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Country profiles on policies to support environment-friendly innovation

Eco-Innovation Policies in The People's Republic of China

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Tsinghua Graduate School at Shenzhen



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**NATIONAL APPROACHES FOR PROMOTING ECO-INNOVATION: COUNTRY PROFILE OF THE
PEOPLE'S REPUBLIC OF CHINA**

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FOREWORD

This report inventories policies in place in China to support eco-innovation. The report is not comprehensive. It reflects Chinese national priorities on energy security, energy efficiency, and a more environment-friendly model of development; it is focused on technologies for renewable energy, energy efficiency and pollution prevention and control; initiatives taken to promote a circular economy are also highlighted; eco-cities projects are mentioned. Policies to support clean production, climate change mitigation and adaptation, and a low-carbon economy are not systematically covered.

The report complements a series of country profiles on eco-innovation policies developed for eight non-EU OECD countries (Australia, Canada, Japan, Korea, Mexico, New Zealand, Turkey and the US). It also complements the eco-innovation roadmaps developed by EU member countries under the Environmental Technology Action Plan.

This series of reports provides an empirical basis for further investigation of policies to support eco-innovation. A short introduction presents the background for this report, including the methodology to develop the country profile, and a brief overview of some of the instruments identified in the country profiles.

The report was drafted by Wanxin Li, Assistant Professor, Department of Public and Social Administration, City University of Hong Kong and Tsinghua Graduate School at Shenzhen, under the supervision of Xavier Leflaive. The Ministry of Environment Protection commented on an earlier draft.

For more information about this OECD project, please contact Xavier Leflaive (xavier.leflaive@oecd.org).

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TABLE OF CONTENTS

FOREWORD	2
GENERAL INTRODUCTION	4
Background.....	4
Policy instruments to support eco-innovation	4
COUNTRY PROFILE OF THE PEOPLE’S REPUBLIC OF CHINA.....	6
Institutions involved in eco-innovation policies in China	7
Public investment in environmental R&D.....	8
Renewable energy technologies.....	11
Technologies for improving energy efficiency	18
Eco-innovation for a circular economy	22
Pollution prevention and abatement technologies	25
Eco-cities: local initiatives to promote innovative environmental solutions	26
A case of international cooperation: Clean Development Mechanism.....	27
Country synthesis.....	28
Annex 1. Five major eco-cities in China	30

Tables

Table 1. NSFC 2001-2008 Grant-Making for Basic Scientific Research	9
Table 2. National Key Technology R&D Projects: 1981-2008.....	10
Table 3. Renewable energy technologies and the stage of their development in China.....	13
Table 4. Classification of Taxation in China	15
Table 5. Available energy saving devices.....	18
Table 6. Sources of funding for pollution treatment 1998-2005	25
Table 7. Policies to support eco-innovation in China.....	29

Figures

Figure 1. Composition of Energy Production and Consumption in China in 2006	12
Figure 2. Composition of Energy Production and Consumption in China 1978-2006.....	12
Figure 3. Energy development goals of China by 2010.....	14

Boxes

Box 1. Debates on block tariffs in the Circular Economy Promotion Law	23
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GENERAL INTRODUCTION

Background

This report is part of the OECD work programme on policies to support eco-innovation. The ambition of this and related reports is to provide an empirical inventory of policies in place in selected OECD and non-member countries to promote eco-innovation. Considering that European countries had developed roadmaps for eco-innovation policies in the context of the European Commission Environmental Technology Action Plan (ETAP), the secretariat prepared an inventory of eco-innovation policies in eight non-EU OECD countries (Australia, Canada, Japan, Korea, Mexico, New Zealand, Turkey and the US) and China.

The objective of this work is to complement the knowledge base on eco-innovation policies and to provide empirical material for additional research on policy issues related to eco-innovation. The outline of each country profile is similar to that of ETAP roadmap, to facilitate comparison.

The work on OECD countries was implemented in coordination with country delegations, which have identified experts in each country who could provide additional information and review initial drafts of the country profile of their country. A consultant (IEEP, Brussels, Belgium) has been commissioned to collect all information publicly available in English on eco-innovation policies in each of the eight non-EU OECD members. Field missions have been organised by the country experts in four countries (Canada, Japan, Korea, the US). During these missions, the Secretariat met with relevant agencies. Draft country profiles have been developed on the basis of desk research and field missions. They have been reviewed by national experts and revised accordingly.

The report on China is based on desk research and interviews undertaken by Wanxin Li, Assistant Professor, Department of Public and Social Administration, City University of Hong Kong.

All country profiles present information which was up-to-date at the end of 2007. In most cases, more recent information has been taken into account.

Policy instruments to support eco-innovation

The country profiles confirm that eco-innovation policies deploy a variety of instruments. They have to adjust to the features of the domestic economy, in particular the knowledge base, the size of domestic markets, and the *vigueur* of the venture capital industry.

In most non-EU OECD countries, public research and development (R&D) remains a major orientation. The US and Japan typically allocate significant public finance to environment-related R&D. However, three trends have emerged: i) some countries are concerned by the competition and trade issues related to such support; ii) public resources are increasingly channelled via Departments not directly in charge of environment policies (Energy, Agriculture, Transport), making inter-agency cooperation even more necessary; iii) the role of research organisations is being redefined, to intensify linkages with the private sector and stimulate the development of marketable outputs; incubators in the US, the National Institute of Advanced Industrial Science and Technology's (AIST) Technology Licensing Office in Japan, or the Important Projects identified by MOST in China illustrate arrangements in this area.

Attracting private funds to finance environmental R&D is another major policy orientation. The

main issue is to reduce risks for private investors investing in environmental R&D projects, while making sure that public money is used effectively and does not crowd out private initiatives. A variety of funds have been established to reduce risks to private investors (e.g. Sustainable Technology Development Canada-SDTC in Canada), or incubators (e.g. The Clean Energy Alliance in the US, Environmental Technology Business Incubator in Korea). Measures are taken to stimulate the venture capital industry and to provide incentives for environment-related projects; e.g. this is the role of the Environmental Venture Fund in Korea.

Environment-related performance standards are being set with the aim of stimulating innovation in goods and services. Such standards are pursued in particular in the field of energy and resource efficiency. However, standards may provide disincentives and can only have a lasting positive effect on innovation if they are timely revised. Schemes such as the Top Runner programme in Japan aim to address this challenge.

Market-based instruments are burgeoning in non-EU OECD Countries. A number of new projects and initiatives have been identified at national or local level. One interesting case is the all-encompassing Emission Trading Scheme envisioned in New Zealand, where equitable sharing of responsibility across sectors and stakeholders is based on the principle of equity across sectors.

There is some evidence that, besides environmental policy instruments and regulation, soft instruments such as voluntary commitments, eco-audits and eco-labels play a role as determinants of innovative behaviour in firms. Voluntary initiatives can become mandatory over time (cf. Stand-by Korea). Industry initiatives abound and, in particular contexts, can change the relationship between the administration in charge of environment policies and the business sector. This is illustrated by Performance Tracks in the US, where the US Environmental Protection Agency (USEPA) and firms enrolled in the programme construct a collaborative relationship; the 1000 Enterprises Programme in China follows a similar path, where NDRC helps build capacity in firms to enhance energy efficiency. This typifies what can be seen as a new phase in environmental policies which sets out to promote broader sustainability, rather than address one single environmental issue. In that perspective, governments rely less on regulatory tools and endeavour to work with industries, in sectors which use materials and/or energy.

In line with the OECD Council Recommendation on Improving the Environmental Performance of Public Procurement [C(2002)3], green procurement initiatives are burgeoning at local and national levels. Guidelines are supported by websites, green products databases, and *pro forma* requests for tenders. The Green Purchasing Network is an international network active in this area.

Some initiatives set out to promote technologies and products developed by one country. Others try to alleviate barriers to the deployment of environment-friendly technologies and products; shared definitions, standards and labels contribute to a level playing field for the creation and diffusion of environment-friendly technologies, products and life-styles. Such efforts are still plagued by institutional problems related to intellectual property rights and international monetary transfers. Typically, the capacity of a national agency to (financially) support one country's side of a multinational joint venture depends on how countries will share the intellectual property rights. Few cooperation projects reach developing countries (with the exception of East Asia, and China).

COUNTRY PROFILE OF THE PEOPLE'S REPUBLIC OF CHINA

China's attitude towards nature and the environment can be divided into four different stages: pre-1949, 1949-1978, 1978-2004, and 2004 forward. Prior to 1949, the idea of nature-human harmony promoted by the Confucianism and the Buddhist doctrine that all living beings are of Buddha spirit had far reaching impact on Chinese economic activity and life style. When Chairman Mao assumed power in 1949 through 1976 the sense of closeness with, respect for and fear for nature was replaced by the call for conquering nature. Since 1978, nature and the environment have been considered as means of production at the disposal of the Chinese people. Although an environmental governance system has been gradually put in place, the period from 1978 to 2004 witnessed the transition to a market economy, rapid industrialization and urbanization, and associated unprecedented environmental degradation. As noted in the Review of Innovation Policy in China¹, China's economic growth has induced high demand for energy and raw materials. Rapid economic growth, industrialisation and urbanisation are leading to environmental degradation and damaging the population's health. Ecological challenges may eventually limit China's further economic development.

After 2004, the central government switched to a new paradigm characterized by "a scientific approach to development," "harmonious society," "cleaner production," "circular economy," and "energy conservation and pollution reduction." This shift responds to domestic and international demands for a cleaner environment in China, with the goal of striving for a more sustainable development path. Science, technology and innovation, in particular environment-related innovation, can contribute significantly to this objective. More recently, this is reflected in the Chinese economic stimulus package, which emphasizes energy conservation, emissions reduction, the development of renewable energy sources and low emission vehicles.

The report highlights instruments in China which contribute to this new perspective by supporting the development and deployment of environment-related innovations in China. The report reflects Chinese national priorities on energy security, energy efficiency, and a more environment-friendly model of development. Accordingly, it is focused on technologies for renewable energy, for energy efficiency and for pollution prevention and control; initiatives taken to promote a circular economy are also highlighted as they illustrate (sometimes non-technological) eco-innovations. Eco-cities projects are particularly emphasised. A short section presents selected information on measures to support the deployment of technologies to abate pollution. The report is not comprehensive: policies to support clean production, climate change mitigation and adaptation, and a low-carbon economy are not systematically covered although they may support eco-innovation.

