The Fondazione Eni Enrico Mattei Series on
«Energy Scenarios and Policy»

Edited by Matteo Manera

Energy Governance, Institutions and Policies in China and the EU

A Comparative Assessment

FEEM PRESS

ENGLISH

The Fondazione Eni Enrico Mattei (FEEM) Series on

«Energy Scenarios and Policy»

Fondazione Eni Enrico Mattei

Foreword

The *Energy Scenarios and Policy* FEEM Press series publishes the output of the *Energy Scenarios and Policy* (ESP) research programme of Fondazione Eni Enrico Mattei. The ESP programme aims to carry out interdisciplinary, scientifically sound, prospective and policy-oriented applied research, targeted at political and business decision makers.

This aim is achieved through an integrated quantitative and qualitative analysis of energy scenarios and policies. This innovative and interdisciplinary approach puts together the major factors driving the change in global energy dynamics (i.e. technology, economy, geopolitics and sociological aspects).

The ESP programme applies this methodology to a wide range of issues (energy demand and supply, infrastructures, financing, market analyses, socio-economic impacts of energy policies) that are explored from economic, geopolitical and institutional perspectives.

Fondazione Eni Enrico Mattei (FEEM) is a research institution and a think tank, whose mission is to foster, through studies, research, scientific dissemination, information and training, a better understanding of sustainable development, and to improve the quality of decision-making in public and private spheres. FEEM pursues its mission by promoting excellence, scientific rigor, the value of ideas and innovation in all its activities in collaboration with numerous partners that form an increasingly wide international network.

Fondazione Eni Enrico Mattei
Corso Magenta 63, Milano – Italy
Ph. +39 02.520.36934
Fax. +39 02.520.36946
E-mail: letter@feem.it
www.feem.it

The opinions expressed in this publication are those of the author(s) alone.

ISBN 9788894170146

Publication registered at the Court of Milan, no. 194 of May 16, 2014

Printed in Milan in March 2017 by Roberto Cremonesi.Co Srl

The Fondazione Eni Enrico Mattei (FEEM) Series on

«Energy Scenarios and Policy»

Energy Governance, Institutions and Policies in China and the EU

A Comparative Assessment

Matteo Manera (ed.)

ENGLISH

FEEM PRESS

Contents

Tables

Figures

Contributors

This monograph originates from the collaboration between the Institute of Industrial Economics of the Chinese Academy of Social Sciences (CASS) and the Fondazione Eni Enrico Mattei (FEEM), on the project entitled "China's Energy Management Policies and Measures, and Their International Comparison", within the Sino-Italian Cooperation Program for Environmental Protection.

Although the material presented in this book is the result of a joint research effort between CASS and FEEM, CASS researchers have contributed to sections dedicated to Chinese energy institutions, policies and case studies, whereas the research team at FEEM is responsible for the sections related to EU energy institutions, policies and case studies.

The FEEM and CASS research teams are made up as follows. Affiliations reported below refer to the period of the project.

FEEM research team:

Andrea Bastianin, FEEM and University of Milan, Italy;

Andrea Bigano, FEEM and Euro-Mediterranean Centre on Climate Change, Italy;

Cristina Cattaneo, FEEM, Italy;

Mariaester Cassinelli, FEEM, Italy;

Alessandro Cologni, FEEM and Edison Trading S.p.a., Italy;

Matteo Manera, University of Milan-Bicocca and FEEM, Italy;

Luca Marazzi, FEEM, Italy, Mouseion Limited, UK and Florida International University, US;

Anil Markandya, FEEM, Italy, University of Bath, UK and Basque Centre for Climate Change, Spain;

Roberta Pierfederici, FEEM, Italy and The Institute for Sustainable Development and International Relations, France;

Michele Plotegher, FEEM and Eni S.p.a., Italy

Fabio Sferra, FEEM, Italy and Climate Analytics, Germany

CASS research team:

Jin Bei, Institute of Industrial Economics, CASS, China;
Shi Dan, Department of Energy, Institute of Industrial Economics, CASS, China;
Li Gang, Institute of European Studies, CASS, China;
Liu Jiejiao, Institute of Industrial Economics, CASS, China;
Bai Mei, Institute of Industrial Economics, CASS, China;
Li Ping, Institute of Industrial Economics, CASS, China;
Zhang Qizi, Institute of Industrial Economics, CASS, China;
Zhu Tong, Institute of Industrial Economics, CASS, China;
Chen Xiaodong, Institute of Industrial Economics, CASS, China;
Zhang Xiaodong, Institute of Industrial Economics, CASS, China.

Preface

Matteo Manera

In the fall of 2007 the Institute of Industrial Economics of the Chinese Academy for Social Sciences (CASS), and the Italian Ministry for the Environment, Land and Sea (IMELS) agreed to develop a joint project entitled "China's Energy Management Policies and Measures and Their International Comparison". The motivation for this initiative was fourfold. First, the fast-growing socio-economic and infrastructural development that China was experiencing had put a huge amount of pressure on international energy markets, in terms of energy demand, energy efficiency, resource depletion, pollution production, and greenhouse gas emissions. Second, the Chinese Central Government was about to draft an Energy Law in which energy management would play a crucial role. Third, as a main decision-making consulting institution for China's Central Government, CASS recognized the need to study the energy management experiences in industrialized countries, with particular attention to the European Union's (EU) Member States. Fourth, IMELS acknowledged the importance of tackling China's energy issues as a priority of bilateral cooperation activities, foreseeing the impact and relevance in the international scene of carrying out such a joint study.

Both CASS and IMELS decided to have a group of experts at the Fondazione Eni Enrico Mattei (FEEM) investigate the current status of the EU's energy system, while a team of researchers from CASS focused on China's energy governance, institutions and policies.

This monograph includes a careful selection of the work carried out by the FEEM and CASS research teams, both individually and as a result of their repeated interactions during the entire project.

The book is organized in two intertwined parts, the first dealing with energy institutions and policies, the second with a sizeable number of comparative case studies. More specifically, the first part surveys the main energy institutions and policies in China and the EU, with a focus on environmental protection. The second part discusses some methodological aspects related to the assessment of energy policies and illustrates, for both China and the EU, several specific policies on energy security, energy conservation, environment and energy access. Postgraduate students, researchers, and practitioners with a solid background in energy and environmental economics are the target audience for this book.

Nearly five years have elapsed since the end of the research project, whose results are the basis of this book. For this reason, each of the eight chapters of this text includes a section of updates, where the reader will find revised statistics, as well as references to current literature and fresh internet links to complement the material reported.

Acknowledgments

To L&G

The production of this book would not have been possible without the contribution of a great many people. I am particularly grateful to: Anil Markandya, whose insightful guidance proved to be a constant beacon for me and all the other members of the FEEM research team throughout the project; Francesca Conti, former researcher at FEEM, who re-read the whole manuscript and brilliantly supported me in the activity of collating and rationalizing the research output; Barbara Racah, publications office manager at FEEM, who patiently and constructively assisted me in all the steps which have led to the publication of this monograph.

PART I

Energy Institutions and Policies

1. Energy Institutions

CHINA

1.1. Evolution of the National Energy Regulatory Authority

The Energy Regulatory System (ERS) is perhaps one of the systems within the regulatory regime of China's economy which have been modified most frequently. During the period 1949-2008, the National Energy Regulatory Authority (NERA) changed at least 18 times, while the Government changed only 10 times in 50 years, always in correspondence with the expiration of a five-year term, with the exception of the Cultural Revolution period (1966-1976) (see Figure 1.1 for a summary of the major changes).

The evolution of the NERA since 1949 has been characterized by three different stages: 1) during the period 1949-1979, the Regulatory Authorities in charge of the energy industry (among which coal, electricity and petroleum) underwent several divisions and re-aggregations, but mainly they have played the role of sector regulators; 2) during the period 1980-1998 the Central Government failed to pursue a centralized energy administration; 3) since 1998, China has been putting significant effort into building an ERS which combines specialized and integrated administration.

The Industry-Specialized Energy Administration (1949-1979)

In October 1949, the Administration Council of the Central Government established the Ministry of Fuel Industry (MFI) as a unified regulatory authority for the energy industry. At the inception of the New China, the industries of coal, electricity and petroleum were very small and weak, so it was unnecessary to set up a separate regulatory agency at the ministerial level. Instead, the General Administrations of Coal, Electricity, Petroleum and Water Resource and Power Generation Construction were established under the MFI to administer coal, electricity and petroleum industries, respectively. After the completion of the First Five-Year Plan of the National Economy, the sectors of petroleum, coal and electricity grew very rapidly. In 1955, to boost industrial development, the State Council (SC) abolished the MFI and established three different Ministries of Industry, namely Coal, Petroleum and Electrical Power, with administrative authority highly concentrated in the Central Government.

Subsequently, the Central Government underwent several alternations of organizational expansion and downsizing, during which the Energy Regulatory Authorities were abolished, aggregated and re-established several times. In 1958, during the SC's organizational downsizing reform, the Ministries of Electrical Power and Water Resources industries were merged into the Ministry of Water Resource and Electrical Power. In 1970, the Ministries of Coal, Petroleum and Chemical Industries were merged into the Ministry of Fuel and Chemical Industry. In 1975, the SC abolished the Ministry of Fuel and Chemical Industry and established the Ministries of Coal and of Petroleum and Chemical Industries. In March 1978, the Ministry of Petroleum and Chemical Industry was divided into the Ministry of Petroleum and the Ministry of Chemical Industries. In February 1979, the Ministry of Water Resources and Electrical Power was split into the Ministries of Electrical Power and of Water Resources (Fengqi and Qingyi, 2002).

Integrated Energy Administration (1980-1998)

During in the period 1980-1998, China failed to conduct comprehensive reforms of the ERS. In 1980, China established the National Energy Commission (NEC). The Director General of the NEC was the legendary one-armed general Yu Qiuli, while Vice-Directors General were the Ministers of Petroleum, of Coal and of Water Resource and Electrical Power. The NEC was established against the background of the electricity, oil and coal shortage which followed the decade-long turmoil of the Cultural Revolution. The Central Government intended to strengthen comprehensive energy administration and thus boosted the development of the energy industry and the improvement of energy supply. In 1982, however, the NEC was abolished, essentially for two main reasons: 1) functions and responsibilities of the NEC heavily overlapped those of the State Planning Commission (SPC), which was the most important government agency in the era of planned economy, holding most of the power in national economic administration (among which project approvals and price control); 2) the Ministries of Water Resources, Electrical Power, Petroleum and Coal industries did not have separate government and business functions, and so the NEC became a mere figurehead (Yijian, 2008).

Despite the failure of the first attempt to unify the administration of energy, market-oriented reforms of the energy regulatory system began to emerge under the increasing pressure of the energy shortage.

In 1985, the SC imposed the separation of government and business functions, mandating government organizations to reduce their direct interventions in entrepreneurial activities, and strengthening their macro-control functions. As a result, it was possible to re-establish an integrated energy regulatory authority.

In June 1988, the SC created the Ministry of Energy, which centralized the functions of the former Ministries of Coal, Petroleum, Electrical Power (from the former Ministry of Water Resource and Electrical Power) and of Nuclear industries, in a bid to strengthen macro-management and unified planning. The Ministry of Energy was not directly involved in the management of enterprises. Rather, its main function was to formulate and implement energy development strategies and policies, as well as to provide services for energy enterprises. At the same time, the SC abolished the Ministries of Coal, Petroleum, and Nuclear industries, and established a number of corporations, among which emerge, for importance: the China National Coal Corporation, the Northeast and Inner Mongolia Coal Industry Group Corporation and the China National Local Coalmines Development Corporation, which were responsible for the administration of the coal industry; the China National Petroleum Corporation, and the China National Offshore Oil Corporation, in charge of the exploration and development of onshore oil and gas resources; and the China National Nuclear Industry Corporation. The SC also abolished the Ministry of Water Resource and Electrical Power, and the Ministry of Electrical Power was merged into the Ministry of Energy (Fengqi and Qingyi, 2002).

These state-owned energy Corporations were basically "ministerial level companies" under the direct control of the SC, at the same level with the Ministry of Energy, making it difficult for the Ministry of Energy to carry out effective administration. In particular, the Corporations of the petroleum and nuclear industries were reluctant to accept the leadership and administration of the Ministry of Energy. Meanwhile, the administrative authority of the Ministry of Energy was to some extent weakened, as the authority to approve energy projects still rested within the State Planning Commission. This situation led to the abolition of the Ministry of Energy during the government reshuffle of 1993, and its substitution by the Ministries of Electrical Power and Coal Industries. In 1994, the Northeast and Inner Mongolia Coal Industry Group Corporation and the China National Local Coalmines Development Corporation were also abolished. Since 1980, the attempts to introduce comprehensive reforms of the energy administration system have basically failed, and the energy administration has reverted back to the initial stage of specialized sectors of energy administration (i.e. coal, petroleum and electricity). This regulatory panorama remained unchanged until 1998, when important reforms of government organization were launched.

Energy Administration as a Combined System (1998 onwards)

In March 1998, the SC launched a new round of massive organizational reforms, whose objective was to set up a government administrative system characterized by high efficiency, coordinated operations and standardized behavior of the energy players, an improved public service system, and top-quality specialized administration teams. According to the scheme outlined above, the SC abolished fifteen ministries and commissions, created four new ones, and renamed three others. As a result, the number of departments under the SC, with the exclusion of its General Office, was reduced from 40 to 29.

The Energy Regulatory Authority abolished the Ministries of Coal and of Electrical Power Industries, and re-organized the Ministry of Coal Industry as the State Administration of Coal Industry, under the jurisdiction of the State Economic and Trade Commission. The State Economic and Trade Commission also set up the Department of Electricity, and the State General Administration of Petroleum and Chemical Industry took over the administrative functions of the electricity, oil and gas industries.

In 2000, the SC restructured the existing supervision system of coalmine safety, and established the State Administration of Coalmine Safety, under the "streamlining, unification and efficiency" principle based on the separation between government and business functions. Under vertical leadership, the new administration was actually the same agency as the State Administration of Coal Industry, but under a different name. The State Administration of Coalmine Safety was an administrative and law-enforcing agency, in charge of the supervision of coalmine safety, taking on the supervisory role on coalmine safety of the State Economic and Trade Commission (Xiangfu, 2003).

In 2001, the State Economic and Trade Commission abolished nine State Administrations under its jurisdiction, among which the State Administrations of Coal and of Petroleum and Chemical Industries.

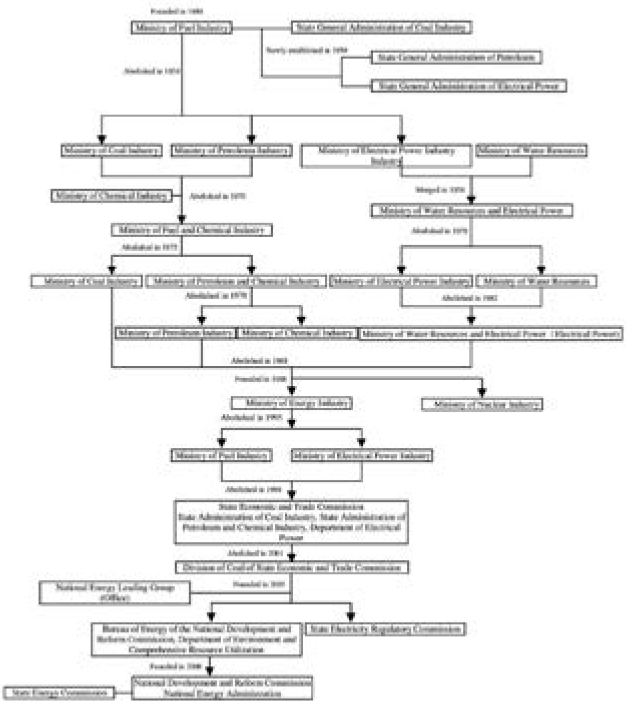
In 2002, the SC issued "Document No.5", which was aimed at conducting market-oriented reforms to break up monopoly and introduce competition in the electricity industry. As a measure associated with the reform of the electricity market, the SC restructured the electricity industry's regulatory system and established a special supervisory agency, the State Electricity Regulatory Commission (Cheng zhang, 2004).

In 2003, the SC decided to strip the State Economic and Trade Commission of its administrative functions related to work safety in the coal, electricity and petroleum industries, and unified those functions in the National Development and Reform Commission. At the same time, the National Development and Reform Commission set up the Bureau of Energy.

In 2005, in view of China's surging energy demand, which underscored the contradictions between supply and demand and the lack of coordination in the development of the energy industry, the Chinese Government strengthened strategic control over energy by establishing the National Energy Leading Group, headed by the Prime Minister and comprising the National Development and Reform Commission, the Ministry of Foreign Affairs, the Commission for Science, Technology and Industry for National Defense, the State-Owned Assets Supervision and Administration, the Ministry of Commerce and the State Electricity Regulatory Commission. As a high-level rule-making and coordinating organization of the energy system at the national level, the National Energy Leading Group provided forward-looking, comprehensive, strategic guidance on crucial matters related to energy planning and policy-making. At the same time, it also set up the Office of the National Energy Leading Group, as its day-to-day administrative body (China's State Council, 2005).

In 2008, China's National Energy Administration (NEA) was established. Previously, the National Development and Reform Commission had acquired, through its Energy Bureau, a broad mandate to manage the energy sector (Growth Analysis, 2014). The National Energy Commission, established in 2010 (Zhiyue, 2010), is a high-level policy-making and coordinating agency, responsible for studying strategies and coping with key issues of national energy security and energy development. The National Energy Administration is mainly responsible for regulating the energy industry and taking over from the National Development and Reform Commission and its subordinate agency, the National Energy Administration, the administrative responsibilities related to the energy industry, as well as the responsibilities of the Office of the National Energy Leading Group and of the Commission of Science, Technology and Industry for National Defense in terms of nuclear power administration[U1].

Figure 1.1
The evolution of China's national energy regulatory authorities (last sixty years)



Source: Research team of the Institute of Quantitative & Technical Economics of CASS: Key Conditions for Setting National Energy Policy, Review of Economic Research, 2006 (No. 36) Issue.

1.2 The Basic Framework of China's Energy Administration

Overview

At present, the framework of the energy regulatory system is in the embryonic form of integrated energy regulatory authorities and specialized regulatory agencies. The national energy regulatory system involves eight government entities, namely the National Energy Commission, the National Energy Administration, the National Development and Reform Commission, the Ministry of Land and Resources, the Ministry of Commerce, the Ministry of Environment, the State Electricity Regulatory Commission[U1] and the State Administration of Coalmine Safety.

The purpose of setting up the National Energy Commission and the National Energy Administration is to strengthen comprehensive administration. The key functions of the National Energy Commission are: to strengthen strategic decision-making and unified coordination on energy issues; to study and work out national energy development strategies; to examine and approve key issues in energy security and energy development. By contrast, the National Energy Administration is primarily responsible for formulating and implementing energy industry plans, industry policies and standards, for the purpose of developing new energy sources and promoting energy conservation.

As the National Energy Commission and the National Energy Administration were recently established, they their immediate job, in their capacity as comprehensive national energy regulatory authorities, has been to coordinate and share tasks with the existing specialized regulatory agencies.

The specialized regulatory authorities include the State Electricity Regulatory Commission[U1] and the State Administration of Coalmine Safety. However, the power of comprehensive regulatory authorities will be further strengthened, along with the responsibilities or functions shared between specialized regulatory agencies and comprehensive energy regulatory authorities. Meanwhile, there does not exist any specialized regulatory agency in the oil and gas industry.

The National Development and Reform Commission, and the Ministries of Land and Resources, of Commerce and of the Environment are involved, to different degrees, in every aspect of energy administration.

The Oil and Gas Industry Regulatory System

The Central Government has maintained more stringent control over the oil and gas industry than over the industry of coal and electricity. Even when the Ministry of Petroleum Industry was abolished, the Government still severely restricted entry into the oil and gas industry. At present, China's petroleum industry is mainly administered or regulated by the National Development and Reform Commission, and the Ministries of Commerce and of Land and Resources, which also formulate the government policies related to the petroleum industry. When the National Energy Administration was established in 2008, the National

Development and Reform Commission transferred its regulatory functions for the oil and gas industry to the National Energy Administration .

In this section, we attempt to discuss industry regulatory issues with respect to each link of the petroleum industry chain, ranging from oil exploration and mining, oil refining, oil and oil product import and export to domestic sales and transportation.

Exploration and Mining. At present, China, through its Ministry of Land and Resources, subjects oil and gas exploration rights and mining rights to a licensing system. The Ministry of Land and Resources is granted the power to administer and regulate oil and gas exploration and development by and in accordance with the Mineral Resources Law enacted by the National People's Congress in 1987 and amended twice in 1996 and 1998, the Administrative Measures for Mineral Resources Prospecting Area Registration promulgated by the State Council in 1998, the Administrative Measures for Mineral Resources Mining Registration, and the Administrative Measures for the Transfer of Exploration Rights and Mining Rights.

According to the foregoing laws and regulations, an enterprise can enter the oil and gas resources prospecting and mining sector, regardless of the ownership nature of the enterprise, only after having received approval from the State Council. Oil and gas prospecting and mining are subject to class 1 state administration; the only way an enterprise can conduct oil and gas prospecting and mining is to file an application to the Ministry of Land and Resources; if the application is approved, the Ministry of Land and Resources will issue an oil and gas prospecting license and mining license; the prospecting license remains effective for up to 7 years but can be renewed for 2 more years after the expiry of the original term if approved by the approval authority; in the event of applying for rolling exploration rights, the applicant can obtain a rolling development mining license valid for up to 15 years (Sanyong, 2006). License issuance is subject to regulatory approval.

Oil Refining. Administering the oil refining industry mainly involves the National Development and Reform Commission and the Ministry of Commerce (the former State Economic and Trade Commission). At present, China regulates the oil refining industry in accordance with "The Opinions on Straightening out and Rectifying Small Refineries and Standardizing Crude Oil and Oil Product Circulation Order (Document No.38)" promulgated by 8 ministries and commissions, among which the State Economic and Trade Commission, and reissued by the General Office of the State Council in 1999 as well as by the Medium and Long-Term Development Plan for the Refining Industry released through the National Development and Reform Commission in March 2006.

"Document No.38" emphasizes government control over primary crude oil processing capacity, imposes stringent control over the plan for allocating crude oil produced at home or imported, and requires centralized oil products wholesale: no crude oil will be allocated to any refinery not approved by the State, any local refinery that has been approved will be subject to restrictive crude oil supply, and producing oil products in the name of fuel oil import or bitumen processing is prohibited; the refineries affiliated with the two major State oil companies are encouraged to process imported crude oil; all oil products (gasoline, kerosene and diesel) produced by any domestic refinery shall be marketed or sold by the wholesale enterprises of the China National Petroleum Corporation and the China Petroleum & Chemical Corporation, and no refinery is allowed to sell oil products on its own. The Medium and Long-Term Development Plan for the Refining Industry states that "The single-line capacity of each new refinery project shall, in principle, reach over 8 million tons per annum; in the case of any Sino-foreign JV refinery project, the foreign investor must possess advanced technology or raw materials supply capability, and the Chinese shareholder shall retain relative control over the JV project.

Oil Circulation. Oil circulation includes oil storage, crude wholesale oil and oil products and retail oil products. The oil circulation industry administration is mainly related to the Ministry of Commerce. In the past, this administration was mainly based on "Document No.38" issued by the State Council in 1998. According to its commitments on accession into the WTO, China should open or deregulate the oil retail market three years after accession into the WTO, and open and deregulate the wholesale market five years after accession into the WTO. At present, the oil circulation industry is administered and regulated in accordance with Crude Oil Market Administrative Measures and Oil Product Market Administrative Measures promulgated by the Ministry of Commerce, which became effective on January 1, 2007.

Crude oil sales and storage. With the fifth anniversary of China's accession into the WTO, the Ministry of Commerce promulgated, on December 4, 2006, Crude Oil Market Administrative Measures prescribing that the state subjects crude oil operating activities to a licensing system.

An enterprise applying for a crude oil sales license must be a mining enterprise that has received the Petroleum Mining License approved by the State Council and has produced crude oil each year, or an import enterprise that imports at least 500,000 metric tons of oil per annum, or an enterprise that enters into a crude oil supply agreement with the aforesaid enterprise for a quantity commensurate with its operating scale for at least one year; in addition, it shall have a crude oil depot with a storage capacity of no less than 200,000 cubic meters.

An enterprise applying for a crude oil storage license shall have a crude oil depot with a storage capacity of no less than 500,000 cubic meters and a crude oil transmission pipeline or special railway line or a crude oil water transport terminal with a capacity of at least 50,000 tons.

Wholesale oil products. The Oil Product Market Administrative Measures effective since January 1, 2007 require that "Enterprises that apply for qualifications of wholesale processed oil operation shall comply with the following conditions: (1) have a long-term, steady supply channel of processed oil (in compliance with one of the following conditions); 1. have oil refining enterprises that comply with the State's industrial policy and have a one-time crude oil processing capacity above 1 million tons, with an annual output of gas oil and diesel oil that complies with the national product quality standard above 0.5 million; or 2. enterprises with processed oil import qualifications; or 3. have processed oil supply agreement with enterprises that have wholesale qualifications of processed oil and the business volume is more than 0.2 million tons for at least one year; or 4. have a processed oil supply agreement with enterprises that have an import volume of more than 0.1 million; (2) the applying body shall have the qualification of a Chinese legal entity with registered capital of no less than 10 million RMB; (3) in case the applying body is a branch of a Chinese legal entity, the legal entity shall have qualifications for the wholesale processing of oil; (4) have a processed oil depot with a capacity of no less than 10,000 cubic meters, the construction of which shall comply with the overall urban-rural program and the oil depot arrangement program, and shall be checked and accepted by departments as land resources, planning construction, safety supervision, public security and fire protection, environmental protection, meteorology and quality supervision; (5) have facilities such as conveyor pipes, occupation railway line, vehicular highways or a water carriage dock that can deal with 10 thousand tons of processed oil" (MOFCOM, 2006).

Oil products retail. According to China's commitment on opening the oil product retail market three years after accession into the WTO, the Ministry of Commerce promulgated the Interim Administrative Measures for Oil Product Market on December 12, 2004. Compared with the interim measures issued two years before, the Oil Product Market Administrative Measures relaxed conditions for enterprises applying for an oil product retail license. A key condition was that "the applicant enterprise shall enter into an oil product supply agreement (for at least three years and with a quantity commensurate with its operational scale) with an enterprise possessing an oil products wholesale license", but there is no restriction on the number of service stations possessed. As regards the entry of foreign invested enterprises into the oil products retail area, such administrative measures prescribe that a foreign investor is not allowed to possess controlling interests if said foreign investor undertakes oil product retail operation in the territory of P.R. China and has 30 or more service stations with different types and brands of oil products sourced from multiple suppliers.

Crude Oil and Oil Product Imports. Crude oil and oil product import has long been under state control, with the government controlling the total import quantity and scheduling import tonnage in a unified way. At the same time, non-state-owned trade enterprises are allowed to import a small amount of oil.

Crude oil imports by state-owned trade companies are subject to automatic import license administration and zero import customs duty. Crude oil imports by non-state-owned enterprises are allowed to grow 15 % per year. To apply for a non-state crude oil trade quota, a non-state-owned enterprise must have rights to use river cargo for crude oil shipping with a capacity of no less than 50,000 tons (or a railway port with an annual reloading capacity of 2 million tons) and a crude oil tank with a storage capacity of no less than 200,000 cubic meters.

Crude Oil and Oil Product Price. China's crude oil and oil products price is regulated by the National Development and Reform Commission. The present basis of oil pricing is "The Crude Oil and oil Product Price Reform Scheme" released and enforced by the former State Planning Commission in June 1998" and "The Circular of the State Planning Commission on the Methods of Improving Oil Price Convergence and Adjusting Oil Product Price" issued and implemented in October 2001.

These regulations prescribe that the price of crude oil shall be determined via consultation by the buyer and seller, based on the costs of domestic onshore crude oil arriving at refineries and the costs of imported crude oil delivered to refineries. Therefore, China's crude oil price was made to converge with the international market price in 1998.

The international price of oil has been rising since the second half of 2003. As a result, China has gradually departed from this oil products pricing mechanism and has instead elected to adjust the price of oil products on an irregular and piecemeal basis, according to such factors as the overall national economic development situation and the social affordability for the price of oil, with the result that a widening gap has formed between the domestic price of oil and its international market price. As the crude oil pricing method remains unchanged, the state treasury offered huge subsidies to China Petroleum & Chemical Corporation consecutively in 2005 and 2006 because it processed a large amount of imported crude oil.

In this circumstance, the National Development and Reform Commission began, in 2007, to adopt the product pricing system of "crude oil plus cost", under which the domestic benchmark retail prices for oil products are calculated by adding refining costs and reasonable profit margins as well as domestic customs duty and oil products marketing fees to the mean benchmark crude oil price of Brent, Dubai and Minas crude oil. The new mechanism departed from the previous method of benchmarking price of domestic oil products against the weighted average of oil products in New York, Singapore and Rotterdam since 2001[U2].

Coal Industry Administration System

China has frequently restructured its coal industry's regulatory regime, with the continually establishing and then abolishing its regulatory authority (the Ministry of Coal Industry). At present, the coal industry's regulatory regime has separated government from business functions; since 2002, China has allowed the price of coal to be determined by market forces, and established a specialized administration for overseeing coalmine safety. At present, the coal industry's administrative and supervisory functions mainly involve the National Development and Reform Commission, the State Administration of Coalmine Safety and the Ministry of Land and Resources. In this section, we attempt to introduce the energy industry's administration system and policy from the industrial perspective. As far as the coal industry is concerned, it is mainly involved in administering coal resources, safety and import/export.

Coal Resources. According to the Coal Law of the P.R. which China enacted and implemented in 1996, coal resources are owned by the state; the state subjects coal development to unified planning, reasonable layout and comprehensive utilization; an operating coalmine requires must obtain a mining license and a production license, must comply with coalmine mining standards, and must reach the mandatory coal resources recovery rate (Fengqi and Qingyi, 2002).

The coal resources regulatory authority is the Ministry of Land and Resources, which is responsible for administering coal prospecting and mining rights; the examination, approval and issuance of coal exploration and mining licenses; the approval of coal prospecting, mining and land usage rights; and the annual review of mining licenses (Zhong, Mei, Gong, Bian and Wei, 2007).

Unlike oil and gas resources, the prospecting and mining of coal resources are subject to the dual registration administration system at the state and provincial levels. As provided in "Document No. 200" (2005) of the Ministry of Land and Resources, for each coal prospecting block or project with an area of 30 or more square kilometers, the prospecting license should be issued by the Ministry of Land and Resources; for other projects, the land resources regulatory authority of the people's government at the provincial level is authorized to issue the prospecting license. Where coal mine or field reserves are equal to or greater than 100 million metric tons, among which coking coal mine or field reserves of at least 50 million metric tons, the mining license shall be issued by the Ministry of Land and Resources; for other coal mines or fields, the land resources regulatory authority of the people's government at the provincial level is authorized to issue mining licenses (CMLR, 2005).

Coal Safety. The State Administration of Coalmine Safety is responsible for coal safety. The State Administration of Coalmine Safety was established to separate the supervision of coal safety from that of production, as an important move to restructure China's coal industry regulatory regime. At present, China has set up a vertical system for supervising coalmine safety. As a law enforcement agency overseeing coalmine safety, the State Administration of Coalmine Safety assumes the supervisory functions granted by the State Council. The provincial administration of coalmine safety was set up in each of the key coal producing provinces (autonomous regions and municipalities) to serve as a regulatory agency directly reporting to the State Administration of Coalmine Safety and carrying out supervisory responsibilities; the provincial administration of coalmine safety set up an office in each of the middle- and large-sized mining areas.

"The Opinions of the General Office of the State Council on Relevant Issues Concerning Strengthening Administration of the Coal Industry" were issued in July 2006 for the purpose of transferring five industry regulatory functions from the National Development and Reform Commission to the State Administration of Work Safety and the State Administration of Coalmine Safety. The five functions include: transferring the coal industry's standard-setting function from the National Development and Reform Commission to the State Administration of Coalmine Safety; and transferring the administrative function for issuing mine manager qualification certificates to the State Administration of Coalmine Safety. The State Administration of Coalmine Safety shall work with the National Development and Reform Commission to guide and supervise the ratification of coalmine production capacity and coalmine rectification and closure; to render opinions on coalmine construction projects subject to approval by the National Development and Reform Commission, and to conduct safety appraisal; to provide review opinions for renovating key state-owned technology for coalmine safety and gas treatment/utilization projects submitted by each province (autonomous region and municipality); to offer guidance for local government supervision of its related coal industry, in relation to coalmine enterprise safety. The oversight power of the State Administration of Coalmine Safety has been further strengthened.

Coal Imports and Exports. China subjects coal import and export to state control. State-owned trade enterprises licensed to conduct coal import and export can apply for coal export quotas. From November 1st to 15th of each year the National Development and Reform Commission accepts applications from coal export enterprises for coal export quotas for the next year. Coal export quotas are allocated by the National Development and Reform Commission in consultation with the Ministry of Commerce. Prior to December 15th of each year the National Development and Reform Commission works together with the Ministry of Commerce to issue to trade enterprises 80% of the next year's total coal export quota; the remaining portion shall be issued no later than June 30th of each year (NDRC, 2004). At present, there are only four licensed coal export enterprises: China National Coal Import and Export Group Corporation, China Minmetals Import and Export Corporation, Shanxi Coal Import and Export Corporation, and Shenhua Group.

Administrative System of the Electricity Industry

Compared with the coal, oil and gas industries' regulatory regime, the electricity industry's regulatory system has been basically streamlined. Except for the project approval on electricity investment and electricity price, or the tariff approval authority still resting with the National Development and Reform Commission, any other supervisory power related to the administration of the electricity industry rests with the State Electricity Regulatory Commission[U1], founded in 2002.

The State Electricity Regulatory Commission is a government institution directly under the control of the State Council, and it functions as a specialized regulatory authority overseeing the electricity industry. The key mission of the State Electricity Regulatory Commission is to ensure a safe, stable operation of the electricity system; to maintain order in the electricity market; to protect the legitimate interests of investors, operators and users, as well as the public interests of society; to follow the Central Government's principles on electricity policy; and to promote the healthy development of the electricity industry.

