new constructed units in other places, then in 2015, 2020 and 2030, the average removal ratios of NO_x in the thermal power industry are expected to reach 36%, 52% and 71%, respectively. In 2020 and 2030, boilers for distributed heat supply and industrial kilns have unit intensities of NO_x emission 5% and 15% respectively lower than that of 2007. (In 2015 the emission intensity is the same as 2007). For NO_x emissions from oil consumption, it is anticipated that in 2015, 2020 and 2030, the national oil consumption will be 30%, 60% and 100% respectively higher than that of 2007. Meanwhile the respective intensities of NO_x emissions from oil consumption will be 10%, 20% and 30% lower than that of 2007, by applying more rigorous emission criterion, improvement of fuel quality, and installation of emission gas purifiers. Combining the above factors, in 2015, 2020 and 2030 the emission of NO_x from oil consumption will respectively be 17%, 28% and 40% higher than that of 2007. In 2015, 2020 and 2030 the emissions of NO_x will be kept under 21 Mt, 19 Mt and 15 Mt respectively. The maximum consumable coal shall be 3.20 Gt 3.15 Gt and 2.65 Gt, respectively.

In the scenario of strengthened control, the coal consumption structure is adjusted gradually, and the coal used for power generation has its ratio increased to 70%. Coal-burning power plants, and industrial and transport sectors are under more rigorous control of pollutant emissions. In particular, the power plants greatly intensify the denitrating work, and coal-burning boilers and kilns greatly strengthen pollutant treatment (Table 7-4 and Table 7-5). In 2015, 2020 and 2030 the average SO_2 removal ratio from the thermal power industry will be increased to 72%, 86% and 95%, respectively. The SO_2 treatment techniques for boilers of distributed heat supply and industrial kilns are progressing quickly, and in 2015, 2020 and 2030 the intensity of SO_2 emission will be respectively reduced to 10%, 30% and 50% lower than 2007. Constrained by SO_2 treatment and emission cap control, in 2015, 2020 and 2030 the maximum consumable coal will be 3.04 Gt, 4.01 Gt and 7.86 Gt. For NO_x emission cap control, in 2015, 2020 and 2030 the average NO_x removal ratio from the thermal power industry will be increased to 44%, 60% and 78%, respectively. The unit intensity of NO_x emission of boilers for distributed heat supply and industrial kilns will be respectively reduced to 0%, 10% and 30% lower than that of 2007. The intensity of NO_x emission from oil consumption will be respectively reduced to 15%, 30% and 50% lower than that of 2007. In 2015, 2020 and 2030 the gross NO_x emissions from oil consumption will be respectively reduced to 11%, 12% and 0% higher than that of 2007 (In 2030 the emission level will be the same as that of 2007). Constrained by NO_x pollution treatment and emission cap, in 2015, 2020 and 2030 the maximum consumable coal will be 3.51 Gt, 3.89 Gt and 5.24 Gt.

In the benchmark control scenario, in 2015, 2020 and 2030 the maximum consumable coal will be 2.58 Gt, 2.97 Gt and 2.65 Gt respectively in China. It is indicated that, by following the more rigorous NO_x control, the maximum consumable coal will be on a decline after 2015 if the SO_2 and NO_x treatment level fails to be improved greatly.

Table 7-4 Scenarios of SO_2 control in China

Scenario	Year	Average SO_2 Removal Ratio of Power Plants	Decreased emission intensity of distributed heat supply, compared to 2007
Benchmark Control Program[B]	2015	64%	5%
	2020	81%	15%
	2030	86%	30%
Strengthened Control Program[S]	2015	72%	10%
	2020	86%	30%
	2030	95%	50%

Table 7-5 Scenarios of NO_x control in China

Scenario	Year	NO_x Reduction % of Power Plants	Decreased emission intensity of distributed heat supply, compared to 2007	NO_x emission increase rate in oil consumption, compared to 2007
Benchmark Control Program [B]	2015	36%	0	17%
	2020	52%	5%	28%
	2030	71%	15%	40%
Strengthened Control Program [S]	2015	44%	0	11%
	2020	60%	10%	12%
	2030	78%	30%	0

These two scenarios are compared at Figure 7-8 below.

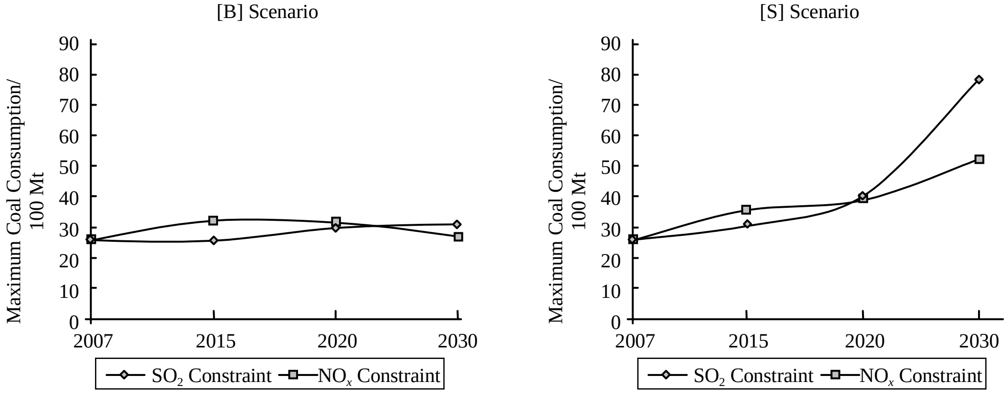


Figure 7-8 Maximum Coal Consumption Constrained by SO_2 and NO_x Emission Caps

In the strengthened control scenario, the maximum consumable coal may increase due to the adjustment of coal consumption structure and intensified pollution control. In 2015, 2020 and 2030 the maximum consumable coal in China will amount to 3.04 Gt, 3.89 Gt and 5.24 Gt respectively. Because of the much upgraded pollution control level, the maximum consumable coal may see a large increase after 2020, but will still be controlled under 3.89 Gt before 2020.

It can be seen from the above analysis that the maximum consumable coal has close relations with the pollutant emission caps, coal utilization style, and pollution treatment intensity. If the pollutant emission caps are more rigorous than anticipated or the pollution treatment level fails to increase rapidly, the maximum consumable coal should be capped to meet the pollutant emission caps.

Meanwhile, due to the pressure for greenhouse gases emission reductions, a limit on greenhouse gases emission growth will have to be set in between 2020 and 2030. In that case, greenhouse gases emission control will become major constraint on coal consumption. The maximum coal consumption based on greenhouse gases emission cap might be much lower than the above calculated results.

7.5.1.3 ***Strategies for Maximum Coal Consumption Control***

(1) Maximum coal consumption controls will have to be initiated in regions such as Changjiang River Delta, Pearl River Delta, and Beijing-Tianjin-Hebei, which are stricken by severe atmospheric pollution. Effective approaches should be used to eliminate the emission of pollutants and reduce the cost of environment protection. In principle, no new coal-burning power plants are to be built in Pearl River Delta and Changjiang River Delta where the atmosphere and environment capacity has been saturated.

(2) Accelerate the adjustment of industrial structure, confine the growth of high energy consuming industries, develop service and high-tech industries, and increase the proportion and level of the tertiary industry in national economy. Meanwhile strengthen the elimination of enterprises with low production capacity and high energy consumptions, and reduce the gross energy demand to decrease the demand for coal consumption.

(3) Promote the advancement of an economical society, give priority to energy saving enterprises, promote the development of energy-saving techniques and industrialization, strengthen the management on energy-saving, and increase the energy efficiency at all the phases of the industrial chain.

(4) Promote green energy techniques and pollutant emission control techniques, update the traditional technologies, optimize the co-existence of energy, environment,

and economic benefits, and apply the cascade and circular utilization of energy and substances to improve energy efficiency.

(5) Implement multi-pollutant co-control. Since control techniques and conditions are already well established, people's health and environmental protection should be maintained by establishing and attaining systematic and scientific atmosphere quality standards and emission standards. Put the issues of atmospheric environment and pollutant control on the same platform or within one framework. Take the co-effects of multi-pollutant control into full consideration in planning benefit maximization and sustainable development so as to work out comprehensive control strategies and management methods. Techniques for cooperative emission reduction such as dust collection, desulfurization, denitrating, mercury control, and CO_2 collection and storage should be developed. Cooperative emission reductions should be encouraged by policies that state the emission control plans for SO_2, NO_x, PM_{10}, Hg, and CO. Planning by administrative agencies should incorporate energy industry development and environment protection in a united way, focusing on energy savings, optimization of energy structure, and furthering of system reform.

(6) The central government should organize the making of a national clean air plan that deals with the major issues concerning urban ambient atmosphere quality, compound atmospheric pollution, regional pollution and climate change, which are to be solved within 20 to 50 years in the future. Systematic technical research and development and engineering demonstration projects should be carried out for air pollution control, with a focus on pollution prevention and the treatment of a particular city cluster in China. This would form the research and development basis for further independent innovative systems. Establish mechanisms and systems for quality management of the regional ambient air in China, promote technical progress and innovations in air pollution control industry, applying energy savings and green techniques in sectors of the national economy.

7.5.2 The Application of Economic Instruments for the Promotion of Sustainable Mining

7.5.2.1 *Active Promotion of Pricing Mechanism on Acquisition of Mining Rights*

The practice of pricing mechanism on acquisition of mining rights should be borrowed from foreign countries. On the one hand, price should be set and money be paid for coal resources before the acquisition of mining rights is made. Coal enterprises can only get the mining rights after paying the lump sum price. The free use of coal mining rights should be abandoned and paid use be practiced in China. On the other hand, coal resources tax should be increased in China to embody the loss of coal resources, rationalizing coal price-forming mechanism, guiding the development of coal industry in a rational and orderly way.

7.5.2.2 *Reform on Coal Resources Taxation Policy*

Speed up the coal resource tax reform process and the coal resource tax plan so as to make it a “weapon” to truly protect China’s coal resources, rationalize the coal pricing mechanism, and guide the sustainable and orderly development of coal industry. The reform of coal resources tax is to be made in the following two aspects: 1) Change the quantity-based taxation into quantity-price-based taxation or price-based taxation, by linking the coal resource tax with the coal price for the purpose of making it play a role in regulating the behavior of market players and protecting coal resources. When coal price is high, the price-based or partially price-based resource tax should also be raised high in order to reduce the profits of the coal industry, adjust the behaviors of the market players, and effectively constrain blind mining in the coal industry. When the coal price is low, then the price-based or partially price-based resource tax should be lowered correspondingly in order to protect the whole coal industry. 2) Increase the tax rate. At present the quantity-based coal tax rate is 3 – 4 RMB, 1% lower than that of the coal price, contributing to one major cause why coal price is distorted in China. The tax rate should be greatly increased to include the loss of coal into the coal pricing system.

7.5.2.3 *Establishment of Eco-Environ-mental Compensation System in Coal Mining*

Based on the implementation of the eco-environment compensation policies in the coal mining industry in some provinces, more systematic study should be given to this program so as to make it more practical and operational. Related experiments should be carried out in some typical coalfields in Shanxi, Inner-Mongolia, and Xinjiang for the trial implementation of eco-environment compensation rules. Lessons learned from the experiments should be extended in the application of eco-environment compensation systems in the coal mining industry throughout China, providing a standardized and market-oriented institution for the management of the eco-environment in the coal mining areas, and offering a finance channel for the control and recovery of the eco-environment damaged by coal mining.

7.5.2.4 *Implementation of Earnest Fund System for Environment Treatment*

Earnest fund system for environment treatment should be established in coal industry in China to deal with the existing environmental problems from coal mining. The earnest fund is to be used to supervise and urge coal enterprises to actualize the requirements stated in the PRC Emission

Standard for Pollutants from Coal Industry, and to effectively urge coal enterprises to adopt pollution treatment approaches, so as to change the status of pollution treatment in the whole coal industry. Expectedly, this earnest fund will strengthen the supervision on the operation of the pollution treatment installations, controlling pollutant emission during the processes of raw coal mining, washing, and the sites for coal storage, loading and unloading, and eliminating the negative impact on the eco-environment.