The report has four sections. Section 1 identifies institutions playing a major role in eco-innovation policies in China. Section 2 inventories mechanisms that support public investment in environmental R&D. Section 3 presents the tools and mechanisms that promote eco-innovation in the three areas identified above (renewable energy, energy efficiency, and circular economy).

¹ OECD (2007), OECD Reviews of Innovation Policy – China - Synthesis Report, Paris

Institutions involved in eco-innovation policies in China

Since 1984, the Chinese national innovation system has experienced dramatic changes. As described in the OECD Innovation Policy review of China, governance of the S&T system, in which the Ministry of Science and Technology (MOST) plays a prominent role, has the following important features:

- The State Council Steering Group for Science, Technology and Education is a top-level co-ordination mechanism, which meets two to four times a year to deal with strategic issues.
- A number of ministerial level agencies – the National Development and Reform Commission (NDRC), the Chinese Academy of Sciences (CAS), the Chinese Academy of Engineering (CAE), sectoral line ministries such as the Ministry of Information Industry (MII) and the Ministry of Agriculture (MOA), and the National Natural Science Foundation of China (NSFC) – play a direct role in designing and implementing S&T and innovation policies.
- A number of other ministerial agencies, notably the Ministry of Finance (MOF), and the Ministry of Commerce (MOC) have significant influence on S&T and innovation policies and implementation, while others, such as Ministry of Personnel (MOP) and the State IP Office (SIPO), also exert an important, albeit somewhat indirect, influence.

The lack of a body with the status to co-ordinate all key policy issues, casts some doubts on the capacity of such a governance system to promote a whole-of-government approach required to implement the strategic goal of building an “innovation nation”.

In addition to the public sector, the OECD Innovation Policy review of China indicates that the business sector has become the dominant R&D actor, now performing over two-thirds of total R&D, up from less than 40% at the beginning of 1990. At the same time, the share of public research institutes has declined from almost half of total R&D to less than one-quarter over the same period. The relative weight of higher education institutions has changed little. Initiatives taken by Chinese enterprises often accompany the implementation of stringent regulations; it reflects the growing technological capabilities (a requisite for technology transfers).

In parallel, over the past few years, China had undertaken reforms to improve the institutional infrastructure of the environmental management system. These reforms can be boiled down to five categories: (1) granting the public open access to environmental information, (2) establishing the National Leadership Committee on Climate Change, Energy Saving and Pollution Reduction, (3) giving teeth to energy efficiency and pollution reduction targets, (4) innovative measures adopted by local governments to pursue environmental excellence, and (5) adopting market mechanisms for pollution reduction.

Most of these reforms are meant to ensure environmental compliance by both local governments and the private sector, explore new ways of achieving sustainable development at the local level, and induce meaningful public participation in local decision-making. While the innovations may still be mainly characterized as top-down, bottom-up initiatives are emerging in some local government settings. In addition to command-and-control approaches, market mechanisms such as emissions trading are also finding application in practice.

In this moving context, institutions involved in policies to support eco-innovation include government agencies, public research organizations, state-owned enterprises, multinational enterprises, and small and medium sized enterprises. At the government level, these include, more specifically, the

Ministry of Science and Technology (MOST), Ministry of Environmental Protection (MEP), and Ministry of Education (MOE) working in collaboration with the Ministry of Finance (MOF), State Administration of Taxation, and Ministry of Commerce. These agencies develop policy instruments to build manpower and knowledge stock for innovation, stimulate innovation and facilitate technological transfer.

Local governments facilitate environment-related technological innovations and the development of the environmental service industry by establishing science and technology (S&T) industrial parks or technology business incubators, devoted to an environmental theme. Nationwide, there are 3% of such S&T industrial parks and technology business incubators devoted to the environment (OECD, 2007, Figure 2.18).

Based on the Environmental Yearbook of China, between 1998 and 2005, 1,237 patents were filed related to environmental technologies. Starting in 2006 the Science and Technology Division of MEP began to publish an annual listing of advanced technologies recommended for pollution prevention and abatement.

Public investment in environmental R&D

Between 1991 and 2004, total investment in R&D in China grew thirteen-fold. Gross domestic expenditure on R&D as a percentage of GDP grew from 1.07 in 2002 to 1.42 in 2006 (compare with 2.3 in OECD countries and 1.8 in EU 25, in 2006). Over the same period, the gross domestic expenditure on R&D has increased from 37.7 to 70.6 billion USD (constant USD, 2000 prices and purchasing power parity; see OECD dataset *Gross domestic expenditure on R&D by sector of performance and source of funds*).

Along with the increase in magnitude, there has been diversification of the methods for channeling funds to R&D activities: these now include public funding in the form of direct investment, tax breaks or subsidies, private foundations partnering with government agencies, and private funding by individual corporations or venture capital pools. The increasing financial support makes it possible to attract talent and implement innovation policies.

Chinese Science and Technology (S&T) and innovation policies in the post-reform (after 1978) period has been formulated to achieve the following objectives: (1) promoting basic research in selected scientific fields with perceived significant potential impact on social progress and economic development; (2) research and development on new technologies in selected high-technology areas of national priority, such as biotechnology, information technology (IT), space technology, energy technology, and new materials; (3) technology innovation and commercialization; (4) support for construction of infrastructure for scientific research; and (5) development of human resource (HR) in S&T and rewards for S&T excellence. In each policy area, the government adopts a set of policy instruments to achieve the objectives.

Support for basic research is provided by various programmes. The most important ones include: the Chinese Academy of Sciences (CAS), the Natural Science Foundation of China (NSFC) programme, and the 973 programme.

Chinese Academy of Sciences (CAS)

The CAS was established in 1949, the year the People's Republic of China was formed. It has branch research institutes—including those which are devoted to specific research areas—all over the country and has become an important host for basic scientific research. Within the CAS system, the

Research Center for Eco-Environmental Sciences and Institute of Geography and Resources focus on topics related to ecology and environment.

Natural Science Foundation of China (NSFC)

In addition to CAS, many universities and research institutes are involved in basic scientific research. They obtain research funding mainly through the NSFC. Established in 1986, the NSFC is the grant making body supported by the Ministry of Finance to promote basic scientific research projects, using peer review and competitive selection processes. The total funds at disposal of the NSFC have increased from RMB 800 million in 1986 to 4330 million in 2007. Table 1 illustrates NSFC basic scientific research support to universities and research institutes.

Table 1. NSFC 2001-2008 Grant-Making for Basic Scientific Research

Year	Total		University		Research Institute	
	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	Funding
2008	8,924 (100)	2,886.47 (100)	7,182 (80.48)	2,278.2 (78.93)	1,622 (18.18)	573.33 (19.86)
2007	7,713 (100)	2,274.57 (100)	6150 (79.74)	1,771.2 (77.87)	1,438 (18.64)	469.36 (20.63)
2006	10,271 (100)	2,685.95 (100)	8,091 (78.78)	2,064.85 (76.88)	2,023 (19.7)	582.37 (21.68)
2005	9,111 (100)	2,258.98 (100)	7,239 (79.45)	1,750.72 (77.5)	1,744 (19.14)	477.21 (21.12)
2004	7,711 (100)	1,675.16 (100)	6,042 (78.36)	1,278.55 (76.32)	1,572 (20.39)	376.67 (22.49)
2003	6,359 (100)	1,322.03 (100)	4,964 (78.06)	1,005.85 (76.08)	1,308 (20.57)	299.37 (22.64)
2002	5,808 (100)	1,156.31 (100)	4,497 (77.43)	879.39 (76.05)	1,232 (21.21)	262.95 (22.74)
2001	4,435 (100)	797.62 (100)	3,415 (77.00)	605.59 (75.92)	975 (21.98)	184.43 (23.12)

Note 1: Funding in RMB, million.

Note 2: Percentage in parenthesis.

Source: Author compilation based on information on the NSFC website, <http://www.nsf.gov.cn/nsfc2008/index.htm>.

973 Programme

973 programme supports basic research. The programme was initiated by MOST in 1998 and funded by the MOF. The 973 Programme contains eight key areas: agriculture, energy, information technology, natural resources and environment, population and health, material sciences, multi-disciplinary research, and important frontiers of sciences. From 2002 to 2007, there were a total of 274 research projects funded, of which 30 were on energy and 32 were on natural resources and environment.

Building capacity: CAS “Hundred Talents” and NSFC “National Distinguished Young Scholars”

In addition to direct financial support to research projects, funding is available to build the manpower needed for scientific research. Since 1998, the Yangtze River Scholars Programme, in which the MOE channels funds from a prominent private foundation, the Li Ka Shing Foundation, has been used to build human capital for the national innovation system. Between 1999 to 2007, 17

scholars won on the Yangtze River Achievement Award, through which each scholar received a grand prize of approximately RMB 1 million (US\$138,000). During the same period, a total of 1,310 scholars or professors were appointed to work in mainland universities under the Programme. In 2005, the programme was extended from mainland institutions to cover institutions in Hong Kong and Macau.

National Key Laboratories Programme

In terms of applied scientific research, the MOST has been playing a major role in identifying key areas for advancement in technology for both industrial development and national defence. In 1986, the High Technology R&D Programme (863 Programme) was established by MOST for the long-term advancement of applied sciences and technology.

MOST identified 16 especially Important Projects for the period of 2006-2020. Those projects will integrate the capacity of enterprises, universities, and research institutes to create technological breakthrough and upgrade industries in China. The MOF will provide seed funds and the participant local governments and enterprises are required to provide matching funds. The Water Pollution Control and Treatment Project (one of the 16 Important Projects) was launched in February 2009. At the Launch Meeting, Liu Yanhua, vice minister of MOST, said the government will create means to ensure financing of the project, for example, government subsidies, interest free bank loans, and venture capital.