In accordance with such laws and regulations as the Regulations on Electricity Supervision and Control and the Renewable Energy Law, the responsibilities of the State Electricity Regulatory Commission include: formulating and publishing the rules and regulations on electricity supervision within the scope of authority pursuant to the applicable laws and regulations, administrative statutes and the Regulations on Electricity Supervision and Control; promulgating and administering electricity business licenses pursuant to the applicable laws and the State Council statutes; exercising supervision and control over the share of power generation enterprises on the electricity market; supervising regulatory compliance in respect of power plant incorporation into power network (grid), power grid interconnection, and power plant versus power grid coordination; conducting supervision over the fair and nondiscriminatory opening up of the electricity market to electricity trading parties; supervising the quality of electrical power and power supply service; supervising electricity safety; supervising electricity prices or tariffs; checking and supervising performance by electricity enterprises in terms of their obligations for renewable energy power generation (NDRC, 2004).

At present, the State Electricity Regulatory Commission has 6 regional offices in North China, Northeast China, Northwest China, East China, Central China and South China; and 11 provincial offices in Taiyuan, Jinan, Lanzhou, Hangzhou, Nanjing, Fuzhou, Zhengzhou, Changsha, Chengdu, Kunming and Guiyang.

EUROPEAN UNION

1.3 Energy Management Agencies[2]

Organizational Structure

The organization of the energy agencies is not centralized, each agency being autonomous, and there is not necessarily any coordination between the various administrative levels.

On the basis of the geographical area of intervention the following kinds of agencies are identified: 1) Supranational: Transnational Energy Agencies and International Networks; 2) National: National Energy Agencies and Energy Agency Associations; 3) Sub-national: Regional and Local Energy Agencies.

Transnational Energy Agencies. Two kinds of transnational energy agencies operate on European territory: the International Energy Agency (IEA) and the Basel Agency for Sustainable Energy (BASE).

The International Energy Agency (IEA, n.d.) acts as energy policy advisor to 27 member countries in their effort to ensure reliable, affordable, clean energy for their citizens; the IEA is an autonomous agency linked to the OECD. Its mandate incorporates the "Three E's" of balanced energy policy making: Energy security, Economic development and Environmental protection. Current work focuses on climate change policies, market reform, energy technology collaboration and outreach to the rest of the world, especially major consumers and producers of energy such as China, India, Russia and the OPEC countries. The IEA conducts a broad programme of energy research, data compilation, publications and public dissemination of the latest energy policy analysis and recommendations on good practices. Among the 27 member countries[U3] several are extra-European countries, such as the United States, Canada and Japan.

The Basel Agency for Sustainable Energy (BASE, n.d.) is a non-profit foundation and UNEP Collaborating Centre (United Nations Environment Programme). It works to promote increased finance sector engagement in sustainable energy in both developing and industrialized countries. BASE develops forward-looking mechanisms to accelerate the financing of sustainable energy markets, with the ultimate aim of contributing globally to climate change and poverty mitigation, conflict prevention and sustainable development.

International Networks of Energy Agencies and Energy Agency Associations. The energy agencies enjoy particular advantages from being part of a network. At the European level several networks are active which are either dedicated to energy agencies or have a substantial number of energy agencies as members. One can cite notably the following ones: 1) Energy-Cities: focused on energy management in urban areas; 2) FEDARENE (European Federation of Regional Energy and

Environment Agencies): focused on energy and environment agencies working at the regional or provincial level; 3) Isle Net: is the network of European Island Authorities which promotes sustainable and efficient energy and environmental management.

These networks are very much present in most of the European Member States in cooperating with and assisting local authorities in the design of energy and environmental policies at their territorial level. These networks facilitate the development of partnerships between their members, thereby encouraging the exchange of experience and the transfer of know-how and technology. The networks give advice on relevant European programmes and funding possibilities. They assist in the formulation of project proposals and the creation of partnerships.

One of the key advantages indicated by the Energy Agency (EA) is the possibility of having easier access to the setup and involvement in European projects. Another major motivation for membership is the exchange with similar organisations in other countries: what one can learn in a positive way from the others and what mistakes should be avoided.

The functioning of these networks is to a great extent financed by membership fees.

Regarding energy association, Local and Regional Energy Agencies can join a national partnership. The Energy Agency Associations are formally established in some cases or purely informally in others. Still, there is uncertainty about their main role: lobbying at the national level, providing services and opportunities for exchange, streamlining information to EAs, and it appears that the potential of these networks has yet to be fully realised. Overlap between the role of the association and the national energy agency is identified in cases where the latter is proactive in networking with local groups.

Local and Regional Energy Agencies. Local and regional energy agencies support the transition to more sustainable energy systems. They spread management practices, provide informational guidance, and offer a range of services based on specific, local needs.

Since 2004 more than 60 new energy agencies have been set up with the support of Intelligent Energy Europe (IEE). They add to about 200 agencies set up under SAVE II, the predecessor of the IEE programme[U4].

Figure 1.2
Energy agencies under IEE (2004)

Source: http://ec.europa.eu/energy/intelligent/agencies/index_en.htm.

The SAVE II (Managenergy, n.d.c) initiative incorporated community action on regional and urban energy management. The aim was to stimulate a 'bottom up' approach to energy management by encouraging local and regional action for energy efficiency, the use of local energy resources and the creation of optimum energy-supply conditions at the local level. To achieve this aim, SAVE II part-funded the collaborative creation of autonomous Energy Management Agencies at the local and regional level, establishing networks to disseminate information to local and regional authorities throughout with the help of FEDARENE, ENERGIE-CITE and ISLENET.

The Intelligent Energy Europe (DG TREN, 2006) programme (Figure 1.2)[U5] is the main Community instrument for non-technological support in the field of energy. Its approach addresses the market barriers that still exist to an efficient use of energy and an increased use of new and renewable energies.

It also contains a strong emphasis on raising awareness amongst those key organisations and individuals who are central to achieving the wider objective, that of accelerating the adoption of energy efficiency measures and the greater use of clean and renewable energy, in particular at the regional and local levels. The IEE programme supports the establishment of new regional or local energy agencies in order to help public authorities, and the communities which they serve, to improve their energy efficiency and to make the most of renewable energy resources (often locally based), thereby contributing to sustainable development (in economic, social and environmental terms), in line with EU policy objectives. Under the IEE Programme 2003-2006, the creation of these agencies was supported with funding from the European Commission. The creation of new agencies will be funded under IEE2 (2007-2013).

Local and regional energy Agencies, established with Community support, should be independent organisations operating on a “not-for-profit” basis, providing a public service, in particular energy advisory services (information, assistance and awareness-raising, training, etc.) for local decision-makers in both the public and private sectors, as well as for householders and individual citizens (Figure 1.3). Agencies may also help local and regional authorities and businesses to formulate energy plans and strategies, and make possible or enhance the ability of local decision-makers to take appropriate decisions on setting up and monitoring energy projects.

The proposal to create a new agency must be submitted by a regional or local public authority based in a country which is eligible to participate in the IEE programme. The proposer must be committed to the creation of a new energy agency within its geographical area of responsibility.

Other stakeholders may support the establishment of a new agency, for example by providing budget funds , free technical assistance, scientific or legal advice or political support. Universities, technical institutes or consultants may contribute to the work of the agency, for example by serving on an advisory board or by working for the agency as sub-contractors.

This link is often not clear and/or not formalized – with many implications: they may act in competition, or waste time developing the same initiatives. National agencies in some cases receive national government funding but do not pass any on to local initiatives (while other national agencies successfully manage funding programmes for local work). National agencies in some cases or on some topics act as ‘programme managers’ and not practitioners, and may have civil service type skills rather than technical or communications skills. Others have technical knowledge which may not be made available effectively to local agencies which are the practitioners. Some regional and local agencies have no formal interrelationship (consequently losing credibility with both LA and other partners), while at the other extreme some have complex and time-consuming structures in an attempt to deal with these issues.

Overview of the Regional and Local Energy Agencies

Identifying the main features of the EAs and evaluating their outputs, performances and future perspectives was the objective of a study carried out in

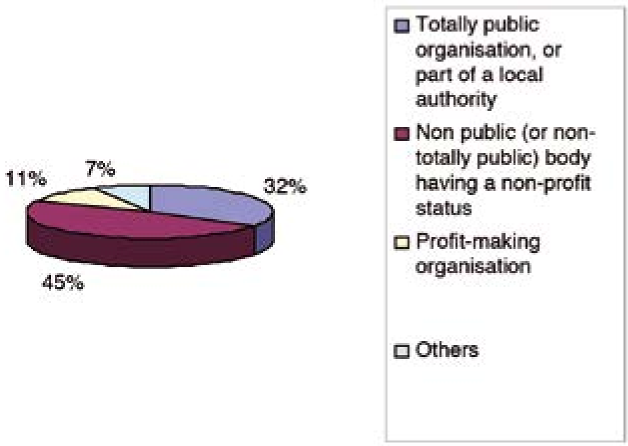
2007 for the European Union Sustainable Energy Week (EUSEW)[DG TREN, 2007]. In order to significantly investigate the current state of the EAs, a statistical analysis of a broad sample of regional and local energy agencies was carried out in 19 Member States.

The report showed that, among the various activities accomplished by the EAs,the most frequently developed tasks were: 1) sustainable energy information and advice to the general public; 2) development of RES projects (action planning, feasibility studies, design, work supervision, tender document drafting, or supply of services/energy); 3) building energy advice, auditing, certification.

Several EAs are carrying out activities, such as information and awareness-raising campaigns, targeted information, and training about new and efficient technologies, in a non-commercial form (using the yearly general contribution of their members), but most EAs also perform commercial activities by selling services very much as private consultants, planners and ESCOs (Energy Service Companies) do. This mix of activity types, although common practice for EAs, sometimes engenders objections about the "fairness" of the EA as free market competitors.

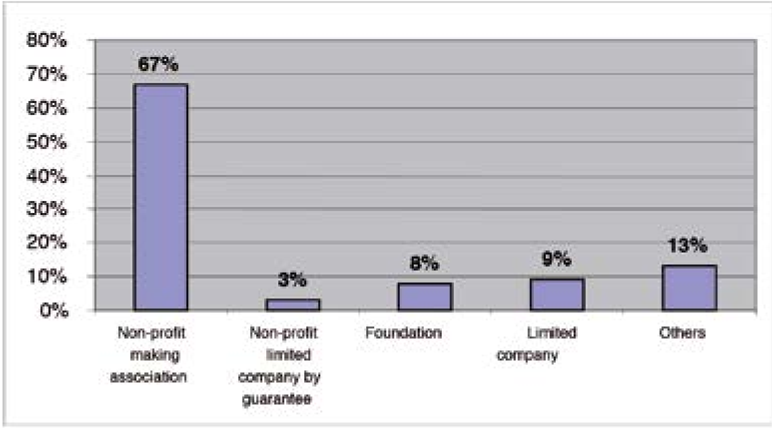
The juridical status of the agencies (Figure 1.4) appears prevalently oriented towards the public and non-profit sector.

Figure 1.3
Type of organization of the regional and local energy agencies



Source: http://ec.europa.eu/energy/intelligent/agencies/index_en.htm.

Figure 1.4
Juridical status of the analysed agencies



Source: Authors' calculation on Ecuba data.

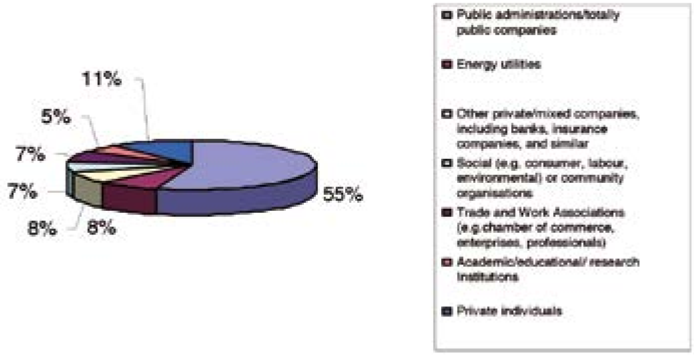
A close partnership with Local Authorities implies strong public control over the agency's management, with a consequent loss of decision-making freedom, an essential requirement for the successful development of the EA. On the other hand, the link to LAs assures financial stability, since LAs are typically the main clients of the energy agencies.

Therefore the key to success for regional and local energy agencies is in maintaining a good relationship with their respective Public Administrations. Most EAs confirm that the main reason for their existence is to provide effective support and services to LAs. At the local level the energy agencies have a 3-year period to demonstrate that the spending of public monies for implementing public energy policies is useful and indispensable. This is the major challenge to tackle. In justifying the spending of public funds it is important to give a precise description of the activities to be carried out and their impact on social well-being.

The EA should operate in contact with different city departments; the most relevant are typically environment, buildings, housing, tourism, transport/traffic, planning and education.

Membership in EA management boards is generally broad, and includes partners who will cooperate in networking with the EA. The board is usually controlled by the Local Administration, but a relevant share of control is held by private individuals and, to a lesser degree, by companies operating in the financial sector and trade associations, as shown in Figure 1.5.

Figure 1.5
Approximate percentage of voting power within the board



Source: Authors' calculation on Ecuba data.

Agency ownership has repercussions on the financing of its activities. A general EA complaint is about the lack of finances for performing routine work. Some organisations focus mainly on large industrial, service and municipality clients, while others prefer general public and smaller energy users, such as small and medium enterprises.

Focusing on the general public and small businesses provides a large potential audience and target group, but has the disadvantage of clients' general inability or unwillingness to finance special projects and consultations. General government-level subsidies are typically required in order to secure stable services for such clients.

Focusing on large energy users can be more practical in terms of securing financial independence; on the other hand it does not provide long-term financial stability and a secure perspective.

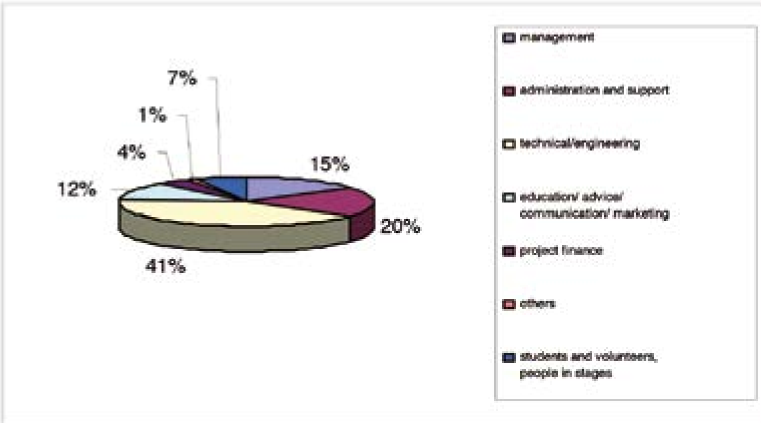
If organisations receive general and regular subsidies, their income may be stable but it is dependent on the political decisions of the central government. On the other hand, if most of the income is obtained from a variety of projects, this enables the organisation to be independent in its decision-making. At the same time, this does not provide long-term financial stability, and limits the organization's ability to work on strategic and global-level policy documents, in collaboration with the LAs.

Some agencies face a lack of project orders from the public sector and rely on private industry to pay for their services.

Several EAs expressed concerns about their financial structure: either too dependent upon a single client (such as the local Municipality), or relying mostly on EU projects (with inherent risks and cash flow problems, and possibly a reduced contact with the local reality). There is a general consensus amongst the EAs that a key strategy is to diversify clients (by different departments of the same administration, different public administrations, mix of public and private clients, and if possible a mix of local, national and European funding programmes). Having multiple clients is a good indicator of flexibility and adaptation to varying conditions, and therefore of stable performance.

Since most of the organizations are small in number of employees, their skills, as well as the managerial skills of the directors, are crucially important. An element of success is the availability of precise and qualified skills within the agency, of a technical, organisational, and communicative nature. As shown in Figure 1.6, the staff is made up prevalently of technical and engineering personnel, coordinated by managers and administrators.

Figure 1.6
Approximate number of full time equivalent staff categories



Source: Authors' calculation on Ecuba data.

Agency aims, as initially established, are effectively political and strategic – not market led. There appears to be a split into two types of surviving agencies: those that continue as environmental pioneers with local government support (typically very small), and those that develop a market niche and are successful as non-profit entrepreneurs. The focus of most EAs is on municipalities – to try to involve them as much as possible in the work in energy efficiency and RES.

Energy agencies must design their own strategy in order to tackle local competition. The most threatening competitors are the private consultants. This may be because of Las' finding it easier to assign small services to individuals rather than to organisations. Engineering companies and public organisations come second and third.

The threats that carry the highest risk to the survival of the agencies come from changes in administration policy, closely followed by a lack of clients' energy resources and change of political majority.

1.4. The Management Mechanism of Energy Industries

During the 1990s the European Union, together with the national governments of the Member States, decided to gradually open inefficient monopolised energy markets to competition. The liberalisation of the European internal energy market sought to increase efficiency in the production, transmission and distribution of energy. Its further aim was to reinforce security of supply and the competitiveness of the European economy whilst respecting environmental protection. The EU has clearly recognised that a functional and competitive internal energy market is essential for ensuring fair prices to citizens and industries. It also ensures that smaller companies have access to the energy grid. A well-functioning market provides incentives for investments in power plants and transmission networks to avoid interruptions in power or gas supply.

Electricity Industry[3]

In the European Union, policy making is aimed at creating an internal market for electricity. EU policy is implemented in two main ways: through sector-specific legislation and via the application of the EU competition rules. In addition, there is a draft of other EU legislation which has a bearing on, but is not specific to, the liberalisation of the sector (state aid rules, public procurement rules, the rules relating to the free movement of goods, services, persons and capital etc.).

At the EU level, it is the European Commission which is responsible for setting competition policy and for enforcing the competition rules (in partnership with the national authorities of the Member States), under the supervision of the Court of First Instance, the European Court of Justice, and national judicial authorities.

Competition in the EU as far as the electricity market is concerned is now regulated by Directive 2003/54/EC[U6] directed at boosting the liberalisation process.

Pursuant to the Electricity Directive, monopoly rights for the generation of electrical power have been abolished in the Member States.

The Acceleration Directive provides for the appointment of (one or more) transmission system operators (TSOs) in each Member State, responsible for the operation, maintenance, development (as appropriate) and interconnection of the transmission system with other systems.

A TSO can be a vertically integrated company. However, in this case, the TSO must be independent, in terms of its legal form, organisation and decision-making, from other parts of the company that are engaged in production, supply or distribution activities (so-called 'legal unbundling'). The TSO must have effective decision-making powers over assets necessary to operate, maintain or develop the network, although the parent company may retain appropriate rights of financial supervision. Integrated companies must also keep separate accounts for their production, transmission and distribution activities ('accounting unbundling'). There is, however, no obligation to separate ownership of assets of the transmission system from the vertically integrated undertaking ('structural unbundling'), and the Acceleration Directive explicitly provides for the possibility of a combined transmission and distribution system operator.

Distribution is defined as the transport of electricity on high-voltage, medium-voltage and low-voltage systems ('distribution systems'), with a view to its delivery to customers, but not including supply.

The Acceleration Directive provides for the appointment of a distribution system operator (DSO) for each distribution system in the Member States, responsible for operation, maintenance, development (as appropriate) and interconnection of the distribution system in a given area. A DSO can be a vertically integrated company. As with TSOs, the Acceleration Directive requires a DSO to be independent, in terms of its legal form, organisation and decision-making from other activities not relating to distribution.

The Acceleration Directive had fully liberalized national electricity markets in accordance with the following timetable: 1) from July 1, 2004, all non-household users should be free to choose their supplier (unless an exemption is granted to a Member State); 2) from July 1, 2007, household customers have also been free to choose their supplier.

Member States may require TSOs to give priority to generating installations using renewable energy sources or waste, or to those producing combined heat and power. Member States may also, for reasons of security of supply, require that TSOs give priority to installations using indigenous primary energy fuel sources, subject to certain quantitative restrictions. The Directive obliged Member States to set up, by October 27, 2003, a system ensuring that the origin of electricity produced from renewable energy sources can be guaranteed ('the green certificate system'). Member States must also ensure that TSOs and DSOs guarantee the transport of green electricity, and may be obliged to provide such electricity with priority access.

Regulation of Electricity Utilities. In order to operate a transmission network in the EU, an undertaking must have been appointed as a TSO by a Member State or a network owner. It is within the discretion of each Member State to determine freely the period for which a TSO is appointed and the other terms of its appointment, taking into account economic and efficiency considerations. Access to the distribution grid is organised in the same manner as access to the transmission grid.

There is no EU-wide entity which is responsible for ensuring the reliability of transmission grids in Europe. However, the TSOs from across Europe meet both generally in the Association of European Transmission System Operators (ETSO)[U7] and often in smaller (regional) groupings to discuss best practice. The Acceleration Directive requires Member States to monitor the security of supply in their respective states. This involves the monitoring of expected demand and envisaged capacity, the quality and level of maintenance of networks, and also measures taken to cover peak demand and shortfalls. Member States are required to publish a report on this monitoring every two years and to forward it to the European Commission.

The Acceleration Directive does not provide for any tariff regulation for the supply of electricity to customers connected to the transmission network. Tariffs charged by distribution companies may, under certain circumstances, be regulated.

The Acceleration Directive allows Member States to impose public service obligations, in the general economic interest, on any undertaking operating in the electricity sector (i.e. not just those that sell power). Public service obligations may relate to security, including security of supply, regularity, quality and price of supplies and environmental protection, including energy efficiency and climate protection.

Member States are also obliged to ensure that all household customers enjoy universal service. Universal service is the right to be supplied with electricity of a specified quality within the territory at reasonable, easily and clearly comparable and transparent prices. To ensure the provision of universal service, Member States may appoint a supplier of last resort, and are also able to impose an obligation on the DSOs to connect customers to the distribution grid under terms, conditions and tariffs approved by the national regulator.

Member States are also to take appropriate measures to protect final customers (with a specific obligation to protect vulnerable customers), and are to ensure high levels of consumer protection, particularly with respect to transparency regarding contractual terms and conditions, general information and dispute settlement mechanisms, and to ensure that customers can switch to new suppliers.

Member States have considerable freedom to define such public interest obligations, provided they are clearly defined, transparent, non-discriminatory, verifiable, and guarantee equality of access for EU electricity companies to national consumers.

Regulatory Authorities. In Europe, the European Commission enforces sector-specific regulation (via the Directorate-General for Energy and Transport), as well as the competition rules (via the Directorate-General for Competition).

The Acceleration Directive requires Member States to establish a specific energy regulator. The regulator is to be responsible for ensuring nondiscrimination, effective competition and efficient market functioning. Equally, Member States are required to have a designated authority responsible for the application of the EU competition rules, in addition to national competition law.

Under the EU competition rules, the European Commission can sanction anti-competitive agreements and abusive behaviour with fines (on top of orders to stop the infringements and/or declarations that agreements are invalid). In addition, it has the power to clear or block mergers, acquisitions and the creation of joint ventures.

Mergers, acquisitions and certain types of joint venture in the electricity sector (as in any other sector) which meet the turnover thresholds to have a Community dimension are subject to mandatory notification to and clearance by the European Commission under the EU Merger Control Regulation. Notifiable transactions may not be implemented before clearance is obtained, unless the European Commission expressly permits this.

The European Commission (Directorate-General for Competition) will assess whether the transaction would significantly impede effective competition, in the common market or in a substantial part of it, in particular as a result of the creation or strengthening of a dominant position. If it does, the European Commission has the power to block the transaction or to approve it, subject to certain conditions (typically, the divestiture of part of the business).

The EU competition rules (Article 82 EC) prohibit undertakings from abusing their dominant position within the common market or a substantial part of it, insofar as trade between Member States may be affected. Examples of abusive conduct by dominant undertakings include refusing access to infrastructure without reasonable justification, charging abusively high or low access prices or applying dissimilar conditions to equivalent transactions, thereby placing certain trading partners at a competitive disadvantage.

Gas Industry[4]

Gas producers across the EU operate a range of structures and are privatised to varying degrees depending on the Member State.

Upstream sales of natural gas (i.e., sales to companies other than end-users) are not specifically regulated at an EU level.

However, the general EU competition rules apply and impose limits on how natural gas can be sold. In addition, Member States are permitted to impose public service obligations, relating to, for example, security of supply and environmental protection, on any company with natural gas activities.

Leases of mineral rights, any rules relating to when, where and how much natural gas may be produced, and any rules relating to the authorisation and/or monitoring of drilling on public land are determined at a national level.

Regulation of Gas Utilities. The ownership and organisational structure for pipeline transportation and storage of natural gas is partially regulated at the EU level. The Acceleration Directive introduced the fiercely debated principle of 'legal unbundling'. Since July 1, 2004, vertically integrated undertakings have been required to separate legally their transmission activities from their production and supply activities and convert them into separate legal entities which are independent in terms of management and decision-making.

The Acceleration Directive has further introduced the mandatory appointment of transmission system operators (TSOs) and distribution system operators (DSOs), either by Member States or by the companies owning the relevant infrastructure. The appointment of operators is designed to facilitate unbundling, create transparency and identify the body responsible for grid operation. It will be within the discretion of each EU Member State to determine freely the period for which a TSO or DSO is appointed, and the other terms of its appointment, taking into account economic and efficiency considerations.

The Acceleration Directive provides that access to transportation and storage systems must be granted on objective, transparent and non-discriminatory terms and can only be refused in certain circumstances.

For downstream transportation systems and LNG facilities, the Acceleration Directive has made regulated TPA mandatory in all Member States from July 1, 2004 onwards. These regulated TPA regimes must be based on published tariffs that are approved (or whose calculation methodology is approved) in advance by the Member State's regulator, and are applied to all eligible customers objectively and without discrimination. The new Regulation on conditions for access to the natural gas transmission networks (the Regulation), which was adopted on September 28, 2005, further regulates the terms and conditions upon which operators of transmission systems must grant TPA.

In particular, the Regulation establishes a degree of harmonisation in relation to: 1) the criteria for setting access charges, which have to be approved by the national regulator and be transparent, reflect actual costs and include an appropriate return on investment; 2) a minimum set of services to be provided by TSOs, among which long- and short-term contracts, and interruptible transmission; 3) the freeing up of the contractual congestion of networks (through reallocating capacity that is contracted for but not used) and physical congestion (through published information on available physical capacity); 4) transparent and non-discriminatory balancing systems; and the creation of secondary markets for trading rights to capacity in transmission networks.

In October 2005, the EU Member States and nine southeast European countries signed the Energy Community Treaty, thereby agreeing to create a southeast European electricity and gas market to provide interconnections with southeast Europe, and thus with the Middle East and Caspian regions. The aim is to put all countries in the area on the same regulatory footing as the EU.

Access to distribution grids is organised in the same way as access to other downstream transportation systems.

EU rules do not currently regulate the ownership and structure of companies engaged in supply or trading activities. For vertically integrated companies, however, the Acceleration Directive[U8] requires the legal unbundling of such activities. The Gas Directive sets in motion the process of liberalising the supply of gas to customers. The Acceleration Directive has imposed a quicker timetable for the liberalisation of national gas markets, so that: 1) from July 1, 2004, all non-household users have been free to choose their supplier (unless an exemption is granted); 2) from July 1, 2007, households have also been free to choose their supplier (unless an exemption is granted).

The Acceleration Directive requires vertically integrated companies to legally unbundle their supply, transportation and distribution activities. Therefore, from the deadlines set out in that directive, there will be no single franchised providers of transportation, distribution and supply services (with certain limited exceptions).

Regulatory Authorities. EU regulation of competition and international relationships in the gas industry is the same as in the electricity industry (See also Section Energy Market Access and Competition Policy).

Special requirements or limitations on acquisitions of interests in the electricity sector by foreign companies are generally not permitted. EU law precludes any obstacles to the free movement of capital between Member States, between third countries and Member States, and to the freedom to establish a company of one Member State in another Member State.

Coal Industry

Overview of the Main European Coal Industries. Coal and lignite presently account for about one-third of the EU's electricity production. This is proof of the resistance of coal to the problems of resource scarcity, supply security and price shocks that have affected other energy sources.

The following section provides a comprehensive overview of the coal industries over the last decade as regards the main hard coal producers within the EU: the Czech Republic, Germany, Poland, Spain and the UK.

The UK industry was privatised in 1994. The post-war restructuring of the British coal industry can be divided into three phases. First, there was what has been called the "domestic competition driven" period from 1947 to the late 1970s, reflecting falling home demand triggered by alternative energy sources such as liquefied natural gas and (later) North Sea oil and gas. Second, there was the "privatisation-influenced" phase from 1980 to 1995; and third, there was the "environmental and global energy market-driven" phase which gained momentum from the mid-1990s. Concerns about the harmful environmental effects of fossil-fuel burning and associated emissions spurred reforms to encourage more efficient use of, and reduced dependency on, coal. However, the immediate problems for the coal industry arose from the low cost and wide availability of imported hard coal and reduced demand from the main users, the power generators.

In Germany, the history of hard coal mining since the end of the Second World War has been divided into two distinct periods. As part of Germany's post-war recovery, mining production rose from just under 40 million tons at the end of the war to over 150 million tons in 1956. In order to meet rising demand, hard coal prices were regulated and several policies were put in place to support mining and boost production. From 1958 the direction of hard coal production and policy changed, with production falling below the 1945 level. Rapid decreases in production in the mid-1960s and in more recent times were often followed by short periods in which production either stagnated or grew only slightly.

Germany's mining companies have undergone significant structural changes. The most important event was the establishment of Ruhrkohle AG(RAG) in 1969. RAG was a merger of many small mining companies in the Ruhr area and became the biggest company in Germany. In 1998 the concentration process was resumed with the formation of Deutsche Steinkohle AG(DSK) (German Hard Coal). DSK operates under the corporate umbrella of RAG, and combines all German hard coal mining activities, including those in the Saar region.

In Spain, the contribution of coal to economic development peaked in the 1950s and 1960s, as a consequence of Spain's isolationism and commitment to energy self-sufficiency. By the 1980s the effects of liberalisation, economic competition and entry into the EU meant that such a non-competitive industry became increasingly vulnerable, and heavily dependent on the energy supply industry and the contacts with it brokered by governments. These guaranteed markets enabled expansion when the rest of the European industry was in decline (in the 1980s employment and production actually rose).

The market was liberalised in 1998 when a long-term restructuring plan (1998-2005) was introduced. Restructuring of the coal industry has taken place with a series of mergers that have left the private sector UMINSA the largest producer (over two million tons), but the state owned sector, HUNOSA is still very significant, employing about a third of the industry's work force.

Other important coal industries are located in the Czech Republic and in Poland. In the Czech Republic, prior to 1990 all the mining companies were state owned. Since then there have been major re-organisations and privatisations that have seen five significant coal mining areas reduced to one. This area, known as Ostravia-Karvina, lies in the Upper Silesian Basin in Northern Moravia, close to the Polish border, where the mining company is 100% privately owned.

In Poland, a major restructuring exercise started in the late 1990s, and these reforms involved a significant amount of public funds.

When restructuring began in the late 1990s, the 71 operating coal mines were divided into three groups: economical mines with long-term economic futures, uneconomical mines which were scheduled for closure, and mines that were economical under specific conditions. As a result of the restructuring process the number of mines has been reduced to 34.

The European Coal and Steel Community. The Treaty establishing the European Coal and Steel Community (ECSC) was signed in Paris on April 18, 1951 by Belgium, Germany, France, Italy, Luxembourg and the Netherlands. It was concluded for a period of fifty years and, having entered into force on July 23, 1952, expired on July 23, 2002.

Historically, the ECSC was the practical follow-up to the Schuman declaration of May 9, 1950, which proposed placing Franco-German production of coal and steel under a common High Authority within the framework of an organisation open to the participation of the other European countries.

The ECSC Treaty creates a framework of production and distribution arrangements for coal and steel, and sets up an autonomous institutional system to manage it. Although its remit is limited to the two branches of industry, the ECSC has had a crucial impact on major economic and political developments in Europe for almost fifty years.

Faced at the start of its existence in the post-war period with a sharp decline in demand for coal and steel which could have plunged Western Europe into a dangerous economic recession, the ECSC functioned smoothly by striking the right balance between production and distribution of resources. Subsequently, when the coal and steel industry entered a deep crisis in the 1970s and 1980s, the ECSC was able to marshal an organised response which made it possible to carry out the necessary industrial restructuring and conversion while placing particular emphasis on the protection of workers' rights, in keeping with the European social model.

After the ECSC Treaty's expiry, the coal and steel industries were placed under the ordinary regime set up by the Treaty establishing the European Community.

R&D in the Coal and Steel Sectors. The ECSC Treaty (Article 55) and the Treaty establishing the European Community (Title XVIII) form the legal basis of technological R&D activities in the coal and steel sectors.

During its 40-year existence, ECSC research has supported the efforts of the Coal and Steel industry by increasing overall research efficiency, enabling the coal and steel industries to jointly undertake large projects which could not have been carried out by individual companies, and creating throughout the Member States a network of researchers who carry on an effective exchange of project-related information. In this way, ECSC research has become an essential complement to the companies' own activities, promoting international cooperation through joint programming and implementation of projects.

The programme promotes collaboration between EU industries and its research laboratories on the one hand, and, on the other, complementary centres of expertise in industry, universities and research institutes. The majority of the projects are of multi-partner and multi-national composition.

The expiry of the ECSC Treaty has meant the end of the ECSC research programme and the transfer of research in the coal and steel industries within the framework of a new European research fund named 'Research Programme of the Research Fund for Coal and Steel'(RFCS). The programme is managed on principles similar to those of the existing ECSC RTD, taking the new guidelines into consideration.

The RFCS is complementary to and is managed externally from the Seventh Framework programme[U9]. With a yearly budget of around 60M€, the Fund supports research projects in the areas of coal and steel.

The long-term strategy of the Programme is based on the priorities identified by the technology platforms of interest to the areas concerned: the European Steel Technology Platform (ESTEP)1 for steel, the Zero Emissions Fossil Fuel Power Plants European Technology Platform (ZEP)2 for coal utilisation, and the European Technology Platform on Sustainable Mineral Resources (ETP SMR)3 for mining aspects.