7.5.3 Establishment of Economic Policy System for Environmental Pollution Control

7.5.3.1 *Reform of Pollutant Emission Charge System*

A pollutant emission charge system has been implemented ever since the beginning of adopting reform and opening policies in China. For more than 20 years, this system has been gradually improved, playing an active role in urging enterprises to treat pollution and reduce pollutant emissions. However, this system cannot cover the pollution treatment cost and the economic loss brought about by pollution, which leads to the situation that the cost for legal pollution behaviors is high while the cost for illegal pollution behaviors is low. So this system proves ineffective to promote enterprises to treat pollution actively. Therefore, it should be further improved. The increased charge on pollution emission will impel enterprises to treat pollution actively, internalizing all the environmental external cost.

7.5.3.2 *Implementation of Environmental Taxation System*

Theoretically, environmental tax and pollution emission charges are both effective economic approaches to control environment pollution and internalize the external environmental cost. However, the environment tax has stronger legal force than pollution emission charge, and is easier to collect, providing a stable financial source for environmental pollution treatment. Therefore, by referring to the practice in developed countries, the atmosphere pollution tax (SO_2 tax, NO_x tax etc.) should be firstly charged to replace the related pollution emission charge for the goal of putting the pollutant emission under control and reducing the environmental impact of energy (for example, coal) utilization phases. Thus, a workable environmental tax system will be finally established in internalizing the external environmental cost.

7.5.3.3 *Reform on Electricity Price Subsidy Policy to Promote Environmental Conservation*

The theoretical basis of the electric power price subsidy policy is to give certain reward to coal-burning power plants to make up, partly, the cost they spend in pollution treatment. Electric power subsidy policy, environmental tax, and pollution emission charge are the effective approaches to internalize the environmental external cost. However, compared to environmental tax and pollution emission charge, the electric power price subsidy policy is to stimulate coal-burning power plants to take active, necessary approaches to control pollutant emission by "replacing punishment with reward". When the pollutant emission charge is increased to the average marginal cost of pollution abatement, then enterprises will be stimulated to take actions of pollution abatement. However, the present low charge of SO_2 emission is insufficient to stimulate enterprises to take actions of pollution abatement. Therefore, it is a necessary complementary approach to the pollution emission charge to include the desulfurization cost into the auditing and determining of electric power price. They will stimulate enterprises to take actions of pollution treatment in a cooperative way. Compared to pollutant emission charge, the electric power subsidy policy is more practical and has stronger stimulation. However, it should not replace the pollution emission charge, as long as we take into consideration the continuity of policies.

7.5.3.4 *Overall implementation of Paid-Index System for Pollutant Emissions*

At present in some places in China, the paid-use system for pollutant emission allowance has been carried out on a trial basis under the pollutant emission cap. A number of modes appeared, such as Xiuzhou mode in Zhejiang. These modes improved the efficiency of the initial allocation of the emission allowance, attaining outstanding effects of environment and economy. Based on the learned experience of paid-use system from foreign countries, the lessons from local experiments, and China's reality, the central government should select some advantaged regions or industries to carry out trials of paid-use system for pollutant emission cap. In consideration of the government's "Eleventh Five-year" policies for pollutant emission cap control, the paid-use emission allowance is mainly for SO_2 and COD. The trial should include the paid allowance for SO_2 emission in the electric power industry and the paid allowance for COD emission in certain areas.

7.5.3.5 *Experiment on Pollutant Emission Trade in Electric Power Industry*

The thermal power industry is a major producer of air pollutants such as SO_2 and NO_x in China. In 2007 the thermal power industry has emitted SO_2 and NO_x accounting for 50.5% and 49.3% of national gross emissions respectively. The pollutant emissions from the thermal power industry affects a wide coverage of areas, for the source of its pollutant emission is normally elevated and its SO_2 and NO_x emissions are evenly spread. As indicated by the trial on SO_2 emission trade in some places in China and the practice of SO_2 and NO_x emissions trading in America, the electric power industry in China has a sound foundation to initiate the practice of SO_2 cap and emissions trading. The successful application of SO_2 cap and emissions trading program in the electric power industry will enable the thermal power industry to apply a NO_x cap and emissions trading program.

7.6 Main Research Findings

7.6.1 Resource Constraints and Strategies for Sustainable Coal Utilization

7.6.1.1 *Abundant Coal Resources and Undesirable Endowment Conditions*

In China, coal resource's occurrence conditions are relatively poor. In terms of geological conditions, most coal resources are deeply buried and of less open-pit mining opportunity, resulting in high proportion of well mining. The pattern of resources is "rich in East and North, and poor in West and South", displaying a reverse pattern of the water resources in China, and the opposite direction between the distribution of coal resources and the level of economic development. The contradictions between the scale of resource development and ecological and environmental protection are becoming increasingly evident. The long distance and mass transportation pattern of coal lead to serious bottlenecks. Since clean coal production and fine processing have just started, the demand for coal is extensive and a large quantity of it is directly combusted with much inefficiency and lagged-behind emission control technology, all of which makes coal resource development, regional economic and social sustainable developments, problems and severe challenges.

7.6.1.2 *Time Schedule for Gross Coal Production Control*

The scale of coal development shall be controlled within the allowable limit of environmental capacity by comprehensively considering market demand, economic benefits, social and ecological benefits, to control total coal development without harming posterity, while considering the contemporary demand. This is calling for changing "making water flow as fast as possible" to "making water flow lastingly though slowly". Coal development shall be scheduled when the diversified environmental tolerances are considered. They include; to relieve the coal resources in the east from water shortage, to develop the coal resources in the west with good planning, to work on new mining techniques, to coordinate the coal resource development and environment protection in western mining areas.

7.6.2 Resource Constraints and Strategies for Sustainable Coal Development

7.6.2.1 *Serious Environmental Degradation Caused by Coal Mining*

Coal mining will influence the environment, including destruction and occupation of land, water pollution and changes in hydrogeological conditions, air pollution, economical production and social life and so on. Moreover, the fragile environment conditions in the western coal-rich areas have become a serious challenge to the sustainable development of coal.

Until now, coal mining subsidence land area has reached 800 000 hectares and its growth is still at the rate of around 40 000 hectares per year. However, only 12% of subsided land in coal mines has been reclaimed, far lower than the average 65% of developed countries. Since 2005, emissions of coal gangue reach about 180 Mt per year. Although the comprehensive utilization rate is in rapid growth, it was only 66% at the end of 2007, lower than 99% of developed countries, with about 3.8 billion tons of accumulated stock. Main coal-producing areas in China are in severe shortage of water, but the coal mines every year should discharge large quantities of pit water. In 2007, emissions of the pit water all over the country reach about 6 billion cubic meters with only 26% utilization, and the distribution area of coal mine water use is uneven. In 2008, coal gas drainage is about 5.8 billion cubic meters and 1.7 billion cubic meters are used with utilization rate at only 29%. In addition, the spontaneous combustion of coal gangue, coal transportation, gas emission and etc have increased air pollution.

7.6.2.2 *Environmental Treatment Targets for Coal Mining Areas*

By 2020, the subsided and damaged land from coal mining shall be recovered up to 75% of the area for that year, and the gangue utilization and disposal proportion shall be 95% of the gangue produced that year, of which the utilization ratio shall be over 85%. The mine water shall have a utilization ratio up to 70%, and the gas utilization ratio 60%. By 2030, the subsided and damaged land for coal mining shall be recovered up to 80% of the subsided area of that year, and gangue use and disposal ratio shall be 100% of the gangue produced that year, of which the utilization ratio shall be over 90%. Hills of gangue shall be basically eliminated. The mine water shall have a utilization ratio of up to 80%, and the gas utilization ratio up to 70%, basically realizing the full treatment of subsided land, full utilization and harmless disposal of “three wastes”, and environment-friendly mining at coal mines.

7.6.2.3 *Comprehensive Guarantee System for Environmental Benign Coal Mining*

We should consider source control, pollution prevention during mining and post-mining control, and promote “water conservation exploitation” technology, “filling” technology, “mining coal and gas in total” technology and so on. Innovate the reclamation technology for existing subsidence land, in line with local conditions, and promote dynamic pre-reclamation technology of subsidence land. We should increase the comprehensive utilization of the new generated coal gangue and other solid waste and safe disposal, meanwhile speeding up the elimination of spontaneous combustion in coal gangue hills. Make full use of coal mine water and improve the level of comprehensive utilization of coal gas. Perfect the environmental management of coal mine security systems, including the establishment of mine closure at the approval stage, management and implementation systems, perfect legal regulation system and scientific and complete a land reclamation deposit system, which will provide effective guarantee for the environmental management objectives and the sustainable development of coal mines.

7.6.3 Environmental Constraints and Strategies for Sustainable Coal Utili-zation

7.6.3.1 *Coal-fired Electricity Generation*

（1）From 1985 to 2007, the proportion of China's power generation from coal rose from 20% to 50% and then to 933 Mt of standard coal. At present, power generation from coal is still on a rise and will remain the main power for a long time. The sustained coal power supply is a key factor for sustained coal utilization in China.

（2）China's coal-burning power produces the total emission 45% of SO_2, 41% of NO_x and 30% of dust. It has been estimated that the emission of CO_2 from coal-burning power is about 40% of fossil energy combustion. In spite of the efforts made in recent years, there is still much room for improvement in terms of coal-burning efficiency and contamination control. In addition to the continued improvement of the existing coal steam-electric technologies, we should actively promote the low carbon objectives for the power structure diversification.

（3）The coal-burning steam-power technology is the main technology in service, and the technological development would be directed to improve steam initial and thermal circuit, such as super-critical, extra supercritical and AD700 centigrade. In addition to conventional coal dust boilers, circulating fluid bed techniques are also widely applied in China. The combustion of mixed coal and biomass for power generation can reduce the discharge of CO_2, which should be developed in the CCS application.

（4）Normally, coal demand for generating electric power will reach 2.123 billion tons. With the rapid development of nuclear power and renewable energy, the total demand for coal would be 1.768 billion tons, which would greatly facilitate the sustainable development of the coal power industry in China. If all the generators are installed with desulphurization and SCR facilities for the purpose of reaching the targeted emission, much effort has to be made to promote coal-burning technology, contamination control technology, environment protection policy making, and denitration in particular.

7.6.3.2 *Distributed Coal Combustion*

(1) To promote the utilization effi-

ciency of energy resources, decrease the amount of pollutants discharged, realize the sustainable utilization of distributed coal-burning technology by learning from the international technology and management experience of distributed coal-burning, popularize the application of the technology and the promote its use.

Distributed coal-burning technology is one of the most important coal utilization techniques which China focuses on. Its coal consumption accounts for 30% of the total amount, including about 5 million units of coal-fired industrial boilers in total, 0.4-0.5 billion tons of coal consumption per year, mainly used for industry and heating, and about 1 million units of coal-fired industrial kilns in total, 0.5 billion tons of coal consumption per year, mainly used for steel and building material production.

In recent years, much progress has been made in distributed coal-burning technology by adjusting industry structure, upgrading and promoting new technologies. But in contrast with advanced international techniques, coal-burning industrial boilers and kilns in China still have low utilization efficiency and large amount of pollutant discharge, causing much waste of coal resources and severe air pollution.

As far as the application of distributed coal-burning technology is concerned, the aim to increase the efficient utilization of coal-burning industrial boilers and kilns and to decrease the amount of pollutant discharge can be realized. So the first tasks at present are to speed up the technique promotion and modification of coal-burning industrial boilers and kilns in use, popularize the advanced techniques, accelerate the promotion of set equipment, learn from international management, introduce market mechanisms, make related preferential policies in financial, taxation, pricing, guarantee system, and thereby ensure the sustainable development of distributed coal utilization.

(2) The adjustment of traditional coal structure has promoted the application of advanced energy saving and environmental protection techniques, and it is the main method of pollutant emission reduction. In the future, with the newly-developed coal conversion, the sustainable development of coal conversion should be realized with technological innovation, industry access mechanism, application of energy saving and environment protection standards, high energy conversion efficiency, regular pollutant emission reduction, and CCS realization.

Coal conversion technology is one of the most important coal utilization techniques. Its coal consumption accounts for 18% of the total amount. At present, the main products of coal conversion in China are coking, ammonia synthesis, CTL, MTO and other traditional products. In the future, with the increasing demand of oil and gas, the coal-converted products for substitution will foresee a great development in China.

In recent years, China has accelerated the structural adjustment of the traditional coal conversion industry such as coking, ammonia synthesis, but lagging efficiency still takes a certain proportion, causing high energy consumption and serious pollution problems. The impact of some pollutant discharges is still gravely felt on the improvement of air and water quality. During the process of newly developed coal conversion, the application of advanced energy saving and environmental protection techniques should be highlighted. Meanwhile, the energy efficiency improvement, air pollutant and CO_2 emission reduction should also be focused on.