In the medium term, the MOST regularly conducts five-year planning in line with the national Five-Year Development Plans. Within each five year period, there are a series of National Key Technology R&D Projects funded jointly by the MOF (through the MOST), and participant local governments and/or enterprises. As illustrated in Table 2, since 1981, the total number of national key technology R&D projects, and funding, has greatly increased. During this period, the share of the funds from the central government has declined. During the 6th Five-Year Plan period, the central government contributed up to 60% of the total funds, while during the 10th, the share taken up by the MOF dropped to only 8.3%. It is clear that the central government has changed its role from a major funder to an advisor and a facilitator.

Table 2. National Key Technology R&D Projects: 1981-2008

Time period	Total number of national key technology R&D projects	Number of environment-related national key technology R&D projects	Total funding (RMB million)	Funding from MOF (RMB million)
1981-1985 (6 th Five-Year Plan)	38	5	2,500	1,500
1986-1990 (7 th Five-Year Plan)	76	4	6450	3,500
1991-1995 (8 th Five-Year Plan)	84	7	9,000	4,520
1996-2000 (9 th Five-Year Plan)	238	9	19,000	5,000
2001-2005 (10 th Five-Year Plan)	213 + western development + Beijing Olympics	??	37,274	3,090

Source: Author compilation based on information published on the MOST website, <http://www.most.gov.cn/>.

Special funds for environmental protection

Although it is unclear exactly to which extent the national S&T programs have facilitated the advancement of environment-related technologies, the governments at both central and local levels have paid more attention to them. Also, because of the increasing push for a cleaner environment in society, corporations, including multinationals, state-owned, and small and medium private enterprises are more willing to innovate to achieve better environmental performance.

Renewable energy technologies

China faces challenges to secure its energy supply. China's annual demand for oil will rise to 0.45-0.61 billion tons by 2020, while the domestic production can only supply about 0.18 billion tons by 2020. Thus, China must continue to increase its reliance on imported oil. Coal comprises more than 60% of the primary energy supply in China (see Figure 1 & 2). China was the largest producer and consumer of coal in 2006. China's coal exports have been declining since reaching a high of 70 million tons in 2003 and are now being outpaced by imports, mainly from Indonesia and Australia.²

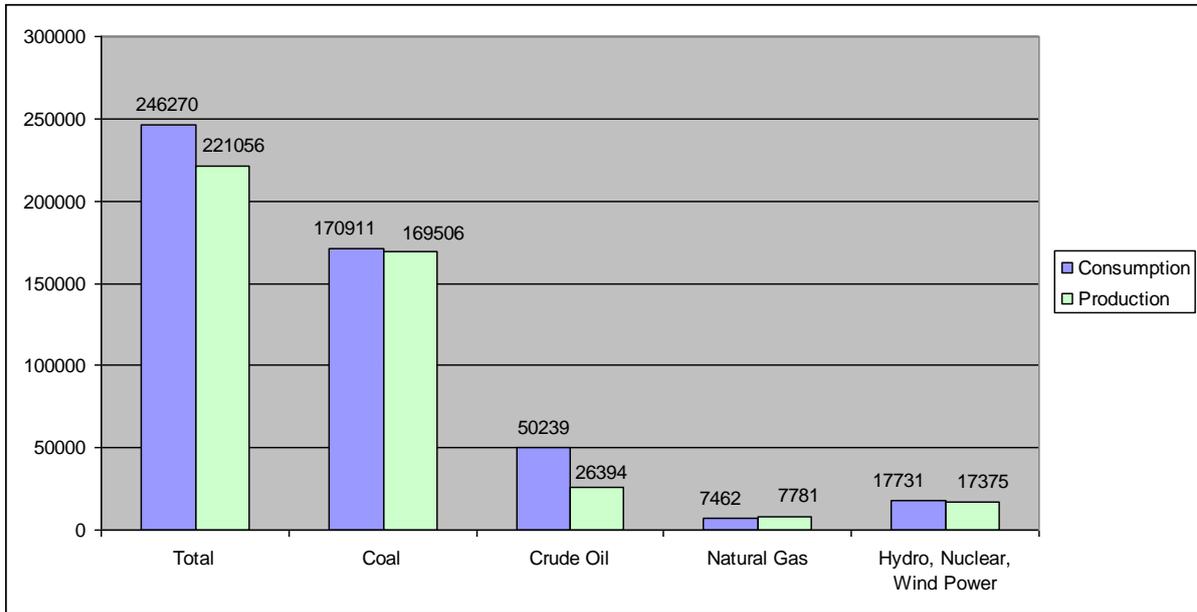
Energy utilization efficiency in China is about 31.2%, 10 percentage points lower than that in developed countries. Between 2000 and 2008, world market prices for energy have doubled. In the longer term, resources will inevitably grow scarcer. This means that rapid growth and industrialization will require China to import more raw materials and energy. The reduction of coal consumption and diversification of the energy mix has become a national strategy to reduce carbon emission. In short, renewable energy and energy efficiency have become rational choices for China if it is to meet its energy needs and build a low carbon society.

China is rich in renewable energy resources. Since the 1970s, the Chinese government has recognized the importance of developing renewable energy for off-grid rural and remote areas and supported development of small hydropower, biogas, and small wind turbines to provide energy and electricity to those isolated populations. While progress has been achieved in developing renewable energy in rural areas, the potential for expanding the use of this clean energy throughout China is great.

The Chinese government has, in recent years, increased its commitment to the development of renewable energy, as outlined in the New and Renewable Energy Development Program 1996-2010. Jointly developed by three key government commissions—the State Planning Commission (SPC), State Economic and Trade Commission (SETC), and State Science and Technology Commission (SSTC), this program aims to improve the efficiency of renewable energy, reduce production costs, and enlarge the share of renewable energy in the overall energy mix. The 1995 Electricity Law also extends support to solar, wind, geothermal and biomass energy for power.

² Kejun J, Xiulian Hu, Xianli Zhu, Garg A, Halsnaes K and Qiang L, 2007. *Balancing Energy, Development and Climate Priorities in China: Current Status and the Way Ahead*. UNEP Risoe Centre on Energy, Climate and Sustainable Development, Roskilde, Denmark, p. 18.

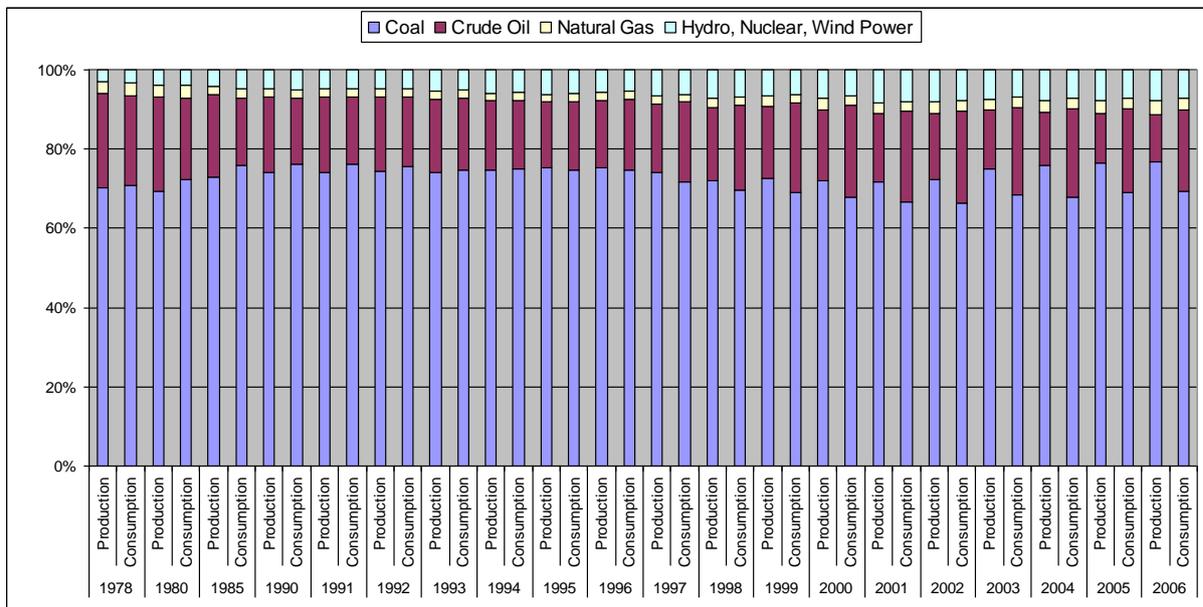
Figure 1. Composition of Energy Production and Consumption in China in 2006



Note: Both energy production and consumption are in 10,000 tons of Standard coal equivalent.

Source: Statistical Yearbook of China 2007, National Bureau of Statistics of China, accessible at <http://www.stats.gov.cn/tjsj/ndsj/2007/indexch.htm>.

Figure 2. Composition of Energy Production and Consumption in China 1978-2006



Source: Statistical Yearbook of China 2007, National Bureau of Statistics of China, accessible at <http://www.stats.gov.cn/tjsj/ndsj/2007/indexch.htm>.

Renewable energy technologies in China have gone through a fast development and commercialization processes. Table 3 lists available renewable energy technologies in China. Although not applied in a large scale, China's installed wind power exceeded 6 GW by the end of 2007—an amount exceeded only in Germany, the U.S., Spain and India. China now has developable hydropower resources amounting to more than 500 million KW. By the end of 2005, China's total installed hydropower capacity reached 117 million KW, ranking the first in the world.

Accompanying technological advancement and expanding market for renewable energy, there is a mix of legislative, administrative, and economic measures adopted by the Chinese government.