Clean Coal Technology. The European Commission has been financially supporting technical and economic research relating to the production and use of coal, and to occupational safety in the coal industry ever since the European Coal and Steel Community Treaty came into force in 1952. This continues today with a focus on clean coal technologies that will enable coal to maintain its important contribution to safe, competitive energy supplies for Europe.

Clean coal technologies are continually developing. Today, 46% efficiency can be achieved by implementing Best Available Technology. With further research into techniques such as Ultra-supercritical combustion, over 50%efficiency is envisaged in the near future. Work is underway to exploit the opportunities of capturing and storing CO_2, which is an inevitable by-product of the thermal use of all fossil fuels.

Oil Industry

Overview. The European Commission emphasises the importance of an effective, accessible, global oil market ensuring competitive supply and stimulating greater efficiency and innovation. In order to contribute to the transparency of the oil product market, the Commission publishes the weekly Oil Bulletin, which describes the price trends of the main petroleum products and the evolution of the taxation of these products in Member States. In order to gain a better insight into the energy markets, the Energy Market Observatory System (EMOS) is being developed. The system has been designed to provide, from 2007 on, reliable and transparent energy market data. It is designed as a vital tool in the identification of threats to a secure energy supply for Europe.

Management of emergency stocks is a key element of a dependable emergency response system. The European Commission thus undertakes coordinating functions for ensuring maintenance of emergency stocks and adequacy of response in the face of both internal and external supply disruptions. This includes gathering and publishing regular oil stock data from Member States.

The European Commission takes responsibility for the implementation of European legislation on security stocks of oil and market observation. It also considers new initiatives that may be taken to help the completion of the internal energy market.

Oil is a global market, but ensuring that all Europeans have access to energy at reasonable prices requires action at a European level. Promoting equitable access to new and existing infrastructure, enhancing market transparency, facilitating access to additional oil supplies, and coordinating effective response in the event of supply disruptions will play a key role in securing available energy at affordable prices.

The Internal Market. Oil has many uses, and the oil industry has many distinct sectors, such as exploration and production, and related services; refining; transportation; and wholesaling and retailing, notably as transport fuel. DG Competition's main involvement with these sectors has been through merger control. Owing to the large size of many oil companies and their globalised nature, many mergers and joint ventures have fallen within EU jurisdiction.

For instance, the European Commission has recently adopted a formal decision under EC Treaty competition rules which renders legally binding commitments entered into by the Spanish motor fuel company REPSOL. These commitments have the effect of opening up its long-term agreements with service stations. REPSOL will free hundreds of service stations from long-term exclusive supply contracts. This will bring a wider choice and scope for reduced prices to the benefit of the consumer.

Security Stocks.[5] The Commission takes responsibility for ensuring publication on a regular and transparent basis of the state of Community oil stocks, in order to: 1) increase the security of supply for crude oil and petroleum products by establishing and maintaining minimum stocks; 2) promote solidarity between the Member States in the event of an energy crisis by putting in place predefined measures and mechanisms which will guarantee coordinated action; 3) manage security of supplies by providing for suitable mechanisms to deal with physical disruption of energy supplies; 4) promote market stability, in consultation with producer countries, by planning possible responses to situations where the markets anticipate a physical disruption of supplies in order to restore the proper functioning of the market.

Member States shall adopt such laws, regulations or administrative provisions as may be appropriate in order to maintain within the European Community at all times their stocks of petroleum products at a level corresponding to at least 90 days' average daily internal consumption in the preceding calendar year. That part of internal consumption met by derivatives of petroleum produced indigenously by the Member State concerned may be deducted up to a maximum of 25% of the said consumption[U10]. The distribution within the Member States of the result of such a deduction shall be decided by the Member State concerned. Stocks required may be maintained in the form of crude oil and intermediate products, as well as in the form of finished products.

Stocks shall be fully at the disposal of Member States should difficulties arise in obtaining oil supplies. Member States shall ensure that they have the legal powers to control the use of stocks in such circumstances. Member States may decide to have recourse to a stockholding body or entity which will be responsible for holding all or part of the stocks. Two or more Member States may also decide to have recourse to a joint stockholding body or entity.

Member States shall submit to the Commission a statistical summary showing stocks existing at the end of each month and specifying the number of days of average consumption in the preceding calendar year which those stocks represent. The Commission shall submit regularly to the Council a report on the situation concerning stocks in the Community, including, if appropriate, on the need for harmonisation in order to ensure effective control and supervision of stocks.

Nuclear Power Industry[6]

The Internal Market. Nuclear power stations currently produce around a third of the electricity and 15% of the energy consumed in the European Union (EU). The sector represents a source of energy with low carbon levels and relatively stable costs, which makes it attractive from the point of view of security of supply and fighting climate change.

In 2005, the EU was the biggest nuclear electricity generator in the world (944.2 TWh(e))[U11]. It has a mature nuclear industry spanning the entire fuel cycle, with its own technological base and expertise. Attention has been focused on the safety and security of nuclear installations and protection of the public. The recent liberalisation of electricity markets has significantly changed the investment scenarios as compared with the 1970s and 1980s, when most nuclear plants were constructed.

The subject of nuclear energy is part of a much wider debate on the security of future energy supplies in the EU, competitiveness, the single energy market, state aids and greenhouse gas emissions.

Of the eight Member States of the European Union now operating nuclear power plants, five (Sweden, Spain, the Netherlands, Germany and Belgium) have adopted or announced a moratorium. Italy renounced nuclear power after a referendum in 1987. This leaves three Member States – Finland, France and the United Kingdom – that have not taken a negative decision. Decisions to expand nuclear energy were recently taken in Finland and in France. Other

EU countries, including the Netherlands, Poland, Sweden, the Czech Republic, Lithuania, Estonia, Latvia, Slovakia, the United Kingdom, Bulgaria and Romania have re-launched a debate on their nuclear energy policy. With 152 reactors spread over the EU 27, nuclear power contributes 30% of Europe's electricity today - however, if the planned phase-out policy within some EU Member States continues, this share will be significantly reduced. To meet the expected energy demand and to reduce European dependency on imports, decisions could be made on new investments or on the life extension of some plants.

The European Atomic Energy Community (Euratom). The groundwork for nuclear energy in Europe was laid in 1957 by the European Atomic Energy Community (Euratom). Its main functions consisted of furthering cooperation in the field of research, protecting the public by establishing common safety standards, ensuring an adequate and equitable supply of ores and nuclear fuel, monitoring the peaceful use of nuclear material, and cooperating with other countries and international organizations. Specific measures adopted at the EU level are geared to protecting the health of those working in the sector and of the public at large, and protecting the environment from the risks associated with the use of nuclear fuel and the resulting waste.

Euratom's general objective is to contribute to the formation and development of Europe's nuclear industries, so that all the Member States can benefit from the development of atomic energy, and to ensure security of supply. At the same time, the Treaty guarantees high safety standards for the public and prevents nuclear materials intended principally for civilian use from being diverted to military use. It is important to note that Euratom's powers are limited to peaceful civil uses of nuclear energy.

The Community institutions are responsible for implementing the Treaty establishing Euratom and for the two specific Euratom bodies: the Supply Agency and the Safeguards Office (which carries out physical and accounting checks in all nuclear installations in the Community).

The Euratom Supply Agency. The Agency must ensure supply by pursuing a common supply policy based on the principle of equal access to resources.

The Agency is therefore responsible for managing the supply of and demand for ores, source materials (e.g. natural uranium) and special fissile materials (e.g. enriched uranium and plutonium) in the EU. In order to carry out this task, the Agency has two key powers: 1) the right of option on ores, source materials and special fissile materials produced in the territories of the Member States; 2) the exclusive right to conclude contracts relating to the supply of ores, source materials and special fissile materials coming from within or outside the Community.

R&D in the Nuclear Power Sector. At present, European research in the nuclear field comes under the Seventh Euratom Framework Programme (FP7) [U9]. In particular, key political and societal concerns, such as management of radioactive waste and safety of existing reactors, plus longer-term energy-related issues, such as innovative fuel cycles and reactors, are addressed.

Sustainable developing of fusion energy and meeting the requirements of the nuclear fission sector in terms of safety, waste management, efficiency and competitiveness are the main objectives of this Specific Programme for nuclear research and training activities.

Among the FP7 projects we bring to your attention the European Joint Undertaking for ITER and the Development of Fusion Energy (or "Fusion for Energy") which was created by the Council of the European Union on March 27, 2007 for a period of 35 years. With a budget of around 4 billion Euros for the first ten years, "Fusion for Energy" will work with European industry and research organisations to develop and manufacture almost half of the high-tech components that make up the ITER project. The members of the Joint Undertaking are the 27 members of the European Union, Euratom (represented by the European Commission) and associated third countries.

Objectives: 1) to provide Europe's contribution to the ITER International Fusion Energy Project to be built in Cadarache, France; 2) to implement the "Broader Approach" agreement between Euratom and Japan; 3) to prepare for the construction of demonstration fusion reactors (DEMO).

"Fusion for Energy" should become a pool of knowledge and expertise for Europe to be in pole position to make demonstration fusion reactors for producing electricity. This fits in well with the Barcelona objectives for embracing the knowledge-based economy.

Future Perspectives. Regardless of the future trends in the nuclear sector, existing nuclear installations must continue to be operated at a high level of safety, and radioactive waste and stocks of spent fuel must be managed in a safe and environmentally sound manner. At the end of their operating lives, nuclear facilities must be decommissioned in accordance with agreed safety practice, and high standards are required in the transport of radioactive materials. There is a growing EU perspective on all these activities, which also considers the situation in the EU Candidate Countries. The protection of the public and the workforce from the harmful effects of ionising radiation forms the basis on which these broader issues of safety and waste management are developed.

The Role of State Aid[8]

The Green Paper "Towards a European strategy for the security of energy supply" of December 2000 drew attention to the opaque nature of state aid in the energy sector and underlined the need to draw up an inventory. The inventory is factual and identifies the main lines of public aid granted to energy since the end of the 90's.It is a first stage which will provide for a future framework for the identification, evaluation and control of public aid.

Gas Industry. According to the Green Paper on supply security, within the 2020-2030 period almost half of electricity production is expected to come from natural gas.

This increase in demand and the multiplication of intra-EU trade will lead to a greater demand for transport infrastructure which attracts most of the national and European support. In some countries public aid to gas exploration has also been noted.

Member States have introduced tax and other measures to speed up the introduction of gas as a source of energy.

Aid for research and innovation is also being distributed and should contribute to reducing external dependence and secure high-quality gas supply at low cost.

Coal Industry. Significant amounts of aid are granted by some producing countries, such as Germany, Spain, France and the UK. Lignite and peat do not benefit from any operating aid. Aid is in steady reduction, obliging the UK to reach a competitive position. Germany has made a commitment to reduce production after the expiration of the ECSC Treaty (July 23, 2002).

Some Member States promote the use of coal in order to produce electricity, and the internal electricity market Directive provides for this possibility.

State aid to the hard coal industry in the European Union is currently governed by the provisions of Council Regulation 1407/2002 of July 23, 2002 for the July 2002 - December 2010 period[U12]. This Regulation provides that state aid may be granted for the restructuring of the hard coal industry, taking into account the social and regional aspects of the restructuring as well as the need to maintain, as a precautionary measure, a minimum quantity of indigenous production to guarantee access to reserves.

Oil Industry. The information at the Commission's disposal does not show that there is much state aid being granted to promote oil production.

European legislation lays down minimum rates for excise duties and also provides for exemptions or reductions which are not meant to promote the use of mineral oils but intended to benefit an economic sector. Furthermore, the tax rate on mineral oil is much higher than that on other sources such as coal or natural gas.

European research funds provided significant support to oil. The objective was to encourage exploitation in the North Sea with a view to ensuring security of energy supply. European research funds are today clearly being reduced.

Nuclear Power Industry. We can distinguish two periods in the history of the sector. In the early days of the European Atomic Energy Community, aid for the construction of nuclear power plants formed part of the endeavours to develop a form of energy that was still in its infancy.

Today, the analysis of the Commission shows that: 1) investment projects notified to the Commission have not received public aid; 2) nuclear research aid is diminishing at both the European and the national levels; 3) EURATOM construction loans have not been used since the end of the 80s; 4) reserves and provisions for decommissioning and for the disposal of radioactive waste are generally set aside by producers; 5) fuel supply does not seem to receive any public aid; 6) the study of fiscal data has not revealed any measure applicable to the nuclear energy sector; 7) the measures taken in the fields of safety, security and civil liability meet the requirements of the relevant international agreements and the Euratom Treaty which require Member States to all take measures to facilitate the conclusion of insurance contracts.

New nuclear plants are generally being built without subsidies, an indication that nuclear energy is increasingly perceived as competitive. This trend marks a change from past practice in a number of EU countries. For instance, Finland's new nuclear plant is being financed by private sources. Similarly, the UK Government has announced that it will be up to the private sector to initiate, fund, construct and operate new nuclear plants.

UPDATES

U1. In 2013 the State Electricity Regulatory Commission (SERC) merged with NEA (Growth Analysis, 2014).
U2. "The Chinese government launched a fuel tax and reform of the domestic product pricing mechanism in 2009, in efforts to tie retail oil product prices more closely to international crude oil markets" (EIA, 2015).
U3. IEA is currently made up of 29 member countries. Poland joined in 2008 and Estonia in 2014 (IEA, n.d. c).
U4. 426 energy agencies are listed in the European Energy Agencies' 2014 Directory (ManagEnergy, 2014).
U5. See Managenergy, (n.d. b) for an updated map.
U6. Directive 2003/54/EC was repealed by Directive 2009/72/EC.
U7. In 2009 ETSO was replaced by ENTSO-E (European Network of Transmission System Operators for Electricity) (ENTSOE, n.d.).
U8. The Acceleration Directive was repealed by Directive 2009/73/EC and Regulation (EU) 994/2010 for security of supply of natural gas.
U9. In 2014 the Seventh Framework program was replaced by Horizon 2020 (EC, n.d. d).
U10. The text is based on Directive 2006/67/EC, which was repealed by Directive 2009/119/EC.
U11. In 2013 the EU was still the biggest nuclear electricity generator (830.6 TWh) (EIA, n.d. a).
U12. Since the expiration of Council Regulation 1407/2002 in 2010, state aid is governed by Council Decision 2010/787/EU, which will expire in 2027.

NOTES

1. The National Energy Administration will become a comprehensive regulatory authority overseeing China's energy industry, but it may also take some time to see this happen because of the transfer and reclassification of functions and authorities. It is also uncertain whether all related functions will be transferred to the National Energy Administration(for example, electricity price regulation). Therefore, we focus on introducing the oil and gas industry regulatory system before the National Energy Administration was established in 2008. The electricity and coal industry's regulatory system will be introduced in a similar fashion.
2. Source: Managenergy, (n.d. a) and Managenergy, (n.d. c).
3. Source: GCR (2006b)
4. Source: GCR (2006a).
5. Source: Council Directive 98/93/EC.
6. Sources: [COM(2006)844 final].
7. Source: EAEC Council (1958).
8. Source: [SEC(2002)1275].

2. Energy Policies

CHINA

2.1 An Overview of China's Energy Policies

China is now the world's largest energy producer and consumer (EIA, n.d.b). Since it has undertaken reforms and opened up to the world community, China's energy policy has played an important role in directing energy supply towards sustainable growth and promoting the development of energy economy. Prior to 2007, China did not have any government document defining a comprehensive energy policy, which instead was mainly reflected in the Outlines of the Program for National Economy and Social Development, energy industry plans and the relevant documents issued by the CPC Central Committee and the State Council. In 2007, China published the whitepaper entitled "China's Energy Conditions and Policies"[U1]. This section summarises the reasons and objectives behind the adjustment of China's energy policy priorities and policies, and analyses, in accordance with the relevant plan outlines and government documents, China's energy policy formation since it has undertaken reform and opened up.

Energy Policy Priorities During the Period 1978-1993

The period from reform and opening up to the mid-1990s marks the initial stage of transition from a planned economy to a market economy. During that period, the restructuring of the economic system greatly liberated productivity and boosted economic growth. However, China's economic development was still beset with supply shortages left over from its former planned economy. To alleviate these energy supply shortages, China adopted a litany series of energy reform measures and incentives which can be summarized in the following three aspects.

I. Investments in Energy Construction to Expand Energy Production. To overcome its energy supply shortages, China issued a series of important documents on economic construction from 1978 to 1994, almost all of which emphasized singling out energy industry development as the top priority. To address the energy construction financing issue, the State Council promulgated important documents concerning economic construction during 1981-1989, and each year reiterated the top priority for meeting the demand for investments in energy construction. After 1990, China began to control the scale of investments and rationalize the order of economic development, but left intact the "Energy First" investment policy to boost energy construction. China continued to attach top priority to energy development.

To resolve as rapidly as possible these energy supply and construction fund shortages, China relaxed the boundaries between energy production sectors and lifted the restrictions on industry access. Coal development forged ahead with "state, collective and individual entities rushing out simultaneously"; oil development proceeded in partnership with some foreign oil companies to conduct joint exploration; the electricity industry absorbed some investment outside of the Electrical Power Authority, together with some additional bank loans.

II. Incentives to Stimulate Energy Production. The objective of China's economic regulatory system reform from 1979 to 1994 was to set up a "planned commodity economy" and take "planned economy as the mainstay, market regulation as the supplement" while introducing the market mechanism into social and economic activities. During this period, the means of production were still produced and sold under the control of the State plan. To arouse the enthusiasm of energy producers to expand production, China adopted a series of economic incentive policies. For instance, the coal industry adopted a "production contracting, over-production sharing" policy; the electricity industry used a variety of policies to "link electricity prices or tariffs to debt repayment" and to "allow whoever invests to use the electricity generated and retain the profit realized". In addition, energy construction projects were subject to a preferential income tax rate of 15%.

III. Specific Objectives and Priorities for Energy Conservation. Energy conservation was emphasized at the initial stage of reform and opening up. In the Sixth Five-Year Plan of National Economy and Social Development, the relevant energy literature first introduced energy conservation, outlined the objectives of energy conservation and listed the key areas and industries of energy conservation. The Government mandated that the energy needed for an annual average of 4% of industrial production growth should be realized by energy conservation and consumption reduction; within 5 years, the energy conserved and reduced should reach 70-90 million metric tons of coal equivalent. Moreover, China also promulgated the Outline of the Policy for Energy Conservation Technology. In its "Seventh Five-Year" Plan, China decided to emphasize the role of economic levers, set up and refine policy measures for ensuring energy supply for thrifty users, imposing surcharges on wasteful ones, rewarding for energy conservation, and arranging preferential credit loans for energy conservation projects. In its "Eighth Five-Year" Plan, China continued to emphasize the objective of energy conservation. In its "Ninth" and "Tenth Five-Year" Plans, China did not single out energy conservation as a specific objective but still considered energy conservation as an important task. It is fair to say that promoting energy conservation has always been a priority of China's energy policy.

Energy Policy Priorities During the Period 1993-2005

By the mid and late 1990s, the shortage economy was basically over in China. Rapid energy production growth has fundamentally altered the long-term trend of demand outstripping supply in China. Meanwhile, China also faced the grave problems of blind development, illicit production, rampant mining and environmental pollution. In particular, there were almost 20,000 household-owned coalmines operating without production licenses. China even suffered an excess of coal and electricity production around 1998 from the impact of the Asian financial crisis. However, China found its oil self-sufficiency capability eroding and fell from a net oil exporter into a net oil importer. In such a situation, China gradually shifted the focus of its energy policy from encouraging production increases to adjusting energy structure, rectifying production order, and speeding up market-oriented reform.

I. Development of Quality Energy and Improvement of the Energy Production Mix. Following the completion of its "Eighth Five-Year" Plan, there was an easing up of the tension between China's energy supply and its demand. However, the structural contradiction between energy supply and energy demand became more acute, with an aggravation of the tension between energy development and the environment. Therefore, structural adjustments became the topmost priority of the energy policy at this stage. In its energy plan, China set itself the objective of energy mix adjustment: increasing the share of clean and efficient quality energy such as natural gas and hydropower, and reducing coal consumption at the load center. The specific adjustment measures were as follows: the electricity industry should restrict small thermal power station development. Beginning from the "Ninth Five-Year" Plan, any greenfield thermal power station shall use turbogenerators with an installed unit capacity of 300MW. China should actively develop hydropower and new energy, boost power grid construction, and pay attention to developing rural power grids. The coal industry should favour large-sized coalmine renovation, build high-output, top-efficiency mines, develop coalbed methane, strengthen clean coal technology research, and close down unlicensed mines and small coalmines that are irrationally distributed, waste resources, and lack safe production conditions;, it should make full use of its large-scale production capacity. Along with the implementation of the Western Grand Development Strategy, China kicked off the twin project of "shipping gas from the west to the east" and "transmitting electricity from the west to the east" to promote western region development while improving the energy consumption mix of eastern and western China.

To promote new energy and renewable energy development, China also issued the Outline of New Energy and Renewable Energy Development in this period, setting out the objective and mission as well as associated strategies and measures for new energy and renewable energy development from the "Ninth Five-Year" Plan up to 2010.

II. Synchronization of International Oil Resources, Energy Development and Environmental Protection. In the "Ninth Five-Year" and "Tenth Five-Year" Plans, the energy policy required setting up the state strategic petroleum reserve system and reshaping a dual petroleum reserve system at the State and enterprise levels. In addition, China also laid down the new development principles of vigorously developing new international markets; speeding up natural gas development; actively carrying out the "going global" strategy, and making full use of domestic and international resources and markets to realize import diversification and develop alternative oil products.

In the "Ninth Five-Year" Plan, China included eco-environmental protection as one of its strategic objectives of energy industry development, and established the principle of synchronizing energy development and environmental treatment. Priority was given to developing clean energy, vigorously developing clean coal technology, restricting and phasing out high-ash and high-sulphur coal production, avoiding and reducing environmental pollution arising from energy development, and promoting the coordinated development of energy, economy and the environment. In the "Tenth Five-Year" Energy Plan, was focused on setting up, improving and raising pollution emission charge rates associated with energy production and consumption to steward enterprises to actively use advanced equipment and production technology, and phase out technologically obsolete and inefficienct power consumption and generation equipment, such as small-sized thermal power facilities.

III. Reforming the Energy Industry Regulatory System and Strengthening the System of Energy Legislation. Proactively promoting reform and driving development via reform was an important part of the energy policy in the "Ninth Five-Year" and Tenth Five-Year" Plan period. China registered significant progress in reforming the energy industry system during this period. First of all, China garnered a major breakthrough in energy price reform, deregulated coal price (excluding coal for power generation), subjected prices to market forces, and leveraged the regulator role of price levers. China adjusted "debt repayment linked to electricity price or tariff" for power generation, and replaced project cost-plus pricing with advanced average social cost-plus pricing; applied the same prices in urban and rural areas, and unified the types of electricity tariff. New energy power generation was subject to a preferential grid admittance tariff. Meanwhile, China adopted an oil pricing mechanism that converged with international market prices after repealing the "dual-track system" and unifying price.

Second, the energy industry regulatory regime also gained significant progress: the electricity industry preliminarily separated government from business functions, affirmed the reform objective of "separating power plant from power grid, bidding for grid admittance and enforcing state supervision", and piloted electricity price or tariff reform in selected provinces and municipalities. The oil and gas industry was restructured to form two major group corporations with integrated operations encompassing upstream and downstream production as well as domestic and international trade, and successfully list them on overseas stock exchanges. Third, state-owned energy enterprises were reorganized into corporations as per the Company Law.

While pushing forward energy industry system reform, China enacted the Electricity Law, the Coal Law and the Energy Conservation Law consecutively in 1995, 1996 and 1997. In addition, it also promulgated some administrative regulations, statutes and detailed rules for implementation for the purpose of filling in the legislative void in respect of energy industry development or adding new contents to the law governing energy supervision.

In writing this section, we referred to the Outline of the Sixth Five-Year Plan for National Economic and Social development of the People's Republic of China, the Outline of the Seventh Five-Year Plan for National Economic and Social development of the People's Republic of China, the Outline of the Eighth Five-Year Plan for National Economic and Social Development of P.R. China, the Outline of the Ninth Five-Year Plan for National Economic and Social Development of P.R. China, the Outline of the Tenth Five-Year Plan for National Economic and Social Development of P.R. China, the Coal Industry Plan, the Electrical Power Industry Plan, the Petroleum Industry Plan and the Key National Energy Development Plans.

Current Energy Policies

In the face of energy production and consumption problems, the focus of China's energy policy has shifted from boosting production and increasing supply into optimizing energy structure, encouraging clean energy development, and paying attention to energy security and the energy environment. In the "Eleventh Five-Year Plan" there are new priority changes in China's energy policy, mainly reflected in the following aspects.

I. Taking Energy Conservation and Emission Reduction as a Restrictive Target of Economic Development. After 2001 energy consumption has been steadily soaring in China. In 2005, energy consumption totaled 2,233 million tons of coal equivalent, representing an increase of nearly 1 billion tons of coal equivalent over the year 2000[U2]. Massive, rapid energy production and consumption has added enormous pressure to China's resources and environment.

During the period from reform and opening up up to the year 2000, China began to register significant energy efficiency increases, along with economic growth; after 2000, however, China's energy utilization rate reversed previous growth momentum and continued to decline. In the "11th Five-Year" Plan for National Economic and Social Development, the Chinese government set an objective of reducing energy consumption per unit GDP unit by 20%. In the first half of 2006, however, GDP growth rose by 10.9%, whereas coal and electricity consumption surged by 12.8% and 12% from a year earlier. So energy consumption growth outpaced economic growth, thereby resulting in a year-over-year increase of 0.8% in energy consumption per GDP unit unit. In the second half of 2006, the energy conservation situation improved, but the annual energy consumption per GDP unit slipped by merely 1.23%, way below the 4% objective set for the year[U3].

It is estimated that China has 114.5 guaranteed years of coal resources, 20.1 guaranteed years of petroleum resources, and 49.3 guaranteed years of natural gas resources. In spite of its abundant coal resources, China is projected to face, at its present rate of consumption, a shortage of 125 billion tons of recoverable coal reserves, 210 billion tons of proven coal reserves and 660 billion tons of prospective coal reserves by 2020. These shortages require an investment in excess of RMB 40 billion. Boosting energy utilization efficiency is of vital importance to sustainable economic development in China.

To realize the twin objectives of reducing energy consumption per GDP unit and slashing pollutant emissions by 10% during the period 2005-2010[U4], most provinces and municipalities have instituted the energy consumption index communiqué system; some regions have incorporated GDP energy consumption indices or targets into the government's official performance evaluation metrics system. Compared with the energy conservation policies of previous five-year plans, the energy conservation policy since the "Eleventh Five-Year Plan" has not only set an energy conservation objective but has also strengthened energy conservation policy enforcement to proactively leverage the role of energy conservation and energy mix optimization in easing climate change.

The energy conservation measures, when fully implemented, will favour structure adjustment, boost industry energy conservation, carry out energy conservation projects, bolster administration energy conservation and promote social energy conservation.

Structural adjustment is intended to realize "low input, low consumption, low emission, high efficiency" economic development, speed up structural optimization and upgrade of industry, vigorously develop new high-tech industries and service industries, severely restrict the development of industries with high energy, materials and water consumption, phase out obsolete production capacity, promote the fundamental transformation of modes of economic development, and accelerate the implementation of an energy conservation industry system.

Industry is an important area of energy consumption in China. Thus efforts must be made to accelerate high-tech industrial development, apply high technology and advanced practical technology to renovate traditional industries; boost energy conservation and consumption reduction especially in iron and steel, non-ferrous metal, coal, electricity, petrochemical, chemical and building materials industries with high energy consumption; launch the "1000-enterprise" energy conservation campaign, and bolster energy conservation of industrial enterprises, each with an annual energy consumption exceeding 10,000 metric tons of coal equivalent; support a number of key demonstration projects for energy conservation and consumption reduction to boost industrial energy efficiency; further improve industrial energy efficiency standards and specifications; force the elimination of obselete energy-consuming products, and improve the access system of an energy efficiency market.

Energy conservation projects include the ten key energy conservation projects for oil conservation and substitution, combined heat and power, waste heat recovery and building energy conservation. These projects aim at encouraging the promotion and application of high efficiency and energy conservation products; vigorously developing energy and land conservation buildings; scientifically developing alternative fuels; speeding up the phasing out of obsolete means of transportation; actively developing public transport and energy conservation and environmentally sound automobiles; boosting energy efficiency of industrial power systems; carrying out green light projects and speeding up promotion and application of high efficiency appliance; accelerating the promotion of rural diesel and coal-saving kitchens and energy-conserving household technology; boosting government entity energy conservation, and leveraging the leading role of government in social energy conservation; establishing a mandatory government procurement system under which the government is forced to purchase energy conservation products; carrying out the energy conservation assessment and approval system of fixed asset investment projects; implementing energy efficiency labels; pushing forward energy administration through contract and energy conservation via voluntary consent; boosting public concern about resources and conservation; and striving to establish a long-term social energy conservation mechanism.

China has singled out energy conservation technology as the top priority of energy technology development, with a focus on developing key energy conservation technologies for high energy consumption industries. Meanwhile, China has vigorously boosted primary and terminal energy utilization efficiency, and encouraged the development of clean coal technology and alternative energy technology.

II. Strengthening the Construction of an Energy Legislative System and an Energy Supply System. At the late stage of the "Tenth Five-Year Plan", in consideration of the excess growth of energy demand, energy supply and demand imbalance, and uncoordinated development of different energy sectors, the Chinese government strengthened macro-control over the energy industry; set up the Leading

National Energy Group headed by the Prime Minister; offered forward-looking, comprehensive and strategic guidance on strategic energy plans and key policies; paid special attention to and actively advanced energy legislation, and enacted the Law on the Promotion of Clean Production and the Renewable Energy Law, as well as associated policy measures; promulgated the amended version of the Energy Conservation Law; boosted efforts to draft an Energy Law, a Recycling Economy Law, an Oil and Gas Pipeline Protection Law and Building Energy Conservation Regulations, while amending the Mineral Resources Law, the Coal Law and the Electrical Power Law. Meanwhile, China also actively commenced oil and gas, crude oil market and atomic energy legislation. As a basic law in the energy area, the Energy Law will coordinate legal regimes among specific energy sectors from a strategic and global perspective. In the "Eleventh Five-Year Plan", China first proposed to build a "stable, economical and clean energy supply system". The State Council Information Office published a white paper entitled "China's Energy Conditions and Policies", stating that:

> Along with China's rapid economic development and the acceleration of industrialization and urbanization, the demand for energy keeps increasing, and the construction of a stable, economical, clean and safe energy supply system faces the following challenges: (1) Prominent restraint on resources and low energy efficiency[...]; (2) Increasing environmental pressure caused by energy consumption, mostly of coal. [...]; (3) Incomplete market system and emergency response capability yet to be enhanced. (State Council Information Office, 2007)

It is understood that the construction of China's energy supply system shall include: 1) the establishment of a domestic energy supply system and the realization of an energy diversification strategy for a coal-based supply system with diversified development of petroleum, natural gas, hydropower, nuclear power, solar energy and other new energy; 2) the establishment of a foreign energy supply system, that is, a multichannel supply system combining market procurement and direct development to ensure a clean, safe, economical and reliable world energy supply and to diversify the sources of oil and gas imports and channels of transportation; 3) the establishment of a global energy diplomacy system in keeping with the new outlook of global energy security and with utilizable energy resources, and vigorously pursuing international cooperation with an overriding emphasis on transnational oil and gas pipelines and other energy transportation channels; 4) the establishment of a strategic energy reserve system, among which strategic, commercial and resource reserves; 5) the establishment of a legislative system for energy conservation; 6) the establishment of an energy price system and energy market mechanism capable of regulating China's energy supply and demand relationship as well as diverse energy value and price relationships.

III. Paying Attention to Energy Security with a Focus on Domestic Energy Supply Assurance.

Secure and stable energy supply includes the economic security of energy supply and the security of energy production. China's dependence on imported oil was projected to reach 61% and 76.9%, respectively, in 2010 and 2020. Any supply disruption will produce a significant impact on the national economy. The international oil price has kept surging in recent years, thus enabling the Chinese oil industry to reap windfall profits. However, China also has to pay rising import prices. In 2005, China's crude oil import and export totaled US$ 50.56 billion, resulting in a trade deficit of US$ 45.16 billion, 38.6% up from a year earlier; oil products import and export totaled US$ 16.8 billion, resulting in a trade deficit of US$ 4.02 billion.

Along with the furtherance of social development, secure energy production is not only an issue of production enterprises but also of the society as a whole. At present, China faces daunting challenges for coal production safety because the output of safe production mines is only 1.2 billion metric tons. Based on the coal output of 2005, unsafe mines accounted for 38.65% of China's coal production. As a result of multiyear consecutive overcapacity production, the safety enhancement investment shortfall of Chinese coal enterprises has cumulatively reached RMB 50 billion. Small-scale coalmines have spent very little on production safety. It is estimated that China has 400 million tons of production capacity requiring safety renovation, 150 million tons of capability failing to reach safety standards, and another 200 million tons of capability facing closure due to failure to meet safe production conditions. Statistics show that the fatalities of China's coalmines per million tons of coal production are 5.68, three times as high as the global average fatality rate. In 2005, there were six grave coalmine accidents, each of which caused 10 or more fatalities.

In retrospect of China's energy policy evolution since reform and opening up, we can find that, to address energy supply shortages, China has pursued an aggressive energy development policy together with an associated energy price policy, a taxation policy, an energy investment policy, an energy technology policy and an energy efficiency policy. Along with the contradiction of the change in energy supply and demand, the focus of its energy policy has been changed to optimize energy structure and to derive a new energy and renewable energy policy, as well as a "going global" policy based on its energy structure policy. The increasingly acute issue of energy security has become the new policy priority.