To promote the sustainable development of coal conversion, first, the opportunity for industrial restructuring should be taken, the replacement of traditional coal conversion technology be accelerated, energy utilization efficiency be promoted, and the amount of pollutant emissions be reduced; second, to learn from advanced management experience within China and abroad to improve the market access threshold, set up the energy consumption and pollutant emission standards to ensure techniques of new coal conversion and environment protection are as advanced as any level in the world, and encourage the coal conversion companies to apply CCS.

7.6.4 Air Pollutants Control in the Coal Industry

7.6.4.1 *Mid- and Long- Term Targets for Air Pollutants Control*

The control objective of the air pollutants' total emission is based on the whole country’s S-N deposition critical loads, atmospheric environmental quality, technology of pollution control and so on, according to three factors.

2015, 2020 and 2030: Sulfur dioxide emissions to be controlled at 19 Mt, 17 Mt and 14 Mt; nitrogen oxides emissions to be controlled at 21 Mt, 19 Mt and 15 Mt.

7.6.4.2 *Maximum Coal Consumption Constrained by the Targets on Air Pollutants Control*

(1) Reference control scenarios.

Coal consumption structure will remain basically unchanged, control rate of sulfur dioxide has increased in various industries, thermal power industry average NO_x removal rate gradually increase, but NO_x emissions from the national oil consumption gradually increase. In meeting the goal of total NO_x emissions in 2015, 2020 and 2030 the maximum consumption of coal is 2.58 billion tons, 2.97 billion tons and 2.65 billion tons.

(2) Enhanced control scenario.

Coal consumption structure has adjusted gradually, the desulfurization and denitrification progress of industry has been further accelerated, NO_x emissions from oil consumption are under control. The targeted amount control of pollutants has been set and the maximum coal consumption at has been targeted at 3.04 billion tons, 3.89 billion tons and 52.4 billion tons in 2015, 2020 and 2030 respectively.

(3) Greenhouse gas emission constraint.

As a result of the pressure for greenhouse gas emissions reduction, China is likely to set the limit for greenhouse gas emissions growth between 2020 and 2030. By then, the greenhouse gas emissions controls will become a major constraint on coal consumption, the maximum coal consumption based on the control of total amount of greenhouse gas emissions may be much lower than the measured results of the above.

7.6.4.3 *Regional Environmental Constraints on Coal Consumption*

In the eastern region, the pollutant emissions have gone beyond the environmental capacity. With a coal consumption increase, the need has to be met for a substantial reduction in the original pollution emissions so as to leave a space for additional emissions by applying practical technologies to minimize the existing pollutant load. As the existing environmental technology is already advanced, the space for reduction is limited, which makes the environmental constraints more difficult and stringent.

In the central region, there is still some environmental capacity, even if not evenly distributed. Shanxi, Henan, Hunan, Hebei, Anhui and other provinces have more sulfur dioxide pollution in cities. The need to develop the coal industry should be assessed on the basis of the existing emissions reductions and best available implementation techniques, which requires much caution if more coal combustion is planned in already seriously polluted cities.

In southwest and the northwest areas, the amount of coal consumption and pollutant emissions per unit area are much lower than the eastern and central areas, and there is a large potential of emission pass rate with a big environmental capacity, but again with an uneven distribution, especially in Guizhou, Sichuan, Chon-gqing, Guangxi in southwest area. Because of the high-sulfur coal, the problem of acid rain is serious, the eco-environment is very fragile in Northwest China. There are serious SO_2 polluted cities in Guizhou Province, Inner Mongolia Autonomous Region, Yunnan Province, Chongqing City, Xinjiang Autonomous Region, Guangxi Autonomous Region, Gansu Province, Shaanxi Province, which needed to be identified and treated carefully. The development of the coal industry needs the comprehensive consideration of these environmental factors, development of technology and improvement of emission compliance rate.

7.6.5 Establishment of Effective Environmental and Economic Policy System and Internalization of External Environmental Costs

The focus should be put on economic policy systems such as environment establishment and the consummation: 1) To implement the system of paid-right for coal mining and to accelerate the coal resource tax reform policy; 2) To establish earnest fund system for coal mining, ecological compensation and the implementation of environmental management; 3) To further reform and improve the system of emission charges and the implementation of environmental tax system; 4) To further deepen the environmental price subsidies through preferential policies; 5) To promote the pra-ctice of paid emissions and the trial of emissions trading for power industries.

7.7 Policy Recommendations

7.7.1 Improve Governance of the Chinese coal value chain

(1) The Chinese government should create a governance structure through either a separate agency, or through further strengthening an existing government agency or department, with the mandate to improve sustainability of the Chinese coal industry by: 1) coordinating the actions and policies of the various government agencies dealing with China's coal value chain; and 2) integrating the planning, investment and operation of the production, transportation and utilization phases of the coal industry within the overarching framework of a national energy policy that incorporates energy supply security, economic, environmental and social objectives.

A critical aspect of this governance function is the emphasis on an integrated energy system policy that facilitates and provides incentives for the optimal development of mine sites, power plants, transmission lines, railways, coal ports, and, increasingly, the siting of geological storage of CO_2 and the routing of CO_2 pipelines.

This agency or department should be responsible for industry policy, strategy and planning at a macro level rather than at the project level.

Once a policy is issued, the new department should focus on the monitoring and compliance with its policies by agencies with local level responsibilities.

To enable effective coordination, this agency or department needs to be at an appropriately high level within the government hierarchy.

The operations of this agency or department should be performed in a manner that does not diminish or undermine the responsibilities of other governmental agencies, such as the Ministry of Environmental Protection or SAWS, to protect the environment or worker and community health and safety.

(2) The Chinese government should strengthen the enforcement powers of the relevant agencies responsible for mining safety supplemented with the following measurements.

Establish clear responsibilities at each level of the enterprise and associated penalties for their breach through legislation, with corollary compensation for workers and their dependents for industrial accidents and disease.

Strengthen the mine inspectorate and the independent investigation of all significant accidents and incidents to provide an opportunity to learn and identify systemic risks and failures.

Encourage a safety ‘culture’ in both management and the workforce including by training and empowering coal miners to take greater responsibility for their own safety.

Grant safety inspectors the authority, in the event of non-compliance with safety regulations, to stop mining operations irrespective of mine type without referral to higher authorities.

Encourage the deployment of state-of-the-art ventilation and dust suppression technology to counter the risks of pulmonary diseases in the coal mining industry.

Offer safety training programs at appropriate educational institutes within major coal producing regions to encourage greater capacity building for regulators, inspectors, operators and workers – progressively make completion of these courses a requirement for holding key safety positions in either regulatory agencies or enterprises.

(3) The Chinese government must strengthen the capacity and enforcement powers of the relevant agencies responsible for environmental protection standards with the following measures:

The “one ballot veto” rule should be strictly applied in cases where proposed projects would not comply with environmental laws and regulations – meaning that projects are not able to circumvent the permitting process.

Independent environmental inspection currently practiced in major key state-owned enterprises should be expanded to the rest of the industry.

To make informed decisions in support of sustainable development at the earliest appropriate stage of planning and more specifically to address cumulative environmental impacts associated with unprecedented development of the coal industry, the implementation of strategic environmental assessment needs to be strengthened in all coal mining areas but especially in ecologically vulnerable coal producing regions such as Shanxi, Shaanxi, Inner Mongolia and Ningxia.

Funding for environmental protection agencies should be guaranteed separately and not be linked to revenues from emissions fees or fees for environmental damages.

The participation of local communities and local interest groups, especially in assessing environmental and social impacts of the different phases of project development in the coal industry should be formalized with specific requirements of input at various stages.

7.7.2 Improve the Regulatory System for Coal Exploitation and Use

（1）The Chinese government must improve the capacity and training of public servants working in all areas of the coal value chain and must reform public sector management practices so that salary and career advancement are tied to performance in ensuring full compliance with all laws and regulations.

（2）Environmentally sound management of coal mining and processing wastes, during operation and eventual site reclamation, needs to be an integral part of the planning and permitting process. In this regard, mine operators must be held accountable for commitments and obligations established during the permitting process. At this stage, improved standards must be established for: 1) ongoing backfilling for subsidence control; 2) soil and ecological protection and reclamation; 3) acid drainage control; 4) solid mine waste management and dust control; 5) monitoring and control of trace elements in water, air and soils to prevent contamination; and 6) obligations to recover fly ash and other by-products for use in production of cement, concrete and other products.

（3）In order to lower the burden on China's coal transport infrastructure and improve combustion performance (to be cleaner and more efficient), standards for coal quality need to be strengthened and more widely adopted in commercial contracts with emphasis on ash and sulphur content reductions. In addition, a single coordinating government body responsible for the energy sector could ensure compatible regulations across coal value chain. For example, coal washing standards in the coal mining industry should reflect thermal coal specifications demanded by the electricity industry which again may reflect specifications for reuse of mineral residuals from coal combustion in building materials.

（4）Compulsory emissions standards for SO_2, NO_x and particulates along the coal value chain need to be tightened for both existing and new plants, with a gradual extension to include VOCs, CO and heavy metals, especially mercury emissions, in the electricity industry. Policy instruments should include minimum performance standards, supplemented with means such as emissions taxes, pollution load based licenses or local, regional and national emission cap and trade systems to meet local air quality objectives and to encourage ‘beyond regulation’ performance.

（5）Water shortage and ecological vulnerability in the western regions requires that the overall capacity of coal development in these regions must be subject to local environmental carrying capacity assessments, which need to be fully reflected in the mine permitting system. Guidelines for such assessments should be defined.

(6) In densely populated regions with insufficient carrying capacity (e.g. land, water, and air pollutants), coal consumption levels need to be constrained by regional caps on air pollutant emissions such as SO_2 or NO_x and local water conditions. In the near future, emissions from coal consumption in China should also be constrained by national targets on greenhouse gas (GHG) emission intensity (per unit of GDP), as recently called for by the Chinese president.

7.7.3 Increase the Application of Market-Based Instruments

(1) The pilot pricing mechanism on acquisition of coal mining rights, that has been an experiment in eight provinces/regions including Shanxi, Inner Mongolia, Heilongjiang, Anhui, Shandong, Henan, Guizhou and Shaanxi, should be extended to all of China.

(2) The Sustainable Coal Development Fund, a fee levied by the Shanxi provincial government since 2007, should be evaluated by the central government with the goal of improving on this experiment and transferring the lessons learned to other coal producing regions of China.

(3) The current levels of environmental levies in China should be evaluated to ensure that they are gradually adjusted toward reflecting the full environmental and social costs associated with production, transport and utilization of coal. For greenhouse gas emissions, the Chinese government should immediately apply to coal used for combustion a universal carbon tax of 60 RMB/t CO_2, and it should be increased over time. At the same time, the government should fund research and development in China on carbon capture and storage (CCS) technology.

(4) Both the pricing of thermal coal and retail electricity must reflect changing domestic and international market conditions in order to ensure an efficient use of coal and other energy resources. To facilitate closer price linkage between energy input costs and retail electricity prices, the existing Coal-Electricity Price Linkage Mechanism needs to be actually implemented by the NDRC.

7.7.4 Foster a Rapid Technological Change in a Sustainable Direction with Emphasis on Green Mining

(1) A national program on “green mining” should be created with the focus

on six main research areas: 1) concurrent mining and reclamation; 2) mined-land subsidence minimization and its management; 3) minimization of coal-related wastes and its environmental sound management; 4) water resource conservation in coal mining and processing; 5) ecosystem protection and risk management in mining areas; 6) safe mine closure and full land reclamation and rehabilitation. Specific green mining technologies with high research, development and deployment priorities include: 1) aquifer protection mining technology to encourage the conservation of water resources in mining areas; 2) subsidence control and backfill mining technologies to protect landscape and surface buildings; and 3) coal mine methane (CMM) / coal bed methane (CBM) techniques to improve coal mine safety and utilization of waste energy with emphasis on the development of methane drainage methods and utilization of low concentration methane.

(2) Rapid development and deployment of more efficient and cleaner coal combustion technologies should be promoted, with emphasis on : 1) ultra-supercritical power generation and integrated gasification combined cycle (IGCC); 2) high efficiency cleaner distributed combustion techniques, including stratified combustion with integrated multi-stage optimization of air distribution systems, high efficiency pulverized coal combustion technology, and multi-coupling combustion; 3) automation technology suitable for the combustion control of various types of coal; 4) key technologies for poly-generation, such as gasification technology, large-scale gas turbines, liquid phase reactors, and new catalyst systems; 5) commercialization of both direct and indirect coal-to-liquid technologies to enable them to fulfill a role as "back-up technology" for China's energy security and perhaps eventually as a means to produce large quantities of hydrogen in combination with CCS; 6) management of combustion and gasification solid byproducts.