Table 3. Renewable energy technologies and the stage of their development in China

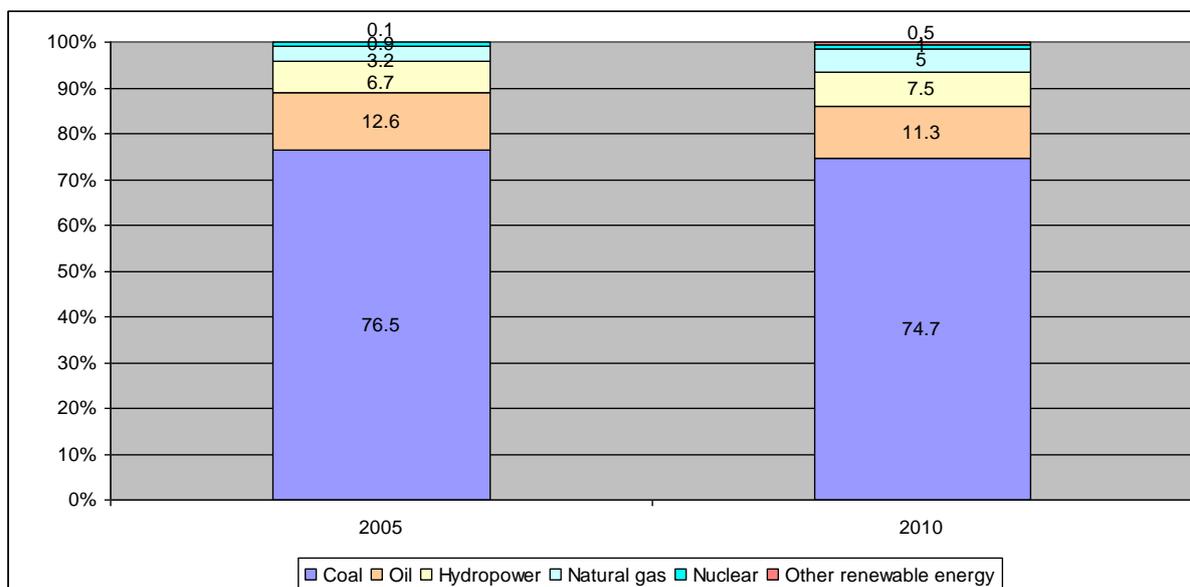
Technology	Development Stage			
	R&D	Prototype	Small scale application	Commercialization
Small-hydro power plant				◆
Solar power water heater				◆
Passive solar house				◆
Solar cooker				◆
Solar dryer		◆		
Solar cell			◆	
Large scale wind power grid operating system			◆	
Small scale and mini wind power grid operating system			◆	
Geothermal power generation technology				◆
Geothermal heating technology				◆
Traditional biomass power technology				◆
Miniature biogas pool				◆
Large and middle biogas technology			◆	
Urban organic waste power generation technology		◆		
Biomass gasification technology		◆		
Tidal power generation technology			◆	

Enacting the Renewable Energy Law and related regulatory framework

The key Chinese renewable related law, the Renewable Energy Law, was passed by the NPC on 28 February 2005. The law is an effort to secure the country's energy supply and to better protect the environment. To reduce China's dependence on coal and oil and diversify its energy supply, the Renewable Energy Law mandates that 10% of the nation's energy production must come from renewable sources by 2020.³ In 2007, the NDRC took a further step in the "Mid-to-Long-Term Development Plan for Renewable Energy", which states that renewables must account for 10% of China's overall energy supply by 2010, and 15% by 2020.⁴ Figure 3 illustrates the desirable composition, according to the Mid-to-Long-Term plan, of energy supply defined by the NDRC.

³ Renewable Energy Law (2005).

⁴ NDRC, 2006, *China's 2020 Renewable Energy Development Plan*. Available at www.ndrc.gov.cn.

Figure 3. Energy development goals of China by 2010

Source: NDRC, 2007, *China's National Climate Change Programme*, accessible at www.ndrc.gov.cn.

In addition, a series of regulations, together with the Law itself, form the legal framework for renewable energy. The regulations are supplemented by the following policy documents.

- *The Eleventh-Five-Year Plan for the Development of Renewable Energy*, issued by NDRC. It defines an action plan for each type of renewable energy⁵.
- *Management Methods on Renewable Energy Power Pricing and Costs Sharing for Trial Implementation* (NDRC). This document provides administrative support for giving preferential prices to renewable energy power and sharing the cost among regions and enterprises. Electricity pricing by category is the government's strategy that helps producers of renewable energy to recover their costs and gain market share. It is mandatory for the power grid companies to purchase all the available renewable energy at a price set by the central government. Cost sharing is a mechanism used to reduce the barrier to renewables due to high-cost project development in some regions and increase the competitiveness of renewable energy with coal and other fossil fuels.
- *Management Rules on Renewable Energy Power Generation*. This document puts in place guidelines for government and industry to follow in dealing with the generation and transmission of renewable energy power. It is clearly stated in the policy document that all the renewable energy generated should be combined to the power grid at a preferential price.
- *Technical Standards on Renewable Energy Power Combined to the Grid*. This document sets up a guarantee system that promises to combine the renewable energy power to the grid; it strengthens the competitiveness of renewable energy power against other traditional sources.

⁵ NDRC. 2008. *The Eleventh-Five-Year Plan for the Development of Renewable Energy* (retrieved from the web, 02/04/08, at: http://www.sdpc.gov.cn/nyjt/nyzywx/t20080318_198289.htm).

It helps to break the monopoly of energy sales network, reduces the trading costs of projects, shortens the waiting time, and gives renewable energy project good credit for financing.

- *Detailed Methods on Fiscal Subsidy and Preferential Taxation for Renewable Energy.* This document sets detailed guidance regarding how to make the financial incentives for the development of renewable energy work.

An industrial development catalogue classifies the maturity of technologies of six major renewable energy sources – wind, solar, biomass, geothermal, ocean tide and hydro, including 88 technologies. This catalogue will also be used as a basis on which R&D, taxation, product pricing and investment policies will be further developed.

By technology forcing on power generators, mandatory purchasing of renewables by power grids, and non-negotiable pricing of renewables in the electricity market, the Chinese government has provided the means to largely increase the market share of renewable energy.

Providing tax incentives

The central government has given favorable tax rates to renewable energy producers (see Table 4). For example, the value added tax (VAT) is set at a 17% level for general products, countrywide. However, power generators using wind, biomass or small hydropower enjoy a much lower level of VAT, thus permitting reduction in the market price for these renewables. Using wind power as an example, the price can be reduced by RMB 5-7 cents per kWh, depending on production costs of the particular wind farm.

Table 4. Classification of Taxation in China⁶

Items	VAT	VAAT(Value-added annex tax)	Income tax
General	17%	8% of VAT	33%
Small Hydro power	6%	8% of VAT	33%
Biogas	13%	8% of VAT	15%
Wind	8.5%	8% of VAT	15%
Landfill gas	0	0	33%

International cooperation to build capacity and raise awareness on renewable energy

China's efforts to develop renewable energy have received strong support from the international community. International and regional development agencies (the World Bank, UNDP, Asia Development Bank) have provided financial assistance and know-how for renewable energy development in China. Some countries, including the United States, Australia, and the Netherlands are actively involved in bilateral aid and technical assistance for renewable energy. Some examples of multilateral and bilateral renewable energy projects are summarized below.

The “umbrella” Agreement on Cooperation in Science and Technology signed by the U.S. and Chinese governments is aimed at maintaining long-term technical cooperation. Specifically, protocols were established to, 1) help China diversify its energy resources and thereby reduce its future demand for oil; 2) mitigate environmental damage associated with energy consumption through deployment of renewable energy and energy efficiency measures; and 3) enhance U.S. industry competitiveness in China's energy market.

⁶ Li Junfeng, Shi Jinli and Ma Lingjuan, China: Prospect for Renewable Energy Development

A Protocol for Cooperation in the Field of Fossil Energy Technology Development and Utilization was established between the U.S. Department of Energy (DOE) and the China's MOST. Under this protocol, five annexes have been established: Annex I for Power Systems; Annex II for Clean Fuels; Annex II for Oil and Gas; Annex IV for Energy and Environment Technologies; and Annex V for Climate Science.⁷ Moreover, in September 2007, the U.S. DOE and the MOST signed a five-year agreement to promote large-scale deployment of next-generation efficiency vehicle technologies in the U.S. and China, specifically focusing on electric, hybrid-electric, fuel cell, and alternative fuel technologies to implement a Protocol for Cooperation in the Fields of Energy Efficiency and Renewable Energy Technology Development and Utilization between DOE and MOST. The US DOE's National Renewable Energy Laboratory collaborates with various partners in China on rural energy, wind energy, business development, geothermal energy, and policy and planning⁸.

The US is cooperating with China in clean coal technology, building on the experience in the US Clean Coal Technology Program. Clean coal projects are being carried out through the Energy and Environment Center in Beijing, and also a cooperative program operated through Tulane and Tsinghua Universities. These projects focus on reducing emissions from utility and industrial boilers, as well as facilitating the entry of American coal preparation equipment and expertise into the China market.

The Sino-Dutch cooperation project "Promotion of Rural Renewable Energy (RRE) in Western China" is being funded by the Royal Netherlands Embassy (RNE) with the support of the Chinese Ministry of Commerce (MOFCOM) and the Chinese Ministry of Agriculture (MOA). The China Association of Rural Energy Industries (CAREI) is the implementing agency for the project. The project aims at the integrated development and application of renewable energy resources (biogas, wind, and hydropower) through development of human resources, construction of demonstration sites and the dissemination of project results. The ultimate objectives of the project are to improve the quality of energy supply to farmers and fishermen living in the Western regions of China, to increase the farmers' and fishermen's income, to alleviate poverty, to improve ecological environment, and to accelerate the "Strategy of Western (China) Development". The duration of the project was five years, i.e. from 9 January 2003 to 31 December 2007. The project comprises the following components: inception; capacity building; construction of 14 demonstration sites in poverty-stricken villages in Gansu, Sichuan, Hubei and Hunan province; technology transfer and dissemination. The technology transfer and dissemination component outputs pertain to i) Renewable Energy policy development and implementation, and ii) the development of models for dissemination of the project results with organisational, financial and technological requirements. Throughout the project, attention was being paid to barriers that either prevent or hinder a genuine, market-based development of RRE in Western China, as well as to possible ways to remove these barriers.⁹

In 2001, the Chinese State Economic and Trade Commission initiated support to develop a National Solar Water Heating Standards, Testing and Certification Program. After 2003 government restructuring, this programme is supported by the National Development and Reform Commission. The UNDP and GEF have been partners with the Chinese Government in this development process.¹⁰

⁷ Congressional statement by David L. Pumphrey before the US-China Economic and Security Review Commission, accessible at http://www.congressional.energy.gov/documents/February_1_-_PI-Pumphrey.pdf.