The increasing attention of the international community to global warming and the worldwide concern with energy security dictate that China's energy security policy is not merely an industrial policy but is also directly related to international relations and diplomacy. It also exerts considerable influence on international geopolitical relations. This is a salient distinction between China's present energy policy and its previous one. In 2006, CPC Central Committee Secretary General Hu Jingtao stressed that China should pay close attention to energy security issues. China is a major energy consumer but, more importantly, an energy producer. Under the "equality, mutual benefit and win-win" principle, we will strengthen cooperation with each energy producing country and consuming country and jointly maintain global energy security. The "new outlook of global energy security" proposed by President Hu includes the three aspects of: 1) strengthening mutually beneficial cooperation on energy development and utilization; 2) establishing an advanced energy technology R&D and promotion system; 3) maintaining a sound political environment for energy security and stability.

In the "Ninth Five-Year" and "Tenth Five-Year" Plan period, in consideration of the worsened contradiction of energy supply and demand, China put forward the "going global" development strategy for the energy industry, while continuing to boost domestic supply. In the "Eleventh Five-Year" Plan, China further emphasized reliance on domestic energy production to meet energy demands, and laid down the basic principle of "relying on domestic supply" to solve China's energy issue[U5]. While ensuring safe production, China strove to boost the domestic energy supply and continued to maintain a relatively high energy self-sufficiency level.

China has long relied on domestic energy resources to develop its economy, with a consistent energy self-sufficiency rate in excess of 90%, far ahead of most developed countries. At present, China has become the world's largest energy producer and attained a strong basis for energy production and supply. While building a "better-off" society, China will continue to develop its domestic energy resources with a focus on optimizing energy structure and boosting supply capability.

The enhancement measures that China has applied to its energy supply capability are: boosting the prospecting activity of its coal rescources, elevating resource assurance, speeding up conglomerations of large coal enterprises, renovating small- and medium-sized coal enterprises, optimizing coal industry mix; enhancing expertise related to coalmine mechanization and integrated coal mining mechanization, advancing clean coal production and utilization, encouraging promotion and R&D related to clean coal technology, speeding up alternative liquid fuel research and demonstration; actively developing a recycling economy, strengthening the environment, promoting a comprehensive utilization of resources, accelerating the marketing of coalbed methane; tapping further into the development potential of major oil producing zones to steadily boost crude oil production and natural gas production; boosting the exploration and development of oil and gas resources, and actively developing non-conventional energy such as coalbed methane, oil shale and oil sand.

With its abundant renewable energy resources, China has had obvious successes in utilizing hydropower, methane and solar energy. In recent years the development of wind, biological liquid fuel and solar energy power has been accelerated and the development and utilization of renewable energies has become an important energy policy of China.

To proactively develop renewable energy, China has enacted the Renewable Energy Law, adopted the policies giving top priority to generating of renewable energy power for grid admittance, and to full electron purchase and preferential price and social cost sharing. Meanwhile, China has also set up renewable energy development funds to support resource investigation, technological research and development, and to carry out project construction and renewable energy development and utilization in rural areas on a pilot, demonstration basis. In the Medium and Long-Term Renewable Energy Development Plan, China set a development objective of enabling renewable energy consumption to reach 10% and 15% of total energy consumption by 2010 and 2020, respectively[U6].

In 2005, volume of development and utilization of renewable energies (excluding biological energy utilized in a traditional way) was 166 million tons of standard coal, approximately accounting for 7.5% of the total consumption volume of China's primary energy[U7] and avoiding an annual discharge of 3 million tons of sulphur dioxide and of more than 400 million tons of carbon dioxide. It was predicted that the total annual utilization volume of renewable energies in China in 2010 would be 300 million tons of standard coal[U8].

China pushed forward its river-based cascade hydropower development, speeded up mega-hydropower project construction, developed small- and medium-sized hydropower stations based on local circumstances, and built pumped storage power plants to an appropriate extent.

At the end of 2005, the installed capacity of hydropower in China reached 117 million kilowatts (among which 7 million kilowatt pumped-storage power stations), approximately accounting for 23% of the China's installed capacity for power generation[U9], and the annual hydropower output was 395.2 billion kwh, accounting for approximate 16% of China's total electric output[U10].

In 2006-2010, there was an additional installed hydropower capacity of 73 million kwh, 13 million kwh of which came from pumped-storage power stations. By 2010, China's installed hydropower capacity reached 190 million kilowatts[U11], 120 million kilowatts of which were from large- and medium-sized conventional hydropower stations, 50 million kilowatts from small hydropower stations, and 20 million kilowatts from pumped-storage power stations. The installed capacity of conventional hydropower stations thus built accounts for approximately 31% of the installed capacity exploitable by China's hydropower technologies.

China will also promote and spread mature technologies for solar energy.

By the end of 2005, the total capacity of photovoltaic power generation in China had reached 70,000 kw[U12], independent photovoltaic power stations had been built in more than 700 towns of 12 counties, and more than 500,000 photovoltaic systems had been put on the market for residential use. As a result, the development of the solar energy photovoltaic industry had been greatly pushed forward. In order to expand the utilization of solar energy and heat, the State actively encouraged the combination of solar energy heaters into the building sectors. Consequently, the market for solar energy heating had been effectively expanded and the production and application of solar energy heating had entered a stable growth stage. By the end of 2005, the installation and operation volume of solar energy heating had reached 80 million square meters.

By 2010, the accumulated installation area of solar energy heating reached 150 million square meters, the installed capacity of solar energy power generation reached 0.3 million kilowatts[U13], and the demonstration projects for photovoltaic power generation by means of megawatt-class networked solar enery, and the test and demonstration work for power generation by means of 10000-kilowatt-class solar energy was carried out so as to enhance the development of the relevant ancillary production systems for the industry and to lay a technical foundation for the scaled application of technologies for solar energy power generation.

Furthermore, China encouraged the diffusion of heat recovery and methane utilization, and increased their market share; actively enhanced the utilization technologies for wind and biomass power generation, built several wind power bases, each with an installed capacity of 1000 MW, and developed industrialization with economies of scale.

By the end of 2005, China had built and networked more than 60 wind power plants, whose total installed capacity had reached 1.26 million kilowatts, and laid a foundation for the large-scale development of wind power. Additionally, there were nearly 250,000 small, independently running wind power generators in remote areas, whose total installed capacity reached 50,000 kilowatts.

Since 2003, China's wind industry has reached a new plateau of rapid growth. In 2006, China's newly-added installed capacity reached 1.337 million kilowatts, a growth of 165.83%; and its accumulated installed capacity reached 2.6 million kilowatts, a growth of 105.23%. By 2010, its total installed wind power capacity reached 10 million kilowatts[U14], and the number of small wind power generators reached 0.3 million, with a total capacity of 75,000 kilowatts.

By the end of 2005, China had developed more than 18 million methane-consuming households and built about 1,500 methane digesters for large animal husbandry farms and industrial organic waste water, and the annual utilization volume of methane reached approximately 8 billion cubic meters, providing high-quality living fuel for nearly 75 million rural residents.

By the end of 2006, the country had built 18.70 million biogas digesters for rural household use[U15], 140,000 for domestic sewage purification, and more than 2,000 biogas projects for animal farms and industrial wastewater, which combined to provide 9 billion m^3 of quality fuel for nearly 80 million rural residents annually.

At the end of 2005, China's installed capacity for power generation from biological substances in China reached approximately 2 million kilowatts, of which 1.7 million kilowatts were generated from the bagasse, 0.2 million kilowatts from rubbish and the rest from the gasification and methane of agricultural and forestry disposals such as rice husks, etc.[U16]

As of the end of 2006, the cumulative installed capacity of biomass power stood at 2.2 million KW[U17], among which 500,000 KW of combined heating and power from sugarcane biogases, and 500,000 KW of power from agricultural and forest waste, agricultural biogas, direct combustion of waste and landfill gas. In that year, the NDRC approved a total of 39 biomass direct combustion-based power projects, involving an investment of 10.03 billion yuan and with a total installed capacity of 1,284 million KW, of which, 90,000 KW were completed by the end of the year. Also in that year, 30,000 KW of power were produced from biomass gasification and waste landfill gas, in addition to 90,000 KW of capacity under construction.

China has developed a host of fixed bed gasifiers and fluidized bed gasifiers which produce fuel gas from stalks, sawdust, rice hull and tree branches. Presently, the more than 800 gasifiers used for drying timber and agricultural and sideline products, and the nearly 600 stalk gasification-based central heating systems in villages and townships, produce 20 million m^3 of biomass fuel gas annually. In addition, over twenty MW biomass gasification-based power generation systems have been applied. During the 11th Five-year Plan period, a pilot project of 6MW biomass gasification-based power generation was developed with the support of the State's 863 Program.

At the end of 2005, the annual utilization volume of grain-extracted fuel alcohol reached 1.02 million tons, and the technologies for fuel alcohol production from non-grain-extraction, such as stem of sorgo and cassava, etc., paved the way for commercial development.

China has diversified its raw materials for producing fuel ethanol, such as sugarcane, cassava and corn, among others. Over the years, the trial planting across the country of sweet hybrid sorghum has created a new variety featuring high sugar content and high yield, with stalk output surpassing 4 tons per mu. Since sweet sorghum stalks make ideal raw material for ethanol, the technologies of for producing ethanol from the juice of sweet sorghum stalks and fiber waste of corn stalks were developed with the support of the State's 863 Program during the 10th Five-year Plan period. Besides, construction and testing of the pilot plant were completed, and a pilot project of 5,000-ton sweet sorghum stalk-based ethanol production, as well as a 600-ton pilot plant for fiber waste-based ethanol production technology, were developed. One direction that China's biomass energy sector could take is the development of biodiesel as a quality biological liquid fuel. However, restricted by the high cost, the development is still in the study and small-scale production stages. The key to making biodiesel available on the market is to use cheap raw materials and improve the conversion rate. In the case of China, the focus should be on renewable oil crops as raw material for producing biodiesel. The Ministry of Science and Technology included biodiesel technology in the State's 863 Program for the 11th Five-year Plan period, and in the International Science and Technology Cooperation Programme. So far, progress has been made in the development of biomass briquetting, pyrolysis and carbonization technologies.

It was predicted that by 2010 the installed capacity for power generation with biological substances would reach 5.5 million kilowatts[U18], the added annual utilization volume of fuel alcohol made from non-grain materials 2 million tons, the annual utilization volume of biological diesel oil 0.2 million tons, the methane tanks for rural residents 40 million, 6300 large-sized methane digesters shall have been built, the annual utilization volume of methane 19 billion cubic meters and the annual utilization volume of solid-shaped fuel generated from the agricultural, forestry and biological substances 1 million tons.

China continues to actively boost rural household methane, biomass and solar energy utilization to provide clean energy for rural households; to promote the application of small rural energy facilities such as diesel-saving energy conservation kitchens, small windpower and micro-hydropower capacity, to boost quality fossil energy supply in rural areas; to increase the proporiton of rural commodity energy consumption; to strengthen rural power grid construction, and power grid coverage; to enhance green energy "showcase county" construction; and to speed up rural renewable energy development and utilization.

As a result of these continual adjustments and improvements, China's energy strategy framework has taken a clear incisive shape. Specifically, China's energy strategy is to "attach priority to energy conservation, focus on domestic supply, diversify energy development, rely on science and technology, protect the environment, strengthen mutually beneficial international cooperation, strive to build a stable, economical, clean and safe energy supply system, and leverage sustainable energy development to support economic and social energy development."

By 2010, the utilization volume of renewable energies will have reached 300 million tons of standard coal[U19], an annual discharge of nearly 4 million tons of sulphur dioxide, 1.5 million tons of nitrogen oxide, 2 million tons of smoke dust and 600 million tons of carbon dioxide will have been avoided and an annual conservation of nearly 1.5 billion cubic meters of water will have been achieved, which can prevent 150 million mu of forest lands from being damaged.

However, we must pay attention to the fact that the development of renewable energies may have negative ecological effects if wrong measures are taken. For example, polysilicon is used for solar energy plates, but a large amount of silicon chloride (an extremely poisonous substance) will be generated from its production process. The generation of hydropower may also have a negative influence on the local environment; therefore, the utilization of renewable energies must strive to enhance environmental protection. The Chinese government realizes that in developing hydropower it is important to safeguard the environment's animal and plant species, that the prevention and treatment of geological disasters and water and soil conservation should be carried out properly; and that the relationship between nature conservation areas should be well coordinated. While a wind power station is being built, the relationship with the wetland and bird conservation areas, scenic spots and natural landscapes, should be well-coordinated and measures should be taken to prevent bird injuries, and noise, light and shadow pollution. As for the utilization of biological substance energies, secondary pollution should be avoided, land and forest resources should be utilized properly, and the exhaustive utilization of natural resources should be avoided.

2.2 Key Future Issues in Energy Policy

I. Improving the Energy Price System and Fully Leveraging the Regulatory Role of Price and Taxation

China's energy costs need to be further adjusted and raised both to boost energy efficiency and to reflect energy resource scarcity. The Government should gradually relax control over oil product and electricity prices; streamline the price relationship between upstream and downstream energy products and fully leverage market price mechanisms; adjust the price ratios among energy products; promote energy mix optimization; improve energy price composition to enable it to fully reflect the relationship between energy supply and demand, as well as the scarcity of energy resources and the externalities of production and consumption. The reform of the energy price system should proceed in coordination with a reform of the energy tax and surcharge system. This reform should move ahead in conjunction with the objective and direction of energy price reform to appropriately raise an energy resource usage tax and the levies from the energy consumption tax in order to reflect the principles of energy resource scarcity and social justice. Meanwhile, China should improve its energy product costs by charging for environmental treatment and business exit expenses for energy products; and promote renewable energy and clean energy production and consumption by way of income tax breaks (or holidays) and consumption subsidies.

II. Proactively Advancing Energy Market Openness and Energy Market System Construction

In order to fully leverage the regulatory role of market prices it is necessary to synchronize with the market access system, so that enterprises can freely accede to or exit from energy production links in shortage or glut in response to market signals. China continues to promote reform and open up, takes full advantage of the fundamental role of the market in allocating resources, encourages diverse economic components to enter energy areas, and actively pushes forward market-oriented energy reform; is unwaveringly improving the coal market system, establishes a healthy and orderly electricity market system marked by separation between government and business, fair competition and orderly opening-up; speeds up reform of the oil and gas marketing system, and promotes the healthy, orderly development of energy markets.

III. Strengthening Reform of the Energy Regulatory System and Energy Market Supervision and Administration

While pushing forward on market oriented reform, China must face the market failure issue. It must further improve its national energy regulatory regime and decision-making mechanism, strengthen unified coordination between the central and local governments, boost overall planning and macro-control for national energy development, thoroughly restructure the energy investment system, establish and refine the macro-control system on investments; further strengthen the standard administration of energy resources, improve the administrative system for mineral resources development, establish and improve the trade system regarding mineral resource royalties and mining rights, rectify and standardize the market order of mineral resource development; leverage combined economic, legal and administrative means to effectively address energy production safety and environment pollution issues facing China, and resolutely shut down any production activities damaging energy resources and the environment, in violation of government regulations.

IV. Establish Mechanisms for Energy Security and International Cooperation

Based on their causes, energy security risks can be divided into geopolitical risk, price risk, force majeure risk and accident risk. Geopolitical risk refers mainly to the disruption of energy supply of an importing country because of its political and diplomatic relationship with an energy exporting or transit country, as well as any internal political upheaval of an exporting or transit country. Energy price risk refers to the potential damage to economic development of drastic short-term energy price fluctuation. Energy price security risk derives from energy political risk (i.e., energy supply disruption). As a result of political and economic changes worldwide, along with the furtherance of economic globalization, energy price security has gradually become a relatively independent risk. Especially since the new millennium, oil prices have been soaring in the absence of energy supply disruption, thus causing them to emerge as an independent risk. Force majeure risk and accident risk refer to the significant losses incurred by energy production and consumption due to earthquakes, hurricanes, strong thunderstorms and major production accidents. Energy supply disruption due to grave natural disasters is not without precedents. Along with energy supply development and universal energy service upgrade, the losses due to the risks of energy supply disruption have become increasingly severe. Therefore, power grid and power generation enterprises need to put in place contingency plans against the massive outbreak of major accidents. Under this principle of unified planning and step-by-step implementation, China should build strategic State petroleum reserve bases and expand the capability of petroleum reserves[U20]; gradually set up a contingency assurance system for oil and natural gas supply to ensure supply security; establish an international energy cooperation mechanism with a focus on mutually beneficial cooperation in energy development and utilization; establish advanced technology R&D and spreading system, and strengthen cooperation to foster a sound political environment for a secure and stable supply.

EUROPEAN UNION

2.3 Towards a European Energy Policy

The European Union, representing 28 countries and roughly 450 million energy consumers, is the world's second largest energy market. Among the most important issues which characterize today's European Energy markets we find: 1) the need for greater investments: in order to meet the expected demand for energy and to renew infrastructures, investments of approximately one trillion euros will be needed over the next 20 years; 2) improved energy security to face threats such as the rise of oil and gas prices, the EU's increased import dependency and the concentration of reserves. In fact the EU's currently import dependency[1] is around 50% and destined to rise; moreover, while today half the EU's gas consumption imports come from only three countries (Russia, Norway, Algeria)[U21], over the next 25 years gas imports are expected to increase to 80%; 3) world energy demand, and consequently CO_2 emissions are destined to rise by some 60 % by 2030. Global oil consumption has increased by 20% since 1994, and global oil demand is projected to grow by 1.6% per year. As a result, the question of environmental protection is high on the EU's agenda; 4) lastly, from a more general perspective, Europe still lacks a fully competitive internal energy market, as well as a common energy policy that would help EU citizens and businesses to reap all the benefits of energy security and lower prices.

This situation requires Member States to form a consensus about how to tackle the current situation in the energy markets. In the attempt to kick-start this process, the EU heads of state and governments, in their summits in October and December 2005, asked the European Commission (henceforth EC) to establish and pursue a common a strategy.

The Green Paper, adopted by the EC in March 2006, laid the basis for a European Energy Policy; this document highlights that the development of a common policy is a long-term project whose ultimate purpose is to coordinate three core objectives: sustainable development, competitiveness and security of supply.

As a foundation for this process, the EC proposes establishing a Strategic EU Energy Review to be presented to the Council and Parliament on a regular basis, covering all energy policy issues. This would help to update the European Council and Parliament by monitoring progress and identifying new challenges and responses concerning energy policy issues. Moreover, the Strategic EU Energy Review can also help to achieve the first core objective, namely sustainability. Indeed, through the Strategic EU Energy Review, the EC's aim is to cover all aspects of energy policy by analysing all the advantages and drawbacks of different energy mixes. Although a country's energy mix is and will remain a question of subsidiarity, its decisions have consequences for other countries and the EU as a whole, both in terms of pollution and energy security. All in all, this should eventually lead to the definition of an overall EU energy mix to ensure security of supply and sustainability, whilst respecting the right of Member States to make their own energy choices.

As for the second core aim, namely competitiveness, the following measures have been set out in the Green Paper: a European energy grid code, a priority European interconnection plan, a European Energy Regulator, and new initiatives to ensure a level playing field, particularly regarding the unbundling of networks from competitive activities.

Lastly, as far as security of supply is concerned, among the possible measures proposed we have: the establishment of a European Energy Supply Observatory and a revision of the existing Community legislation on oil and gas stocks, in order to ensure management of potential supply disruptions. In order to meet and fine-tune the three core objectives, the Green Paper identifies a set of six priority areas and a list of concrete proposals. Let us now give a quick recap of the six priority areas.

First, the EU needs to complete its internal gas and electricity markets. The development of a single European electricity and gas market would bring down prices, improve energy security and boost competition. In the attempt to fulfill such requirements, five key points need attention: 1) the development of a single European grid whose access conditions are to be harmonised by means of common rules on regulatory issues concerning cross-border trade, namely a European grid code; 2) an interconnection plan: at the Barcelona European Council in 2002, the EU heads of state and governments agreed to increase minimum interconnection levels between Member States to 10%. Additional electricity interconnection capacity is necessary between many countries (in particular for Ireland, the Baltic States, Spain, France and Malta). As for the gas market, public and private investments in infrastructure need to be encouraged; 3) to improve electricity generation capacity; 4) to harmonise the level and effectiveness of unbundling of transmission and distribution from competitive activities[2]; 5) to create a framework capable of boosting the competitiveness of EU industry.

The second action area aims at strengthening the solidarity between Member States, in order to improve the security of energy supply. Among the possible steps towards this objective the EC proposes: the establishment of a

European Energy Supply Observatory for enhancing transparency on security of energy supply issues within the EU, revising the existing Community legislation on oil and gas stocks in order to ensure that Member States can deal with potential supply disruptions, and improving physical security of infrastructure by defining common standards.

A more sustainable, efficient and diverse energy mix is identified as the third priority area. As anticipated above, the Strategic EU Energy Review is identified as a means for defining common strategies concerning the choice of a sustainable environmental energy mix that could improve security of supply while allowing Member States to be independent on this issue.

The fourth action area is strictly related to the third one and addresses the challenges of global warming. An Action Plan on energy efficiency and a new Roadmap for renewable energy sources should be adopted by the EC to select the measures necessary for the EU to save 20% of the energy that it would otherwise consume by 2020.

Environmental concerns are also addressed to some extent in the fifth action area, in its aim to develop and deploy new energy technologies in order to secure energy supply and improve sustainability and competitiveness. The EC proposes to establish a strategic energy technology plan in order to develop and market promising energy technologies.

Lastly, the Green Paper stresses the importance of laying the foundations for a common external energy policy to effectively face challenges such as the high volatility of energy prices, the increasing dependency on imports, and climate change. The aforementioned Strategic EU Energy Review would be a tool for checking progress in this direction. Moreover, a common EU energy policy should concern itself with the following key points: 1) a clear policy for securing and diversifying energy supplies, and enforcing energy partnerships with producers, transit countries and other international actors. The EU has established relations with major international energy suppliers, among which OPEC and the Gulf Cooperation Council. As for its relations with Russia, the EU's most important energy supplier, these are currently regulated by the EU-Russia Partnership and Cooperation agreement[3] of 2007[U22]. In addition, the Green Paper highlights the importance of intensifying efforts to secure Russia's ratification of the Energy Charter Treaty[4][U23] and the conclusion of negotiations on the Transit Protocol[5]. In the context of widening the European energy market the European Neighbourhood Policy and its Action Plans are two important tools. According to the European Union's official website:

> The European Neighbourhood Policy (ENP) was developed in 2004, with the objective of avoiding the emergence of new dividing lines between the EU and its neighbours and instead strengthening the prosperity, stability and security of all concerned. The central element of the European Neighbourhood Policy is the bilateral ENP Action Plans agreed between the EU and each partner. These set out an agenda of

political and economic reforms with short and medium-term priorities.

The European Neighbourhood Policy applies to the EU's immediate neighbours by land or sea: Algeria, Armenia, Azerbaijan, Belarus, Egypt, Georgia, Israel, Jordan, Lebanon, Libya, Moldova, Morocco, the Palestinian Authority, Syria, Tunisia and the Ukraine. 2) Reacting effectively to external crisis situations. Until 2011 the EU had no formal instrument to deal with external emergency supply events[U24]; it has therefore been proposed to create a monitoring mechanism to provide early warnings and to enhance response capabilities in the case of an external energy crisis. 3) Integrating energy into other policies with an external dimension. A common external energy policy will permit a better integration of energy objectives into broader relations with third countries and the policies which support them. To this end, the EC suggests strengthening the relations with countries facing similar energy and environmental challenges, such as the US, Canada, China, Japan and India. 4) Energy to promote development. With this aim, the Commission proposes that its Strategic Energy Policy Review should: identify infrastructure priorities for the EU's security of supply (including pipelines and LNG terminals) and agree on concrete actions to ensure that they are realised; provide a roadmap for creating a pan-European Energy Community with a common regulatory space; identify a renewed approach with regard to Europe's partners, including Russia, the EU's most important energy supplier, to reflect their interdependence, and, lastly, propose a new Community mechanism to enable rapid and coordinated reactions to emergency situations concerning external energy supply.

What emerges from the Green Paper is that the three policy objectives - competitiveness, security supply security and sustainability - are closely interlinked and complementary; indeed as pointed out in DG COMP (2006):

> Competitive markets provide the necessary signals for investment, which leads to supply security in the most cost efficient manner. Similarly, the creation of a competitive internal market will allow the Union's energy companies to operate in a market of a larger dimension, which will improve their ability to contribute to security of supply. At the same time, market forces oblige European operators to use the most cost effective methods of production, which in the appropriate regulatory environment can benefit sustainability. Consumers will be able to choose between different providers and contract schemes, and could thus reduce their electricity costs and adapt their consumption to market developments. Competitive, cost reflective prices will help encourage energy efficiency, which can reduce the dependence on external suppliers and which supports the Union's objective for sustainability and security of supply.

2.4 *EU Principles and Legislative Tools*

The relationship between the EU and the Member States is regulated by the principle of subsidiarity. It is explicitly sanctioned in Article 5 of the Treaty establishing the European Community[6]: "In areas which do not fall within its exclusive competence, the Community shall take action, in accordance with the principle of subsidiarity, only if and in so far as the objectives of the proposed action cannot be sufficiently achieved by the Member States and can therefore, by reason of the scale or effects of the proposed action, be better achieved by the Community. Any action by the Community shall not go beyond what is necessary to achieve the objectives of this Treaty."

This principle, further stressed by Article I-11-3 of the European Constitution[7], is also embodied in one of the main binding acts of the Community Institutions, namely the Community Directives. A directive is a legislative act of the European Union which requires Member States to achieve a particular result without dictating the means for achieving that result. It can be distinguished from European Union regulations, which are self-executing and do not require any implementing measures. Directives normally leave Member States with a certain amount of leeway as to the exact rules to be adopted. Directives can be adopted by means of a variety of legislative procedures, depending on its subject matter.

When adopted, a Directive gives Member States a timetable for the implementation of the intended outcome. Member States are required to make changes to their laws in order for the Directive to be implemented correctly. If a Member State does not adequately comply with the requirements of the Directive, the European Commission may initiate legal action against the country.

Before a Directive is enacted, White and Green Papers represent a sort of preliminary step towards its legal definition.

Green Papers are documents published by the European Commission to stimulate discussion on given topics at the European level. They invite the relevant parties (institutions or individuals) to participate in a consultation process and debate on the basis of the proposals they put forward. Green Papers may give rise to legislative developments that are then outlined in White Papers. Commission White Papers are documents containing proposals for Community action in a specific area. As mentioned above, they could follow a Green Paper published to launch a consultation process at European level. When a White Paper is favourably received by the Council, it can lead to an action programme for the Union in the area concerned.

2.5 A Short Review of EU Energy Policy

In this Section, the EU normative framework, as far as the implementation of a common Energy Policy is concerned, is briefly outlined. In particular, a short review of Directives, Regulations and other initiatives by the EU institutions is given. Relative documentation is divided into the following four categories: 1) energy saving and efficiency policy; 2) energy security; 3) renewable energy sources policy; 4) energy market access and competition policy.

Energy Saving and Efficiency Policy

The European Community is working intensely to improve energy efficiency in all sectors and at the same time to increase the use of renewable energies. Energy efficiency can be a key factor in improving self-sufficiency and reducing GHG emissions. In this context the Green Paper on Energy Efficiency points out that the EU could save at least 20% of its present energy consumption in a cost-effective manner, equivalent to EUR 60 billion per year.

In order to support a better integration of energy efficiency measures into national legislation, the European Commission has proposed several directives which have been adopted and are now in force. These concern broad areas where there is significant potential for energy savings, such as: 1) End-use Efficiency & Energy Services; 2) Energy Efficiency in Buildings; 3) Eco-design of Energy-Using Products; 4) Energy Labelling of Domestic Appliances; 5) Combined Heat and Power (Cogeneration).

As far as the first point is concerned, Directive 2006/32/EC[U25] published on May 17, 2006, sets an indicative energy savings target of 9% on total energy use, over a period of 9 years, to be reached by means of energy services and other energy efficiency improvement measures. According to Article 14(2) of the Directive, Member States submitted their first National Energy Efficiency Action Plan (NEEAP) to the Commission in June 2007. In their NEEAPs, Member States show how they intend to reach the 9% indicative energy savings target by 2016.

The building construction sector offers the largest single potential for energy efficiency, since it accounts for 40 % of EU energy requirements (Eurostat, 2007). Among the main Community legislation initiatives for this sector are the Boiler Directive (92/42/EEC), the Construction Products Directive (89/106/EEC)[U26] and the buildings provisions in the SAVE Directive (93/76/EEC)[U27]. The Directive on the energy performance of buildings (EBPD 2002/91/EC)[U28], in operation since January 2003, builds on those measures with the aim to carry out an ambitious step-ahead to increase the energy performance of public, commercial and private buildings in all Member States. In order to support the implementation of the Directive, the European Commission established the EPBD Buildings Platform, which provides information services for practitioners and consultants, experts in energy agencies, interest groups and national policy makers in the European Member States.

The existing implemented directives for Eco-design of energy-using products are related to ballasts for fluorescent lighting (2000/55/EC), household electric refrigerators and freezers (96/57/EC), and hot-water boilers fired with liquid or gaseous fuels (92/42/EEC). However those directives were amended in July 2005 by Article 21 of Directive 2005/32/EC[U29]. The latter defines conditions and criteria for setting requirements regarding environmentally relevant product characteristics (such as energy consumption). In principle, the Directive applies to all energy-using products (except transport vehicles) and covers all energy sources.

Energy demand in households accounts for 25% of the EU's final energy needs. Among the most important directives are energy labelling for electric refrigerators (2003/66/EC), electric ovens (2002/40/EC), air-conditioners (2002/31/EC)[U30], dishwashers (1999/9/EC) and household lamps (98/11/EC)[U31]. Other directives are related to household dishwashers (97/17/EC)[U32] washing machines (96/89/EC), combined household washer-driers (96/60/EC) household electric tumble driers (95/13/EC)[U33], household washing machines (95/12/EC)[U34], household electric refrigerators, freezers and their combinations (94/2/EC)[U35], and other household appliances (92/75/EEC)[U36].

As far as CHP is concerned, the Community strategy outlined in the Commission's cogeneration strategy of 1997 sets an overall indicative target of doubling the share of electricity production from cogeneration to 18% by 2010. The indicative target was taken up in the Communication on CHP (COM(97)514 final), providing for an analysis of the barriers and strategies for its realisation. Afterwards, Directive 2004/8/EC[U37] was introduced. This Directive aims at reducing energy demand as a means to achieve security of energy supply, and to contribute to the EU's carbon-saving targets. As the indicative target value from the 1997 strategy is out-dated, the Directive does not include targets but it urges Member States to carry out analyses of their potential for high-efficiency cogeneration. Therefore the overall objective of the Directive is to create a framework to facilitate and support the installation and proper functioning of cogeneration where a useful heat demand exists or is foreseen.

In conclusion, the European Commission's efforts focus on removing barriers to a well-functioning market and to internalising external costs of energy use. These objectives are pursued with the help of Community technology research and demonstration programmes, (such as the RTD Framework Programmes) and with proactive support programmes (for example Intelligent Energy – Europe Programme). Information on databases of projects supported by the European Commission is also available.

Progress to Date. The European Commission clearly stated that one of the priorities of its Member States should be reduction in energy consumption, improvement in energy saving and energy efficiency. In this direction the European Commission has adopted a number of policies, expressed through directives and action plans toward improving energy efficiency in the EU energy system. Directive 2006/32/EC[U38] of April 5, 2006 on energy end-use efficiency and energy services, for example, indicates for its Member States an overall national indicative energy saving target of 9% for the Directive's ninth year of application, which is the period 2008-2016. This target should be achieved by means of energy services and other energy efficiency improvement measures. The Directive states, moreover, that each Member State should submit a National Energy Efficiency Action Plan (NEEAP) to the Commission by June 30, 2007. These NEEAPs should report how they intend to reach the 9% indicative energy saving target by 2016: in particular, it should describe the respective energy efficiency improvement measures, planned to meet the saving targets and their estimated impacts. Furthermore, the NEEAPs should report the compliance of its Member States for the provisions of an exemplary role of the public sector, as well as information and advice to final consumers.

It should be noted that the European Union has highlighted the existence of a potential energy saving of over 20% by 2020, which can be met removing waste and inefficiency. Realizing these potentials will bring to some 390 million tons of oil-equivalent energy saving, along with large energy and environmental benefits. For example, it is estimated that there will be a CO_2 emissions reduction of 780 Mt CO_2 with respect to the baseline scenario, which is more than twice the EU reductions needed under the Kyoto Protocol by 2012. On the basis of the policies and measures contained in the Green Paper on Energy Efficiency: "Doing More with Less", an Action Plan has been presented in October 2006, by the European Commission[U39]. The Plan is built on the existing EU energy efficiency legislation and its objective is to provide a framework which helps to achieve the 20% saving potential. This framework is constituted by a list of cost-effective measures, by priority actions to be either immediately initiated or executed gradually along the Plan's six years period. The NEEAPs will integrate well with the objectives of the Action Plan, insofar as the latter represents the instruments for monitoring, reviewing and updating the plan.

The Commission has published an impact assessment report for the Action Plan for Energy Efficiency, which makes it possible to quantify the effects of the action proposed. The estimates however contain a certain degree of uncertainty insofar as a wide range of topics, at all levels of policy and decision makers, is involved. After evaluating a large set of possible instruments, some priority actions have been selected on the grounds of their impact on energy saving. Table 2.1 lists the priority actions along with associated potential energy saving[U40].