(3) Aggressive national pursuit of advanced clean coal technologies with the intention of using the application of these to the domestic market as a means of developing Chinese know-how and a Chinese manufacturing capacity that can become a significant export opportunity as the world shifts toward "the green economy" of the future. Policies focused on specific technologies pathways include: 1) regulations that lead to the development and widespread domestic deployment of deNO_x, desulphurization and particulate reduction technologies in China; 2) regulations that lead to the development of coal-biomass co-firing technologies, including advances in boiler design, boiler process control, combustion technologies, fuel-blend control and fuel handling systems; 3) establishment of a national CCS research centre;

4) financial assistance for up-front capital costs and preferential power tariffs for China's first pilot CCS plants; 5) a mandate that requires by 2015 that a small but growing share of all new coal burning facilities are equipped with emerging CCS capabilities; and 6) a mandate that all new facilities that do not include CCS already, must, at a minimum be designed and constructed as "carbon capture ready"; and 7) an aggressive Chinese effort to fully benefit from international mechanisms that might support the development of CCS, much in the way that China has engaged in the Clean Development Mechanism of the Kyoto Protocol.

(4) Resource characterization and monitoring through the coal value chain that includes: 1) a high resolution geological and geophysical survey of China detailing coal resources by type and characteristics and the potential sites suitable for carbon storage; and 2) the development of a national GIS-based capability that would assist in planning the location and capacities for coal mining, electricity generation, electricity transmission, coal transport, CO_2 transport and CO_2 storage.

AppendixⅠ Progress on Environment and Development Policies in China (2008 - 2009)

CCICED Chief Advisors and Support Team

Introduction

The China Council for International Cooperation on Environment and Development (CCICED), a high level policy advisory body approved by the Chinese Government, is entrusted with the task of providing policy recommendations in the area of environment and development for the reference of, and implementation by decision makers. At its 2009 Annual General Meeting, both Chinese and International Council Members will deliberate and discuss policy-related issues based on research findings of the Council Task Forces, and formulate policy recommendations that are subsequently submitted to the State Council and relevant government agencies and departments. CCICED Council Members and funding partners are very concerned about the level of impact the Council's recommendations have had on China's formulation and adjustment of policies influencing environment and development. Therefore, since 2008, the CCICED Secretariat has entrusted the Chief Advisors Group with the task of tracking policy shifts concerning China's environment and development, and where possible assessing direct and indirect impacts of CCICED policy recommendations on policy formulation. This effort is to be prepared as an annual written report.

Of course the formulation and readjustment of major policies by governments everywhere is a comprehensive decision making process. Therefore it is hard to attribute the formulation of a particular policy to the recommendation or suggestion of a single agency or organization. Due to the complexity of policy development, it is also difficult to directly connect a specific CCICED policy recommendation submitted in the previous year with a specific policy formulated the next year. This Report does not seek to assess how many CCICED recommendations are being implemented by the government, but rather it aims to report on overall progress and achievements China made in environment and development in the past year, and to provide the readers with a policy context in which they could make their own judgments in terms of practical impact of those policy recommendations.

By doing so, it should become relatively easier to see the impact the Council recommendations have had on particular policy formulations. Although it is still a difficult task, the report will make an effort to draw connections between certain important policy developments in the past year with the Council's recommendations. This is being done in the hope that it will demonstrate to what degree the recommendations are being considered or implemented, and which ones might help China realize long-term environment and development policy targets, even if they are not applicable in the near future.

This Report consists of two parts: Part I summarizes those major policy developments and changes made since the 2008 CCICED Annual General Meeting that are highly relevant to CCICED policy recommendations; Part II, an annex, gives a brief review of the key CCICED policy recommendations for 2007-2008. The report represents opinions of Chinese experts of the Chief Advisors Group, and it is for the reference of the Council members and stakeholders.

Part I. Policy Achievements on Environment and Development in China

A. Background

In 2008, China maintained its rapid economic development in spite of the adverse impact brought by severe natural disasters and the global financial crisis, with a 9% annual GDP growth rate. In the first half of 2009, China's GDP still increased at an annual rate of 7.1% even though the world was badly hit by the financial crisis.

To address the economic crisis, China has adopted a stimulus package, used economic structural readjustment as a major weapon to overcome the economic turmoil, and, in the meantime, continued to push for energy conservation and emission reduction (ECER) as well as protection of the ecological environment.

- China continued to improve energy structure by increasing the use of renewable energies. China's annual energy consumption was 2.85 billion tons of standard coal, up by 4.0% compared to the previous year. China installed wind power facilities of 6.3 million kWs, with a total capacity reaching 12.15 million kWs, an annual increase of 106%. Hydropower capacity reached

163 million kWs, and nuclear 8.85 million kWs. Energy consumption per unit of GDP dropped by 4.59% from the previous year. In the first 3 years of the 11^{th} Five-Year Plan, China saw a drop of 10.1% in energy consumption per unit of GDP, saving 300 Mt of standard coal and cutting CO_2 emissions by 750 Mt, cumulatively achieving half of the target set for the five years of the 11^{th} Five-Year Plan.

- In 2008, COD level and SO_2 emissions dropped by 4.42% and 5.95% to 13.207 Mt and 23.212 Mt respectively. Compared with 2005, COD level and SO_2 emissions decreased by 6.61% and 8.95%. In the first half of 2009, the two indicators further dropped by 2.46% and 5.4%. In July, 2009, ECER List for 31 provinces was released to the public.
- By June 2009, China had increased its urban sewage treatment capacity of 40 Mt per day, reaching 90% of the total target in the 11^{th} Five-Year Plan; had newly added 1 204 desulfurization-equipped coal burning po-wer generators with a total installed capacity of 412 million kw; the ratio of generators with desulfurization equipment to all thermal generators had jumped from 12% in 2005 to the current level of 66%.
- Nationwide, China had closed small thermal generating facilities equivalent to 54.07 million kws, 1.5 years ahead of reaching the target of 50 million kws; had eliminated backward production capacities in cement by 140 Mt, iron by 60.59 Mt, steel by 43.47 Mt, and coal by 64.45 Mt, and pulp and paper by 5 Mt, accounting for 80% of the target of 6.5 Mt. China's automatic monitoring and controlling system for key pollution sources had covered 85% of the state controlled enterprises, and China's desulfurization efficiency in power plants had increased from 50% in 2005 to 80% in 2008.

In terms of overall environmental quality, in the first half of 2009, the average concentration level of MnO_4^{-1} for surface water under national monitoring is 5.3 mg/L, a decrease of 1/3 from the 2005 reading of 8.0mg/L. The quality of the surface waters under national monitoring had a reading of 55.8% belonging in Classes I-III, an increase of 15.3% compared with that in 2005. Of the 113 cities selected as environmental protection priority cities, the average concentration of SO_2 is 0.045mg/Nm^3, a decrease of 1/3 from 2005 reading of 0.070mg/L, with fair to good air quality days reaching 91.3%, an increase of 8.2% from that of 2005.

The current year (2009) is critical for implementing the 11th Five-Year Plan. The State Council submitted to the Standing Committee of the NPC its interim implementation assessment report concerning the 11th Five-Year Plan. The assessment reveals sound overall implementation of the Plan. The report points out that, looking into the future, there is a need for further adjustment and balance of economic development in order to reach the targets, including those for environment and development. The assessment report indicates that China, with its good record in achieving longer-term targets, may well be in a position both to respond to current global economic slowdown and to achieve longer-term targets set in the 11th Five-Year Plan if proper policy adjustments are made.

B. Responding to Economic Turbulence and Promoting an Environment and Development Strategic Transition

The year 2008 marked the 30th anniversary of China's reform and opening up. Over the three decades, China has worked a world economic miracle with immense economic and social changes. In his speech delivered at the meeting to commemorate the 30th anniversary, Chinese President Hu Jintao reviewed the achievements and experience in the nation's reform drive, expounded on new problems facing China, and shared his vision as to where China would go. Hu reiterated China's longer-term development objectives: turning China into a well-off society by 2020, and realizing modernization by the PRC's100th anniversary. However, China is confronted with daunting challenges in its quest for those goals. He also pointed out that China should harmonize human development and nature, innovate development philosophies, change the growth mode, pursue sustainable development, promote strategic econ-omic restructuring, enhance independent innovation capacity, and build a resource-conserving and environment-friendly society. In particular, President Hu stressed that China would not deviate from its development path as a result of the short-term economic turbulence. China needed to stick to its development course of high productivity, prosperous life, and sound ecological environment, even with the spread of global financial crisis.

In 2008 and 2009, economic turmoil resulting from the global financial crisis has presented adverse impacts and uncertainties for environmental protection in China and in other nations. The 2008 CCICED annual general meeting was held at a time when the impact of the crisis was spreading. In its Policy Recommendations, CCICED, while commending the Chinese economic stimulus package, raised its concern of preventing environmental protection from becoming a sacrifice of the crisis, and also proposed recommendations such as translating challenges into opportunities, promoting scientific approaches to development and achieving sound and rapid development; tightening regulation to ward off the risk of economic growth at the cost of environmental protection in some localities; increasing green government purchase and fostering development of environmental industries; changing growth mode by speeding up innovation in clean energy and production processes, nurturing clean industries and developing low carbon economy; and accelerating reforms in resource and energy pricing.

At the 2nd session of the 11th National People's Congress convened in March 2009, Premier Wen Jiabao pointed out in his Report on Government Work that in addition to responding to the ongoing economic recession, China needed to pursue ECER and ecological and environmental protection vigorously. The government work report highlighted the relations among economy, energy and environmental protection; took into full account energy conservation, clean and renewable energies, emission reduction, and identified rural environmental protection and adaptation to climate change as priorities. The following areas were stressed by Premier Wen:

(1) Focusing on energy conservation in industry, transportation and construction sectors, continuing the development of ten major energy-saving projects, and implementing conservation measures in areas such as motor, furnace, automobile, air-conditioning and lighting, among others.

(2) Pursuing circular economy and clean energy; continuing to economize on the use of energy, water and land; proactively developing nuclear, hydro, wind, and solar power, together with other clean energies; facilitating the industrial application of clean coal technology; enforcing national standards concerning energy consumption and environmental protection, promoting energy-saving technologies and products, and strengthening the comprehensive use of resources.

(3) Fine tuning policies on energy-saving and environmental protection, and enhancing implementation of those policies in accordance with indicator, assessment and monitoring systems.

(4) Launching ECER action for all, with government departments and agencies, SOEs and non-profit public organizations taking the lead.

(5) Stepping up pollution prevention and control in major river basins and regions; controlling desertification; speeding up development of ecological projects such as major green shields, protection of natural forests and controlling sand storms in Beijing and Tianjin; protecting ecological en-

vironment in waters, forests, grasslands and wetlands; pressing ahead with overall control of rural pollution; putting mineral resource exploration and development in order; and properly using marine resources.

(6) Carrying out national programs responding to climate change and enhancing response capacity; investing more in basic research and capacity building in meteorology, earthquake, disaster prevention and relief, and mapping.

In June 2009, the National Task Force for Responding to Climate Change and the State Council Task Force for ECER convened a meeting, at which the commitment to further institutional reform and achieving ECER was reinforced. Proposed measures include: 1) strictly limiting the development of industries featuring high energy consumption and emission; 2) focusing on major projects and major areas, increasing fiscal investment in major projects and attracting private input, and encouraging 'old for new swap' in automobiles and household appliances; 3) pursuing Circular Economy; 4) promoting the use of energy-efficient products; 5) furthering reform by improving economic recovery policies and management policies in environment; 6) stepping up regulation in ECER and stressing accountability; 7) strengthening capacity building through accelerating improvement of statistical, monitoring and assessment systems concerning ECER, training more qualified employees and using more advanced technologies; 8) actively participating in international cooperation, and particularly strengthening bilateral, regional and multilateral cooperation in energy conservation, new energy and low carbon technologies. The meeting also registered China's commitment to a constructive role in facilitating the achievement of positive results at the upcoming Copenhagen UN climate change meeting when hard choices will be made regarding the very survival and development of human beings.