⁸ <http://www.energy.gov/news/5518.htm>.

⁹ <http://www.tudelft.nl/live/pagina.jsp?id=78906b6f-6737-400e-ad47-93e3dd73cf9d&lang=en>

¹⁰ NDRC/UNDP/GEF Project, "Capacity Building for the Rapid Commercialization of Renewable Energy in China," CPR/97/G31, initiated in May 1999 through 2006.

The World Bank has been actively engaged in the energy sector, especially in renewable energy development through loans and carbon financing in China (Figure 4). The Bank's active portfolio in EAP energy includes 20 lending projects with a total value of USD \$3.5 billion. The Bank also manages a complementary portfolio of 12 projects supported by the Global Environmental Facility (GEF) worth USD \$160 million. The Renewable Energy Scale-up Program, launched on 16 June 2005, will help enable commercial renewable electricity suppliers to provide energy to the electricity market efficiently, cost-effectively, and on a large scale. It aims to support the implementation of a national policy framework that would require a share of electricity to utilize renewable resources—a mandated market policy. This mandated market policy is required to address the failure of the market price for thermal electricity to reflect the pollution costs that burning fossil fuels has had on society. This World Bank program will support implementation of necessary laws and/or regulations, as well as a range of other measures to strengthen commercial capacity to scale up renewable energy markets. The program will also directly support a small number of investment projects¹¹.

Barriers in developing renewable energy

China's abundant renewable energy resources and huge potential market, combined with the growing concern about energy-related environmental problems, have fuelled the demand for more vigorous development of renewable energy. However, a series of institutional, financial, and technical barriers have to be overcome before significant progress can be made in developing such clean energy sources.

Mainly relying on administrative measures does not enable the Chinese government to penalize the grids that refuse to purchase power from renewable sources because of their high costs. This is caused not only by the relative immaturity of the renewable energy industry and its products, but also by the current exclusion of externalities in cost calculations and an inability to access subsidies that are available to the established fossil-fuel energy industry. Especially, as the current renewable energy applications are small in scale and scattered, it is difficult for power grid companies to extend their existing system when government or the market do not provide adequate economic incentives and financing mechanisms.

On the power generation side, renewable technologies are more likely suited to the construction of new facilities rather than to the retrofitting of old ones. Capital assets depreciation impedes the potential construction of new facilities. Existing equipment is rarely replaced if it has not been written off or if it has not reached its useful life. Most companies regard existing equipment as a sunk cost and prefer to continue to benefit even after the depreciation period. Renewable energy technologies are harder to sell, due to the specific characteristics required by each plant or company for their production process.

The market has not been developing following exactly what the laws and policies prescribed and does not yet provide a "level playing field" with respect to renewable energy. Renewable energy markets in China are often small and fragmented and renewable energy products and technologies often have to compete with low-cost or subsidized fossil fuels and nuclear energy. In addition, customers are poorly informed with regard to the carbon intensity of different sources of electricity supplies. Consequently, both the supply and demand side favour more the electricity generated from conventional sources.

¹¹ <http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/EASTASIAPACIFICEXT/EXTEAPASTAE/0,,contentMDK:21121918~pagePK:64168445~piPK:64168309~theSitePK:2822888,00.html>

Technologies for improving energy efficiency

The 11th Five-Year Plan has set an ambitious target for energy efficiency, aiming to reduce energy consumption by 20% per GDP unit by the end of 2010 from what it was in 2006. Before the take off of the Chinese economy, the central government placed a heavy emphasis on energy saving and energy efficiency because of its concern for China's self-sufficiency given the low level of productivity then existing. During the post 1978 economic reform period, GDP growth became a desirable goal and thus the scale of production and consumption has been largely increased without concern for energy consumption. As a result, wasteful practices are widespread in buildings, transportation systems, and manufacturing. However, energy saving devices are available in the Chinese market (see Table 5). The following legislative, administrative, and economic measures are adopted to support their diffusion and to improve energy efficiency in the Chinese society.

Table 5. Available energy saving devices

Sector	Energy Saving Device
Road transportation	advanced internal combustion engines and hybrid vehicles, improvements in engine design and materials and advanced biofuels
Water air and rail transport	advanced aerodynamic structures, advanced diesel propulsion systems, high speed and electric trains and development of larger vehicles to increase passenger and freight intensity
Cement	fluidised bed kiln technology, blended cements, preheaters and precalciners, dry raw feed preparation, geopolymers
iron and steel	single vessel smelt reduction and strip casting technology, increased recycling rates
chemicals rubber and plastic	Membrane separation technology, advanced steamers and boilers, better material design and heat recovery technologies, advances in refrigeration, reduced process leaks, optimizing furnace temperatures, reducing run times
wood, pulp and paper	fluidised bed technology, high intensive drying techniques, black liquor gasification
primary aluminum	advanced cathode designs, carbothermic technology, inert anodes
Mining	technologies to reduce methane pipeline losses, improvements in grinding technologies and the increased implementation of control based management practices
Agriculture	utilisation of fugitive abatement technology, increased livestock productivity, improved feed quality, more efficient fertiliser and irrigation practices, anaerobic digesters, aerobic manure composting
Residential and commercial sectors	compact fluorescent globes, light emitting diodes, improved building design and insulation, ground source and absorption heat pumps, solar heating/ hot water/cooling systems, more efficient refrigerators and ventilation systems, magnetic induction cooktops, high performance gas burners and microwave convection ovens
other industries	more advanced boilers, motors and steam systems, fluidised combustion technology, low emission energy sources

The Energy Conservation Law and its Amendment

The Energy Conservation Law was initially enacted in 1997 and has played an important role in improving energy efficiency in China. However, it was widely recognized the law does not provide strong enough incentives or compulsory measures to conserve energy. To provide specific guidelines and implementation plans, NDRC launched the Medium and Long-term Plan of Energy Conservation in 2004. This plan covers two phases: 2005-2010 and 2010-2020. In this plan, detailed energy conservation targets were set up. Key actions and comprehensive policy measures were also put

forward. As a consequence, the law on paper was left behind practice. It became clear that a significant amendment was necessary.

After several rounds of consultation, the National People's Congress amended the law in 2007; the new law took effect on April 1, 2008. The amended law expands coverage to regulate energy saving in building and transport sectors, improves the management regime and the standards system for energy conservation, and imposes greater penalties for violations.¹²

However, the most noteworthy feature of the amended law may lie in its emphasis on various forms of economic incentives for energy conservation, with related support policies and measures. For example, the amended law requires that both central and local governments shall establish special funds to support manufacturing devices that conserve energy, provide tax benefits and subsidies to those who produce and use the listed energy-saving technology and products, provide financial assistance to the promotion of energy-saving products, and encourage financial institutions to give more lending to energy-saving projects.

Another significant feature of the amended law is that, for the first time in a law or regulation, success in meeting energy conservation targets is identified as an assessment criterion for evaluating official performance.¹³ It may be anticipated that this legal requirement, by which officials assume political responsibility for failure to achieve energy saving goals, will urge them to take energy conservation more seriously. It may also help enhance awareness that it is none other than the local government that should take the leading role in China's energy saving work.

Formulating energy efficiency standard for energy intensive products

Without energy efficiency standards, consumers and producers of energy consuming devices do not know where the floor level lays for energy efficiency. For some energy intensive sectors, such as the petrochemical industry, metallurgical industry, chemical industry, power industry, construction materials industry, etc., efforts have been made to develop specific energy efficiency standards. It is claimed that measures to improve energy efficiency are the cheapest and fastest way to curb demand and emissions growth in the near term, and the savings are particularly large in China.¹⁴ For example, if tougher efficiency standards for air conditioners and other household appliances are enforced, by 2020, the estimated energy saving is equivalent to the amount of power generated by the Three Gorges Dam.¹⁵

Energy Efficiency of Public Buildings

Energy consumption by office and residential buildings account for about 16% of total energy use, ranked one of the three major end-users in China. More importantly, the share is expected to grow to 25% by 2020. The increasing demand on new and improved infrastructure, especially with the rapid urbanization process, more than 300 million people will become city dwellers in the next two decades or so, presents both a challenge and an opportunity for building energy efficiency. In 2005 China promulgated the Design Standard for Energy Efficiency of Public Buildings (standards on design of residential buildings had been issued earlier). The latest policy, as stated in the Comprehensive Work

¹² See e.g., chapter 2, section 3 of chapter 3, and chapter 6, Energy Conservation Law (2008).

¹³ Article 6, Energy Conservation Law (2008).

¹⁴ IEA. WEO 2007.

¹⁵ Ibid.

Scheme on Energy Saving and Pollution Reduction, shows that the State will tighten the administration of energy conservation in buildings to save 12.50 million tons coal equivalent. Without meeting the energy consumption standards, new building projects cannot be approved. The Regulations on Inspection of Completed Energy-saving Projects is under consultation and is expected to be issued soon.

Energy-saving products

China has adopted a voluntary certification system for energy saving devices, such as light bulbs, refrigerators, and air conditioners. The State first initiated the voluntary certification of energy-saving products in 1999. The China Standard Certification Centre (CSC) is entitled to undertake the certification work. To promote the energy-saving products, the national government issued the List of Energy-saving Products in Government Procurement in 2004; this aligns with the Medium- to Long-Term Strategic Plan for the Development of Science and Technology, which for the first time assigns public demand an important role in economic development and the promotion of innovation. The list of eligible energy-saving products is updated periodically. All the products on the list have been certified, and are given preferential considerations in governments purchasing decisions.

The Transportation sector

Transportation accounts for about 11% of total energy consumption in China, and is expected to rise to 16% by 2020. Targeting the transport sector is an important part of China's energy-saving strategy. Energy saving can be achieved by improving fuel efficiency of vehicles as well as reducing driving by developing better public transportation. Pursuant to the Comprehensive Work Scheme on Energy Saving and Pollution Reduction, the central government considered an increase in the fuel tax, which would potentially reduce energy consumption.¹⁶ On 5 December 2008, the National Development and Reform Commission, Ministry of Finance, Ministry of Communication, and the State Administration of Taxation jointly released the draft Reform Plan of the Pricing of and Taxing on Refined Oil and called for public comments. After rounds of heated debate, a new fuel tax was introduced on January 1, 2009.