Table 2.1
Impact assessment of selected policy options

Option Description	Potential Energy Savings (Mtoe)
EU to develop scheme recognising retailers providing information on energy efficiency by allowing public recognition through logo or certification scheme.	6
EU to encourage Member States to include energy efficiency training and information in national education curriculum for primary and secondary schools as part of sustainability awareness.	10
EU to include running costs in Energy Efficiency Product Listing /labelling or equivalent consumer information EU/MS to extend EPBD to include smaller buildings (<1000 m2), inspection requirements to smaller installations and higher minimum standards for public buildings	18
EU to adapt appliance label regulation as to regular updating of the label system, in order to stimulate the marketing of ever more efficient appliances, and extend the system to other devices.	2
	80
EU/MS to set up regulation and/or incentives to increase the average conversion efficiency per fuel type, by installing new plants with best available technology (BAT)	20
EU/MS to promote/require regulatory change towards facilitation of penetration of "off-grid" power generation – many obstacles to be removed through different measures	16
EU/MS to promote/require regulatory change towards facilitation of penetration of "grid-connected" CHP, via different measures	14
EU to introduce new CEN STANDARD to regulate district heating systems	2
EU to incentivate the use of intermediaries for small energy efficiency loans etc., for example by extending access to ECB or (through Energy Services Directive obligation) MS capital as a revolving fund for "soft loans"	13
EU/MS to increase policy support for ESCOs through 1) dissemination of their activities; 2) the development of EU wide quality standards for ESCO projects; 3) standardised project monitoring and verification schemes; 4) model contracts and 5) improve access to (private) financial sources (e.g. cooperation with private banks). These measures could be combined with providing low-interest loans to ESCO projects	<6
EU to incentivate production of energy efficient products through favourable taxation rate in Member States	15
EU/MS to make driving costs more km-depending. For instance, The car or road tax can be made variable. Finally, area and congestion charges used for traffic management also have a km reduction effect.	3 to 5
EU to: 1) Set maximum CO_2 emission standards for different types of cars (absolute, related to specific performance properties, or related to the mean value of all cars sold by one company). 2) Make more stringent agreement with car and truck producers after 2008-2009.	28

Table 2.1
(continued)

EU/MS to restrict unnecessary power of car engines by technical devices such as maximum speed limiters and/or limitation of maximum acceleration. Or limit the maximum power related to the vehicle weight (or maximum load) for new cars and trucks.	11
EU/MS to decrease fuel use by making fuel more expensive. By making reducing the differences between countries, the incentive of buying cheap across-border fuel will decrease. Second, a lower car tax can be introduced when an efficient car is bought or a financial penalty is applied, which make the purchase of a less efficient (second hand) car much more expensive. Third, a bigger difference in road tax related to the fuel consumption of a car can be introduced. Even a km charge can be fuel economy dependent.	22
An EU-wide policy for labelling fuel-efficient tyres or minimum performance requirements for tyres, tyre pressure indicators (dashboard tyre pressure sensors mandatory on cars and freight vehicles, valve pressure indicators compulsory on existing vehicles tyres from 2010) and free facilities at service stations.	15

An interesting study has been published by the World Energy Council[U41], to review and evaluate some energy efficiency measures around the World[9]. The study focuses in particular on five measures - mandatory energy audits, energy service companies (ESCO's), energy incentives for cars, energy efficiency obligation for energy utilities, and a package of measures for solar water heaters - and it covers institutional aspects, regulations and financial measures. The analysis has been conducted by means of case studies.

Clear conclusions are stated:

A crucial role of pricing for the promotion of energy efficiency is recognized. A correct price signal should be provided to consumers, to build incentives for modifying their behaviour or acquiring energy-efficient equipment. Fiscal and pricing policies are a strong instrument for internalising long-term costs and benefits in energy markets.

It is emphasized that the establishment of institutions, such as agencies, is necessary to design, coordinate and evaluate programmes and measures. Moreover, they prove to be important for contracting various types of stakeholders, such as companies or banks.

Mandatory efficiency standards are another important instrument for energy efficiency. Their effect is maximized if policy makers provide both consumers and manufacturers or constructors with signals of future regulations well in advance, so that they can adapt in advance of these. Moreover, it is stated that standards should be regularly updated to be effective.

Innovative standards for buildings are more costly than current standards, but the extra cost drops rapidly due to the externalities generated by the learning effect. Therefore the application of the most efficient appliances and buildings should be boosted by complementary policies aimed at increasing their market share. These efficient appliances and buildings are highly effective in reducing the cost and facilitating the implementation of new regulations.

Regulations on buildings or equipment need to be enforced. In fact, enforcing the existing regulations may promote efficiency as much as innovating the regulations.

Energy efficiency norms for appliances and equipment contribute to differentiating between low and high efficiency equipment. Moreover, they can be used for advertising incentive policies, such as tax credit or eligibility for funding schemes.

The industry sector provides the best results in terms of energy efficiency progress, whereas passenger transport and households are the worst performing areas. On the one hand, increased income and lifestyle changes have partially offset technical energy efficiency gains. In this regard, technologies such as speed limiters, thermal regulation of room temperature, automatic switch off of lights and light sensors should be promoted to reduce the effect of wasteful behaviour and to limit the rebound effects[10]. On the other hand, the bad performance of the transport sector is due to a rapid surge in energy demand and the existence of limited real measures implemented so far.

Other studies evaluate the impact of past energy efficiency policies and instruments. Among these, Geller et al (2006) list the results of the evaluation of the most effective programs: 1) application of energy codes; 2) voluntary industrial agreements; 3) pricing initiatives; 4) financial incentives at the national level; 5) EU-wide appliance labelling and standards; 6) agreement on CO^2 emission intensity.

It is to some extent possible to report the effective amount of energy saved, even if it may be hard to disentangle the effect of a single policy from the combination of market forces and ongoing technological changes. Therefore, the following measures should be interpreted with caution: 1) thermal insulation reduced heating energy consumption per unit of floor area by 30% between 1978 and 1993 (Germany); 2) the voluntary agreements program with industries allowed an increase in energy efficiency of 20% for the industries covered between 1989 and 2000 (the Netherlands); 3) taxes on carbon emission or fossil fuels are responsible for an estimated 3.3% reduction in CO_2 emission as of 2002 (Germany); 4) voluntary agreements signed by the EC and appliance manufacturers contributed to a 20% decrease in energy consumption of washing machines and dishwashers, as well as a 25-35% reduction in standby power consumption of TVs and VCRs (various countries in Europe); 5) labelling and standards dropped the average electricity consumption of refrigerators and freezers by 27% between 1990 and 1999 (various countries in Europe).

Through an econometric exercise, a study commissioned by the association of the Italian industries, (Confindustria) identifies which policies best contributed to increasing energy efficiency in the 16 EU countries between 1980 and 2004[11].

The conclusions of the analysis are the following: 1) in the residential sector energy efficiency is particularly affected by heating regulation and by subsidies and tax reductions associated with energy policies (such as the eco-tax). Also, measures which apply to the production side, such as financing at low interest rates, proved effective; 2) in the transport sector, it is worth mentioning measures such as the tax reduction incentive for eliminating old and polluting cars, car-sharing, commuter plans and traffic management; 3) in the industrial sector, mandatory technology standards, financing at low interest rates, information activities, education and outreach are effective.

Policies on EU Supply Security

The first document addressing the issue of security of energy supply was Council Directive 68/414/EEC of December 20, 1968, which imposed an obligation on EEC Member States to maintain minimum stocks of crude oil and/or petroleum products (OJ L 308 of December 23, 1968), a directive that was amended by Council Directive 98/93/EC of December 14, 1998. Accordingly, Member States are now required to stockpile gasoline, diesel, kerosene and certain fuel oils.

The diversification of energy supply sources was considered one of the main objectives of the EU's energy policy also in its White Paper on Energy Policy (January 1996) Com (95) 682 Final January 1996. In particular, in order to achieve this goal, the development of domestic energy sources and the possibility of enhancing energy efficiency are stressed as the main points to be undertaken.

On November 29, 2000, the Commission adopted a Green Paper on security of supply ('Towards a European Strategy for the Security of Energy Supply'), in order to launch a debate on the geopolitical, economic and environmental stakes involved in securing the EU's energy supply. Since energy consumption (oil and natural gas in particular) is expected to grow steadily during the next years, while in the same period production will probably diminish, it is argued that energy self-sufficiency will be impossible to achieve. Therefore, policies are required to a) curb the growth in demand and b) manage the dependence on supply. Key instruments for substantially reducing increased energy demand are: 1) the completion of the internal market; 2) a general review of energy taxation; 3) plans aimed at energy saving and diversification of energy sources; 4) dissemination of new technologies.

On the contrary, the dependence on external energy supplies can be managed by diversifying energy sources in view of an increasing dependency on third countries for both gas and oil and by developing less polluting energy sources. With regard to this second point, new legislative initiatives on the use of renewable energy sources and on energy efficiency are proposed. Primary options for action in relation to security of supply, the environment and rural populations are represented by the development of new and renewable forms of energy, the possibility of maintaining access to resources and continuing to ensure external supplies.

The 2006 Green Paper: "Doing more with less" identified five different EU energy policy goals: adopting a single approach in dealing with strategic energy issues; diversifying the mix of primary energy resources; becoming the world's most energy-efficient region; becoming the world leader in low carbon energy research and development; and completing the internal energy market by 2007. With regard to the development of a robust European Energy Policy, different priority points were underlined: a common European external policy for security of energy supply; increase in the use of clean and indigenous energy sources; a strategic plan for European clean energy technologies; Europe-wide action on energy efficiency, together with the completion of the internal European electricity and gas markets by 2007.

Problems related to security of energy supplies were addressed by the Security of Electricity Supply Directive (2005).[12] Although this Directive seems to follow the Commission's 2001 Green Paper, some differences can be noticed. In fact, while the former document was mainly concerned with a reduction of import dependence, the Draft Directive described technical measures aimed at achieving the security of the electricity system. Different areas were involved in the measures contained in the proposed Directive: 1) Adequate level of generation capacity: regulatory authorities imposing performance standards on transmission, and distribution system operators have to be introduced in order to "ensure that transmission and distribution systems are operated on an adequately reliable standard, in co-ordination with neighboring countries"; 2) Adequate balance between demand and supply: sufficient investments have to be implemented to ensure a sufficient equilibrium between demand and generation capacity; 3) Network investment: regulatory authorities of Member States have to ensure sufficient investment in the network; 4) Appropriate level of interconnection for the development of the internal market: detailed requirements were placed on transmission system operators concerning the submission of "plans for cross-border interconnections to the regulatory authority".

The Security of the Gas Supply Directive of 2005[U42], which is a direct consequence of Directive 2003/55/EC of the European Parliament and of the Council concerning common rules for the internal natural gas market (June 26, 2003) and repealing Directive 98/30/EC, OJ L. 176 (July 15, 2003), has the main objective of implementing the measures directed at ensuring an adequate level of gas supply security and the proper functioning of the internal gas market, an adequate level of transparency and respect for free-market mechanisms.

Accordingly, Member States are required to: 1) establish policies for maintaining secure natural gas supplies; 2) reporting certain details regarding impact on competition, gas storage capacity and long-term gas supply contracts; 3) protecting consumers ("household customers") against supply disruptions; 4) establishing gas storage facilities; 5) preparing or updating national emergency measures.[U43]

Progress to Date[13]. Energy markets that ensure secure and sustainable energy supplies at competitive prices are essential for achieving growth and consumer welfare in the European Union. In this context the EU decided to open up Europe's gas and electricity markets to competition and to create a single European energy market. The process of market opening has significantly changed market functioning, provided new market opportunities, and led to the introduction of new products and services. However, while progress has been made, full market opening has not yet been achieved and barriers to free competition remain.

In order to support an efficient internal energy market, the European Union finances electricity and projects for gas transmission infrastructure of European interest. A yearly budget of about 25 M€ is spent mainly to support feasibility studies. Most of the projects cross national borders or have an influence on several EU Member States.

The Trans European Energy Networks "TEN-E" are integral to the European Union's overall energy policy objectives, increasing competitiveness in the electricity and gas markets, reinforcing security of supply, and protecting the environment.

The European Commission guidelines for TEN-Energy, adopted in 1996, comprise a list of energy Projects of Common Interest (PCI). The list was revised in 1997 and 1999. Revised guidelines came into force in June 2003, aimed at promoting the development of the internal market for electricity and gas supplies. In particular, these guidelines set out priority projects, which were identified as the most important for security of supply or for the competitive operation of the internal energy market.

With the last enlargement wave the 2003 guidelines needed to be updated to accommodate the ten new Member States and nations outside the EU's new borders. The recent guidelines were published in the Official Journal of the European Union on September 22, 2006[U44].

MVV Consulting (2006) has reviewed the progress made in the implementation of TEN electricity and gas projects during the period 2004–2006. In total, 32 electricity projects of European interest have been reviewed. An overview is given in Table 2.2 and Figure 2.1.

Table 2.2
European electricity transmission projects

Project Name	Countries Involved	Status[14]
Avelin (FR) - Avelgem (BE) line	*FR BE*	*F*
Moulaine (FR) - Aubange (BE) line	*FR BE*	*Finalised / Study phase*
Lienz (AT) - Cordignano (IT) line	*AT IT*	*S*
New interconnection between Italy and Slovenia	*IT SI*	*S*
Udine Ovest (IT) - Okroglo (SI) line	*IT SI*	*S*
S. Fiorano (IT) - Nave (IT) - Gorlago (IT) line	*IT*	*F*
Venezia Nord (IT) - Cordignano (IT) line	*IT*	*A*
St. Peter (AT) - Tauern (AT) line	*AT*	*A/S*
Südburgenland (AT) - Kainachtal (AT) line	*AT*	*A*
Austria-Italy (Thaur-Brixen) interconnection through the Brenner rail tunnel	*AT IT*	*S*
S. Fiorano (IT) - Robbia (CH) line	*IT CH*	*F*
Sentmenat (ES) - Bescanó (ES) - Baixas (FR) line	*ES FR*	*A*
Valdigem (PT) - Douro Internacional (PT) - Aldeadávila (ES) line and "Douro Internacional" facilities	*PT ES*	*S*
Philippi (GR) - Hamitabad (TR) line	*GR TR*	*C*
Undersea cable to link England (UK) and the Netherlands	*UK NL*	*A*
Undersea cable to link Ireland and Wales (UK)	*IE UK*	*S*
Kassø (DK) - Hamburg/Dollern (DE) line	*DK DE*	*S/C/A*
Hamburg/Krümmel (DE) - Schwerin (DE) line	*DE*	*A/C*
Kassø (DK) - Revsing (DK) - Tjele (DK) line	*DK*	*A/S*
Vester Hassing (DK) - Trige (DK) line	*DK*	*F*
Submarine cable Skagerrak 4 between Denmark and Norway	*DK NO*	*S*
*Poland - Lithuania link**	*PL LT*	*S*
Submarine cable Finland - Estonia (Estlink)	*FI EE*	*F*
Fennoscan submarine cable between Finland and Sweden	*FI SE*	*A*
Halle/Saale (DE) - Schweinfurt (DE)	*DE*	*A*
Neuenhagen (DE) - Vierraden (DE) - Krajnik (PL) line	*DE PL*	*A/S*
Dürnrohr (AT) - Slavětice (CZ) line	*AT CZ*	*S*
New interconnection between Germany and Poland	*DE PL*	*S*

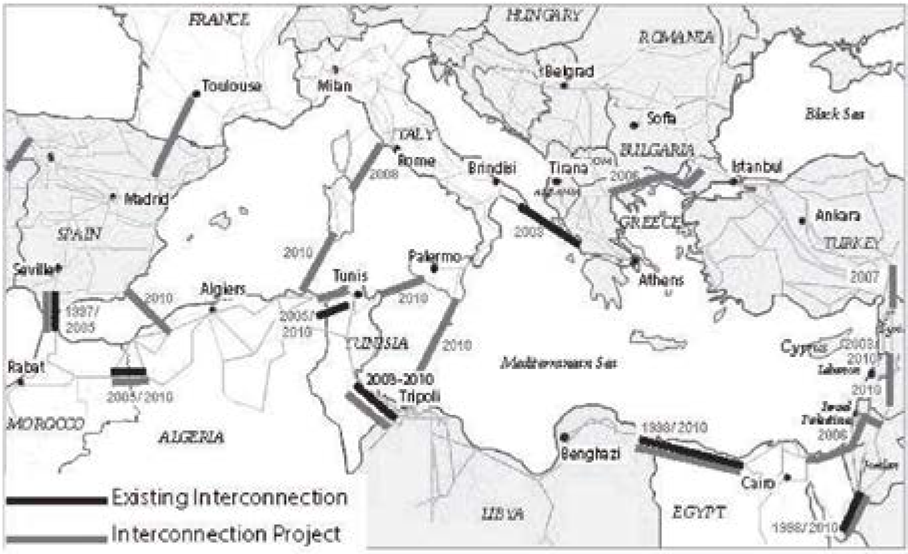
Table 2.2
(continued)

Vel’ký Kapušany (SK) - Lemešany (SK) - Moldava (SK) - Sajóivánka (HU)	*SK HU*	*S*
Gabčíkovo (SK) - Vel’ký Ďur (SK)	*SK SK*	*A*
Stupava (SK) - South-East Vienna (AT) line	*SK AT*	*S*
Electricity connection to link Tunisia and Italy	*IT TN*	*S*

Notes: * Including necessary reinforcement of the Polish electricity network and the Poland - Germany profile in order to enable participation in the internal energy market.

Source: Implementation of TEN-E projects (2004-2006) Evaluation and Analysis – MVV Consulting

Figure 2.1
European electricity transmission projects



Source: OME. Published by MVV Consulting.

Europe’s gas supply will become more dependent on Russia, the Caspian Sea region and the Middle East because of the strong growth of demand for natural gas in Europe, and increasing depletion of older European gas fields.

Table 2.3
Natural gas pipeline interconnection projects to Europe

Project Name	Countries Involved	Status
North European gas pipeline	*DE RU*	*C/S/A*
Yamal - Europe gas pipeline	*PL BY,DE*	*S*
Natural gas pipeline linking Denmark, Germany and Sweden	*DE SE*	*A*
Increase in transmission capacity on the Germany – Belgium - United Kingdom axis	*DE BE,UK*	*S/C*
Algeria - Tunisia - Italy gas pipeline	*DZ IT*	*C*
Algeria - Italy gas pipeline, via Sardinia and Corsica, with a branch to France (GALSI)	*DZ IT*	*S*
Medgaz gas pipeline (Algeria - Spain - France - Continental Europe)	*DZ ES*	*A*
Turkey - Greece - Italy gas pipeline	*GR IT TR*	*C/A*
Turkey - Austria gas pipeline	*AT TR*	*A*
Libya-Italy (Gela) gas pipeline	*LY IT*	*F*

Source: Implementation of TEN-E projects (2004-2006) Evaluation and Analysis – MVV Consulting.

In total 15 gas pipeline sub-projects have been reviewed, which condense to 10 PEI due to the inclusion of subprojects into the PEI (see Table 2.3).

One PEI has been put into operation (Libya - Italy (Gela) gas pipeline in 2004), 4 projects are in the construction phase (some with components under authorisation or in study), and 3 projects are in the authorisation phase. 2 projects are under study, though the Yamal – Europe gas pipeline is in the early study phase of identification.

Table 2.4
European projects for LNG regasification terminals

Project Name	Countries Involved	Status
LNG in Santa Cruz de Tenerife, Canary Island (ES)	*ES*	*A*
LNG in Las Palmas de Gran Canaria (ES)	*ES*	*A*
LNG in Madeira (PT)	*PT*	*S*
LNG on the island of Cyprus, Vasilikos Energy Centre	*CY*	*S*
LNG on the island of Crete (GR)	*GR*	*S*
LNG at Le Verdon-sur-Mer (FR, new terminal) and pipeline to Lussagnet (FR) storage	*FR*	*S*

Table 2.4
(continued)

LNG at Fos-sur-Mer (FR)	*FR*	*C*
LNG at Huelva II (ES), extending existing terminal	*ES*	*C*
LNG at Cartagena II (ES)	*ES*	*C*
LNG at Cartagena III (ES)	*ES*	*A*
LNG at Galicia (ES), new terminal (Mugardos/El Ferrol)	*ES*	*C*
LNG at Bilbao (ES), new terminal (+extension)	*ES*	*F/C*
LNG in the Valencia Region (ES), new terminal	*ES*	*F/C*
LNG in Barcelona (ES), extending existing terminal	*ES*	*F*
LNG in Sines (PT), new terminal	*PT*	*F*
LNG at Revithoussa II (EL), extending existing terminal	*GR*	*C*
LNG on the North Adriatic Coast (IT) (at Monfalcone)	*IT*	*A*
LNG on the North Adriatic coast (IT) (at Muggia)	*IT*	*A*
LNG offshore in the North Adriatic Sea (IT) (Rovigo)	*IT*	*C*
LNG terminal on the South Adriatic Coast (IT)	*IT*	*A/S*
LNG at Brindisi (IT)	*IT*	*C*
LNG at Taranto (IT)	*IT*	*A*
LNG at Gioia Tauro (IT)	*IT*	*S*
New LNG in Italy (Sicily) (Porto Empedocle)	*IT*	*A*
LNG at Livorno (IT), offshore	*IT*	*A*
LNG at Rosignano (IT)	*IT*	*A*
LNG at Zeebrugge (BE) / Dudzele (second phase of capacity extension	*BE*	*C*
Construction of a second LNG terminal in continental Greece	*GR*	*D*
Polish LNG Project	*PL*	*S*

Source: Implementation of TEN-E projects (2004-2006) Evaluation and Analysis – MVV Consulting

Whereas in Northern and Continental Europe new pipelines will enable imports, in the Mediterranean countries both LNG and pipelines will fill the gap. LNG allows a much greater diversification of supply sources and transport routes. However, in the field of underground gas storage the overall European component is still missing. With overall European demand growing continuously, it is to be expected that by 2015 underground storage shortages will expand. A cross-border European solution might have to supplement traditional national market-based approaches from the past.

Among these 29 LNG terminal priority projects (see Table 2.4), 2 were put into operation (the extension of the LNG terminal in Barcelona (ES) and the new terminal in Sines (PT)). 10 projects are under construction and 9 are in the authorisation phase. 7 projects are in the study phase, including one project where authorisation has started. The construction of a second LNG terminal in continental Greece has been cancelled due to alternative options.

We should also consider that several LNG projects in Italy have been deleted (LNG projects deleted in Gioia Tauro, Montalto di Castro, Rosignano and Vado Ligure). Actually, the only LNG terminal in operation in Italy is at Panigaglia, with an annual capacity of 3,5 Bcm/y).

While progress has been made toward creating an efficient internal energy market, full market opening has not yet been achieved. Barriers to free competition remain. Significant rises in wholesale gas and electricity prices that cannot be fully explained by higher primary fuel costs and environmental obligations, and persistent complaints about entry barriers and limited possibilities to exercise customer choice led the Commission, in June 2005, to open an inquiry into the functioning of the European gas and electricity markets. The sector inquiry conclusively demonstrated the conflicts of interest that exist when one and the same company sells gas and electricity and controls the pipes and cables other potential suppliers need in order to reach customers. Clearly these companies have no commercial interest in allowing rival suppliers access to this essential infrastructure. Therefore legislative change is also needed, not least in order to achieve effective unbundling.

Renewable Energy Development Policies

Different documents have been prepared by the European Commission in order to boost the use of renewable sources (RES, hereafter). The first document that it is worth noting is the White Paper on Energy Policy (January 1996). In an attempt to reach the objectives of 1) environmental protection, 2) security of energy supply, 3) industrial competitiveness, this document invited the sector to adopt adequate technology standards. As for the renewable content, national and local authorities were invited to adopt policies mobilizing significant resources in order to boost the production of energy from RES, and to foresee specific programmes or subsidies which accorded with competition policy regulation. In addition, this document acknowledged that RES constitute in the long term the main sustainable energy source. Finally, instruments for implementing a strategy aimed at RES development were introduced.

The White Paper on renewable energies set out a common strategy and an action plan to double the share of renewable energy from 6 to 12% in Gross Inland Production by 2010[U45]. In addition, this document established sub-targets in the various sectors, preserved flexibility in view of the enlargement of European community and initiated a tri-annual review procedure.

Political priority was given to new and renewable energy sources also in the Green Paper on security of supply (see above). This document argued that RES offer a "potential to be exploited". A target was consequently established with regard to the total energy consumption that should be produced by using this energy source (12% of total energy consumption in 2010). However, the achievement of these objectives required financial or tax incentives.

In particular, as for the achievement of a 12% target for energy consumption in 2010, the mobilisation of financial support for RES was a key instrument. Financial aid is, in particular, justified on the grounds that RES do not have the same development facilities that other sectors have had. Therefore, temporary levies on a share of the profits of other conventional operators in the energy sector are an example of measures that could be implemented.

In order to increase the contribution of renewable energy sources to electricity production in the internal market for electricity and to create a basis for a future Community framework, Directive 2001/77/EC[U46] of the European Parliament and the Council (Directive on the promotion of the electricity produced from renewable energy sources in the international electricity market) established national targets for electricity from renewable energy sources (RES).

In particular, according to the Commission, if these targets were met, consumption of electricity from renewable energy sources would rise from 14% in 1997 to 22% by 2010[U47]. Progress made by Member States toward achieving their national targets would be monitored by the Commission[U48].

In addition, the Directive abstained from proposing a harmonised Community-wide support system for RES. On the contrary, it obliged the Commission to make, if necessary (and within four years), a proposal for such a harmonised support system. Experiences gained in Member States with the operation of the different national support systems should be taken into account.

Finally, in order to promote RES this Directive established the following technical issues: Member States were obliged to 1) assure guaranteed access for RES-E, 2) issue guarantees of origin of RES and 3) assure that the calculation of costs for connecting new producers of RES should be transparent and non-discriminatory.

The Directive on Combined Heat and Power (CHP) and the Directive on liquid biofuels (Directive 2003/30/EC on the promotion of biofuels) established as targets the doubling of the share of CHP from 1994 and 2010 (from 9% to 18%)[U49] and a minimum use of biofuels and their de-taxation, respectively.

Finally, support programmes on RES have been introduced. While the Vth Framework Programme (ENERGIE) set as its main objective technological development, the ALTERNER II Programme tried to fill the gap between demonstration and commercialization. Non-technological actions and studies aiming at overcoming non-technical barriers were also established in accordance with this program. The total budget of the two programmes (spread between 1998 and 2002) was, respectively, 1,042 million Euro and 74 Million Euro.

Also, regional Policy and Structural Funds dedicate budgets for deployment of RES in most promising EU Regions (in this case, the total budget was equal to 487 million euro, spread between 2000 and 2003).

Renewable energy sources are at present unevenly and insufficiently exploited in the European Union. According to EUROSTAT, 2001 in the European Union

Energy mix in 1998, this energy source accounted for only 6% of total energy production,[15] of which 86.6% hydro (9.0% biomass and waste).

In order to reduce dependence and Greenhouse Gas emissions[16], the development of RES is viewed as a clear priority for the European Union. However, in order for the EU strategy for RES to be successfully implemented, political initiatives should be accompanied by adequate and timely legal and financial support. In particular, as far as the improvement of energy efficiency is concerned, the achievement of the ambitious target of an 18% increase by 2010 in comparison to 1995 levels, of energy efficiency, public financing as well private investment in RES would be fundamental in the next years.

Progress to Date: the Case of Renewable Electricity. In order to achieve the energy policy goals of sustainability, security of supply and improved competitiveness laid down in the Green Paper[17] (2006), the production of renewable energy is promoted across Europe. The European Commission (EC) has produced a large number of documents/directives dealing with renewable energy sources (RES). In November 1997 the EC adopted the Communication "Energy for the Future: Renewable Sources of Energy - a White Paper for a Community Strategy and Action Plan"[18]. The White Paper put forward the indicative objective of increasing the share of RES in gross inland consumption to 12% in 2010[U45].

Since the publication of the White Paper, important policy developments have underlined the key role of RES in ensuring sustainable energy supplies for the Community, reinforcing social and economic cohesion, developing European industry and contributing to job creation.

In what follows we will focus on the Directive about the promotion of electricity from renewable energy sources in the internal electricity market of 2001, which established a Community framework for electricity from renewable energy sources (RES-E)[U46].

Member States are obliged to establish national targets for the future consumption of green electricity. These national targets would lead to a 21% share of electricity produced from RES in total Community (EU-25) electricity consumption by 2010[U50]. A 21% share of RES-E would contribute substantially towards the global target of 12% RES in gross national energy consumption by 2010. The Directive also established a basis for the promotion of RES in the internal electricity market and tackled a number of technical issues, which were fundamental to the further development of green electricity.

Partly induced by this legislation, Member States have put in place a range of support measures for promoting renewable electricity; these are a set of market based instruments that compensate for the various market failures which result in a competitive disadvantage for RES, compared to conventional energy. Currently, within the EU27, 27 different national support schemes are in operation. The different support schemes have developed partly because they are linked to other national priorities, such as employment and regional development, and partly because national electricity markets themselves still show very different characteristics and remain highly segmented.

Article 4 of this Directive required the Commission to submit a report on the mechanisms for supporting renewable electricity in 2005. This was the Commission's "The support of renewable electricity[20]" Communication, which assessed national support schemes on the basis of a set of performance indicators. The report concluded that, rather than immediate harmonisation, a coordinated approach based on cooperation between countries and optimisation of support schemes was more appropriate.

On January 23, 2008, the Commission put forward a proposal[21] for a new directive on renewable energies to replace the existing measures adopted in 2001[U51]. According to the proposal, each member state should increase its share of RES in an effort to expand the EU's share from 8.5% today to 20% by 2020. A 10% increase in biofuel use in transport fuel consumption was included within the overall EU objective.

The Commission also proposed a series of interim targets, in order to ensure steady progress towards the 2020 targets; 1) 25% average between 2011 and 2012; 2) 35% average between 2013 and 2014; 3) 45% average between 2015 and 2016; 4) 65% average between 2017 and 2018.

Consistently with the principle of subsidiarity, EU countries are free to decide their preferred RES mix in order to take account of their different potentials.

This proposal is accompanied by a document dealing with the assessment of support schemes for electricity from renewable energy sources,[22] which is the main object of the remainder of this section. A more detailed version of this report can be found in the OPTRES's Interim report[23].

Member States use a variety of market instruments to subsidise renewable electricity; a country's support scheme is often changed or fine-tuned over time with the goals of adopting the best-practices and/or optimizing the ones which are in use. The recent "history of support schemes" in the European Union is depicted in Figure 2.2, which shows the support schemes adopted in Member States between 1997 and 2006. Market-based instruments that governments can use to subsidise renewable electricity can be divided into two categories: investment support (e.g. capital grants, tax exemptions or reductions on the purchase of goods) and operating support (e.g. price subsidies, green certificates, tender schemes and tax exemptions or reductions on the production of electricity).

Quota obligations are used in seven Member States: Belgium, Italy, Latvia, Romania, Sweden and the UK. Under quota obligations, governments impose an obligation on consumers, suppliers or producers to source a certain percentage of their electricity from renewable energy. This obligation is usually facilitated by tradable green certificates. Accordingly, renewable electricity producers sell electricity at its market price. In order to avoid paying penalties to the government, suppliers must prove that they reach their obligation by buying green certificates.

Under tendering, used in the past in three Member States (i.e. France, Ireland, and the UK), a tender is announced for the provision of a certain amount of electricity from a given technology source, and the bidding should ensure that the cheapest offer is accepted.

Feed-in tariffs and premiums, used in 18 Member States, are granted to operators for the electricity they feed into the grid; while feed-in tariffs take the form of a total price per unit of electricity paid to the producers, premiums are granted to producers on top of the electricity market price.

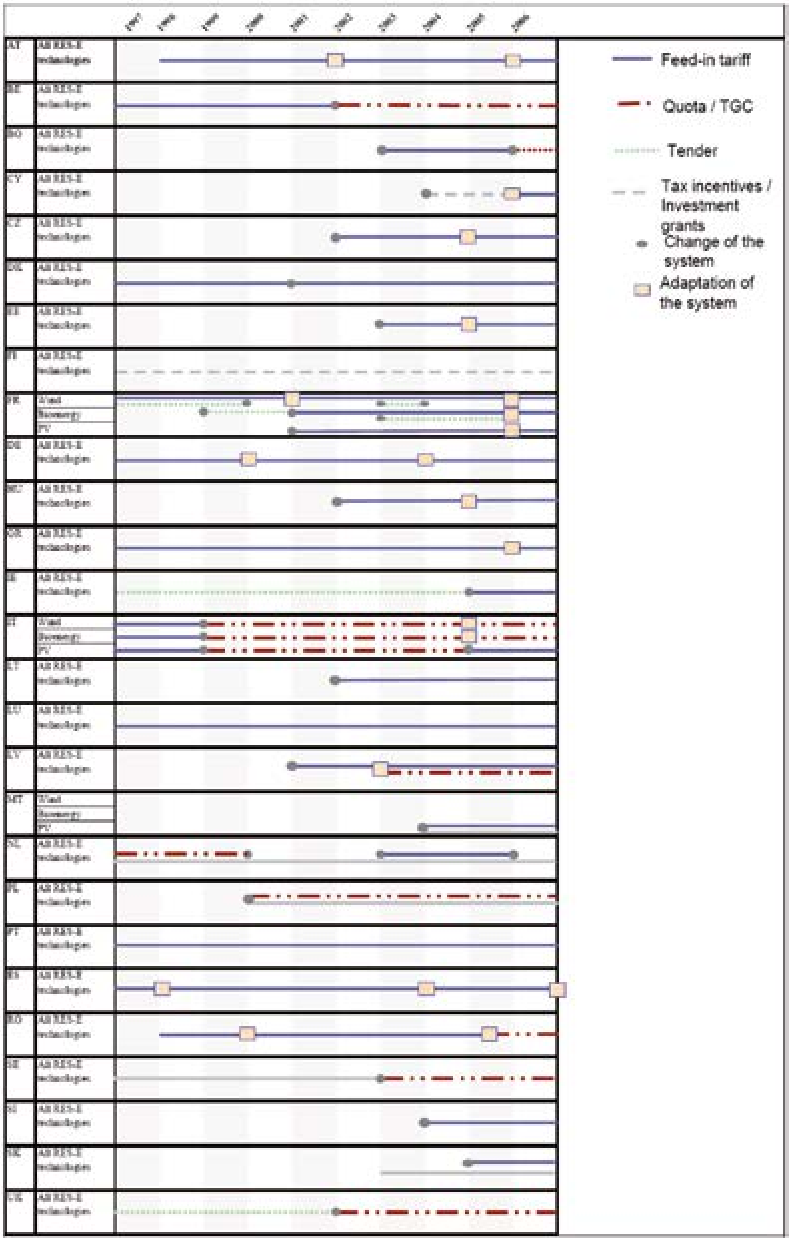
Fiscal incentives exempt producers of RES-E from certain taxes (e.g. carbon taxes); their effectiveness depends on the applicable tax rate. For instance while the Nordic countries, which apply high energy taxes, have been able to use tax exemptions to stimulate the use of RES-E, countries with lower energy tax rates have coupled them with other measures.