The Ministry of Environmental Protection (MEP) also identified 6 priorities for this year at the 2009 National Environmental Protection Work Conference: 1) zeroing in on pollution reduction; 2) expanding domestic demand and taking environmental infrastructure development as an effective means to accomplish reduction targets; 3) speeding up the initiation of treatment and control projects in major river valleys, by seizing the opportunities presented by proactive fiscal policies; 4) taking rural environmental protection as a new priority area; 5) clinging to environmental security and making environmental monitoring as a top priority for capacity building; and 6) stressing reform and innovation and improving environmental economic policies. China is speeding up the reform of pricing on resource based products and environmental protection levy, which has provided a good opportunity for improving environmental economic policies, a policy support for innovative environmental protection mechanism.

From the 2009 work plan for both the central government and its departments, it can be seen that China needs to achieve a strategic shift in environment and development while simultaneously responding to the economic turmoil. Reflected in the work plan are some of the Policy Recommendations by CCICED in 2007 and 2008, including translating challenges into opportunities to achieve sound and rapid development, avoiding new pollution and damage to ecological environment as a result of new projects, properly balancing government regulation and market mechanism and innovation and stability, and stepping up rural environment management.

C. Major Policies Developments in Environment and Development over the Past Year

（1）Strengthened Environmental Protection within Economic Recovery Efforts.

To address the adverse impacts of global financial crisis, China has adopted measures to expand domestic demand. The 4 trillion RMB stimulus package will focus on livelihood projects, infrastructure, ecological development and post-disaster reconstruction. China will also readjust and rejuvenate ten major industries, promote corporate consolidation and reorganization, support enterprises in their efforts to effect technological upgrading, phase out outdated capacity, enhance industry clustering and resource allocation efficiency. In particular, ECER and ecological protection have become part of the stimulus package, with an investment of 5.25% of the 4 trillion RMB, or 210 billion RMB in total.

In the stimulus plan, China has put ideas like Green Governance, New Trends in World Industrial Revolution, Technological and Institutional Innovation into policy practice, many of which are also the focus for CCICED. In its 2008 Policy Recommendations, CCICED proposed that China needs to speed up its shift in economic growth model, increase innovation in clean energy and production techniques, nurture and develop clean industries, develop low carbon economy, enhance capacity to deal with pollution and climate change, all aimed to achieve long-term prosperity in China. At the roundtable meeting in April 2009, CCICED proposed again that China needed to promote green development by pursuing green and low carbon economy. In May 2009, Vice Premier Li Keqiang attended a MOF meeting that aimed to support emerging industries such as new energy and energy conservation, stressing the need to keep up with the trends in green economy development worldwide; to combine maintaining growth and expanding domestic demand with structural readjustment and upgrading; to facilitate the development of emerging industries to address new economic problems in China, and to foster new growth area for rapid development in the long run.

Large-scale investments in development projects promised in the stimulus package pose great pressures on environmental regulations. The economic growth and environmental protection once again face off as rivals. Initiation of new projects intended to maintain growth without compromising environmental well-being is the key to delivering on the pledge of economic recovery without damaging the environment. This approach also will determine the outcome of environmental projects in the package and the success of the development model shift.

CCICED 2008 Policy Recommendations noted that the global financial crisis has fundamentally exposed the immense risks accompanied by overconfidence in the market in the absence of effective regulation. The market needs to play a positive role in environmental protection. The functioning of market measures cannot do without effective regulation and capacity building such as emission monitoring, data standardization, emission reduction appraisal and noncompliance penalties. MEP has tightened the review and approval process for new projects, imposing EIA upon all projects featuring High Energy Consumption, Emission and Resource Reliance (HECERR), thus emphasizing environmental control strictly from the very source. MEP has postponed or withheld the approval of 14 projects with potential environmental risks in chemicals, petrochemicals, steel, thermal power, pulp and paper, with a total investment of 104 billion RMB.

Noncompliance penalties have been made more severe. In April 2009, MEP and NDRC, together with 6 other agencies announced a plan to launch joint environmental actions, restricting industries with HECERR characteristics, and conducting checkups in iron and steel and arsenic-involving industries. The action plan also deals with noncompliance in sewage treatment plants and landfills, in an effort to reduce emissions from those facilities. In June, MEP terminated construction projects by China Huadian Corporation and China Huaneng Corporation; granted the most severe EIA penalties in China's history against the two power giants; and suspended approval of construction projects proposed by the two corporations other than those involving new energy and pollution control.

The National Audit Office has stren-gthened environmental audit of SOEs and made public ECER information of 41 SOEs whose performance in this regard has been fair, although still having such problems as lower effectiveness in energy conservation, over-discharge of SO_2 and major pollutants. There are eight underperformers listed by the Office, i.e., Sinopec, China Huaneng, China Huadian, China Guodian, China Datang, China Aluminum, Baogang Steel, and Angang Steel.

In the past year, environmental enforcement, monitoring and inspection have all been strengthened, with improvement in cooperation and coordination among central and local governments. This helps to address increasingly complicated environmental problems and boost effectiveness of environmental policies and measures.

The establishment of Northern China Regional Environmental Supervision and Investigation Institution (RESII) marks the completion of China's environmental supervision system, with the Inspection Bureau under MEP at the national level and 6 RESII sub-offices in 6 regions (South, Southwest, Northeast, Northwest, East and North regions). The system will conduct enforcement inspection in response to local governments' non-performance on environmental responsibilities in favor of local economic growth. Multi-ministerial and multi-provincial cooperation in dealing with water pollution has been strengthened. In 2009, cross-ministry joint meetings have been held many times, involving MEP, NDRC, MOF, MLR, MOHURD, MOA, MOC, and MWR, with focus on water pollution control in Taihu Lake area, Songhuajiang River, and the middle and upper reaches of the Yellow River.

（2）State Policy to Develop Low Carbon Economy and Respond to Climate Change.

Responding to climate change is another focus of CCICED. In the Policy Recommendations of 2007 and 2008, CCICED stated that China needs to make new contributions to addressing climate change and sustainable development under the principle of common but differentiated responsibilities, translate international environmental cooperation into sustainable development cooperation, and enhance South-South cooperation; in the long run, China needs to develop a low carbon economy, on the one hand to solve domestic environmental and resource problems, and on the other hand to strengthen its capacity to address climate and to boost its international competitiveness; thus, more attention is needed in low carbon economy on the part of the Chinese government; China needs to make technological and policy preparations, set targets for low carbon economy in the 12^{th} Five-Year Plan and integrate it into current strategies and actions.

In March 2009, the working meeting of the State Council presided over by Premier Wen addressed climate change issues. The meeting stressed that China, as a responsible developing nation, was fully aware of the importance and immediateness of addressing climate change issues, and it believed that real and effective international cooperation was needed to address this common challenge faced by all countries. China would adhere to the principle of common but differentiated responsibilities to pursue sustainable development, fulfill its international obligations commensurate with its development stage and capacity, and play its due part in addressing climate change. The meeting made the following requests:

1) Integrate climate change response into national economic and social development plans; take greenhouse gas emission control and climate change response targets as key criteria for longer-term development strategy and plans at all levels of government;

2) Implement the national climate change program; strive for the targets of 20% reduction of unit GDP energy consumption and 10% increase of renewable energy use set in the 11th Five-Year Plan; continue to improve and implement the national program in the 12th Five-Year Plan;

3) Develop a green economy; in light of the strategy of obtaining growth by expanding domestic demand, foster new growth areas featuring low carbon emission, and build low-carbon industrial, construction and communications systems;

4) Strengthen capacity building to fight climate change; formulate strategies and plans to advance technologies; conduct low-carbon pilot programs; promote energy-conserving, environment-friendly pro-duction, lifestyle and consumption; increase monetary input to back the implementation of climate change policies and measures;

5) Improve legal systems to fight climate change; establish supporting laws and regulations, formulate standards, monitoring and assessment framework, and improve regulatory systems and supervisory mechanisms;

6) Actively engage in international exchange and cooperation; continue to conduct policy dialogue and exchanges in responding to climate change; expand cooperation channels; speed up introduction of funds, technologies and human resources into China; and absorb advanced low carbon technologies and technologies in dealing with climate change from other countries.

In August 2009, the Standing Committee of the NPC adopted a resolution concerning climate change, recommending integration of adaptation of climate change into legislative proposals. The resolution calls for more efforts by China to conserve energy and cut emission; enhance capacity to adapt to climate change; fully utilize technologies; develop green and low carbon economy; integrate climate change response into sustainable development and national economic and social development plans, with specific goals, targets and requirements; raise public awareness and encourage public participation; and mobilize all citizens to be part of the cause.

In September, President Hu Jintao participated in the UN climate change summit, noting that China would integrate climate change response into its economic and social development plans and take forceful measures: 1) to pursue energy conservation and boost energy efficiency to achieve notable reduction in unit GDP energy consumption by 2020 compared to that in 2005; 2) to further develop renewable and nuclear energy, with a goal of making non-fossil energy account for 15% of the primary energy consumption mix by 2020; 3) to increase forest carbon sinks, with an objective of increasing forest coverage by 40 million hectares by 2020 over that in 2005, and a rise of 1.3 billion cubic meters in stock volume; and 4) to develop green economy, low carbon economy and circular economy, and promote climate-friendly technologies.

（3）Legislation Reform on Resou-rces and Environment.

Emergence of new environmental problems requires new laws, regulations and standards, or revision of existing ones. In 2009, legislation proposals, laws and regulations concerning resources, energy and environment in need of revision include: the Laws on Energy, Renewable Energy(revised), Air Pollution Prevention and Control (revised), Coal (revised), and Mineral Resources (revised); and the Regulations on Environmental Monitoring, Pollution Prevention and Control in Animal Farming, Management of Ozone Depleting Substances, Water Saving, the Management of Taihu Lake, the Protection of Wetlands, the Discharge Permit, and the Regulation on Urban Water Discharge and Sewage Treatment.

According to MEP statistics, MEP completed the development and revision of 123 national environmental standards in 2008. Currently there are 1 100 national environmental standards.

In addition to all of above, the State Council promulgated the Regulation on the Environmental Impact Assessment for Planning in October 2009. Governed by the Regulation are areas including land use plans, development and exploration plans for regions, river basins and marine areas, and special plans concerning agriculture, industry, animal husbandry, forestry, energy, water resource, communications, urban development, tourism and natural resource exploration, all subject to EIA, in a bid to prevent pollution and ecological damage from the very beginning and to secure sustainable development.

（4）Energy Efficiency and Pricing Policies.

To achieve the binding target of cutting unit GDP energy consumption, two main measures were taken to reduce GDP energy consumption per 10,000 RMB by 20% in 2010 compared to that in 2005, i.e., boosting energy efficiency and restructuring the energy portfolio. CCICED 2008 Policy Recommendations calls for boosting energy efficiency, developing clean energies, and technological innovations. The Council proposed that to stimulate demand and markets for innovative environmental technologies, it would be necessary to provide incentives such as subsidies to businesses and individuals using environmental technologies and products and cut promotional cost, [and] increase state monetary input in environmental innovations by setting up an environmental innovation fund to support major clean technologies.

To have an effective and standardized energy conservation inspection system that ensures implementation of measures and realization of targets, NDRC has enacted the Rule for Energy Conservation Inspection to enforce the Law on Energy Conservation. Twenty-four provinces and municipalities, including Shanghai, Beijing, Zhejiang, Shandong and Liaoning, have established their own inspection agencies to achieve conservation targets.

Over the past year, China has cut taxes on energy-efficient technologies and increased fiscal support for energy-saving products, covering areas such as industrial equipment, household conservation, transportation and construction. The newly revised policies regarding value-added tax provides tax favors to businesses that use new energy-efficient and conserving technologies to phase out those high in energy consumption. China also presses ahead with the ‘10 major projects’, supports technological upgrading by enterprises, promotes conservation-oriented renovation of public and residential buildings, and encourages the use of contracted energy management. It also provides subsidies to consumers using environment-friendly products and has reduced purchase tax for low-emission automobiles.

China also provides subsidies to promote the use of efficient lighting products, and supports conservation and new energy auto pilot programs in 13 cities like Beijing, Shanghai and Chongqing. New energy sources and renewable energy are developing quickly, with booming hydro, nuclear, wind and solar power stations. By the end of 2008, installed wind power capacity had exceeded the 11th Five-Year Plan target, ranking fourth in the world. In March 2009, MOF and MOHURD jointed launched the Solar Energy Roof program, awarding 20 RMB per Watt to homeowners installing solar power generators. MOF is now developing the Golden Sun Program to open the solar PV market in China. It is projected that installed solar PV capacity will reach 20 million kws by 2020.