Energy efficiency labelling

The government strives to make it easy for consumers to distinguish energy efficient products from those that are inefficient and thus make it possible for producers to charge a premium on their environmentally friendly products.

The Administrative Measures on Energy Efficiency Labels was first enforced on 1 March 2005. Since then, a mandatory labelling scheme has been phased in, first applied to household appliances including air conditioners, washing machines and refrigerators. The government has issued a series of implementation guidelines on the format of the labels and the testing and inspection methods to determine the appropriate energy efficiency grades A Catalogue of Products Adopting Energy Efficiency Labels (fourth batch) was issued late in 2008, providing a clear guidance for both the public and industry¹⁷.

¹⁶ For discussion of the imposition of the fuel tax, see e.g., the column in Xinlang Net: Fuel tax is about to be imposed, available at: <http://finance.sina.com.cn/focus/zgkzrys/index.shtml>.

¹⁷ Report joined issued by NDRC and General Administration of Quality Supervision, Inspection and Quarantine, available at: http://www.ndrc.gov.cn/zcfb/zcfbgg/2008gonggao/t20081105_244788.htm.

Subsidies to users of energy efficient devices

In April 2008, the MOF and NDRC decided to subsidize households who purchase energy saving bulbs, with subsidy for up to 50% of the price. In February 2009, the MOE and NDRC reiterated the policy, but this time the number of bulbs to be subsidized was increased from 50 million to 100 million.¹⁸

However, better analysis of price-demand elasticity is needed before such policies can be fine-tuned.

Building capacity in industry to improve energy efficiency

In 2006, as one of the pillar measures to pursue the Five Year Plan 20% reduction goal in energy intensity by 2010, NDRC launched “A Thousand Enterprises Program” in 2006.¹⁹ The Program recognized industry as the largest energy user, selected 1,008 top firms that together consume one-third of all China’s primary energy, and instructed them to formulate individual energy efficiency improvement plans in cooperation with local officials.²⁰ Those enterprises cover nine industrial sectors that are energy intensive. Through technology rectification, energy audit and energy consumption metering systems, the firms are expected to save 100 million tons of coal equivalent by 2010. Local governments are also required to develop similar programs with an additional 100,000 smaller firms in order to achieve the 20% reduction national goal by 2010. It is reported by NDRC that 7.8% of the 1008 enterprises failed to meet their energy saving targets in 2007.²¹

An important part of the programme is government support so that enterprises can build capacity to achieve their energy efficiency targets. NDRC and its subordinates at local levels have made efforts to transition from a conventional regulator, who only gives orders without taking into account individual enterprise’s specific conditions, to a technical adviser and helper, who actively help foster individual enterprise’s ability to accomplish its task.

The patterns of energy consumption vary from sector to sector. And thus, energy conservation measures have to be case specific. While enterprises may not always have the necessary information to choose the best suitable energy saving technology, regulators may be in a better position to gather such information and give advice to the enterprises. In the “A Thousand Enterprises Program”, government agencies not only perform the conventional regulator’s role such as monitoring and supervising, but provide enterprises with expertise in choosing the most appropriate conservation measures for them. NDRC and its local agencies also held workshops informing the enterprises of various aspects of the program and training their personnel to carry out the energy conservation work.

The transition in the role of government in this program reflects the regulator’s attempt to institute capacity building for the enterprises to improve their energy efficiency, by which China’s

¹⁸ <http://www.sinchew-i.com/node/78099?tid=213>.

¹⁹ This energy conservation action plan in a thousand enterprises is jointly initiated by NDRC, National Energy Office, the National Bureau of Statistics, General Administration Quality Supervision, Inspection and Quarantine and SASAC, but NDRC and its subordinates at local levels take the leading role in the implementation.

²⁰ Ibid.

²¹ Xinhua Net, China Petroleum and Chemical Corporation and other 73 enterprises failed to meet the energy saving target in 2007. (retrieved from the web, 06/12-08, available at: http://news.xinhuanet.com/fortune/2008-09/05/content_9799579.htm)

20% reduction goal stands a better chance to be realized. The transition is not easy because it requires fresh thinking and strenuous efforts from the government to be able to positively deviate from the conventional style. In addition, the change may not necessarily be welcomed by the regulated entity. Regulators in the “A Thousand Enterprises Program” encountered implicit resistance from some enterprises when they tried to understand better the enterprise’s operation and the potential for energy saving. Managers in these enterprises expressed concerns that once the regulator obtains more information about the enterprise, they may lose bargaining power when negotiating for a lenient energy conservation target or may run the risk of being imposed of a more stringent goal. Building trust between the regulator and regulated entities remains a challenge in building capacity in the industry.

Another case in point is the “Ten Key Programs”. In early 2004, ten key energy-saving programs were identified in the Medium and Long -Term Special Plan for Energy Saving and emphasized in the Opinions on Implementing the Ten Key Energy-saving Programs in 11th Five-year Period. The ten programs include technological rectification of boilers, heat-power combined production, utilization of waste heat and pressure, oil product replacement, power equipment update, energy saving in buildings, green lighting, energy conservation by government agencies and monitoring of energy saving. The ten programs, if successful, are expected to save 240 million tons of coal equivalent, accounting for about 40% of the 20% reduction target.

Eco-innovation for a circular economy

The circular economy approach focuses on the life-cycle of economy-environment interactions. It builds on the industrial ecology tradition which promotes the restructuring of industrial processes along the lines of ecosystems, whereby the waste of one manufacturer becomes the input of another (Frosch and Gallopoulos 1989). The term “circular economy” was first used in the Western literature in 1980s (Pearce and Turner 1990) to describe a closed system of economy-environment interactions. In Germany and Japan the interpretation of circular economy is based on the management of waste through 3R. The underlying vision is that the present linear flow of materials (resource – product – waste) needs to be transformed into a circular flow (resource – product – recycled resource). The Circular Economy was adopted by the Chinese Government in the 11th five year plan as the development model for China to strive for. The following measures have been taken with the aim to establish full-fledged development mechanisms which will boost a circular economy.

A legislative basis to promote Circular Economy

The Circular Economy Promotion Law (2008) not only experienced rounds of heated debate and major revision, but faced strong disagreement over certain proposed articles and was even called rather advanced for a China at an early stage of developing a circular economy.²²

The proposal to enact a law to promote a circular economy (CE) in China was raised as early as 2005 by the Environmental and Natural Resources Protection Committee of the National People’s Congress (ENRPC) in the belief that circular economy would strike a better balance between economic growth and protecting the environment than the previous model of extensive development.²³ However, the idea was not fully supported by the existing administrative structure and division of

²² Sun, Youhai & Zhang Tainzhu, *Study on Legal Framework for Promoting Circular Economy in China*, 2008, China Legal Publishing House.

²³ Sun, Youhai & Zhang Tainzhu, *Study on Legal Framework for Promoting Circular Economy in China*, 2008, China Legal Publishing House.

responsibilities among different ministries. It was a radical innovation in China and raises concerns, in particular on implementation: some critics argued that the legislative proposal failed to provide a clear answer to the issue of the potential overlapping responsibilities, as the law would involve multiple government agencies, including NDRC, MEP, MOF and MST.

In the final enacted legislation, NDRC and its subordinates are entrusted with the primary responsibility for the implementation of the law while environmental agencies only play a secondary role. However, it should be noted that, although NDRC and its subordinates are relatively more powerful than other administrative organs, they do not have a separate, let alone efficient, law enforcement unit to perform effectively the supervision function.

Another interesting detail about the law enactment is that the title for this legislation was eventually changed from Circular Economy Law to Circular Economy Promotion Law. One reason for renaming the law was that China is still at an early stage in developing circular economy. Most of the provisions in the draft bill are aimed at guiding and promoting its development, with the characteristics of an initial phase of enacting a circular economy.

The Circular Economy Promotion Law is innovative in the sense that, unlike conventional laws that mainly regulate existing entities and their relationships, it aims to provide a regulatory framework for transforming the mode of development of the country. Sometimes such attempt may be deemed as a little “too advanced”, but it would not be harmful to enable both government and industry to become familiar with advanced environmental concepts as early as possible and start the intake of knowledge and built-up of expertise whenever possible.

Box 1. Debates on block tariffs in the Circular Economy Promotion Law

Debate over the Circular Economy Promotion Law can be observed through debates on a block tariffs mechanism (by level of consumption) for the utilities such as water, electricity and natural gas consumed by urban residents.

While drafters of the initial proposal advocated such progressive price structure, the article was deleted in the second round of review by the Standing Committee of NPC. Officials from the Law Commission explained that the decision to delete was based on three concerns: first, it may heavily and disproportionately influence low-income families as they are more vulnerable to such price increase; second, technically, it is not easy to set appropriate thresholds for families' consumption of electricity, water and natural gas as the amounts vary greatly; third, it would be unfair to impose progressive prices only upon residential families while leaving out much larger users such as industrial facilities. However, some members within the Standing Committee believed that making use of price leverage would help reduce substantially the consumption of natural resources in China and the low-income families could be subsidized if they cannot afford the minimum utility use. Therefore they suggested retaining such a provision²⁴

As a compromise, the final text includes a provision that states: [The] State should develop a pricing policy that helps conserve and reasonably utilize natural resources, and leads enterprises and individuals to conserve and reasonably utilize resource products such as water, electricity, natural gas, etc.²⁵

²⁴ Zhang Ruidan, Circular Economy Promotion Law has finally be passed, retrieved from the web, 03/12-08, available at: <http://www.caijing.com.cn/2008-08-29/110009215.html>

²⁵ Article 46, Circular Economy Promotion Law (2008).

Pilot projects with industries and local authorities

In 2005 the Chinese government launched the first round of CE pilot projects in seven key industrial sectors with the participation of forty-two leading enterprises, four waste recycling and reuse areas, thirteen industrial parks, and ten provinces or cities. In 2007, a second round of pilot projects expanded the coverage of sectors and regions. As of 2008, most of the pilot projects are still under implementation, and many other enterprises, industrial parks, cities and provinces have expressed an interest in participating.