Both in 2005 and in 2008 the Commission assessed the performance of national support schemes, evaluating them in terms of effectiveness and efficiency.

The effectiveness of a support scheme refers to the increase of electricity generation potential owing from such a policy, as compared to a suitable reference quantity (e.g. either the gross electricity consumption or the additional available RES). The effectiveness of a Member State's policy is measured as the ratio between the change of the electricity generation potential during a given period of time and the additional feasible mid-term potential until 2020 for a specific technology[24].

The efficiency of a support scheme is determined by comparing the total support received for RES-E with its generation cost; the distance between the level of support and the generation cost indicates the degree of cost-efficiency of the policy. The analysis of the effectiveness and efficiency of various support schemes is shown in Figure 2.3. As for the effectiveness of the policies, the main results of the Commission's assessment can be summarized as follows: 1) the highest levels of effectiveness of the policies promoting wind energy, biogas and photovoltaic (PV) technologies has been found in countries using feed-in tariffs; 2) the effectiveness indicators for the new Member States have been on the average much lower, with the exceptions of Latvia and Hungary; 3) as for biogas and PV technologies, the effectiveness indicator suggests low performance levels; 4) the effectiveness of low-cost technologies, such as sewage gas and certain types of biomass, has been particularly high in countries with non-technology-specific support schemes; 5) while the Irish tendering system, replaced in 2006 by feed-in tariffs, showed moderate effectiveness, the new Danish tendering scheme for offshore has been the most effective scheme for supporting this technology in Europe; 6) other support mechanisms, such as investment grants and tax rebates, are difficult to measure because they are usually used as additional policy tools.

Figure 2.2
Selected support schemes in member states



Source: OPTRES (2007)

As for the efficiency of support schemes, we have the following results: 1) two thirds of the Member States display a level of support which allows them to cover generation costs for both onshore wind and solid biomass. This implies an improvement with respect to the 2005 assessment; in fact then only 50% of the Member States were able to cover generation costs; 2) increased levels of support can be observed in the Czech Republic, Estonia, Greece, Portugal, Slovakia and Slovenia; 3) as far as small hydro technologies are concerned, two thirds of the Member States seem to provide sufficient support; 4) as for biogas, things have remained almost unchanged from the last report; indeed, the level of support is considered to be either insufficient to cover generation costs, or at the lower end of the cost range in more than half of the Member States; 5) PV technologies are generally poorly subsidised across the EU, with the exception of Germany, Luxembourg, Netherlands, Italy, Spain, the Czech Republic and Austria.

Another way of assessing the efficiency of the policies supporting RES technologies is to consider the correlation between the effectiveness indicator and the average expected profit[25] from investments in renewable electricity by using the same support scheme. This correlation helps us to disentangle whether the success of a policy is determined by high financial incentives or by other factors (such as stability, lower investment risk or market access)..

Panel (a) of Figure 2.4 shows the observed effectiveness of policies for onshore wind compared with the expected profit from these technologies; the same analysis has been carried out for electricity generated from forestry biomass, and it is depicted in panel (b) of the same figure. The main conclusions are the following: 1) for onshore wind, in 2006, well-adapted feed-in tariff systems were typically more effective at a relatively low producer profit level; 2) France, with persistent administrative barriers preventing the development of wind energy, is an exception to this general rule; 3) quota systems achieve a rather low effectiveness at comparably higher profit margins for onshore wind; 4) as for biomass feed-in tariffs. they generally achieve a low to moderate effectiveness at a lower profit compared to quota systems; 5) Finland, where tax incentives are used as the main support schemes, has generally performed best in terms of effectiveness and efficiency.

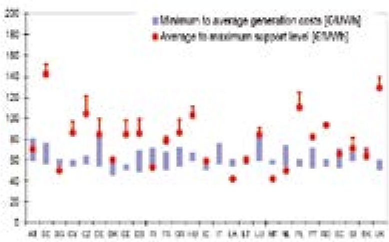
Lastly, let us briefly consider the perception of the advantages and disadvantages of different support schemes, as reported by OPTRES and EWEA[26] through the stakeholder consultation[27].

The most important issues regarding support instruments are the following: 1) irrespective of the kind of support scheme, the long-term stability is, according to stakeholders, an essential requisite for attracting investors, projecting developers, and allowing sufficient time for project planning and realisation; 2) in countries with a strong feed-in tariffs system, such as Germany and Spain, many stakeholders expressed a clear preference for the present system, indicating attractive tariffs, long-term stability and transparency as major strengths of this tool; 3) the majority of the stakeholders acknowledge that an instrument with a long-term framework is a prerequisite for the cost-efficient promotion of RES-E technologies; 4) market-based instruments, such as quota obligations coupled with tradable green certificates, only seem to be able to stimulate the market development of already mature technologies; 5) it is suggested that penalties should be set for a longer period of time, thus creating more market transparency regarding the financial consequences of non-fulfillment of the obligation; 6) many stakeholders from the new Member States pointed out that they consider the introduction of market-based instruments premature; on the contrary, they suggest maintaining and improving the feed-in tariff system; 7) investment grants are considered an appropriate tool for stimulating new technologies and demonstration projects; 8) setting long-term targets for renewable energy is considered by many stakeholders as an important element for creating a stable environment for investments in renewable energy; 9) several stakeholders pointed out that international trading of green electricity should be coordinated.

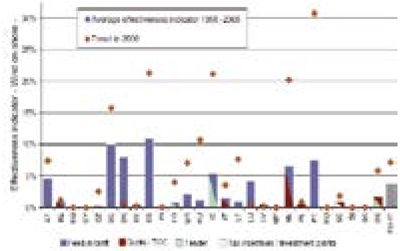
Figure 2.5 shows how support instruments were ranked according to the preferences expressed by a selected group of stakeholders. Note that a system with fixed feed-in tariffs was ranked first by the respondents of the survey. Investment grants were ranked second, slightly better than the score attributed to the premium tariffs. Quota obligations based on tradable green certificates were ranked fourth, while the smallest number of preferences was given to the tender system.

Figure 2.3
Efficiency and effectiveness of support schemes for RES-E

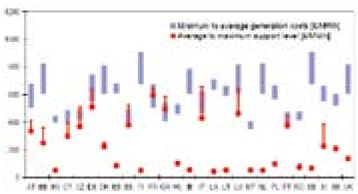
(a) onshore wind



(b) onshore wind



(c) onshore wind



(d) onshore wind

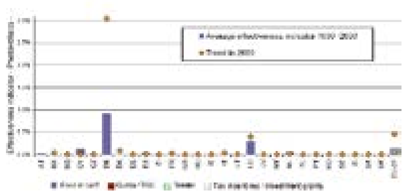
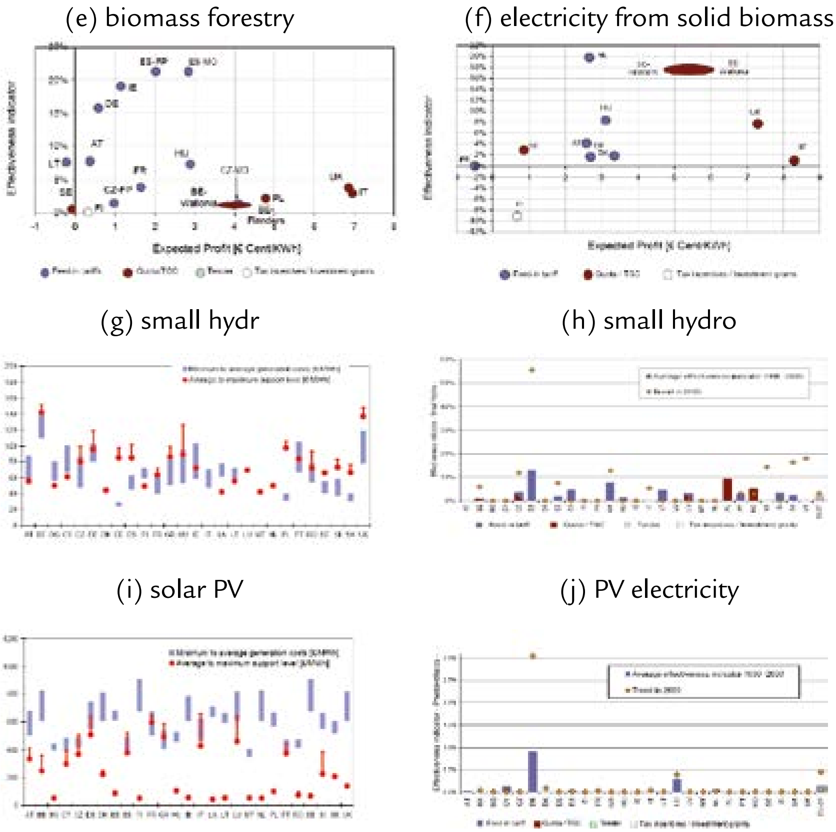


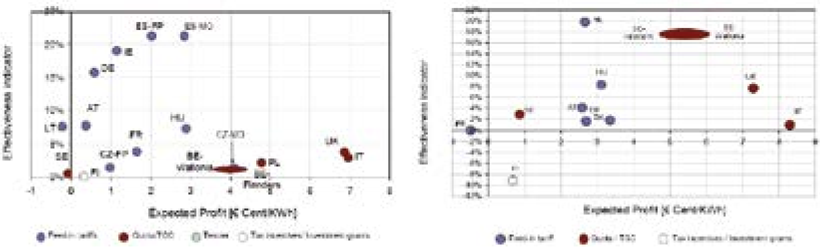
Figure 2.3
(continued)



Notes: the first column shows price ranges (average to maximum support) for direct support to (a), (c), (e), (g), (i) in EU27 compared to long-term marginal generation costs (minimum to average costs). The second column shows the effectiveness indicator for support schemes to (b), (d), (f), (h), (j).
Source: OPTRES (2007).

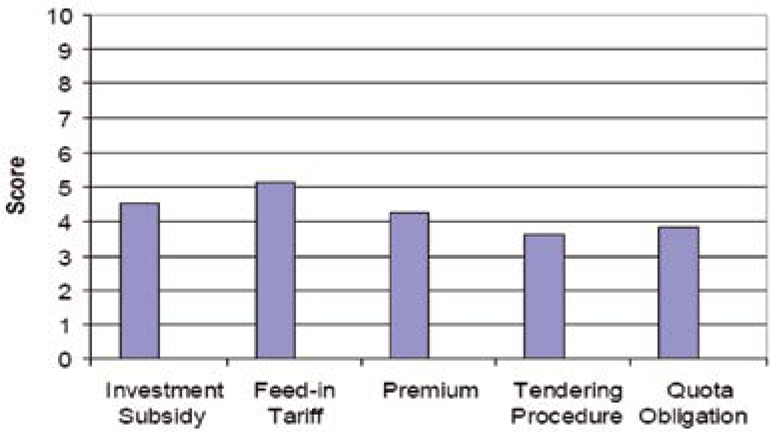
Figure 2.4
Historically observed efficiency of support for onshore wind and forestry biomass: effectiveness indicator compared to expected profits (years 2006 and 2005)

(a) onshore wind (b) forestry biomass



Source: OPTRES (2007).

Figure 2.5
Score of support instruments



Source: EWEA-RE-Xpansion project (2005).

Energy Market Access and Competition Policy

Since it is argued that well-functioning energy markets, able to guarantee secure energy supplies at competitive prices, have a key role in the achievement of higher growth and consumer welfare, a set of EU Directives, policy papers and national initiatives have been introduced. The main purpose of these documents is to eliminate barriers between Member States and to establish guidelines directed at developing a common market along the lines of the electricity and natural gas markets.

The liberalisation process in the EU began in the early 1990s with the adoption of two directives concerning the transparency of gas and electricity prices charged to industrial end-users (Directive 90/377/EEC of June 29, 1990) and the transit of electricity through transmission grids (Directive 90/547/EEC of October 29, 1990).

The former measure is aimed at introducing an obligation to Member States to communicate to the Statistical Office of the EC both prices and details of the national price system.

On the contrary, the objective of the latter directive is to liberalize electricity trade among Member States.[28] The adoption of these directives can be considered as the first phase of liberalisation of the electricity sector.

As far as natural gas is concerned, the first attempt to regulate the natural gas market was with Directive 94/22/EC of 1994 (Hydrocarbon Licensing Directive). According to this provision, "Member States are not permitted to maintain, within their territories, natural gas production monopolies by reserving to particular companies perpetual and exclusive rights for the prospection, exploration and production of natural gas".

Following a proposal for a directive to the Council of the European Communities, aimed at a gradual and partial liberalisation of the electricity Market, Directive 96/92/EC was adopted (1996, second phase in the liberalisation process). This Directive (the Electricity Directive), set out common rules for the internal electricity market (namely, generation, transmission, and distribution of electricity) and the obligation by all Member States (with the exceptions of Belgium, Ireland and Greece) to bring into force laws, regulations and administrative matters before the February 20, 1999. This Directive was integrated by Directive 2001/77/EC of September 27, 2001 on the promotion of electricity produced from renewable energy sources.

Another normative framework that addresses the issue of a process of liberalisation of the natural gas market is Directive 98/30[U52], concerning common rules for the internal market of natural gas (directive to be implemented by August 2000). According to the main objectives of the Directive, by 2008 Member States had to open up to competition at least 33% of their gas markets. Consequently, detailed rules on the organisation and functioning of the natural gas sector were established.

Finally, it is to be noted that, according to a proposal made in March 2001 to revise the old Electricity Directive 96/92/EC (1996), a second Electricity directive was introduced (2001). Different areas are affected by these two provisions, according to the following scheme, namely:

I. *Generation:* for the construction of new power plants, Member States can adopt either one of the following two options: a) tendering, b) authorization. Under tendering, the amount of capacity required to be built and the specifications bidders would need to meet, are established by an official body. On the contrary, under authorization, the only requirement is compliance with planning law and its specifications (concerning safety and commercial credentials) on the part of companies that wish to build plants;
II. *Retail supply:* conditions are introduced on Member States for a gradual

opening of the retail market for large users and distributors. Member States should provide their own definition of "eligible customers" (that is, customers who are free to change suppliers) by establishing the minimum requirements they have to satisfy (e.g. connection to the transmission grid, minimum annual consumption they are able to reach);

III. *Transmission and distribution:* with regard to the measures to be implemented in order to ensure that all competitors have non-discriminatory access to the network, it has been established that an independent system operator should be able to operate on the transmission system. In particular, it should be responsible for maintaining and developing the network and its interactions. Hence, generators and retailers have to be able to get their power to final consumers;

IV. *Unbundling:* in order to avoid a situation where integrated companies are able to exploit their ownership of the network by damaging competition in generation and/or retail businesses, Member States have to introduce measures directed at some corporate separation of the network and retail/generation activities. In particular, the vertically integrated sector should be unbundled into four segments (i.e., generation, transmission, distribution and supply). On the contrary, because of security reasons, transmission and distribution are allowed to remain natural monopolies.

This Directive also considers the possibility of an independent authority to be designated in order to resolve disputes that could arise between companies. In addition, countries characterized by dominant national ownership are required to open their markets and move to privatisation. Finally, conditions on international trade are examined. Countries are allowed to prevent foreign companies from competing in the national market, provided that a reciprocity condition is not satisfied.

Similarly to the 1996 Electricity Directive, the Natural Gas Directive (1998) sets up measures directed at introducing responsibilities in construction of major gas facilities; transmission and distribution; unbundling; and regulation.

In 2003, the adoption of Directive 2003/54/EC[U53] (which replaced the previous Electricity Directive), and Regulation 1228/2003 (on conditions for access to the network for cross-border exchanges of electricity) marked the starting point of the third phase in the liberalisation of the electricity and gas sectors.

An important objective of these two Directives was to establish a more robust EU framework of rules designed to open and integrate national markets. Accordingly, a date for the full market opening (July 2004 for non-household consumers, July 2007 for all consumers)was set. In addition, stricter rules for national network access regimes and the unbundling of vertically integrated utilities were introduced. Directive 2003/54/EC strengthened the requirements which Directive 96/92/EC had introduced, with regard to the need to separate network segments from competitive segments. To ensure organization and decision-making independence (and, consequently, avoid to discriminatory access and conflicts of interest), a legal separation and minimum criteria are imposed.

Finally, in order to provide a better regulation of national markets, the directives also make it mandatory for Member States to have regulatory authorities with a minimum set of powers and responsibilities.

Other (more recent) important documents are the Regulation (on cross-border trade) in electricity 1228/2003/EEC[U54] and Directive 2005/89/EC. While the former regulation sets rules for the transmission of electricity among Member States as well as conditions for access to the network for cross-border exchanges of electricity (this regulation entered into force on July 1, 2004 and was directly applicable Community law), the second document is related to measures for safeguarding electricity supply and infrastructure investment.

Following the European Directives outlined above, a competitive internal market for electricity and gas has been progressively introduced across the European Union. With regard to the present situation of competition in the electricity and gas sectors, the initial opening of energy markets can be argued to have achieved good results. However, a single competitive European energy market is still far from being realized. The current state of competition in the gas and electricity markets can be analyzed by considering five different points: 1) market concentration; 2) effective unbundling of network and supply activities; 3) entry of new competitors; 4) lack of reliable and timely information on markets; 5) existence of regulatory gaps. Here follows a detailed analysis of these five points.

Regarding the first point, as the Energy Sector Inquiry[29] points out, many national markets display a high degree of concentration of the industry. In certain electricity markets there also seems to be a tendency towards a growing vertical integration between generation and supply activities, which might lead to a reduction of liquidity on the wholesale markets concerned, an effect that could aggravate the risks associated with concentration. In addition, there has recently been an increasing number of cross-border acquisitions or attempts by incumbent gas and electricity companies to merge. Because of the decrease of incentives for competitors to make new investments , the development of effective competition has been impeded.

As far as the electricity sector is concerned, it is argued that proper integration of national markets and pressures from imports have achieved levels that are still unsatisfactory. In fact, percentages associated with interconnection capacity available to the market among many Member States remain quite low. Consequently, at many EU borders congestion of the electricity network is a not infrequent phenomenon.

In 2002, in Barcelona, the European Council decided to introduce the objective that all Member States must have an interconnection capacity equivalent to at least 10% of their national consumption. However, this objective has not yet been achieved. Lack of integration among national markets is also due to entry barriers. In the case of electricity, insufficient interconnections among many Member States may lead to congestion.

At the wholesale level, although trading is more developed, sales of electricity are generally affected by a significant level of concentration in generation. An analysis of trading on power exchanges shows that, in a number of them, generators are able to exercise market power by raising prices, a concern which has also been expressed by many customers.

An analysis of generation portfolios also shows that the main generators have the ability to withdraw capacity to raise prices. Although trading positions on forward markets are characterized by less concentration, it is still argued that electricity markets depend on too few suppliers with long positions.

For natural gas, access to supplies for new entrants, as well as the scope for moving gas around the European network, remains limited. Hence, wholesale trade has been slow to develop, and the incumbents remain dominant on their traditional markets.

In fact, incumbents largely control upstream gas imports and/or domestic gas production by trading only a small proportion of their gas on gas exchanges ("hubs").

Competition at the retail level is often constrained because of reduced possibilities of entry of new operators. Consequently, competitive pressures, as well as customer choice, remain limited.

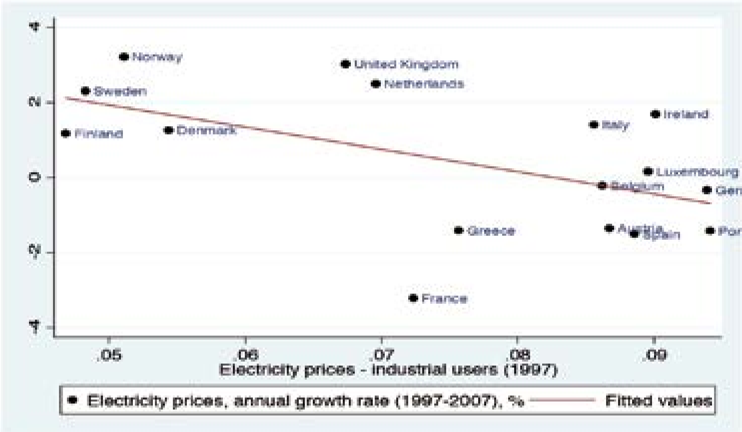
All in all, for services throughout the supply chain, the potential entry of new firms continues to depend on vertically integrated incumbents. In the context of the Energy Sector Inquiry, a study on concentration levels in the electricity sector has shown that, during peak hours, concentration levels, even in the less concentrated markets, reach significant levels. In many countries, even during off-peak hours, markets remain highly concentrated.

Finally, by tradition LNG has been imported by national incumbents who also own LNG terminals, and this situation has prevented LNG imports from increasing downstream competition.

A key indication of the persistence of high levels of concentration is represented by the existence of convergence/divergence of prices across the EU. According to standard economic theory, when trade is easy in an integrated market, prices tend to converge. In other words, competition among different European companies could keep prices close together across the EU, or at least between adjacent Member States or regions.

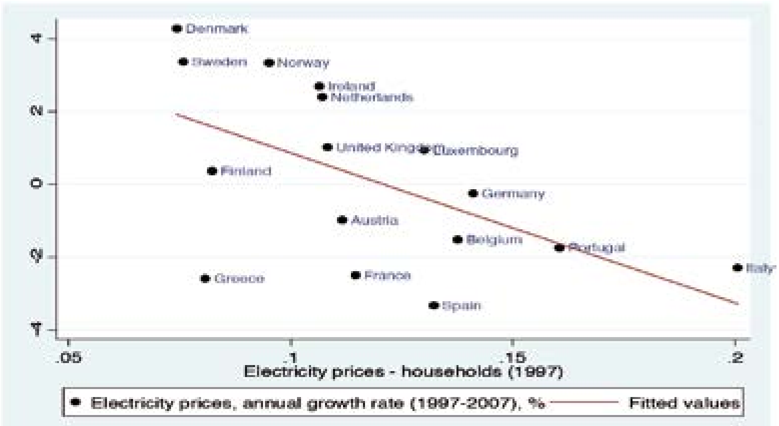
Despite recent price increases, electricity prices have decreased over the last 10 years in real terms. Also, prices of other fuels such as natural gas and oil (equally important for certain industries), have increased more significantly than electricity prices over the last three years. However, in some cases, differences in electricity price for industrial customers in the EU are still significant. On the other hand, wholesale price levels have started to converge in some neighbouring countries.

Figure 2.6
Convergence of electricity prices, industrial users (β-convergence)



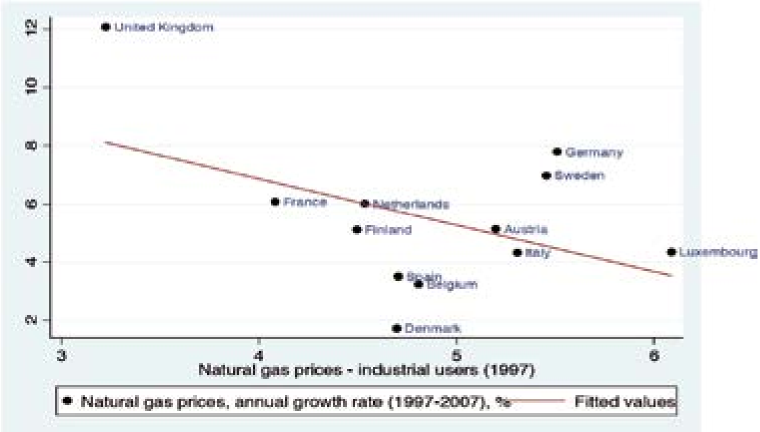
Source: Authors' computations on data from Eurostat. Prices are expressed as Euro per kWh.

Figure 2.7
Convergence of electricity prices, households (β-convergence)



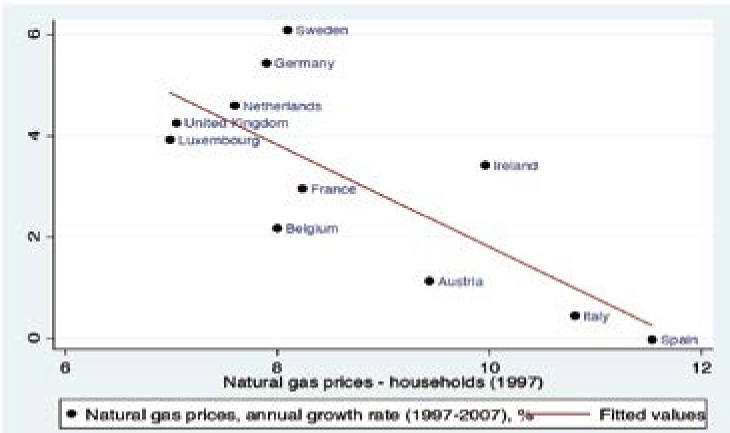
Source: Authors' computations on data from Eurostat. Prices are expressed as Euro per kWh.

Figure 2.8
Convergence of natural gas prices, industrial users (β-convergence)



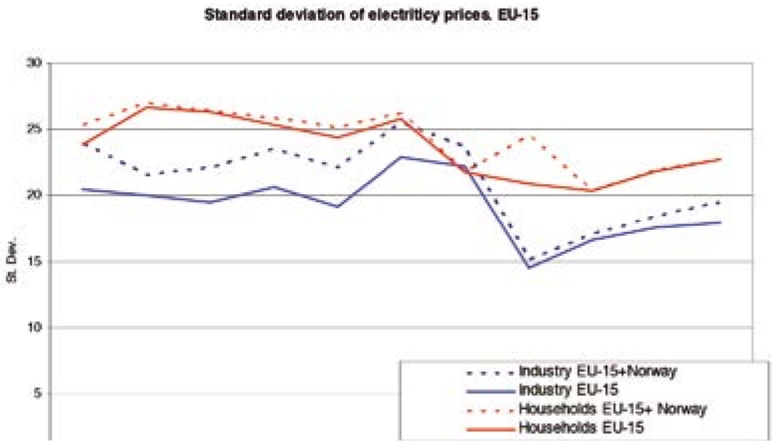
Source: Authors' computations on data from Eurostat. Prices are expressed as Euro per Gigajoule.

Figure 2.9
Convergence of natural gas prices, households (β-convergence)



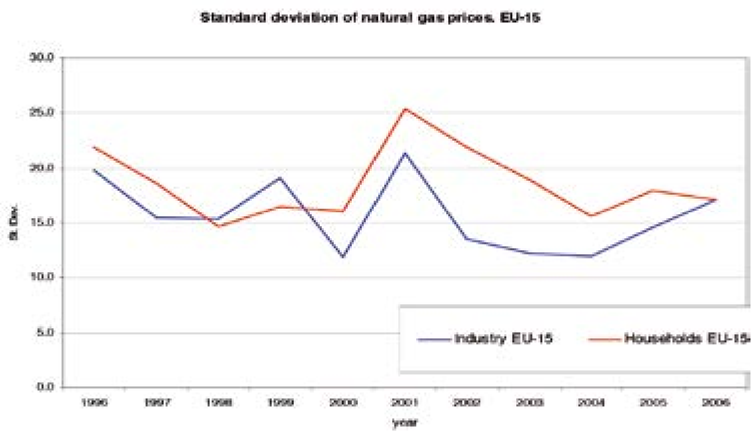
Source: Authors' computations on data from Eurostat. Prices are expressed as Euro per kWh

Figure 2.10
Convergence of electricity prices (σ-convergence)



Source: Authors' computations on data from Eurostat. Standard deviations are computed based on indices (EU-15= 100).

Figure 2.11
Convergence of natural gas prices (σ-convergence)



Source: Authors' computations on data from Eurostat. Standard deviations are computed based on indices (EU-15= 100). Because of data availability, this figure refers to the following countries: AU, BE, FR, DE, IE, IT, LU, NL, SP, SW, UK.

Figures 2.6-2.9 show convergence of real electricity and natural gas prices[30] among the 15 European countries plus Norway. Figures 2.6-2.9 plot the value of electricity and natural gas prices in 1997 against their compounded average growth rate for the period 1997-2007.[31] A clear negative relationship between the growth rate and the initial value of prices is shown to exist for both the industrial and the household sectors. This is a clear signal of β-convergence of prices among European countries. In particular, it is worth noting the success countries such as Austria, Spain and Italy have obtained in reducing upward pressures on prices.

However, movements of standard deviation for both electricity and natural gas prices during the period 1997-2007 (see Figures 2.10 and 2.11) show that the degree of dispersion of prices has not yet decreased. In fact, during this period there has been only limited σ-convergence.

From the previous analysis, although we can argue that a process of price convergence has started, we can conclude that the development of regional markets (to be considered as an intermediate step before ultimate integration at the EU level) is still underdeveloped. A notable exception is the relatively well-functioning Nordic electricity wholesale market.

Currently, significant competitive constraints are imposed on cross-border sales. Rarely are companies (namely, incumbents of other countries) able to enter markets. In fact, the number of newcomers to the market has recently decreased. Consequently, only a very small fraction of new electricity generation projects has recently been commissioned by non-incumbents. Therefore, it has been pointed out that the internal energy market trade is currently underdeveloped. In fact, between 2000 and 2004, cross border flows of electricity as percentage of total consumption has increased only by 2 percentage points (from 8-9% to 10.7%). It has followed that, in merger procedures under EU competition law, "relevant markets" continue to be associated with domestic dimensions[U55].

Regarding the second point, as it has been seen, effective unbundling of network operation from the competitive parts of the business is actively monitored by the European Commission. In fact, it is an essential factor in ensuring independent network operation and non-discriminatory access to networks for all market participants. It is argued that an insufficient level of unbundling of network and supply interests has a negative impact on market functioning and on incentives to invest in network capacity.

At the moment, the tightened unbundling rules in the new directives are not yet fully effective in practice. In many instances (and, especially, in the cases of gas transmission and distribution system operators) the late implementation of the Directives by most Member States has prevented the process of unbundling from being completed[U56].

New entrants often lack effective access to networks (in the natural gas market, also to storage and to liquefied natural gas terminals). A certain degree of discrimination is still present in the market. Incumbents, in particular, are alleged to favour their own affiliates. According to this form of vertical integration, operational and investment decisions are not taken in the interest of network/infrastructure operations, but on the basis of the supply interests of the integrated company (including grid connection for competing power plants).

This form of vertical foreclosure was found to exist by way of the integration of generation/imports and supply interests within the same group. In addition, the incentives for incumbents to trade on wholesale markets are reduced, leading to sub-optimal levels of liquidity in these markets. In particular, the prevalence of long-term supply contracts between gas producers and incumbent importers makes it very difficult for new entrants to access gas on the upstream markets. Similarly, electricity generation assets are in the hands of a few incumbent suppliers or are indirectly controlled by them on the basis of long-term power purchase agreements giving the incumbents control over the essential inputs into the wholesale markets. Low levels of liquidity are an entry barrier to both the gas and the electricity markets.

As far as market integration is concerned, the potential associated with cross-border sales has not yet been completely achieved. Incumbents rarely enter other's domestic markets as competitors. Market integration is hampered by insufficient or unavailable cross-border capacity and different market designs.

In the electricity market, it is still argued that an insufficient level of interconnector capacity hampers integration. On the other hand, long-established bottlenecks are difficult to eliminate on account of a lack of adequate incentives to invest.

Furthermore, on certain borders, long-term pre-liberalisation capacity reservations still exist, despite the fact that such reservations are incompatible with EC law, unless they were notified under Directive 96/92/EC[US7] (see ruling of the European Court of Justice). Improving access to existing interconnectors requires better methods of congestion management. However, better use of capacity is often not in the interest of vertically integrated network operators.

As for natural gas, available capacity on cross-border import pipelines is limited. New entrants are unable to secure transit capacity on key routes and entry capacity into new markets. Very often, the primary capacity on transit pipelines is controlled by incumbents based on pre-liberalisation legacy contracts which are not subject to normal third-party access rules.

Incumbents have little incentive to expand capacity to serve the needs of new entrants. This is reinforced by ineffective congestion management mechanisms, which make it difficult to secure even small volumes of short-term, interruptible capacity on the secondary market. In many cases, new entrants have not even been able to obtain a sufficient amount of capacity when there have been expansions of transit pipeline capacity. Expansions have generally been tailored to the needs of the incumbents' own supply businesses.

All in all, despite the fact that effective unbundling is necessary to create a level playing field in the balancing markets and to reduce barriers to entry, the current level of unbundling of network and supply interests is not able to enhance market functioning. Incentives to invest in networks are still low and not enough to raise the current (insufficient) level of unbundling of network and supply activities. Table 2.5 shows that, therefore, in around half of the Member States ownership of the electricity transmission network is unbundled. For many countries unbundling in gas transmission has not been implemented yet.

Table 2.5
Ownership of the electricity and gas transmission network

	Electricity Transmission			Gas Transmission		
	Legal	Ownership	Unbundling not implemented	Legal	Ownership	Unbundling not implemented
Austria	X	X				
Belgium	X			X		
Denmark		X			X	
Finland		X				
France	X			X		
Germany	X			X*		
Greece	X					
Ireland	X					X
Italy		X		X		
Luxembourg	X					X
Netherlands		X			X	
Portugal	X					
Spain		X		X		
Sweden		X			X	
UK		X			X	
Norway		X				
Estonia	X					X
Latvia	X					X
Lithuania		X				X
Poland	X					X
Czech Republic		X				X
Slovakia	X					X
Hungary		X		X		
Slovenia		X				X
Cyprus						
Malta						

Notes: * Partly legal.

Source: Commission of the European Communities (2005) "Communication from the Commission to the Council and the European Parliament. Report on progress in creating the internal gas and electricity market".

The third point worth stressing is the existence of constraints to competition due to contractual clauses. An analysis based on measurements of market structure reveals that, in certain markets, long-term contracts and, to a lesser extent, reserve requirements can reinforce concentration levels. Because the existing level of interconnection capacity is insufficient to significantly reduce concentration, in many Member States the number of competitive offers that customers receive is particularly unsatisfactory. Competitive offers from non-incumbent suppliers are still lacking, while supply offers from abroad are mostly absent. In addition, the duration of retail contracts for industrial customers and local distribution companies continues to have a substantial impact on the opportunities for alternative suppliers to successfully enter the market.