The 2008 CCICED Policy Recommendations suggested that China speed up the reform of resource and energy pricing and internalize the environmental cost resulting from the use of resources and energy, given the price falls in mineral resources and crude oil. In December 2008, the central government working meeting on economy proposed to conduct further pricing reform and to establish a pricing mechanism that reflects supply and demand, scarcity, and environmental damage cost. In January 2009, MOF, NDRC and MWR jointly issued the Rule for Water Resource Fee Collection, covering hydro and thermal power plants directly under the central government. An extra 50% of the water resource fee will be imposed on enterprises featuring high energy consumption and pollution. For water used beyond the quota, a progressive pricing system will apply.

（5）Environmental Economic Policies and Market Measures.

Market-based environmental economic policies have become an indispensable part of China's environmental management. Over the years, CCICED has stressed the importance of such policies in its Recommendations. The 2007 version emphasized the historic role of economic measures in promoting environmental protection, and proposed to fully leverage market-based economic policies to achieve strategic transition in environment and development, with environment tax, resource and energy tax, green credit, environmental insurance, ecological compensation and emission trading as major measures. The 2008 version also stressed the importance of regulation on top of economic measures.

Over the past year, a number of measures used in China deserve attention.

The environmental pollution responsibility insurance pilot is progressing steadily. Initial results have been achieved in Hunan, Jiangsu, Hubei, Ningbo, and Shenyang. China's first claim settlement in pollution responsibility insurance has been completed successfully, signaling the initial progress in green insurance practice. In early September 2008, a pesticide maker in Zhuzhou, Hunan province bought an environmental responsibility product from Ping'an Insurance that in late September compensated more than 120 households for a chemical leak from the maker that polluted the vegetable land in its vicinity. Jiangsu Province initiated ship pollution insurance. The city of Wuhan set aside 2 million RMB to subsidize those insurance policy holders to up to 50% of the premium paid.

Four insurance companies in Ningbo city have conducted business in pollution liabilities, and pilots are being carried out in transportation of hazardous substances and chemicals. Shenyang city has taken the lead on incorporating environmental liability insurance into local legislation: the Regulation on Prevention and Control of Hazardous Waste Pollution in Shenyang City, effective as of Jan. 1st 2009, provides that 'the city supports and encourages insurers to offer hazardous waste pollution liability products; and enterprises dealing in the production, collection, storage, transportation, use and disposal of hazardous waste to buy such products.

Emission trading is developing. Cross-regional cooperation is strengthened based on emission trading pilots. Shanghai Environmental Energy Exchange has signed a cooperation agreement with Hangzhou Property Right Exchange to build an emission trading platform in the Taihu Lake area. The two parties hope to explore new ways to promote cooperation among regional exchanges. In 2008, the Taihu Lake area became the first area in China to introduce pre-paid use of emission rights and a trading pilot. On August 5th, China's first voluntary domestic carbon emission trade was settled: Tianping Automobile Insurance from Shanghai paid 277 699.6 RMB to purchase the 8,026 tons of carbon emission reduction target achieved by Beijing's Green Transit during the Olympics, in order to offset the carbon emission resulting from the company's operations since its establishment in 2004. It became China's first company voluntarily purchasing emission reductions to offset its own emissions.

Green purchase by the government has been boosted. China is improving policies concerning government purchase by giving priority to energy-conserving products, making green government procurement a key factor in promoting circular economy. State Council agencies have issued purchase lists of energy-saving products and green products. In 2008, green purchase by the Chinese government accounted for over 30% of government's total procurement; some 150 billion RMB out of the total 500 billion RMB of government purchase fund will go for green procurement.

（6）Environmental Innovation and Policy Support System.

The 2008 Policy Recommendations points out that China's only way out at this critical moment of meeting challenges is to innovate. Given its reality of less innovations in the environmental area, China needs to strengthen innovation capacity, solve institutional problems hindering innovation, increase monetary input, protect IPR and strengthen all-round impact assessment in the process of innovation; and suggests that China develop and initiate a National Environment Innovation Action Plan 2010-2020.

In January 2009, Premier Wen noted at the State Council technology task force meeting that the extensive growth model has presented huge pressures on population, resources and the environment. Rapid and steady economic development, upgrading of industrial structure, shift of the growth model, and a resource-conserving, environment-friendly society all rely on technological advances and improvement in workforce qualifications.

Over the past year, China has further increased input in major technological innovations in resources, environment and sustainable development. The MOST has initiated major technology research projects in energy conservation, new energy source automobiles, water pollution control, urban sewage treatment, comprehensive environmental control in rural area, recovery and rehabilitation of soil in polluted industrial sites, and biomass fuel use. Meanwhile, national sustainable development demonstration zones, resource-conserving and environment-friendly community pilots are expanding. The strategy of environmental protection and sustainable development innovation is spreading from the central level to local and corporate levels.

In July 2009, the MOST assessed the implementation in the 11th Five-Year Plan period of the Longer-term National Plan for Development of Science and Technology 2006-2020. One major assessment area is the supporting and guiding role of technological innovation in structural readjustment, changing growth model and improving livelihood, and particularly its positive role in responding to financial crisis, fostering strategic and emerging industries.

With the challenges of pollution reduction targets and technical requirements of controlling pollution sources, emissions compliance, and improving ecological environment, MEP has proposed setting up a national technical supporting system step-by-step for emissions reduction, especially for supporting the standards for cutting and controlling NO_x emissions, and the policies concerning pollution control technologies. Priorities for environmental technology in 2009 are the promotion of environmental technology innovation, the establishment of systems for environmental standards and for environmental technology management; strengthening the capacity for environmental technology innovation and strengthening scientific decision-making mechanism. MEP will accelerate the establishment of innovation projects and set up technological support projects. In terms of environmental standards, the existing standard systems for air and water quality will be improved, and new systems for noise and soil will be established. For major industries like iron and steel, non-ferrous metals, pulp and paper, and power generation, existing national standards for pollutant discharge need to be revised and raised for tighter emission control. Standards for emerging key industries need to be developed. In promoting environmental technology system, the National List of Advanced Pollution Control Technologies and the List of State-encouraged Environmental Technologies will be renewed.

（7）National Action Plan for Environment and Health.

The 2008 Policy Recommendations suggest that China adopt effective precautionary measures to ward off environment and health risks; establish a government-led environment and health management system with extensive participation; strengthen legislation; increase fiscal input and boost capacity building; make public information concerning environment and health and encourage public participation; and focus on key regions and major problems.

In September 2009, MEP and MOH convened the 4th National Forum on Environment and Health which identified human health as a core part of environmental protection. MEP has taken actions in the following areas: 1) conducting comprehensive treatment and control of environmental problems in major river basins, urban air and rural soil. More than 500 million RMB was set aside for rural environmental efforts, and 600 villages with severe environmental problems were dealt with; 2) strengthened capacity building in monitoring. In the past two years, MEP invested over 15 billion RMB in environmental monitoring capacity building; 3) conducted national survey of soil pollution and census of pollution sources. By 2008 year end, 78 940 samples of soil and crops have been obtained, and 78,852 have been analyzed; and around 3 million effective survey figures have been collected; 4) promoted the implementation of the National Action Plan for Environment and Health 2007-2015, which has been jointly developed by MEP and MOH. MEP has initiated research work on the impact of water, air, and soil pollution on human health, and further improved the air quality assessment standard system, laying down the foundation for updating the Action Plan.

In 2009, in light of health problems caused by heavy metal pollution, MEP has convened working meetings for heavy metal pollution control to identify countermeasures and made follow-up plans for action. MEP proposed to develop the Implementation Program for Comprehensive Control of Heavy Metal Pollution, through conducting overall inspections, preparing control plans, putting in place special control funds and providing information and public education. It also recommended that a special environment and health survey in major regions and river basins be initiated, followed by development and formulation of relevant regulations and laws, after a baseline is obtained, with an effort to establish a comprehensive monitoring system for environment and health. A prevention, early warning and emergency response system should be established for environmental damage to human health, with the improvement of risk prevention level in this area. Information sharing and public education should be strengthened to help raise public awareness and foster self-protection consciousness.

（8）Local Actions: Experience from Green Olympics to Green Shanghai Expo.

The 2008 Policy Recommendations stated that a successful green Olympics leaves precious environmental protection legacy for China: on the one hand, green construction projects have served as role models and urban infrastructure has improved environmental quality and served public interest; on the other hand, deeply-rooted ecological awareness and ideas, enhanced environmental management, information disclosure and public participation have all exerted far-reaching impacts on economic and social development. The 2010 Shanghai World Expo would provide a wonderful opportunity to spread Green Olympics experience, and China needs to make the Expo greener.

Following the Beijing Olympics and Paralympics, many measures adopted during the Games have been retained, such as vehicle bans. In addition, Beijing has intensified environmental efforts, such as the accelerated phase-out of vehicles failing to meet new emission standards, and the development and promulgation of supportive policies to eliminate vehicles causing severe pollution.

Shanghai is striving to stage a Green World Expo by drawing on Beijing's experience. The host city is now implementing a 3-year environmental action plan centering on ECER and environmental quality improvement, with noticeable results in pollution control in key regions, including continued drop of total pollutant discharge and steady improvement in environmental quality. The Environmental Assessment Report on the 2010 Shanghai World Expo released by UNEP in August 2009 points out that, in 2009, Shanghai's investment in environment has tripled that of 2000 to reach 42 billion RMB or 6 billion US dollars. The UNEP Report notes several positive aspects related to environment and development. The number of days during a year with a rating of Excellent Air Quality has reached 101, up by 68% from 60 days 5 years ago. In terms of transportation, Shanghai will build a rail transit system of 400 kms prior to the Expo opening. Shanghai's management philosophy of 'Prioritizing Public Transit' is worth promoting worldwide. Despite challenges common to all cities, Shanghai boasts experience worthy of learning for cities in China and across the world. Environmental efforts in preparing for the Expo will not only benefit 70 million Expo visitors, but leave a green asset for the city's 20 million residents.

（9） Information Disclosure and Pu-blic Participation.

Promoting information disclosure and public participation has always been a key proposition of CCICED to improve China's environmental governance over the years. One 2007 Policy Recommendation points out that to realize the historic transformation in China's environment and development strategy, China needs to increase public participation for all to play a role in achieving that change, and encourage the participation of NGOs. The 2008 version reiterates the importance of information disclosure and public participation to other policy recommendations, and it suggests that for China's environmental decision making to have a sound public basis and confidence, China must effectively enforce environmental laws and regulations, adopt more economic measures in environment, and put in place reliable information disclosure mechanism. Behavior change resulting from law enforcement will play a decisive role in fostering technical innovation and improving environmental and health conditions. Likewise, credible information disclosure will form a basis for positive change.

Over the past year, new progress has been made in China's environmental information disclosure and public participation. Both in terms of scope and extent, improvement has been considerable in information disclosure. Hearing of cases involving public environmental interest by local courts marks the historic breakthrough in public participation. No doubt, this has opened a new chapter of public participation in China's environmental protection.

The Rule for Environmental Administrative Review newly revised in December 2008 has further expounded on the application for administrative review, validation period, and conditions, as well as ways and timeframe for environmental agencies to handle administrative review cases. This will help clear access to administrative review and safeguard the rights and interests of citizens, legal entities and other organizations. In June 2009, MEP opened environmental hotlines to receive complaints of environmental emergencies, interprovin-cial pollution, and environmental problems falling into the direct jurisdiction of MEP. The public may use the hotlines to report environmental problems not solved at the local level, and check responses to the reported problem via the hotline.

D. Conclusion

Over the past year, China, together with other nations, has experienced a rare financial crisis and economic downturn. China has adopted proactive measures to overcome the adverse impact of the global recession, containing the downturn in the second half of 2008. The economy is now rallying and China is expected to attain its 2009 GDP growth target of 8%. More importantly, such achievement has not come at the expense of the environment. China has fulfilled its macro economic policy goal for environment and development set at the beginning of the crisis, i.e., China would not sacrifice its environment for economic stability.