Establishing an evaluation system

To enhance the accountability of local officials and corporate managers, the Chinese government introduced a trial Circular Economy Evaluation Indicators System in 2007. The system has two levels of indicators—at the level of the industrial park and more macro level indicators. For each level, four types of indicators were identified:

- resource output indicators (GDP volume produced per unit of primary resource consumed);
- resource consumption indicators (resource consumption per unit output of products or GDP);
- resource reuse indicators; and
- waste emission indicators.

These indicators have been introduced in some recent CE programs. For the second round of CE pilot projects, all participants (enterprises, industrial parks, and cities) were asked to establish their CE targets for 2010 and 2012 based on this indicator system, and monitor and report their progress.

Challenges in developing a circular economy in China

Implementing the circular economy approach is challenging. Local governments weigh the relevant benefits and costs, and then decide whether to adopt such an approach. For example, the author surveyed 35 Suzhou city government officials in 2006 on their acceptance of and expectations for circular economy. It was found that, although the majority of bureaucrats involved in the efforts strongly supported and agreed that the circular economy approach was important for sustainable development, about one-third of the survey respondents were unsure whether the nation should put every effort into developing the circular economy. Besides generating environmental and social benefits, one-third of the survey respondents argued that the circular economy approach cannot be adopted unless it can also generate economic benefits. It should be noted that this was before circular economy was actively promoted and implemented in China.

In such a context, the already big and growing waste recycling industry is left unattended by government. Of a total of 5,000 enterprises, with 160,000 waste collection centres and a labour force of nearly 10 million, a large portion of the enterprises are small enterprises that operate underground, exerting health risks for their workers and communities nearby.²⁶ They are also very vulnerable to the fluctuation of the global market, an effect shown by the recent sharp downturn due to the global economic recession. And thus, the Chinese government is faced with the challenge of regulating waste

²⁶ China Recycling Resource Network. 2006. Available at: <http://www.bj3r.com/Front/content.jsp?id=247>, 中国再生资源网,2006-10-24

processors that are neglecting environmental and social costs while ensuring this industry is economically viable and competitive.

Pollution prevention and abatement technologies

Based on information disclosed by the Chinese National Patent Commission and the Ministry of Environmental Protection, there are 106 environment-related technologies recommended by the MEP. Those technologies were invented to treat sulfur dioxide, dust, wastewater, sludge, and noise, to recycle and dispose used materials including electronic devices, biomass, municipal wastes, etc.

Over the years, a large amount of funds have been allocated to pollution treatment in China (Table 6). While from 2000 to 2005, the total amount of investment has increased by 91.4%, the percentage of public funding, including both government budgetary funds and special funds for environmental protection, has dropped from 28.8% in 2000 to only 6.2% in 2005. This implies local governments and enterprises have diversified their financing mechanisms for pollution control projects. For example, they both became more interested in taking up low interest bank loans, or attracting foreign investment.

Table 6. Sources of funding for pollution treatment 1998-2005

Local currency

Year	Total Investment in Pollution Treatment Projects	Government Budgetary Funds	Special Funds for Environmental Protection	Percentage of Public Funds
2005	4,581,900	77,800	206,001	6.2%
2004	3,081,100	137,100	111,313	8.1%
2003	2,218,000	187,521	123,800	14.0%
2002	1,883,663	419,555	67,893	25.9%
2001	1,745,280	363,457	83,245	25.6%
2000	2,393,791	621,841	67,051	28.8%
1999	1,527,307	73,770	50,235	8.1%
1998	1,220,461	106,410	44,940	12.4%

Source: Author compilation based on information from the *Environmental Yearbooks of China 1999-2006*

The technological development and increasing investment in pollution prevention and control are stimulated by a more stringent environmental management system in China. In the 11th Five-Year Plan, the total amount of SO₂ and COD discharge is set to be reduced by 10% by the end of 2010. To reduce SO₂ emissions, the NDRC and MEP worked together to close down highly polluting small power plants and force enterprises to adopt desulphurization technology. Electricity generated by power plants with desulfurization facilities will enjoy a favorable tariff rate of RMB 0.0015 Yuan higher than that produced by power plants without desulphurization facilities. To reduce COD discharge, the MEP has urged the local governments to build wastewater treatment plants and shut down enterprises of certain highly polluting industries such as textile. Comparing with the year of 2005, SO₂ emissions increased by 1.5% in 2006 and decreased by 3.18% in 2007, and COD discharge increased by 1% in 2006 and decreased by 2.18% in 2007. Even though in general, pollution charges are still significantly lower than the cost of pollution reduction, many enterprises adopted low cost pollution treatment technologies. For example, the cement industry and coal-fired power plants witnessed a wide adoption of dust control measures after the introduction of the Measures on Collecting Pollution Discharge 2003 (Amended). However, the Measures failed to provide enough economic incentive for enterprises to invest in expensive pollution control facilities.

Eco-cities: local initiatives to promote innovative environmental solutions

Top-down approaches have traditionally been dominant in China's environmental protection works. The central government often plays a leading role by launching environmental campaigns, issuing policies and passing mandates to local agencies. Meanwhile, innovative ideas and measures adopted by local government in the pursuit of environmental excellence have surfaced in the past few years. The most outstanding case is the eco-city program.

The concept of an eco-city is not new to Chinese people. By 2008, around 60 cities from 22 provinces have announced various plans to build so-called "eco-city" and the number keeps increasing²⁷. It seems that eco-city has become another environmental buzzword that induces local government to experiment in their localities. However, the understanding of how the concept should be implemented is ambiguous. Some projects are completely new construction projects (Shijiazhuang, Chengdu), some are urban planning towards ecological friendly approach (Huizhou, Nanchang), some are entertainment parks (Zibo), and some aim to build an entirely new city with an eco label (Chongming Island).

The rationale for eco-cities

The rationale and driving forces behind the booming eco-city movement are multi-fold: first, it is essentially a reaction from the local level to the central government's call for sustainable development (China first called for the 'Sustainable Development Strategy' in 1992) and ecological civilization (China first called for 'Ecological Civilization' in 2007).

Second, it is also an attempt from the local level to balance the thirst for economic development and the urge for tackling serious environmental problems. While economic development still remains the paramount priority on local official agendas, they also face the strong pressure from both central government and the public to enhance the quality of local environment. How to strike a proper balance between the two seemingly conflicting goals becomes an issue that local governments have to address. Adding an environmental or ecological label to construction projects or urban planning goes in that direction.

Third, the proposition of building an eco-city may sometimes originate partly from the desire to distinguish the locality from others to attract foreign investment and receive preferential financial treatments. As ecological conservation gains wider recognition among various stakeholders, packaging new development projects with environmental considerations is appealing to local residents. The Sino-Singapore eco-city which is located at the Binhai New District, Tianjin, is a good example.

Fourth, some eco-city programs are proposed as pilot project that puts certain ecological ideas into practice in order to tackle urgent environmental and other issues and to present a replicable model for wider application. For instance, in the Dongtan (Shanghai) case, it is claimed that the build-up of an eco-city will illustrate how new city development can provide innovative ways to address issues like food supply, air pollution, water shortage, use of renewable energy, energy security, and climate change. Shanghai Industrial Investment Corporation (SIIC), planners of this project, declare their ambition to make Dongtan the first world's eco-city and to stimulate the sustainable development of other cities in China and the rest of the world.²⁸ Being "carbon-neutral" is the essence of this eco-city

²⁷ Juho Rissanen, Urbanization in China and Eco-city projects, Presentation at Tekes Sustainable Communities Programme: China Seminar. 13 August, 2008.

²⁸ Gordon Feller, First Eco-City Planned for China, 04 January 2007, Sustainable Land Development Today.

project, according to Arup, the British company that was commissioned by SIIC to carry out the design for Dongtan.²⁹

Being carbon-neutral implies that all the power will be generated from renewable energy sources such as wind, solar and biogas from municipal waste, rather than from fossil fuel. The selling point of a carbon-neutral city is that, with regard to the otherwise ambitious criteria used to decide and define what is required for being qualified as an eco-city, a city can claim to be carbon-neutral by proving that its energy is supplied from non-GHG emitting sources.

Basically, most of the current eco-city projects still remain at a planning stage. The necessary infrastructure and expertise, along with sufficient policy support and affordable technology, takes time. Among all the proposed eco-city programs, five projects deserve special attention due to their scale, prominence and uniqueness: Dongtan (Chongming Island, Shanghai); Wanzhuang (Hebei Province); Binhai new district (Tianjin); Changxingdian (Beijing); Guiyang (Guizhou Province). They are briefly described in Annex 1.

Barriers to eco-cities

Building eco-cities, like sustainable development, has made its way into mainstream discussions. Apart from the exciting ideas, the recent practice has revealed the following barriers.

Definitions need to be refined. The current ambiguity in the concept has caused confusion and failure in one so-called eco-village project in China--the Huangbaiyu case.³⁰ The lack of adequate definition may make other localities hesitate to experiment with the eco-city idea. Technologies that are necessary to carry out the ecological function of eco-cities are rarely commercially affordable at the time of planning, which may cast shadow on the feasibility of the program.

In addition, effective policy support, such as financial subsidies or tax preferences, is not always easy to obtain for eco-city projects. It also takes strenuous efforts to secure the huge amount of funds that are needed for implementation.

A case of international cooperation: Clean Development Mechanism

At an international level, China is actively making use of the Clean Development Mechanism (CDM), the market mechanism offered by the Kyoto Protocol to produce mutual economic benefits for both investing and project hosting countries.

It is reported that China is by far the largest source of CDM credits, accounting for more than 40% of those generated to date.³¹ China even has a larger share (52.75%) in the expected average annual CERs (Certified Emission Reduction) from registered projects by host party (up to 10/10/2008).³² Within the CDM credits already obtained, a majority comes from destruction of

²⁹ Peter R. Head & J. Gary Lawrence, 2008, *Urban Development to combat Climate Change: Dongtan eco-city and risk management strategies*.

³⁰ Details about the Huangbaiyu case can be found at BBC, Dejan Sudjic, *Make Cities Work: China*, (retrieved from the web 15 January 2009, available at: <http://news.bbc.co.uk/2/hi/asia-pacific/5084852.stm>).

³¹ Pew Centre on Global Climate Change. 2007.