In particular, the degree to which the industrial customers are tied to incumbent suppliers on a long-term basis differs significantly among Member States. In electricity markets, certain standard contracts contain restrictions which raise competition issues. Currently, while incumbents receive benefits from balancing markets, conditions on these markets are a clear obstacle for newcomers. In other words, the size of the current balancing zones is too small, leading to increased costs and protecting the market power of incumbents.

In addition, the markets on which transmission system operators (TSO) have to acquire balancing and reserve energy are still characterized by high levels of concentration, giving generators scope for exercising market power. This can result in entry barriers for new suppliers facing a great risk of high imbalance prices and/or high network charges (since balancing costs are included in network costs). In some Member States the structural relation between TSOs and their affiliated generation provides an incentive for the TSO to buy excessive reserve capacity and/or to pay high prices, thereby favouring their affiliated generation subsidiary.

With regard to natural gas, the duration of retail contracts for industrial customers and local distribution companies can significantly affect the probability of alternative companies successfully entering other domestic markets. Therefore, long-term gas contracts, though necessary to underpin the financing of major new gas infrastructure, are a negative feature affecting competition.

To summarize, the cumulative effect of long contract durations, together with the presence of contracts of indefinite duration, tacit renewal clauses and long termination periods on the feasibility of reducing market concentration, can be significantly negative.

Finally, with regard to natural gas supplies, effective competition between different suppliers is also hindered by restrictions on how customers can dispose of their gas. In fact, regarding delivery points, restrictive practices by suppliers still characterize this market.

Even with regard to the natural gas market, an obstacle that new suppliers have to face is associated with the current characteristics of balancing operations.

The small size of current balancing zones has raised the level of complexity and costs associated with shipping gas between Member States. In particular, the existence of rules and obligations about reserving at each border point a capacity that may differ between countries has significantly increased costs. These problems are further exacerbated by the time dimension of the balancing period: the shorter the balancing period, the higher the risk of imbalance for the supplier. All these aspects create major obstacles for new suppliers to enter the market, which the vertically integrated incumbents have little incentive to remove.

Furthermore, balancing charges, clearing costs and penalty charges introduced by incumbents are not completely transparent and often contain unjustified penalty clauses.

Regarding the information issue, in the current situation only the incumbents are able to obtain the information necessary to trade effectively in the market. This represents a clear obstacle to fair competition among different energy companies. For electricity, data on operations of generation capacity and gas storage suggest that rules on proper market conduct and supervision differ significantly between Member States and that, as far as transparency requirements are concerned, harmonisation at the EU level is not yet sufficient[U58].

At present, there is an informational asymmetry between the vertically integrated incumbents and their competitors. Many users have limited trust in the price formation mechanisms, while regulated supply tariffs below market prices discourage new entry. Furthermore, the existence of regulated supply tariffs is a clear obstacle to the entry of new operators on the markets.

Electricity price formation is complex. According to the Energy Sector Inquiry, although increases in the price of primary fuels may have played a role in recent electricity price development, this is not enough to fully explain the recent price hikes. Similarly, effects of the EU CO_2 emissions trading scheme on electricity prices have not been yet completely explained.

Import contracts for natural gas use price indices that are linked to oil derivatives (e.g. light fuel or heavy fuel) and prices have therefore closely followed movements in oil markets. This linkage results in wholesale prices that fail to react to changes in the supply and demand changes, an effect that could also damage security of supply. No clear trend towards more market-based pricing mechanisms can be observed in long-term import contracts.

Finally, regarding the existence of regulatory gaps, it can be stated that, since over time regulators have gained experience and strength, the work of regulatory authorities can be defined as generally good. However, it is argued that the powers of regulators are insufficient to ensure that a transparent, stable, non-discriminatory framework develops and to enhance investments in the sector. For instance, in several Member States regulated tariffs have generated negative effects on the development of competitive markets. In fact, they have been set at very low levels compared to market prices. In addition, since they cover a large part of the market, a process of "reregulation" followed (Energy Sector Inquiry).

Similarly, special measures to reduce electricity bills for energy intensive industries have been considered. Such schemes must be compatible with antitrust and state aid rules.

All in all, the main objective of the Electricity and Gas Directives - to maintain and improve the position of customers - is being, generally, met in terms of customer satisfaction. Surveys of consumers' perceptions have suggested that the quality of the electricity and gas services provided is generally deemed satisfactory. It can be concluded that fears of introducing competition would be followed by a decline in service standards or problems in the provision of a universal service have proved to be unfounded.

Nevertheless, the objective of introducing competition at the EU level (i.e., to expose companies to EU-wide competition) has not yet been achieved in most markets. Although in real terms prices of electricity have decreased with respect to 1997[32], both at wholesale and retail levels, electricity and gas markets remain "domestic in scope". Since the high level of concentration of the pre-liberalisation period has not been reduced, incumbents are likely to continue to exercise market power.

Table 2.6[U59] shows the degree of concentration for electricity and natural gas markets. In particular, countries are classified according to the value of the Herfindahl-Hirschman Index (HHI)[33]. According to this table, the electricity sector of several countries is classified as "highly concentrated". For instance, in Belgium, France and Ireland the HHI is higher than 5000. For natural gas, only the UK shows moderate rates of concentration. For all other countries, the HHI has values lower than 1800.

Table 2.6
Concentration of electricity and natural gas industries

	Electricity (generation)	**Gas (import and production)**
Very highly concentrated (HHI above 5000)	*BE, FR, GR, IE, PT, EE, LV, SK, SI*	*All others*
Highly concentrated (HHI between 1800 and 5000)	*DE. IT, ES, LT, CZ*	*AT, IE, IT, ES, NL*
Moderately concentrated (HHI between 750 and 1800)	*AT, NORDIC, NL, UK, PL, HU*	*UK*

Source: Technical Annex to the Report from the Commission to the Council and the European Parliament and DG TREN calculations.

In addition, wholesale gas and electricity markets are not working properly: markets are still characterized by high prices and limited choice for consumers.

This analysis shows that additional efforts have to be made in order to complement regulation and hence achieve efficient and reliable electricity and gas markets. In particular, what is needed is a more proactive use of competition policy tools to ensure that the opened markets really work for consumers, according to the following points (see also Energy Sector Inquiry): 1) concentration in balancing markets could be reduced if the geographical size of the control areas were enlarged. A size increase of the control areas (an instrument for improving market integration and simplifying trade) could follow the process of harmonization of balancing market regimes; 2) although Europe is in many respects in a favourable position, access to new gas sources usually requires the construction of new transport infrastructure, i.e. pipelines or liquefied natural gas (LNG) facilities (see also Section on transportation of natural gas). In this regard, the European Commission points out that increasing attention should be given to the strategic dimension of its energy relations with third countries. In particular, it is argued that LNG supplies from less concentrated downstream markets are necessary to ensure both security of supply and competition between upstream suppliers. Recent trends, however, point to more capacity going to new entrants and to producers themselves. If such effects were not frustrated by anticompetitive rules or behaviour, a positive impact on fostering downstream competition could arise; 3) more reliable and timely information on the markets is needed. In particular, network users require more transparency than the minimum requirements currently set by EU legislation. Of particular importance is data relating to network availability, especially for electricity interconnections and gas transit pipelines. Data on the operation of generation capacity and gas storage also need to be more widely available; 4) in order to ensure a level playing field, information has to be available on an equal footing and in a timely manner to all market participants. In this case, improved transparency would minimise risks for new market players and so reduce entry barriers. Hence, trust in the wholesale markets and confidence in price signals would be enhanced. Obviously, an important aspect to consider is that no collusion takes place on the basis of the published information. Furthermore, although commercial confidentiality is important, this should not be allowed to undermine effective transparency by being given too wide an interpretation. Finally, more effective and transparent price formation could deliver the full advantages of market opening to final consumers; 5) ensuring liquidity is crucial to improve confidence in price formation on gas hubs, which will allow for a relaxation of the linkage to oil. All in all, the Commission argues for the importance of appropriate rules on transparency, together with obligations to disclose key information, such as available generation capacity.

2.6 Public Finance and Tax Policies

The European Community (EC) framework for the taxation of energy products and electricity establishes general arrangements concerning fiscal policy matters related to the energy sector[34]. Loosely speaking, this Council Directive extends the Community system of minimum rates of taxation (long applied only to mineral oils) to coal, natural gas and electricity when they are used as motor or heating fuels.

Moreover, the Directive is an important policy tool that Member States and the European Union as a whole can use in order to find the optimal balance between "competitiveness", "sustainability" and "energy security", namely the three core energy policy objectives laid down in the Green Paper[35]. In fact, the purpose of the Directive is threefold: first, reducing distortions of competition between mineral oils and other energy sources could help to improve the operation of the internal market; second, as far as security of supply and sustainability are concerned, encouraging a more efficient use of energy can reduce both dependence on imports and greenhouse gas emissions. Lastly, with the aim of lessening the environmental impact of economic activities, Member States are authorized to grant tax advantages to businesses that take measures to reduce their emissions. Of note is the fact that the Directive leaves ample room for improvements at the country level; provided that Member States comply with the rates of taxation imposed by the Directive, they are allowed to fine-tune the taxation in accordance with their needs and socio-economic characteristics (other examples will be given below).

Let us now look more closely at the content of this Directive. Its main purpose is to set minimum rates of taxation to be levied on energy products and electricity when they are used as motor or heating fuel; on the contrary, these commodities are exempted from taxes if are used as raw materials, for purposes of chemical reduction, or in electrolytic and metallurgical processes. Accordingly, minimum rates of taxation are set for motor fuel, motor fuel for industrial production or commercial use, heating fuel and electricity. More precisely, the energy sources for which the directive sets minimum rates are the following: diesel, kerosene, LPG, natural gas, petrol, unleaded petrol, heavy fuel oil, coal, coke and electricity.

In order to alleviate the tax burden, it also allows Member States to refund, in full or in part, taxes paid by businesses that have invested in the rationalisation of their energy use. Moreover, Member States may apply total or partial exemptions or reductions in the level of taxation of: 1) energy products used under fiscal control in the field of pilot projects for the technological development of more environmentally-friendly products or in relation to fuels from renewable sources; 2) bio fuels; 3) forms of energy which are of solar, wind, tidal or geothermal origin, or from biomass or waste; 4) energy products and electricity used for carrying goods and passengers by rail, metro, tram and trolley bus; 5) energy products supplied for use as fuel for navigation on inland waterways (including fishing), other than for private pleasure craft, and electricity produced on board a craft; 6) natural gas and LPG used as propellants.

For some Member States the Directive defines transitional periods during which they are required to gradually reduce the gap between their rates and the new minimum rates of taxation.

While this Directive addresses the taxation of energy commodities, March 28, 2007 Green Paper on market-based instruments for environmental and related policy purposes raises crucial questions about the promotion of market-based instruments to be used for environmental protection. In fact, the Commission promotes the use of market-based instruments, including quota trading schemes, taxation measures and subsidies, to achieve environmental and other strategic objectives, not only within the EU; the Commission also suggests promoting market-based instruments at the international level, and in particular to its trading partners. This Green Paper also asks whether there is room for relieving the Energy Taxation Directive in order to establish a clearer link between energy taxation and environmental concerns. It is argued that dividing the tax into energy and environmental elements, with energy sources taxed according to their energy content and their environmental impact (greenhouse gas emissions and other polluting emissions), would ease the promotion of more environmentally friendly energy sources, in particular renewable energy.

In theory, market-based instruments could have the following advantages over regulatory instruments: external costs are internalised (i.e. taken into account in the end price); they allow businesses greater flexibility in meeting their objectives and thus lower compliance costs; they give firms an incentive to invest in innovation to reduce their impact on the environment; they support employment when used in the context of green fiscal reform.

Two main types of market-based instruments are used at the Community level: 1) instruments influencing prices, thus altering them, such as taxes and financial or fiscal incentives; 2) instruments influencing quantities, by which a maximum quantity is set (in absolute terms or per unit of output): tradable permit schemes, such as the greenhouse gas emissions trading scheme, which sets a maximum emission quantity of a particular pollutant.

Instruments influencing quantities offer greater certainty and visibility in achieving specific objectives (e.g. emission limits), while price influencing instruments offer certainty of the cost of achieving the objective (e.g. taxes) and are generally easier to implement.

This Green Paper is especially concerned with transport, which is a major contributor to air pollution and CO_2 emissions. The Commission has already proposed linking passenger car taxes to CO_2 emissions and including the aviation sector in the greenhouse gas emissions trading scheme; moreover, it firmly supports an exchange of information on urban transport, in order to spread best practice identified in successful local experiments such as the

London Congestion Charge.

All in all, from this concise survey of EU finance and tax policies, what emerges is a strong commitment of the European Commission to achieving its three core energy policy principles, "competitiveness", "sustainability" and "energy security", while respecting the principle of subsidiarity of Member States, as stated in the EU Constitution. What also emerges is that it is not an easy task to accomplish and that, while important progress has been made, there is still a long way to go.

FOCUS ON CHINA'S ELECTRICAL POWER AND IRON AND STEEL INDUSTRIES

2.7 Energy Saving and Emission Reduction Policies in Electrical Power Industry

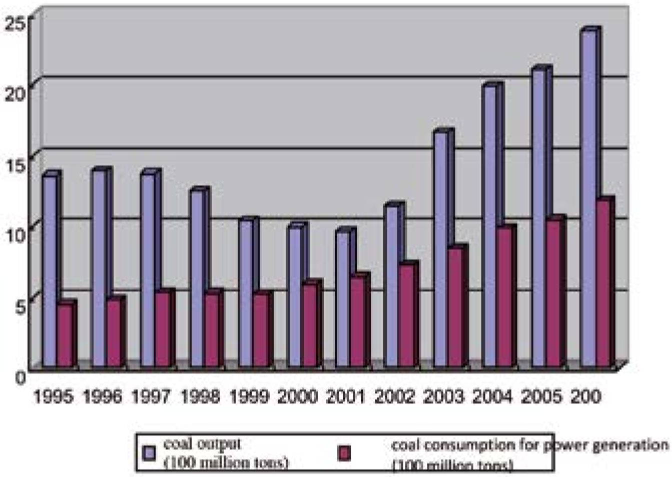
Current Status of Development and Energy Efficiency of China's Electrical Power industry

Energy Consumption in the Electrical Power Industry: Taking Coal as the Main Resource[U60]. Coal takes an absolutely superior position among the fossil energies consumed by China's electrical power industry (see Figure 2.12). In 2006, coal consumption for the electrical power industry was 1.182 billion tons, accounting for 49.62% of the domestic coal output in that year. 90% of the coal consumed by the electrical power industry was used for power generation and 10% was used for thermal supply. As for power generation, in recent years the installed capacity of thermal power in China has been growing more rapidly than the total installed capacity of China's electrical power industry. As a result, the frame of power generation that takes thermal power as its main resource has been further enhanced. In 2006, the proportion of thermal power in domestic power output was as high as 83.17%. Nearly 99% of thermal power output comes from the coal combustion and the remaining 1% from fuel and gas combustion (natural gas, coal gas, LPG, etc., included).

Since 1995 China's coal output has undergone notable fluctuations. In the 1997-2002 period domestic coal output plunged, reaching its nadir of 964 million tons in 2001, from a high of 1.373 billion tons in 1997: a drop of more than 30%. Since 2002 coal output has been rapidly growing, and reached 2.382 billion tons in 2006, 2.47 times its 2001 output.

However, in the 1997-2002 period coal consumption in the electrical power industry showed a steady growth, going from 451 million tons in 1995 to 1.182 billion tons in 2006, a growth of 162%. The proportion of coal consumed by the electrical industry from the domestic coal output grew from 32.76% in 1995 to 53.51% in 2002, and then dropped slowly to 49.62% in 2006.

Figure 2.12
Coal output in China and coal consumption in the electrical power industry (years 1995-2006)



Source: Statistic Yearbook for China's Energy in 2007

Structure of Installed Capacity for Power Generation: the Predominance of Coal-Fired Power[U61]. The installed capacity for the electrical power in China has shown a constantly rapid growth (see Table 2.7). In 2007, it was 713.29 GW, 4.17 times over that of 1990, comprising 145.26 GW of hydropower, 3.03 times over that of 1990; 554.42 GW of thermal power, 4.44 times over that of 1990; 8.85 GW of nuclear power, 28.5 times over the 300,000 kw in 1991.

Table 2.7 Installed capacity for power generation

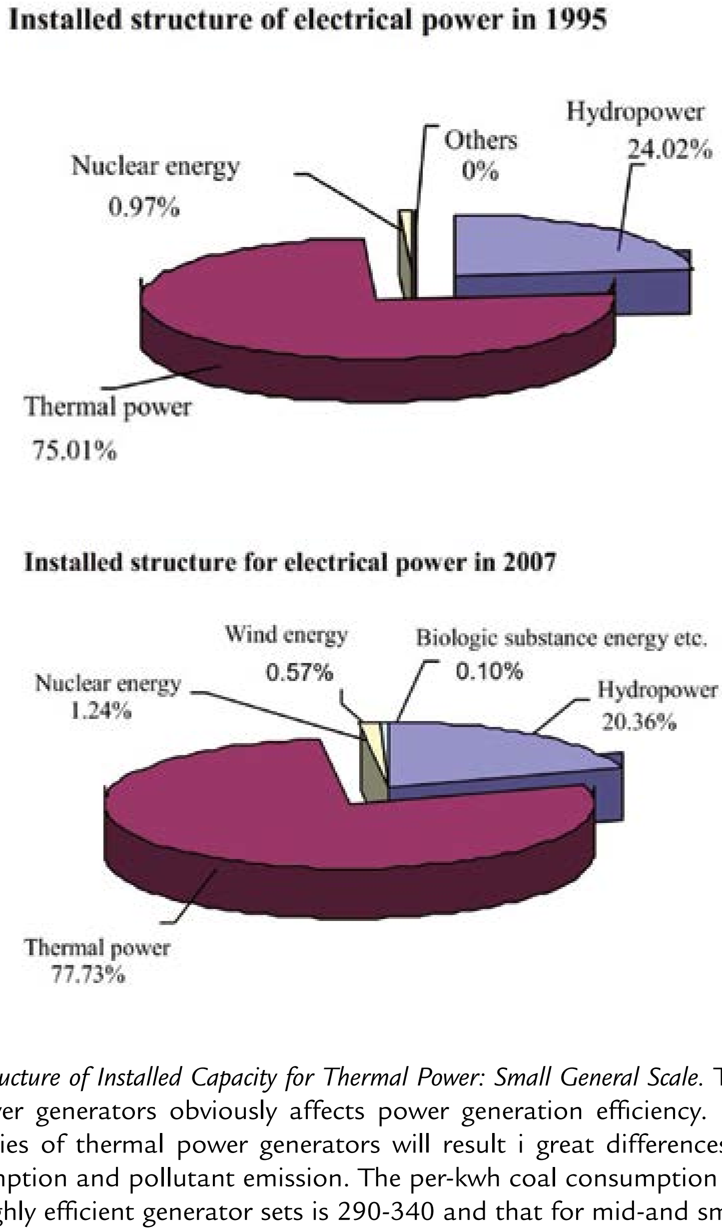
	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007
Installed capacity of power generation devices at the end of year (in GW)	*137.89*	*217.22*	*319.32*	*338.49*	*356.57*	*391.41*	*442.39*	*517.48*	*622.00*	*713.29*
Hydropower	*36.05*	*52.18*	*79.35*	*83.01*	*86.07*	*94.90*	*105.24*	*117.39*	*128.57*	*145.26*
Thermal power	*101.84*	*162.94*	*237.54*	*253.01*	*265.54*	*289.77*	*329.48*	*391.37*	*484.05*	*554.42*
Nuclear power	□	*2.10*	*2.10*	*2.10*	*4.47*	*6.19*	*6.84*	*6.84*	*6.85*	*8.85*
Others		*0*	*0.33*	*0.37*	*0.49*	*0.55*	*0.83*	*1.88*	*2.53*	*4.76*

Source: China Electricity Council

In the structure of installed capacity for power generation in China, thermal power takes an absolutely superior share, which shows a growing trend (see Figure 2.13). In 1995, the share of installed capacity for thermal power was 75.01% and that for hydropower and nuclear power was, respectively, 24.02% and 0.97%. In 2007, the proportion of installed capacity for thermal power and nuclear power grew respectively to 77.73% and 1.24%, but that for hydropower was reduced to 20.36%. In addition, the proportion of installed capacity for wind power and biological substance energy, etc., was, respectively, 0.57% and 0.1%. Although the proportions of installed capacity for nuclear power, wind power and biological substance power, etc., showed a notable growth, the total proportion of non-thermal power generation capacity was reduced from around 25% in 1995 to 22.27% in 2007.

More than 99% of thermal power generators in China are coal-driven, so the proportion of fuel and gas generators is negligible in the calculation. By comparison, the proportion of installed capacity for coal power in the structure of power generation in the USA in 2006 was only 31.7%, but the shares of natural gas generator sets and nuclear power generator sets with high efficiency were respectively 39.4% and 10.2%. The prevalent use of coal for power generation has determined the characteristics of relatively low energy efficiency and high emission of this sector, and it is the main reason for the characteristics and difficulties of China's energy management. Meanwhile, it also shows that China's electrical power industry has a great deal of potential for energy saving and emission reduction by adjusting the structure of its generator sets.

Figure 2.13
Change of installed structure for China's electrical power



Structure of Installed Capacity for Thermal Power: Small General Scale. The scale of power generators obviously affects power generation efficiency. Different capacities of thermal power generators will result i great differences in coal consumption and pollutant emission. The per-kwh coal consumption for large and highly efficient generator sets is 290-340 and that for mid-and small-scale generator sets can reach 380-500k. The coal consumption for 50000kw generator sets is approximately 440g/kwh, 30-50% more than the coal consumption for large generator sets.

In recent years, though China's electrical power industry has placed its small thermal power plants under strict control and encouraged the construction of large-scale generator sets, the general scale is still small and the installed capacity of generator sets below 300,000kw still accounts for a large proportion (see Table 2.8). In 2006, the installed capacity of generator sets below 300,000 accounted for a share of 45.3%[U62], of which, 18.77% belonged to generator sets below 100,000kw. The proportion of installed capacity of highly efficient generators of no less than 600,000kw was only 18.42%. Therefore, the optimization of the structure of installed capacity scale for thermal power plays an important role improving energy efficiency and emission reduction in the electrical power industry.

Table 2.8
Installed structure of thermal power generator sets in China (year 2006)

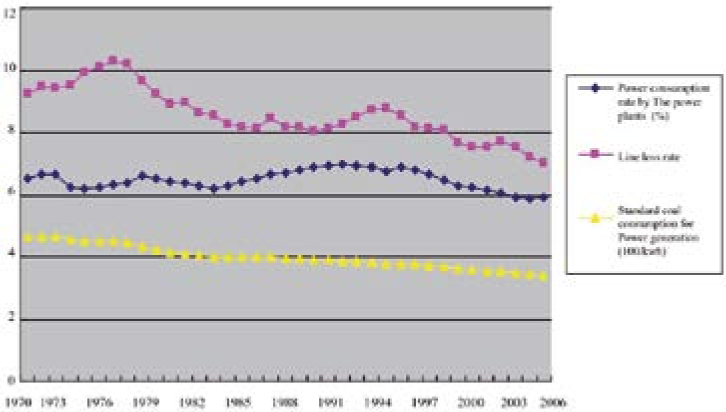
Category of index		Calculation unit	Total number of generator sets	Proportion in the capacity in the statistic scope (%)
Generator sets more than 6000kw	*Total*	*Quantity*	*6243*	*100*
		10000kw	*44711.6*	
≥ 600000kw	*Subtotal*	*Quantity*	*132*	*18.42*
		10000kw	*8234.7*	
300000-600000kw	*Subtotal*	*Quantity*	*508*	*36.25*
		10000kw	*16208.5*	
200000-300000kw	*Subtotal*	*Quantity*	*241*	*11.11*
		10000kw	*4966*	
100000-200000kw	*Subtotal*	*Quantity*	*558*	*15.45*
		10000kw	*6909.6*	
< 100000kw	*Subtotal*	*Quantity*	*4804*	*18.77*
		10000kw	*8392.8*	

Source: China Electricity Council - Report on Development of China's Electrical Power Industry in 2007

Steady Growth of Energy Efficiency in the Electrical Power Industry. The power consumption rate, the power transmission loss rate and the standard coal consumption for power generation of a power plant are the technical and economic indices for the measurement of energy utilization efficiency in the electrical power industry (see Figure 2.14). In 1970-2006, the energy utilization efficiency in the electrical power industry generally showed a steady growth trend, but the energy efficiency changes reflected by the three indices have different characteristics. The standard coal consumption for power generation showed a trend of gradual reduction and decreased by 121g, or 26.13%, from 463g/kw in 1970 to 342g/kw in 2006.

The line loss rate shows fluctuations around the general decreasing trend and reached two local maximum values, respectively, in 1976 and 1995. The rate in 1970-1976 grew from 9.22% to 10.32% and then showed a fluctuating decrease over the next 20 years. In 2006 it dropped to 7.04%. In a 27-year period the rate dropped by 31.78%, if we consider the highest line loss rate in the 1970-2006 period, i.e. 10.32% in 1976, or by 23.64% if based on 9.22% in 1970.

Figure 2.14
Changing trends for power consumption rate, line loss rate and standard coal consumption for power generation of power plants in electrical power industry



Notes: The common unit for standard coal consumption for power generation is g/kwh. For convenience of mapping, the unit in the diagram is 100g/kwh, but we still use g/kwh in the written description. The changing trend of the power consumption rate of the power plants is from growth to drop and its declining trend since the 1990s has been more obvious, but the diagram shows characteristics of its being high in the middle and low on both ends. The smallest value appears in 2006 and the highest value (7%) appears in 1992. If a comparison is made between 5.93% for 2006 and 6.54% for 1970, the drop is only 9.33%. If compared with the highest value in 1992, its drop rate in 2006 reaches 15.29%.

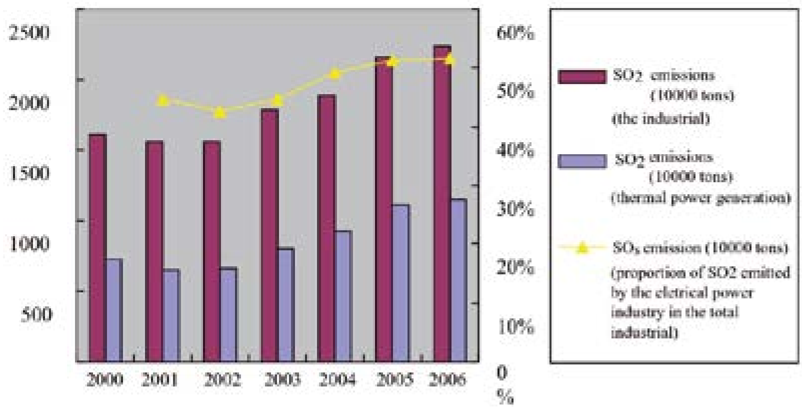
Source: Web station for SERC of PRC

Emission from Electrical Power Industry

SO_2 Emissions. In 2000-2006, SO_2 emissions from industrial sectors and thermal power sectors in China showed a general growth, except for a slight drop in 2001 and 2002 (see Figure 2.15). In 2006, there were 22.376 tons of SO_2 emissions from industrial sectors in China, an increase of 38.77% from 2000.

The electrical power industry is the sector mainly responsible for SO2 emissions in China, and its share of total industrial SO_2 emissions shows a growing trend. In 2006, SO_2 emissions from thermal power plants reached 11.55 million tons, a 4% increase from the previous year, accounting for 51.7% of China's total industrial SO_2 emissions in China. The five provinces with the highest SO_2 emissions from thermal power plants were Henan, Guizhou, Inner Mongolia, Jiangsu and Hebei, accounting for 34.8% of the national total. 2297 sets of desulphurization facilities, 861 more than in the previous year, were installed in the 1571 thermal power plants around China earnestly investigated by the MOE. These facilities removed 407 tons of SO_2, an increase of 76.8% from the previous year. The removal rate reached 26%, a 5.3% increase, but it is far lower than the average SO_2 removal rate (33.5%).

Figure 2.15
Change of SO_2 emissions in China's industries

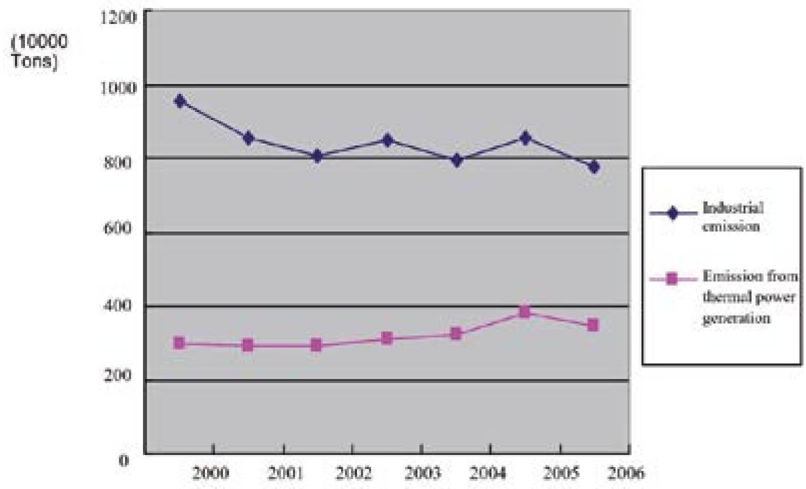


Source: Yearbook for China's Environment Statistics 2000-2004; Bulletin for China's Environment Statistics 2005-2006

Smoke Dust Emissions. Since 2000, smoke dust emissions from the industrial sectors of China have generally shown a declining trend (see Figure 2.16), decreasing from 9.533 million tons in 2000 to 7.749 million tons in 2006, a drop of 18.7%. In the same period, smoke dust emitted from the thermal power generation sectors increased from 3.013 million tons to 3.467 million tons, a rise of 15.1%. However, the growth rate of smoke dust emission from the thermal power generation sector is much slower than those of installed capacity of thermal power generation and of thermal power output. In the same period, the installed capacity for thermal power generation in China grew by 104% and thermal power output increased by 70.6%.

In fact, the smoke dust control level of the thermal power generation sector in China in this period has seen an obvious rise. At present, electric dust removers with no less than four electric fields are often used for the newly-built coal power plants, and the average de-dusting efficiency can reach more than 99%. Most of the electric dust removers for coal power plants that have gone into production recently are designed and manufactured on the basis of a dust removal quality and concentration of 50mg/m^3 or lower, which has reached the advanced international level; meanwhile, bag-type dust removers have been installed for a group of generator sets.

Figure 2.16
Dust smoke emissions from the total industry and the electrical power generation sector in China (years 2000-2006)



CO_2 Emissions. In accordance with the data provided by the CARMA webstation, in 2006 the USA was still the country with the highest CO_2 emissions, reaching 2.8 billion tons[U63]. With its high industrialization level and many thermal power plants, the CO_2 emissions from USA power plants account for 25% of the world's total. China follows with an annual emission scale of 2.7 billion tons. However, per-capita CO_2 emissions in China are only 2 tons, compared to no less than 9 tons in the USA.

The composition of power generation fuels and the technical level for power generation are the main factors affecting CO_2 emissions per unit of power output. The higher the coal proportion, the smaller the capacity of the generator set and the more CO_2 will be emitted per unit of power output. Usually, CO_2 emissions per unit of power output of small generator sets (lower than 12000kw) are three times higher than that of 300,000kw generator sets. Since fossil fuels, primarily coal, will continue to lead the thermal power and electrical power generation in China in the future, the thermal power generation sector will be the main source of CO_2 emissions in China.

The varieties of coals used for power generation in China are mainly smoke coal, smokeless coal, meager coal and brown coal, etc. The combustion of different kinds of coals will generate slightly different greenhouse gases. In 2006, coal consumption for power generation in electrical sectors of China was 1.182 billion tons, equivalent to 844 million tons of standard coal. Calculated at an average emission of 0.75 tons of CO_2 per ton of standard coal burned, the carbon emission volume from thermal power generation in 2006 was 633 million tons, accounting for 23.4% of 2.7 billion tons of domestic carbon emission. So, it is the industrial sector with the highest carbon emission in China.

Current Status of Policies for Energy-Saving and Emission Reduction in China's Electrical Power Industry

General Program for the Electrical Sectors in the Period of the Eleventh Five-Year Plan[U64]. In accordance with China's objectives for economic and social development and its national energy strategies, and in combination with the rules and characteristics of the electrical power industry, the state has regulated the development program for energies and electrical power. The program has devised its plans from multiple aspects, such as protection of resources, structural adjustment, environmental protection, technological progress, improvement of efficiency, demand for funds, manufacture of devices and conservation of electrical energy, and it has comprehensively solved the problems that occur in the development of the electrical industry so as to realize a safe, stable and reliable supply of electric power.

It was announced in the Eleventh Five-year Plan for Energy Development in April 2007 that the overall arrangement for energy construction in China in the Eleventh Five-year Plan period would be as follows: orderly development of coal; accelerated development of petroleum and natural gas; active development of hydropower, provisions for environmental protection and proper solutions to immigration problems, optimal development of thermal power and advancement of nuclear power construction; strong encouragement for developing renewable energies. The Eleventh Five-year Plan set power plant targets for 2010: reduction of coal consumption for thermal power supply to 355g/kw, decrease of in-plant electricity consumption rate (as a fraction of total electricity generated by a plant from 5.9% to 4.5%, increase of central heat supply coverage in urban regions from 30% to 40%, exceeding 40 million kilowatts of power generated by combined generator sets for heat and electrical power, and reduction of the electric network line loss to around 7%. On March 22, 2006, the conference for the Standing Committee of the State Council examined and principally approved the Program for Mid- and Long-term Development of Nuclear Power in 2005-2010. This program clearly stated the intention of actively pushing forward nuclear power construction and the rapid development of nuclear power technologies. In 2020, the installed capacity for nuclear power will reach 40 million kw and its share in the nationwide total will be increased to 4%. On June 7, 2006, the conference for the Standing Committee of State Council examined and principally approved the Program for Mid- and Long-term Development of Renewable Energies. This program aims at improving the share of renewable energies in the energy structure and actively favours the industrialized development of renewable energy technologies. In accordance with these objectives, in 2010 and 2020, hydropower will reach 190 million and 300 million kilowatts, and wind power will reach 5 million and 30 million kilowatts.[38]

Access to the Electrical Power Market. With respect to standards and requirements for access to electric power projects, the NDRC has successively published a number of relevant documents[39]. These documents have put forward the access requirements for resource saving on construction projects of electrical power plants. It is stated that projects for coal power plants characterized by large capacity and high efficiency, and concerned with water conservation and environmental protection, should be planned. Supercritical and ultra-supercritical generator sets should be planned and constructed principally for those power plants using coal coming from distant coalmines. Coal power plants with a coal consumption no higher than 275g/kwh standard coal will be planned and constructed preferentially in the coastal regions in East China, which has a shortage of coal resources. For joint heat-electricity generation projects, back-pressure heat-electricity joint generator sets will be arranged preferentially and their installed capacity for power generation will not be calculated into the control scale of electrical power construction. If the back-pressure generator sets cannot satisfy the demand for thermal supply, the construction of large highly efficient thermal supply generator sets with a unit capacity of no less than 200000kw is encouraged.