Currently, the crisis and turbulence are still very much a reality. It is impossible to foretell what changes will take place in the future. But one thing is for sure. Consistency in environment and development policies will guarantee success for China in the future. And, in light of major policy adjustments and trends, it may be positively projected that China is in a position to seize the opportunity presented by the crisis to speed up the strategic transition in environment and development and effect the historic transformation in environmental protection. Some policy developments in the past year deserve attention:

(1) Environment and economy have never been so coordinated as in the past year in China's policy grouping. Within the stimulus package, investment in energy conservation and environment has taken up a large proportion. While other industries were struggling for survival, environmental industries, new energy and energy-conserving sectors have received unprecedented attention, being regarded as a key growth engine for economic recovery. Policy ideas like green economy, low carbon economy have been quickly embraced by the government and adopted by top decision makers. All these have shown that China's strategic transition in environment and development has entered an acceleration period.

(2) China's environmental governance capacity has been greatly enhanced. At the very beginning of MEP's establishment, there were reserved attitudes towards the effectiveness of MEP's institutional reform. The past year's reality showed that regulatory capacity of the environmental authorities has been substantially improved in such a crisis. MEP has insisted on a stronger environmental protection in the stimulus package, and tougher penalties against non-complying behaviors. Environmental agencies had never before convened meetings as frequently as it did last year to coordinate environmental efforts at the central and local levels. This also reflects the fact that the establishment of MEP and its more powerful operational position have drastically enhanced China's environmental administrative capacity and authority.

(3) Policy measures for environmental protection and sustainable development are being used in more areas, at more levels, and through more channels. Economic policies and market measures are finding their way into practice with positive roles. The development process of policy measures, from development at the national level to pilot projects at the local level and back to national promotion of the pilot findings, has been quickened. Flexibility and adaptability of economic policies and market mechanisms are well noted.

(4) Public environmental awareness has not faded away with economic growth. More channels are open to public participation. Enthusiasm for environmental protection has not waned. This has laid a solid foundation for strategic transition of the China's environment and development in the future. Raised public awareness means the balance between environment and development, and the days favoring one over the other are gone forever.

(5) China has become more intertwined

with the rest of the world in environmental protection and sustainable development, attracting more attention in global environmental affairs. China's role is not limited to its being the largest developing country with significant influence in world environmental matters. It is more about a more responsible China in addressing world environmental problems, and a more positive role. In particular, China's stance and proposals in fighting global climate change have demonstrated its willingness to fulfill its international obligations commensurate with its development phase, and to take positive actions.

Looking back at the progress made in China's environment and development over the past year, CCICED should be proud of its work. We would like to see a CCICED that exerts its due influence on the development and adjustment of China's policies in environment and development. We expect that China will effect its strategic transition in a decade or so when the nation still enjoys blue sky, green hills and clear water along with economic prosperity.

Part 2. Annexes : CCICED Policy Recommendations 2007/ 2008

Annex 1 : Policy Recommendations to the Government of China (November 2008, Concise Version)

The Second Annual General Meeting of Phase IV of the China Council for International Cooperation on Environment and Development (CCICED 2008 AGM) with the theme of "Harmonious Development through Innovation" was held at a time of great turmoil in the world's financial markets, with the threat of severe global recession, but also a call for "re-regulation". CCICED believes that an appropriate mix of incremental and transformative changes through innovation is needed to build a new relationship of environment and development in China and globally. Environmental progress should be intensified over time, first through incremental improvements, and later by leaps and bounds, as the investments now being made in sustainable development innovation produce better technical solutions.

Nowhere is this need for innovation greater than in addressing environment and energy relationships and the global need to address reductions in greenhouse gases. The global environmental situation continues to decline, with direct effects on China through trade, climate change and in other ways. The worsening global economic situation threatens social, economic and environmental progress of all nations, including China. Council members appreciated the Chinese position that the global economic slowdown therefore must not be allowed to stand in the way of environmental progress. And that the economic stimulus package developed by China has incorporated environmental aspects. During this time of rebuilding the world's financial system and new economic growth paths, China could benefit by positioning its investments towards activities that will allow it to shape the nature of future world growth, for example as a supplier of renewable energy products and services.

The Council's reports and discussions again underscore the need for effective implementation and enforcement of strong environmental legislation, greater use of credible economic instruments, and a more scientific approach to the development and dissemination of reliable environment and development information as means to build confidence and public trust in China's environmental decision making.

1. Transform Challenges into Opportunities for Further Implementation of a Scientific Development Approach.

(1) Seek Opportunities in the Wake of the Financial Crisis, and Advance "Sound and Rapid" Environment and Development Initiatives.

It is recommended that the Chinese Government should be fully aware of risks and opportunities, and take the following actions:

1) Strengthen supervision and environmental management in the execution of the domestic stimulus plan, so as to prevent regions from boosting economic growth at the expense of environment in their response to the financial crisis.

2) Consider not only environmental protection as one of the investment priorities of the stimulus package, but also carry out examination of supply chain environmental consequences and strengthen green procurement policies. These steps will boost the development of environmental protection industries and convey the strong determination of the government that environmental protection can be maintained even in the wake of the financial crisis.

3) Take advantage of the opportunities arising from the financial crisis in order to advance transformation of the development mode for the domestic economy. This can be done by boosting the development of clean energy and technical innovation, low carbon economy and by strengthening capacities in the area of environmental protection and climate change in the remaining years of the 11^{th} Five-Year Plan, and particularly during the 12^{th} Five-Year development period.

4) Advance energy price reform and further internalize environmental externalities with the plunge of oil and commodities prices. It is advisable for China to adopt a long term "escalator" approach to gradually raise energy prices. It means small, but periodic and predictable rises of prices or introduction of additional environment or energy taxes, with information transparency to fully prepare the general public and reduce possible resistance.

5) And for the longer-term, develop

Low Carbon Economy.

The Chinese government should attach great importance to the development of Low Carbon Economy (LCE) and get prepared for action, particularly in terms of technology options and feasibility analysis. The development of a low carbon economy will benefit China both internally, in terms of addressing resources and environmental problems, and externally by contributing to the fight against climate change and raising international competitiveness. China should consider specifying low carbon economy related targets in the 12th Five-Year Plan for economic and social development, and incorporate low carbon economy in current strategies and actions.

(2) Create a Better Mix of Government Regulation and Market-Based Mechanisms, and between Factors Favouring Innovation and Those Favouring Stability.

Some of the most important market based approaches will require significant levels of capacity building for adequate management and supervision, including improved emissions monitoring, consolidation and standardizing of emissions data, designating a legal registry for emissions reductions, and enforcing non-compliance with much stiffer penalties.It is important for the Chinese government to maintain the balance between innovation and stability. Innovation helps encourage public engagement, promotes fairer benefit distribution and betterment of social welfare, it will help promote the development of a harmonious society.

(3) Step up Infrastructure Construction and Quality for Optimized Development and Harmonious Society.

A massive and systematic program is needed to achieve a more balanced development among various social and economic aspects. The foundations for harmonious society should be strengthened, including the moral and cultural basis for scientific development. If environmental factors are built into this more advanced approach to development, the chances for sustainability will be enhanced.

(4) Strengthen Rural Environmental Management and Help Improves Overall Environmental Protection of China.

Against this backdrop, China should create a bigger role for environmental protection as part of the overall strategic goal of building a new socialist countryside. The environmental priorities of rural areas should include greater attention to rural environmental management system and capacity building, environmental infrastructure, drinking water safety, soil contamination, indoor air quality management, and exploration of an integrated urban-rural environmental management mechanism and eco-compensation. The eco-compensation policies should be expanded to include climate change mitigation and adaptation needs, and damages cost by air pollution. Efforts on these priorities will improve overall environmental protection throughout China.

(5) Develop Innovative Environmental Management Systems and Mechanisms Based on the Successful Experiences of Green Olympic Games.

In its effort to host a Green Olympic Games, the Chinese government adopted successful measures to promote pollution prevention and control planning, environment-friendly buildings and infrastructure, environmental information disclosure, public participation, commercialization of the innovation technologies employed in the Green Olympics, control of trans-boundary emissions through the establishment of a regional environmental management system, tail gas pollution control, the phase out of heavily polluting enterprises, etc. China should review these successful experiences and develop standardized and long-term mechanisms of environmental management to improve the environmental quality of Beijing and other parts of the country on a continuing basis. The 2010 Shanghai Expo offers a new opportunity for the implementation of the "Green Olympics" experience, The Government of China should integrate more green measures in the planning and implementation of a "Better city, Better Life" Expo.

(6) Review the Experiences of the Past Three Decades and Continuously Improve the Environmental Management System.

It is now necessary to systematically review the strategic ideas, theories, policies and managerial practices in the field of environmental protection over the past 30 years. The environmental management system reform of the next step should be further integration of environmental responsibilities of different ministries, which optimizes the central government organization and helps raise capacity and efficiency. For the new environmental ministry, current attention should be focused on capacity building and financial resources. Responsibility, power, capacity and efficiency should be integrated in this super ministry, which can put people first and better serve the general public.

(7) Make New Contributions to Global Sustainable Development and the Building of a Harmonious World.

It is the right time for China to make a more substantive contribution towards global sustainable development and a harmonious world. Stabilizing the financial system, sustaining rapid economic growth and resolving environmental problems in China are in themselves great contributions to the world. Meanwhile, based upon the principle of common but differentiated responsibility, China should make new contributions to the global fight against climate change and sustainable development; and expand its existing environmental international cooperation into cooperation for sustainable development, with strengthened cooperation between China and other developing countries.

2. Introduce a National Action Plan or Program for Environmental Innovation, 2010-2020.

Introduce a *National Action Plan/ Program for Environmental Innovation 2010-2020 for China.* The action plan should define the strategic goals, targets, and measures of environmental innovation of China, and address technological, institutional, social and organizational aspects of innovation. The Action Plan/Program should be supported by key projects and increased investment, and consideration should be given to the following two points.

(1) Strengthen Indigenous Innovation Capacity by Setting up a Special Program for Clean Technology Innovation, National Research Centers for Environmental Innovation, Sectoral Industrial Environment Research Institutes, and a System of Cross-disciplinary Sustainability Innovation Lab-oratories.

(2) Adopt an Integrated Approach to Address Mechanisms, Institutions and Capacity Development Required for Full Application of Environmental Innovation.

(3) Set Up an Improved National Information System for Environmental Quality, Environmental Pollution and Environmental Science and Technology Knowledge, with an Expanded Scope for Information Disclosure in order to Encourage Wider Public Involvement in Environmental Innovation Activities.

3. Expedite the Establishment of a National Management System for Environment and Health.

On the basis of the National Action Plan for the Environment and Health 2007-2015, that the Government of China should accelerate the development of a national management system for the environment and health as well as an environmental management system based on "putting people first". In order to achieve this goal, efforts should be made in the following six areas: 1) Stick to Prevention as the Main Approach and Take Effective Measures to Reduce Environmental and Health Risks. 2) The Government Must Bear the Main Responsibility of Environmental and Health Issues. The Government Therefore Should Strengthen its Leadership in the Management System while Encouraging Extensive Public Participation. 3) Establish and Strengthen Legislation for Environment and Health based on the Polluter Pays Principle. 4) Increase Financial Investment in Capacity Building for Environmental and Health Management, Research, and Compensation. 5) Improve Disclosure and Access to Environmental and Health Information and Encourage Public Participation. 6) Undertake Targeted Intervention Measures to Address Prominent Problems in the Field of the Environment and Health.

Annex 2: Policy Recommendations to the Government of China (November of 2007, Concise Version)

At the 2007 China Council for International Cooperation on Environment and Development (CCICED) Annual General Meeting, members reviewed the work of several task forces and other inputs, and produced five key recommendations focused on the theme of Innovation for an Environment-Friendly Society. It is Council's view that China has entered a Strategic Transformation Period, when many shifts in environment and development policy are needed.

In other countries where rapid transformation of environment and development has occurred, the following four key factors often are present: public participation and involvement of institutions from the whole of society; concern for health and environment galvanize action; need for a progression of changes over a 5 to 10 year period (or longer) is apparent; and, international pressures for action exist.

Over the coming years there will be a need to focus the attention of the whole society and government at all levels to create a new relationship of environment and development that satisfactorily addresses problems at local, national, regional and global levels via the use of a broader range of instruments, and with the active involvement of business enterprises. China needs early warning systems that identify problems at an early stage, and creative approaches to tackle problems that have resisted easy solutions. China is at a stage where its ecological footprint is still relatively low, especially when measured on a per capita basis. But China's overall influence on the world is growing, and globalization has important effects within the country. Therefore environment and development policy choices taken within China to a considerable extent need to be integrated with those elsewhere in the world.