³² UNFCCC. 2008. (Retrieved from the web 12/10/08 at: <http://cdm.unfccc.int/Statistics/Registration/AmountOfReductRegisteredProjPieChart.html>).

trifluoromethane (HFC₂₃), representing roughly 90% of all the issued CERs.³³ Other key project types involve the capture of methane from landfills and nitrous oxide (N₂O)—both are potent GHG. An increasing number of renewable energy and energy efficiency projects are getting registered in the past two years and is expected to represent a larger share in China's CDM projects.

It is claimed by some researchers that China's dominance in the carbon trading market is partly due to its entrepreneurship in developing CDM projects and also to its relatively low risk investment environment, compared to other host countries.³⁴ As early as 2005, NDRC, along with some other ministries, issued *Measures for Operation and Management of Clean Development Mechanism in China*, which provides policy framework as well as detailed instructions for industry to effectively participate in CDM.³⁵ It is reported that the CDM office under the NDRC has provided clear guidance on eligibility, application and approving procedures, and benefits sharing for registering as a CDM project. And thus potential applicants are better equipped to make a successful registration. The establishment of three carbon trading centres in Beijing Hong Kong and Tianjin in 2008 also provides trading platforms for the carbon credit transactions. All these institutional arrangements have effectively created a friendly investment environment for both overseas investors and domestic enterprises. The CDM project boom then came as no surprise.

However, there also exist barriers for the development of CDM in China. For instance, it is a long procedure for the Executive Board (EB) to pass a methodology for assessing a new type of CDM projects. Therefore, only a small number of CDM projects that registered with NDRC could eventually be approved by EB and create financial benefits for the host enterprises. Most other registered projects will be refused and have no way to recover their financial costs—which are not always small. How to ensure enterprises are not intimidated by the potential loss of their initial investments still remains an issue unsolved. In addition, since most applicants in China normally lack expertise to participate in CDM, they are often placed in a disadvantageous position when negotiating with foreign investors who are usually better equipped with relevant knowledge. As a result, the contract price for CERs tends to be relatively low and core mitigation technology transfer rarely takes place; the intended CER contract price is one of the major criteria for approval by the National Executive Board.

It should also be noted that there are costs involved in international climate change cooperation and the costs may be huge for China. While the CDM projects generate financial income for both industry and government in a short term, they may exhaust relatively low-cost carbon mitigation options available in China. In a long term, China may be left with fewer economically affordable mitigation options when it has to shoulder carbon reduction responsibilities in the future.

Country synthesis

Like the OECD member countries, China has been using various means to support and promote environment-related innovation, including public investment in R&D, mobilizing financing from multiple sources, government procuring environmentally friendly products, adopting prescriptive measures, adopting market-based instruments, awareness raising and capacity building, and acting globally.

³³ Pew Centre on Global Climate Change. 2007.

³⁴ Pew Centre on Global Climate Change. 2007.

³⁵ NDRC. 2005. *Measures for Operation and Management of Clean Development Mechanism in China*. (retrieved from the web 12/10/08 at: <http://cdm.ccchina.gov.cn/english/NewsInfo.asp?NewsId=905>).

Policy mixes are characterised by the strong legacy of the planned economy, as the programmes or plans are the main instruments for addressing policy priorities. They are biased in favour of large, national firms. It is not clear how effective such heritage from the planning culture can be in promoting market-driven innovation.

Eco-innovation policies reflect a broader trend noted in the OECD Innovation Policy Review of China, namely the partial shift from an early reliance on the supply of foreign technology, to boosting investment in science and technology and building a high-performing “enterprise-based innovation system”.

The table below gives a comprehensive review of the policy instruments that have been put in use by the Chinese government to promote environment-related R&D activities, renewable energy, energy efficiency, pollution prevention and control, and circular economy, as well as to construct a better institutional infrastructure for China’s environmental management.

Table 7. Policies to support eco-innovation in China

Public investment in environmental R&D	Chinese Academy of Sciences
	Natural Science Foundation of China
	973 Programme
	Building capacity: CAS Hundred Talents Programme and NSFC National Distinguished Young Scholars Programme
	National Key Laboratories Programme
Mobilizing financing from	Special funds for environmental protection
	National Key Technology R&D Projects
	National New Product Programme
	Torch Programme
	Spark Programme
	Technical Innovation Fund for Small and Medium-sized S & T Firms
Green public procurement	Yangtze River Scholars Programme
	Energy efficiency requirements for public buildings
Prescriptive measures	List of Energy-saving Products in Government Procurement
	Renewable Energy Law (NPC)
	Renewable Energy Power Pricing and Costs Sharing for Trial Implementation (NDRC)
	Technical Standards on Renewable Energy Power Combined to the Grid
	Energy Conservation Law (amended in 2007)
	Energy efficiency standards for energy-intensive products
Market-based instruments	Circular Economy Promotion Law
	Emissions trading
Awareness raising and capacity building	US-China Protocol for Cooperation in the Fields of Energy Efficiency and Renewable Energy Technology Development and Utilization
	Sino-Netherlands Promotion of Rural Renewable Energy (RRE) in Western China
	World Bank Renewable Energy Scale-up Program
	A Thousand Enterprises Program launched by NDRC to improve energy efficiency
	Photovoltaic (PV) School
	Catalogue of Products Adopting Energy Efficiency Labels
	Measures of Environmental Information Disclosure (Trial)
	Setting up indicators and evaluation systems for energy efficiency, pollution reduction, and circular economy
Acting globally	Participating in the global carbon market via CDM

Annex 1. Five major eco-cities in China

Dongtan (Shanghai)

Dongtan, three-quarters the size of Manhattan, is a farming town adjacent to Shanghai. The Dongtan eco-city proposal has received wide media coverage since 2005. Planners claim that they are aiming to build local communities that are not only environmentally friendly, but also socially, economically and culturally sustainable. The eco-city of Dongtan envisions a multi-phase build-up. The proposed eco-city will be home for 30,000 inhabitants in 2010 to 500,000 in 2040 and will consist of three pedestrian-friendly villages. Major works incorporated in the program include: reducing ecological footprints by 64%; achieving integrated urbanism and virtuous cycles ; diversifying energy supply by building combined heat and power plants and using renewables such as wind, solar and biogas; decreasing water consumption by 43% and water pollution discharge by 88% through capturing and purifying water and proper wastewater recycling; producing agricultural yields equal to the loss of productive land required to build the city; achieving zero carbon emissions from energy for vehicles; reducing landfills that damage the environment.

Wanzhuang (Hebei)

The Wanzhuang project is commissioned to the same British company, Arup, which devised the development strategy for Dongtan project. Unlike Dongtan where the local population is small, this eco-city has 15 villages and a local population of 30,000. It is expected that inhabitants would reach 330,000 when the project is completed in 2025. In the development plan that Arup put forward, emphasis of building this new eco-city was placed upon ensuring the highest available standards in energy and water use, protection of natural resources, and promotion of social harmony and a healthy lifestyle. It is also stated that a low-carbon economy featured by clean manufacturing, IT, and modern agriculture would provide valued job opportunities and absorb increasingly skilled local residents. What stands out to be a distinct feature of the Wanzhuang project is that, the "...unique cultural character and heritage, agricultural fibre, and villages of Wanzhuang will not be eroded or lost to urban development, but rather enhanced through sympathetic development". Planners also try to understand the local people. They believe that "...current residents will be empowered by engaging them into modern farming and food production techniques, making the land more productive, strengthening positive links between the urban and the rural, preserving social networks and allowing for the creation of business and social capital."

Binhai (Tianjin)

The Sino-Singapore eco-city project is an attempt of international cooperation for building an environmentally-friendly and resources-conservation city in China. The whole program is to be completed by 2018 and the first stage was started late in 2008. One feature of the project is that, unlike most other eco-city programs that are run by pure local capital, this project was sponsored jointly by the Chinese and Singapore investors and managed by a joint venture corporation formed by both parties. Planners of the project put forward the aim of producing a demonstration city that achieves "three harmony" (SAN HE) and "three can" (SAN NENG). The former refers to the harmony among humans, harmony between social and economic activity and harmony between human and environment; while the latter means the project can be implemented, replicated and promoted. Two other ecological features of Binhai project are: it will not occupy any arable land and it will be located in areas lacking water resources. These two conditions reflect the Chinese government's attempt to

explore new models of industrial development in light of the fact that ecological concern has become too important to be ignored.

Changxindian (Beijing)

The Changxindian eco-city program is a response to the request of achieving sustainable development in Beijing. The project aims to make better use of land and set new models for urban planning in light of promoting circular economy. Like the above proposed eco-cities, planners in Changxindian set the target of largely reducing the dependence on natural resources and the consumption of fossil fuels as well as of putting energy into circular use and taking in more renewables. Innovative features in this project's design include: saving 20% of the land by means of denser inhabitation; smart spatial planning to minimize journeys between home and key destinations such as schools, public transportation hubs and hospitals; reducing CO2 emissions by 50% and water consumption by 20% and increasing reuse of wastewater by 80%; achieving social harmony by devoting 15% of all the residential units to low-income families.

Guiyang (Guizhou Province)

Unlike the eco-city projects in Dongtan, Wanzhuang and Changxindian that are adjacent to large and wealthy cities such as Beijing or Shanghai, Guiyang is the capital city of a much less developed inland province, Guizhou in southwest China. The attempt of Guiyang's striding towards an eco-city goal is different from the above eco-city projects in the sense that it is not aiming to build an entirely new city but tries to make full use of the advantages of an existing city to make it more ecological. Guiyang's effort pays less attention to land use or urban planning, but more to its environmental endowments. Guiyang is rich in natural resources—42 percent of the city is forested and it is called a naturally air conditioned city. The city also won titles of "Forest City" and "Mountain Resort". Other than focusing attention to conventional industrial development, as many other inland cities do in order to boom local economy, Guiyang claims that it will pursue its economic development by marching on the path towards creating an eco-city. It intends to achieve that target by emphasizing tourism, culture, logistics, agriculture and other ecological industries. In effect, the city announced a new index system and a range of new measures to evaluate and supervise the city's ecological condition in 2008. It is expected that the city will receive a large share of increased per capital GDP from ecology-related service sectors.