The Council believes that innovations in policy, institutions, choice of regulatory instruments, and technology applications are essential at this point in China's environment and development improvements.

The five recommendations made to the State Council are summarized below. The original wording of each recommendation is provided plus a short summary of important points related to each.[1]

1. Strengthen and add new policies and mechanisms to achieve emission reduction targets.

(1) Develop a new "Five Shifts" Approach to pollution control by (1) reducing

[1] The summary of CCICED recommendations is based on the longer version of recommendations agreed at the AGM and published as Chapter 1 in the proceedings of the AGM (CCICED Annual Policy Report 2007. *Innovation for an Environment-Friendly Society*) CCICED, Beijing. 208pp.

total emissions; reducing pollutants from all industries; moving from total control of single pollutants to coordinated control of many pollutants; shifting emphasis from numbers of environmental protection projects to an emphasis on their quality; moving from administrative to market-based instruments.

(2) Establish an economy-energy-po-llutant emissions reduction technology access platform for improved early warning and response for emissions reduction.

(3) Construct a total emissions reduction system focused on resource and energy inputs, and greater efficiency in production and end-treatment of pollutants.

(4) Reform performance assessment of local officials to incorporate a simple to apply, locally appropriate consideration of energy and emissions reduction, and of enterprise compliance.

(5) Improve technical support capacity at central and local govern levels, including a more integrated environmental information system, scientific indicator system, accurate surveillance of emissions reduction, and a more rigid examination and evaluation system for emissions reduction.

(6) Improve operability of COD (Che-mical Oxygen Demand) reduction programs for key polluting industries and non-point source pollution.

(7) Examine how pollutant emissions can be further reduced most cost-effectively in the 12^{th} Five-Year Plan, including environmental taxes, resource pricing, emissions trading, appropriate environmental financing, and through high-performing administration and management with upgrading of laws and regulations.

2. Integrate chemical environmental strategy into China's overall national environmental and health management systems.

(1) Establish China's "Environmentally Sound and Strategic Management of Chemicals System, focused on environmental testing, evaluation, monitoring and management of chemicals.

(2) Take prevention as the key measure, with strengthened surveillance and regulation, a long-term action plan for risk assessment and give early attention to high risk chemicals, shift to cleaner production and "green chemistry", and be WTO-compliant.

(3) Formulate a special law or regulations on chemical environmental administration, covering classification and labeling, notification of new chemicals, environmental monitoring, right-to-know in release of toxic chemicals, and better environmental accident prevention and emergency response.

(4) Establish a system for release reporting of toxic pollutants and a publication

system to inform the Chinese public and to help them become participants in decision-making.

(5) Promote voluntary measures on the part of chemical enterprises, including Responsible Care, product stewardship, and clarify the legal status of voluntary agreements made under the Cleaner Production Promotion Law.

3. Seize the opportunity provided by China's strategic transformation of its environment and development mode.

There is a need to solve three problems: move from top down to more inclusive decision-making that builds better support from stakeholders and among all levels of government; provide detailed and effective policies, capacities and plans that are still missing; and get better value from existing funding, while continuing to increase the amount and flow of environmental investments.

(1) Build public awareness and participation of the whole society, including on sustainable consumption, environment and health, monitoring of local development, and direct participation in environmental improvement. Participation of environmental non-governmental organizations (NGOs). Training and education for policy makers and administrators, especially at local levels and within enterprises—capacity building for environment and development.

(2) Accelerate improvements to China's existing environmental protection systems. This effort should include: upgrading SEPA to a full ministry and strengthening local environmental protection bureaus (EPBs) by providing more financial, human and technical resources; rewriting of key laws such as the 1989 Environmental Protection Law; setting stringent standards with enforcement; reforming the penalty systems; providing better enabling mechanisms for sustainable development; and improving the environmental judicial system.

(3) Making full use of market based policies including environmental taxation, resource and energy taxation, green credits, environmental insurance, ecological compensation, emissions trading, etc.

(4) Review current levels of environmental assessment to determine amounts actually spent on high priority activities, and where necessary redirect funds to these priorities. Encourage private sector investment for innovations in the industrial sector, and initiatives that support Circular Economy.

4. Address the challenges brought on by economic and environmental globalization in a more timely and effective way.

(1) Gradually change the current growth mode of trade to take into account the relationships among resources, environment and trade. Import products and technology with high embodies energy

and resource content. Reduce export of goods and commodities with high embodied energy and resources. Substitute goods that require high energy in their production or use. Shift trade towards a mode relying on quality improvement, increase of value-added, and structural optimization.

(2) Optimize regional structure for manufacturing goods for export, with strict environmental upgrading of industries in eastern areas, and introduction of environmentally friendly processing in the middle and west of China. Levy environmental pollution tax on high energy consumption and pollution industrial sectors, and assign environmental damage costs. Introduce advanced environmental technology, and promote energy saving and emission reduction activities.

(3) Strengthen environmental aspects of trade in recyclable and waste goods, including better management of these aspects within China and with trading partners. Life cycle analysis for imported recyclables. Enforce strict entry standards. Restrict the re-export of raw materials produced from these imported recyclables. Work with other nations to honour international agreements intended to combat illegal trade in toxic wastes.

(4) Develop regulations for environmental impact assessments on key market supply chains for raw products entering China, including agricultural products, wood, biofuels and minerals. Take steps to prevent negative environmental influences in the countries of origin, including illegal timber trade, and activities banned under CITES (Convention on International Trade in Endangered Species of Flora and Fauna).

(5) Strengthen environmental management of Chinese companies that invest or operate overseas, and improve their Corporate Social Responsibility (CSR).

(6) Enhance China's participation in bilateral and multilateral environmental cooperation. Set up more complete implementation mechanisms within China for those agreements which China has signed. Participate more actively in construction of global environmental regimes. Expand technical cooperation on environment and development, especially with developing countries.

(7) Combine energy and pollution emissions reduction to develop an industrial system with relatively low CO_2 emissions, thus moving China on a pathway consistent with a Low Carbon Economy.

5. Construct a "Conservation Culture" through innovation.

This effort will depend upon setting out the right enabling conditions for "eco-innovation". These conditions include: unleashing creativity within research systems; financial investment oriented to environment and sustainable development innovation (including more venture capital); regulatory frameworks that favour innovation and support development of environmental technology markets; and evaluate/monitor environmental impacts of novel products.

(1) Mobilize both national and local interests to implement eco-innovation. Take enforcement measures, planning, awareness raising and capacity development. Create regional innovation clusters.

(2) Strengthen and popularize environmental technology research and development, and remove commercialization obstacles.

(3) Take action to overcome market failures. Private enterprise should become the major players for an environmental society. Address limited markets for environmental technologies, weak pricing signals, limited sanctions, and strengthen green procurement. Broader use of preferential loans for activities with use of environmental technologies. And denial of loans for activities that do not.

(4) Raise public quality of environmental science and technology—a scientifically literate public with a social environment where the value of eco-innovation can be demonstrated.

Appendix II　Name List of Council Members

Mr. Li Keqiang	Vice Premier, State Council **Chairperson of the Council**
Mr. Zhou Shengxian	Minister, Ministry of Environmental Protection (MEP) **Executive Vice Chairperson of the Council**
Ms. Margaret Biggs	President, Canadian International Development Agency **Executive Vice Chairperson of the Council**
Mr. Xie Zhenhua	Vice Chairman, National Development and Reform Commission (NDRC) **Vice Chairperson of the Council**
Mr. Klaus Töpfer	Former Executive Director, United Nations Environment Programme **Vice Chairperson of the Council**
Mr. Børge Brende	Secretary General, Norwegian Red Cross **Vice Chairperson of the Council**
Mr. Zhu Guangyao	**Secretary General of the Council**
Ms. Wang Jirong	Vice Chairwoman, Environment Protection and Resources Conservation Committee, National People's Congress
Ms. Jiang Zehui	Vice Chairwoman, Committee of Population, Resources and Environment, National Committee of the Chinese People's Political Consultative Conference
Mr. He Yafei	Vice Minister, Ministry of Foreign Affairs
Mr. Zhang Shaochun	Vice Minister, Ministry of Finance
Mr. Li Ganjie	Vice Minister, Ministry of Environmental Protection
Mr. Yi Xiaozhun	Vice Minister, Ministry of Commerce
Mr. Ning Jizhe	Vice Minister, Research Office, State Council
Mr. Ding Zhongli	Vice President, Chinese Academy of Sciences (CAS); Academician of CAS
Mr. Shen Guofang	Professor, Former Vice President of Chinese Academy of Engineering (CAE); Academician of CAE; Chinese Chief Advisor of the Council
Mr. Liu Shijin	Vice President, Development Research Center, State Council
Mr. Feng Zhijun	Professor, Counsellor of the State Council
Mr. Li Xingshan	Professor, Former Academician Dean, Central Party School of the Communist Party of China

Mr. Zhou Dadi	Senior Research Fellow and Former President, Energy Research Institute, NDRC
Mr. Lu Yaoru	Professor, Chinese Academy of Geological Sciences, Ministry of Territory and Resources; Academician of CAE
Mr. Zou Deci	Professor and Senior Urban Planner, China Academy of Urban Planning and Design, Ministry of Construction; Academician of CAE
Mr. Zhou Wei	Professor and President, Research Institute of Highway, Ministry of Transport
Mr. Wang Hao	Professor and Director, Department of Water Resources, China Institute of Water Resources and Hydropower Research, Ministry of Water Resources; Academician of CAE
Mr. Ren Tianzhi	Professor and Deputy Director, Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences
Mr. Wang Wenxing	Professor and Senior Advisor, Chinese Research Academy of Environmental Sciences; Academician of CAE
Mr. Niu Wenyuan	Professor and Chief Scientist, Institute of Policy and Management, CAS
Mr. Ma Xiangcong	Senior Research Fellow, Institute of Law, Chinese Academy of Social Sciences
Mr. Ding Yihui	Professor and Senior Advisor, China Meteorological Administration; Academician of CAE
Mr. Hao Jiming	Professor and Dean, Department of Environmental Science and Engineering, Tsinghua University; Academician of CAE
Ms. Sarah Liao	Senior Advisor to the Vice-Chancellor of the University of Hong Kong on Environmental and Sustainability Matters; Former Secretary to the Environment, Transport and Works of the Hong Kong Special Administrative Region Government
Mr. Roger Beale	Senior Associate, the Allen Consulting Group, Australia; Former Portfolio Secretary, the Department of Environment and Heritage, Australia
Ms. Soledad Blanco	Director, International Affairs and LIFE, DG Environment, European Commission
Mr. Corrado Clini	Director General of Sustainable Development and Research Department, Ministry for the Environment, Land and Sea, Italy
Mr. Gordon Conway	Professor of International Development Centre for Environmental Policy, Imperial College, London, UK
Mr. Daniel J. Dudek	Chief Economist, Environmental Defense Fund, USA
Mr. John Forgách	Chairman of the Board, the Equator LLC in New York; Brazil
Mr. Arthur Hanson	Distinguished Fellow and Former President, International Institute for Sustainable Development, Canada; International Chief Advisor of the Council

Mr. Stephen B. Heintz	President, Rockefeller Brothers Fund
Mr. James Leape	Director General, World Wildlife Fund
Ms. Julia Marton-Lefevre	Director General, International Union for Conservation of Nature
Mr. Lars-Erik Liljelund	Director General, the Swedish Primeminister Office
Mr. Lim Haw Kuang	Executive Chairman, Shell Companies in China
Mr. Dirk Messner	Director, German Development Institute
Mr. Mark Moody-Stuart	Chairman, Hermes Equity Ownership Services, UK
Mr. Mohammed Valli Moosa	Chairman of Lereko Investments and Sun International Ltd., South Africa; Former Minister, Ministry of Environmental Affairs and Tourism of the Republic of South Africa
Mr. R.K. Pachauri	Director General, the Energy and Resources Institute, India Chair of UN Intergovernmental Panel on Climate Change
Mr. Achim Steiner	Executive Director, United Nations Environment Programme
Mr. Björn Roland Stigson	President, World Business Council for Sustainable Development
Mr. Hau Sing Tse	Senior Vice President, Canadian International Development Agency, Canada
Ms. Laurence Tubiana	Director, Institute of Sustainable Development and International Relations, France
Mr. Hans van der Vlist	Vice Minister, Ministry of Housing, Spatial Planning and the Environment, the Netherlands
Mr. Kandeh K. Yumkella	Director General, United Nations Industrial Development Organization