Electricity Pricing Policies. The policies for electricity pricing are important components of policies for saving electrical resources and concern the instructions for production operation of electric power enterprises, as well as the price for electricity consumers.

On April 16, 2004, the NDRC published "Notice for Further Removal of Contradictions in Electricity Price and Standardization of Its Management", requiring the further adjustment of the sales price of electricity, the removal of preferential electricity prices regulated by local governments, standardized management of price of network electricity and study and suggestions for a time-based electricity price in peak hours. In order to sort out the price relationship between coal and electricity, after approval from the State Council, the State decided to establish a linked mechanism for the prices of coal and electricity. On February 5, 2004 the NDRC issued Notice for Opinions for Establishment of Linked Mechanism for Prices of Coal and Electricity and determined the linked action of prices of on-grid electricity and coal, as well as prices for the sale of electricity and on-grid electricity. The rule is that if the price of coal rises by more than 5% in any six-month period, electricity prices can be adjusted accordingly, but the electrical power enterprises should bear 30% of the rise in coal price. The two linked actions of coal-electricity price in China in 2005 and 2006 alleviate, to a great extent, the market differences between coal and electrical power, and have played an active role.

In accordance with the requirements in "Notice from the Office of State Council for Printing and Issuing Reform Program for Electricity Price" of 2003, and in order to favour the electricity price reform and the mechanism for the formation of electricity price, the NDRC released "Notice for Printing and Issuing Implementation Measures for Electricity Price Reform" in 2005, which included "Rules and Regulations for Price Management of On-Grid Electricity", "Interim Rules and Regulations for Price Management of Power Transmission and Distribution" and "Rules and Regulations for Price Management of Sold Electricity," and determined the measures and systems for electricity price management adaptable to the new requirements from the electricity system reform. These documents have played important guiding roles in promoting electricity price reform and standardization of electricity price management and have a milestone importance for the electricity price reform. In order to curb the blind development of projects with high energy consumption, promote the adjustment and optimized upgrade of industrial structure, improve the energy utilization efficiency and favour the coordinated development of the economy, the environment and resources, and in light of the requirements of domestic industrial policies, in 2004, the State grouped the enterprises into four categories, based on their energy intensity level: "eliminated", "restricted", "permitted", "encouraged". Each category has a specific electricity price. In September 2004, the NDRC and the SERC jointly released Notice for Further Execution of Differential Electricity Prices and Relevant Issues to Pricing Policies for Plants with Self-generated Electricity, and further perfected the polices for differential electricity prices. Soon afterwards, they issued Notice from the NDRC for Relevant Issues to Continuous Implementation of Different Pricing Policies (2005), Notice from Office of State Council for Transmission of Opinions from NDRC for Perfection of Differential Pricing Policies (2006) and Notice for Stern Implementation of Polices for Differential Electricity Prices and Prohibition of

Self-release of Preferential Electricity Price (2007), and required each province (municipality and region) to take to heart the application of these policies for differential electricity prices.

Rules and Regulations for Energy-saving Generation Dispatch. The traditional power dispatch in China is basically the power dispatch mode with an average power distribution. Under the mechanism for networking with price competition, some small thermal power generator sets with high pollution and high energy consumption can be networked with a competitive low price since they have digested the depreciation of fixed assets; however, big thermal power generator sets with big investments, high costs and highly-efficient environmental protection cannot bring their power generation capability into full play because of their high price of generated electricity. Even some hydropower and nuclear power generator sets cannot be networked for power generation because of the limitation of the "dispatching plan", resulting in waste of energies and resources.

In August 2007, the NDRC, the SEPA, the SERC and the ONELG jointly published "Rules and Regulations for Energy Saving Generation Dispatch (proposal)". In December 2007, they jointly issued Program for Trial of Energy Saving Generation Dispatch and Detailed Rules and Regulations for Implementation of Measures for Energy Saving Generation Dispatch under document No. 523 of NDRC, and selected Guizhou, Sichuan, Guangdong, Jiangsu and Henan as the trial provinces for energy saving generation dispatch.

In the energy-saving generation dispatch scheme, renewable power generation resources are dispatched based on fuel consumption rates and pollutant emission intensities of generator sets orders from low to high, and the dispatch of fossil-based resources is carried out under the premises of guaranteeing a reliable power supply and following the principle of energy saving and economy so as to reduce as much as possible energy, resource consumption and pollutant emissions. The rules and regulations for energy-saving generation dispatch schedule generators assigning an order of priority to the categories of power generation resources: 1) renewable resources such as wind energy, solar energy, marine energy and hydro-energy etc.; 2) renewable energies such as biological substance energy and geothermal energy, etc., and rubbish that satisfies the environmental protection requirements; 3) nuclear power; 4) coal-fired power plants 5) fuel-fired generator sets.

The implementation of new rules and regulations for the dispatchment of electricity will face technical problems that need further perfection, for example, the safe and reliable operation of the power network in some regions, normal power supply of the power network in some regions, the dispatchment authority, the economy of the power network, the local power supply structure, the sequencing range of generator sets, the peak adjustment and standby capacity, local small generator sets, the "take or pay" supply of natural gas as well as generator sets for joint thermal-electric generation and comprehensive utilization. However, if we consider the whole country, the main influences are those affecting the policies for the price of electricity.

The new dispatchment mode causes great changes in the interest frame, so it is a precondition to establish a corresponding interest compensation mechanism. Usually, the price of on-grid electricity from the medium and small coal-burning thermal power generator sets is low (this is also the reason why the actual utilization hours of small generator sets is high), and the energy-saving and environment-protective generator sets in thermal power plants are those that have been newly put into operation and have a large capacity. The benchmark electricity price implemented by these generator sets is relatively high and the energy-saving dispatchment will be carried out by those provinces (municipalities and regions) relying mainly on thermal power. So, the implementation of rules and regulations for energy-saving dispatchment can increase the price of networked companies for purchasing electricity, and the economic interest of power plants, electricity networks and consumers should be considered. If the price of generated and on-grid electricity is directly determined in accordance with the current management rules and regulations from the state, after the implementation of energy-saving dispatchment, the average price for on-grid electricity will rise around China, which will directly influence the interest of the electricity network company, the electrical power company or the power consumers; therefore, the relevant economic policies are in need of adjustment.[40]

Policies for Closing Small Thermal Power Generator Sets. During the Tenth Five-year Plan, the state encouraged the policies for closing the small thermal power plants, but the results have been far from ideal. On January 20, 2007, the State Council approved and transmitted Opinions on Accelerated Closing of Small Thermal Power Generator Sets issued by the NDRC and the ONELG (Document No.2 issued by the NDRC), marking the resumption of closing small thermal power plants that were suspended in the Tenth Five-year Plan period and the acceleration of its progress.

According to this document, the following categories of coal-burning (fuel-burning) units were targeted for closure during the period of the Eleventh Five-Year Plan: 1) generator sets with a capacity below 50000 kw; 2) units below 100,000 kw that have been operating for over 20 years; 3) units below 200,000 kw that have reached the end of their design lives; 4) units with coal consumption 10% higher than the provincial average or 15% higher than the national average in 2005; 5) units that have not satisfied environmental protection and emission standards, those that should be closed in accordance with the relevant laws and regulations, and those that the relevant departments of the State Council expressly required to close.

As for those on-service generator sets for thermal-electric generation and comprehensive utilization of resources, the online monitoring should be required and certification and periodic checks should be organized by the provincial level government. Dispositions must be defined to rectify and modify those plants that cannot satisfy state regulations. In case they have not been modified in due time or they still fail to satisfy the requirements after modification, they must be closed.

This policy aim was to realize the following three objectives in the Eleventh Five-year Plan period. The first was to guarantee the closing of more than 50 million kilowatts of small coal-burning thermal power generator sets in China[U65], among which fuel-burning generator sets with a total capacity of 7 million-10 million kilowatts. The second objective was to form an energy-saving capability equivalent to 50 million tons of standard coal and reduce SO_2 emissions by more than 1.6 million tons by closing small thermal power generator sets. The third objective was to construct a group of highly efficient and environmentally-protective generator sets as well as generator sets that use clean energies and renewable energies.

In order to guarantee the realization of the above objectives, three ancillary measures were put forward:

1) Multiple departments shall cooperate to close small thermal power generator sets. As for those generator sets that should be closed in due time, the electricity regulatory authority should withdraw its electrical business certificate in time, the electricity network enterprises and the relevant departments should dismiss them from the electricity network and should not purchase the electricity generated by them, the electricity dispatch organ should not dispatch power generation to them, and financial institutions such as banks should stop issuing loans to them.
2) The arrangement of an encouragement mechanism that combines the construction of large capacity units and the closing of small capacity units. The NDRC shall connect the establishment of new projects and the closing of old ones in examination and approval policies, i.e., 300,000 kw generator sets can be constructed if 240,000 kw small generator sets have been closed; 600,000 kw generator sets can be constructed if 420,000 kw small generator sets have been closed; 1 million kw generator sets can be constructed if 600,000 kw small generator sets have been closed;
3) Reduce the price of on-grid electricity from small thermal power generator sets and favour the transfer of their power generation rights; strengthen the monitoring and inspection of pollution discharge from power plants by reducing the price of on-grid electricity from the small thermal power generator sets; promote the closing of small thermal power generator sets; allow the small thermal power generator sets that have been closed in advance or in due time to transfer their power generation to larger generator sets at an on-grid price no higher than the original price.

Progress[U66]. By the end of December 2007, 14.38 million kilowatts (or 553 sets) of small thermal power generation units were shut down. The units shut down had 2,600 kilowatts of unit capacity. Among the 553 small thermal power generation units, 256 (with 10.52 million kilowatts of generation capacity) were shut down by the top 5 power generation companies, local investment companies and local state-owned companies, accounting for 73.1% of the total shut-down capacity; 297 (with 3.86 million kilowatts of generation capacity) were shut down by private businesses and other businesses, accounting for 26.9% of the total shut-down capacity. Shandong, Henan, Guangdong, Jiangsu and Shanxi were the top 5 provinces in terms of shut-down capacity, shutting down 1.717 million kilowatts, 1.543 million kilowatts, 1.294 million kilowatts, 1.139 million kilowatts and 1.007 million kilowatts of generation capacity, respectively. After these small units were shut down, large units were installed to generate the same amount of electrical power, reducing coal consumption by 18.80 million tons, SO_2 emission by 290,000 tons, and CO_2 emission by 37.60 million tons each year (Zhang, 2008).

Demand Side Management (DSM). In order to guarantee a safe, steady, sufficient supply of electrical power and scientifically guide electrical power consumption in 2003, the NDRC issued its Notice for Management of Power Consumption and put forward the detailed requirements for power consumption. On May 27, 2004, the NDRC and the SERC made a general arrangement for the DSM in Guidance Opinions for the Enhancement of Power DSM, and each province (municipality and autonomous region) published relevant management measures.

Since the Tenth Five-year Plan, a cumulative power consumption of 100 billion - 120 billion kwh, has been saved in China, about 20 million kilowatts of peak load has been transferred, more than 60 million tons of raw coal have been saved, about 1 million tons of SO_2, and 150 million tons of CO_2 emission have been avoided.[41]

The power DSM has made great progress, but, compared with the large energy-saving potential of terminals in China and the best practice of other countries, there is ample margin for improvement, and there are many problems and obstacles lying ahead, in particular its weak long-term effective mechanism. Foreign experiences show that the establishment and perfection of a long-term effective mechanism is an essential support for effective long-term implementation of demand management.

Analysis of the Effects of Policies for Energy Saving and Emission Reduction

The policies for energy saving and emission reduction in the electrical power sector can refer to both power supply and power demand. Policies operating on the supply side will mainly adjust the power structure, reduce the proportion of thermal power, improve the structure of thermal power generators and increase the proportion of highly-efficient large-capacity generator sets; while those operating on the demand side will improve the energy consumption efficiency of terminals by enhancing demand management.

Here, our analysis is based on the data for 2006 and focuses on the period 2007 - 2010.

Effects of Policies for the Adjustment of the Power Supply Structure. In accordance with the adjusted Plan for Development of Renewable Energies in the Eleventh Five-year Plan, published by the NDRC in March 2008, by 2010 190 million kilowatts of total installed capacity for hydropower, 10 million kilowatts of total installed capacity for wind power, 5.5 million kilowatts of total installed capacity for power generation with biological substance energy and 300,000 kilowatts of total installed capacity for power generation with solar energy would be realized (see Table 2.9). China also defined the adjustment of nuclear power development strategy in the Eleventh Five-year Plan by moving from "proper development" to "active development," and the installed capacity for nuclear power was expected to reach 20 million kilowatts in 2010[U67]. In the following paragraphs we will evaluate the effects of each of the above targets.

1) An increase of 60 million kilowatts in the installed capacity of hydropower.
   In 2006, the installed capacity of hydropower in China was 130 million kilowatts, the power output was 414.8 billion kwh and the utilization time was 3190 hours. After the implementation of the full price purchase strategy for power generated with renewable energies in 2007, the above-mentioned indices for hydropower development witnessed a sizeable growth. In fact, encouraged by this policy, the utilization time of hydropower generation devices in 2007 showed a notable rise of up to 3532 hours, an increase of 139 hours as compared with 2006.
   By 2010, 60 million kilowatts would be added to the installed capacity of hydropower and the annual power generation would reach 211.9 billion kwh, assuming 3532 hours of utilization time of devices.
   In 2006, the coal consumption for power generation in China was 342 g standard coal/kwh. The annual average reduction rate of coal consumption for power generation in the 1970-2006 period was 1%. On the assumption that this rate would still be maintained in the 2007–2010 period, the coal consumption for power generation in 2010 would reach 329g standard coal/kwh[U68]. Thus, the increase of the installed capacity of hydropower would reduce coal consumption by 69.72 million tons of standard coal.
   The varieties of coals used in China for power generation are mainly smoke coal, smokeless coal, meager coal and brown coal. The quantity of greenhouse gases discharged during the combustion of different kinds of coal is slightly different. The average value for the CO_2 discharge coefficient of coal in China, calculated by different project groups, is 0.711 tons of carbon/ton of standard coal.[42] The discharge of CO_2 avoided by the newly

added installed capacity for hydropower amounts to 69.72 million tce × 0.711 tons of carbon/tce = 49.57 million tons.

2) An increase of 7.4 million kilowatts in the installed capacity of wind power. In 2006, the cumulative installed capacity of wind power in China was 2.6 million kilowatts. If calculated in accordance with the 10 million kilowatts of installed capacity planned for 2010, the newly added installed capacity by 2010 would be 7.4 million kilowatts. On the assumption that the annual operating time for wind power is 5000 hours, the annual power output of newly-added wind power generators would be 5000 hours × 7.4 million kwh = 37 billion kwh. Therefore, the quantity of coal saved and CO_2 emissions avoided by the increase of 7.4 million kilowatts of wind power installed capacity can be calculated as follows. Coal savings: 37 billion kwh × 329 g standard coal/kwh = 12.17 million tons of standard coal; reduction of CO_2 emissions: 12.17 million tce × 0.711 tons of carbon/tce = 8.65 million tons.

3) An increase of 4.3 million kilowatts in the installed capacity of biological substance energy. In 2006, the installed capacity of biological substance energy in China was 1.2 million kilowatts and the power generation material was mainly straw. The newly-added installed capacity for power generation with various types of biological substance energies in 2010 would reach 4.3 million kilowatts. Supposing the annual operating time is 5000 hours, the annual power output from the newly-added generators shall be 5000 hours × 4.3 million kw = 21.5 billion kwh. Therefore, the quantity of coal saved and CO_2 emission avoided due to the increase of 4.3 million kilowatts of biological substance energy can be computed as follows. Coal savings: 21.5 billion kwh × 329 g standard coal/kwh = 7.07 million tons of standard coal; reduction of CO_2 emission: 7.07 million tce × 0.711 tons of carbon/tce = 5.03 million tons.

4) An increase of 220000 kilowatts in the installed capacity of solar energy. In 2006, the installed capacity for solar energy in China was only 80000kw. The newly-added installed capacity in 2010 will reach 220000 kw. Supposing the annual operating time is 3000 hours, the annual power output from the newly-added generators shall be 3000 hours × 220000 kw = 660 million kwh. Therefore, the quantity of coal saved and CO_2 emission avoided due to the increase of 220000 kilowatts of solar energy capacity can be calculated as follows. Coal savings: 660 million kwh × 329 g standard coal/kwh = 217140 tons of standard coal; reduction of CO_2 emission: 217140 tce × 0.711 tons of carbon/tce = 154386 tons.

5) An increase of 11 million kilowatts in the installed capacity of nuclear power. The installed capacity for nuclear power in China in 2006 was 9 million kilowatts and in 2010 it will reach 20 million kilowatts. On the assumption that the annual operating time is 6500 hours, the annual power output from the newly-added 11 million kilowatts of installed capacity for nuclear power would be 11 million kw × 6500 hours = 71.5 billion kwh. Therefore,

the quantity of coal saved and CO_2 emissions avoided can be computed as follows. Coal savings: 71.5 billion kwh × 329 g standard coal/kwh = 23.52 million tons of standard coal; reduction of CO_2 emissions: 23.52 million tce × 0.711 tons of carbon/tce = 16.72 million tons.

In a word, by adjusting the power supply structure, in particular by increasing the installed capacity of nuclear energy and renewable energy, 112.7 million tons of standard coal were able to be saved and 80.13 million tons of CO_2 emissions were able to be avoided in China in 2010.

Table 2.9
Estimates of energy savings and emission reductions brought forth by the policies for adjustment of power supply structure in China's electrical power sector (year 2010)

	Hydro power	Wind power	Biological substance energy	Solar energy	Nuclear power	Total
Newly-added installed capacity (10000kw)	*6000*	*740*	*430*	*22*	*1100*	*8300*
Saving of coal (10000 tons of standard coal)	*6972*	*1217*	*707*	*22*	*2352*	*11270*
Reduction of CO2 emissions (10000 tons)	*4957*	*865*	*503*	*16*	*1672*	*8013*

Effects of Policies for Closing Small Thermal Power Generator Sets and Improving the Structure of Thermal Power Generator Sets. The total installed capacity of the small generator sets affected by the policy of the Eleventh Five Year Plan would reach 115 million kilowatts, accounting for 30% of the total installed capacity for thermal power. The objective of this policy is to close more than 50 million kilowatts of small coal-burning generator sets in the period of the Eleventh Five-year Plan.

On the assumption that 50 million kilowatts of small coal-burning generator sets have been closed in 2010, and that 5600 hours of annual thermal power utilization time, an additional annual power output of about 280 billion kwh would be borne by large generator sets. If coal consumption for power generation was assumed to be 440 g/kwh for small generator sets and 329 g/kwh for power generation in 2010, the conservative estimation of the annual saving of coal would be (440 g/kwh -329 g/kwh) × 280 billion kwh = 31.08 million tons of standard coal and the CO2 emission avoided would be 31.08 million tce × 0.711 tons of carbon/tce = 22.1 million tons.

Effects of DSM Policies for Energy Saving and Emission Reduction. The electricity DSM refers to the power consumption management activities that guide electricity consumers with effective measures to scientifically and properly save electricity, improve the efficient utilisation of electrical energy, optimize resource allocation, protect the environment and realize the electricity service at the lowest price. Currently, the electricity DSM mainly includes energy efficiency management, load management and sequential power consumption, and has great potential for improving the efficiency of electricity consumption and the load rate of the electricity network.

In accordance with NDRC data, by enhancing the DSM for electrical power, about 150 billion kwh were able to be saved in China in the Eleventh Five-year Plan.[43] If the 329g/kwh is taken as the coal consumption for power generation in 2010, 49.35 million (150 billion kwh × 329 g/kwh) tons of standard coal were able to be saved and 35.09 million (49.35 million tce × 0.711 tons of carbon/tce) of CO_2 emissions avoided.

In a word, by adjusting the power supply structure, replacing small thermal power generator sets with large ones and enhancing polices such as DSM, 193.13 million (112.7 million tce + 31.08 million tce + 49.35 million tce) tons of standard coal were able to be saved and 137.32 million (80.13 million tons + 22.10 million tons + 35.09 million tons) tons of CO_2 emission avoided in China in 2010.

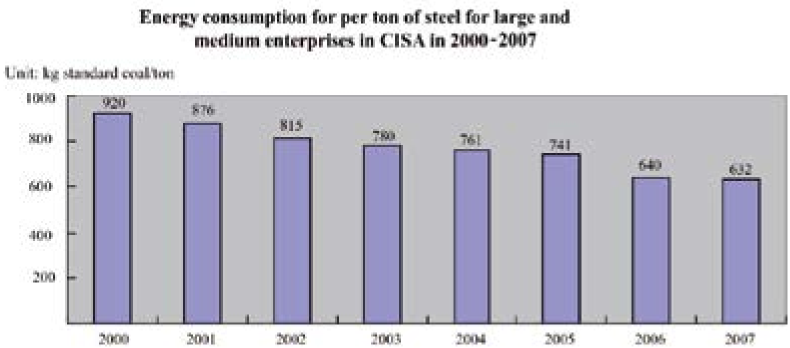
2.8 Analysis of Polices for Eliminating Backward Capacity from China's Iron and Steel Sector

Background for Eliminating Backward Capacity from the Iron and Steel Sector

The iron and steel industry is an important energy consumption sector in China, and its annual energy consumption reached 596.68 million tons in 2012, accounting for more than 15% of China's total energy consumption (NBS, n.d.). The iron and steel industry developed very quickly and its output increased by 175% in less than five years. On the one hand, this abrupt growth resulted in a relative capacity surplus; on the other hand, the small production capacity and scale of a certain number of iron and steel enterprises, and their primitive technologies, brought about a great waste of resources and energy. In comparison with the advanced international level, the energy consumption per ton of steel in China is at least 20% higher. Calculated in accordance with current output, the energy consumed in excess each year would reach 12 million tons of standard coal. It was clearly stated in the Eleventh Five-year Plan that the restrictive indices of a "20% reduction of energy consumption per GDP unit and a 10% reduction of the total discharge of main pollutants"[U4] would be realized in the Eleventh Five-year Plan. Energy saving and emission reduction has went from an isolated task to become China's entire strategic target. As one of the key energy-consuming sectors, the iron and steel industry would become the key sector for energy saving and emission reduction.

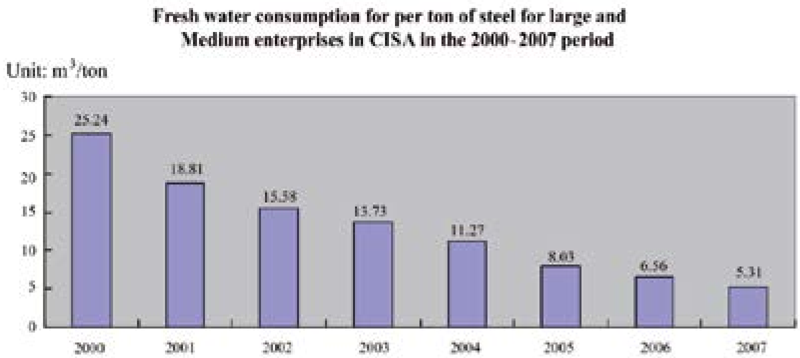
High Energy Consumption of China's Iron and Steel Industry. The comprehensive energy consumption per ton of steel in the iron and steel industry in China was 2040 kg of standard coal in 1980, 1611 kg in 1990 and 1240 kg in 1999. In the 1990–1999 period, 45.987 million tons of standard coal was accumulatively saved in the iron and steel industry in China[44]. According to CISA's statistical results, for large and medium iron and steel enterprises comprehensive energy consumption per ton of steel was 632.12 kg standard coal in 2007, a reduction of 287.88 kg as compared to 2000. The reduction of energy consumption in the 2000-2007 reached 31.29%, as shown in Figure 2.17[U69].

Figure 2.17
Energy consumption per ton of steel for large and medium enterprises (years 2000-2007)



In 2007, fresh water consumed per ton of steel by large and medium iron and steel enterprises was, in CISA's statistic scope, 5.31 m^3, a reduction of 19.93 m3 as compared to 2000. The reduction of water consumption in the 7-year period was 78.96%, as shown in Figure 2.18.

Figure 2.18
Fresh water consumption per ton of steel for large and medium enterprises (years 2000-2007)



If we take the energy consumption per ton of steel in the Japanese iron and steel industry in 2004 as the advanced international level, the energy consumption of large and medium iron and steel enterprises, in CISA's statistical scope, is about 10% higher than the international level (see Table 2.10).

Table 2.10
Comparison between energy consumption of large and medium enterprises in China and Japan (year 2004)

Item / Country	Comparable energy consumption for per ton of steel	Coking process	Sintering Process	Iron-making process	Converter process	Rolling process
Japan	*656*	*95*	*53*	*396*	*-2.7*	*62*
China	*705*	*142.13*	*66.72*	*465.12*	*33.74*	*92.91*
Difference ± number	*+49*	*+47.13*	*+13.72*	*+ 69.12*	*+36.44*	*+30.91*
Difference ± percent	*+7.47*	*+4.96*	*+25.89*	*+17.45*	*+13.5*	*+49.85*

Notes: unit of measurement is kg standard coal/ton

Since the capacity composition for China's iron and steel industry has obvious structural characteristics, the crude steel produced by the whole sector in 2004 was 274.707 million tons. 233.543 million tons of it were produced by those large- and medium-sized iron and steel enterprises in the statistical scope, accounting for 85.02% of domestic output; 41.164 million tons were produced by the other medium and small enterprises, accounting for 14.98% of domestic output. Compared with the large and medium enterprises, the medium and small enterprises are obviously inferior in energy consumption.

Table 2.11
Comparison of energy consumption indices between large/medium enterprises and medium/small enterprises in China (year 2004)

Item / Comparison	Comparable energy consumption for per ton of steel	Coking process	Sintering Process	Iron-making process	Converter process	Rolling process
Large and medium enterprises	*705*	*142.13*	*66.72*	*465.12*	*33.74*	*92.91*
Backward level	*1045*	*266*	*109*	*592*	*152*	*133*
Difference ± number	*+340*	*+123.87*	*+42.28*	*+126.88*	*+118.26*	*+40.09*
Difference ± percent	*+48.23*	*+87.15*	*+63.37*	*+27.28*	*+350.5*	*+43.15*

Notes: unit of measurement is kg standard coal/ton

Table 2.11 shows that the energy consumption indices for China's medium and small enterprises are backward and exceed by about 50% the general level of large and medium iron and steel enterprises. In consideration of this factor, the energy consumption level in the iron and steel sector generally exceeds by about 20% the advanced international level. The main reasons for such a big margin are:

1) The concentration of China's iron and steel industry is low, the enterprise scale is small and the enterprises are scattered
   In 2005, there were only 18 enterprises in China whose crude steel output was more than 5 million tons, accounting for only 46.36% of the national crude steel output. In 2004, the output of the four enterprises with the greatest output of crude steel in Japan accounted for 73.22% of the total

in the country, that of the three major enterprises in the USA accounted for 61.09% of the total, that of the five major enterprises in Russia accounted for 78.69% and that of the two major enterprises in South Korea accounted for 82%. In accordance with CISA's statistics, there are 871 enterprises with iron-making and steel-making capabilities in China. If the annual crude steel output of 349.3615 million tons in 2005 is taken for calculation, the average crude steel output for each enterprise is only 401,000 tons. Thus the enterprises are small in scale and scattered in distribution.

2) There are obvious margins between the quantity of large equipment for the iron and steel enterprises in China and that in developed countries.
   In 2004, Japan's gross crude steel output was 112 million tons, but there were only 28 blast furnaces and 62 converters in Japan. In accordance with CISA's statistics, at the end of 2004 there were 1131 blast furnaces in China. Of them, 18 were blast furnaces with a volume of not less than 1000 m^3 and their capacity accounted for 31.96% of the total[U70]; the other 1113 were blast furnaces with an effective volume of less than 1000 m^3, and their capacity accounted for 68.04% of the total. At the end of 2004, there were 553 steel-making converters in China. Of them, 3 were converters with a volume of more than 300 tons and 51 were converters with a volume of 120-299 tons. Their respective capacities accounted for 2.17% and 22.57% of the total; 499 were small converters with a volume of less than 120 tons, and their capacity accounted for 75.26% of the total.
3) Energy-saving technologies and popularization of equipment are low.
   Generally, except for a small number of large iron and steel enterprises, multi-stratification is present for process, technology and equipment, and improprieties exist in the process and structure of iron and steel enterprises. They are affected by the relative backwardness of energy-saving and environmental protection technologies, as well as by the non-adoption of advanced energy-saving processes, technologies and equipment.
4) The recovery utilization rate of secondary energies is low.
   Measured in accordance with current blast furnace- converter-steel rolling processes in China, the total energy consumption for the production of one ton of steel is 716 kg standard coal, and the effective utilization rate in the production process is only 27%. Besides, 73% of the thermal energy is represented by the residual heat in the production process. Residual heat is made up of the chemical heat of gas (combustible coal gas) exhausted in the production process, which amounts to 44% of the thermal energy, and the high-temperature physical heat from the solid substances in the production process, which corresponds to 29% of the thermal energy. Generally speaking, the recovery and utilization rate of chemical and physical heat generated in the production process of iron and steel enterprises in China is low, which is one of the important reasons for its high energy consumption.

Capacity of the Iron and Steel Sector and Structural Contradictions. There is an excess capacity for some medium-level and low-level iron and steel products. The backward capacity accounted for about 20% of the total in the sector, while the capacity for iron and steel products with high added value cannot satisfy the domestic market demand. In 2006, the self-supply rate of steel bars reached 107.27% for ordinary wire rods, 104.63% for threaded steel bars and 106.92% for hot-rolled wide steel strips. The supply of these products generally exceeded the demand; however, the self-supply rate was only 81.99% for silicon steel plates with high added value, 85.19% for cold-rolled wide steel strips and 90.75% for zinc-coated sheets. So, the capacity is obviously insufficient and cannot satisfy domestic market demand, a problem that can only be solved by importing steel bars.

In 2006, the iron and steel sector completed an investment of 260.2 billion yuan on fixed assets, a growth of 0.8% over 2005. As for the structure of capital investment on the projects in progress, 5.94% was allocated for iron-making projects, 33.31% for steel-making ones and 60.75% for the deep-processing projects of steel bars. The growth rate of investments shows a declining trend, and capital investments are turning to the optimization of product structure. But in accordance with the statistics for the end of 2006, the total volume of designed investments on projects in progress in the whole sector reached 686.056 billion yuan. This shows that the trend of blind expansion of capacity is still present, the investment scale is too big and investment risk is constantly on the rise. In particular, the large amount of newly-added capacity, if put into operation, will increase the necessity and essentiality of eliminating backward capacity.

Pollutant Discharge from the Iron and Steel Industry[U71]. The existence and high proportion of backward capacity is a primary cause of high energy consumption and high pollutant discharge of the iron and steel sector. In 2006, if we consider the large and medium iron and steel enterprises, the comprehensive energy consumption per ton of steel was 645 kg standard coal, a decrease of 7.06% over 2005; the comparable energy consumption for each ton of steel was 623.04 kg of standard coal, a decrease of 6.19% over 2005; freshwater consumption per ton of steel was 6.56 tons, a decrease of 14.9% over 2005. For each ton of steel, SO2 discharge decreased by 4.1%, smoke dust discharge decreased by 2.99%, powder dust discharge decreased by 1.76% and the COD discharge decreased by 8.43% (see Table 2.12).

In 2007, the comprehensive energy consumption per ton of steel was 632.12 kg of standard coal, a decrease of 1.3% over 2006; freshwater consumption per ton of steel was 5.31 tons, a decrease of 17.42% over 2006. Because of the reduction of per unit energy consumption, the total energy consumption of the large and medium iron and steel enterprises in 2007 was 225.806 million tons of standard coal, an increase of 25.6943 million tons and an increase of 12.84%

over 2006. It was 2.82% lower than the growth rate of crude steel output in 2007. As for pollutant discharge, in 2007, total SO2 emissions from large and medium iron and steel enterprises was 756367.91 tons, a drop of 0.51% over 2006; total COD discharge was 59964.78 tons, a drop of 8.76% over 2006; the total volume of industrial powder discharged was 382274.92 tons, a drop of 2.79% over 2006; the total volume of smoke dust discharged was 156648.36 tons, an increase of 3.02% over 2006.

The energy consumption of the whole sector accounted for 14.71% of the nationwide total , the discharge volume of industrial wastewater accounted for 8.53% of the total. and the discharge volume of industrial powder dust accounted for 15.18% of the total. The difference between the large and medium iron and steel enterprises and the advanced international level was being narrowed because of the constant improvement of processing, equipment and technological levels, and because enterprises such as Baoshan Iron and Steel Co., Ltd reached the advanced international level. Generally speaking, the difference between the energy consumption in China and the advanced international level is 10-15% and the pollutant discharge has been in part effectively under control. As for those medium and small enterprises with backward technologies and equipment, the process of energy consumption of small blast furnaces with a volume of less than 300 m3 is around 200 kg of standard coal per ton higher than the advanced domestic level; the process of energy consumption of small converters with a capacity of 20 tons is around 90kg of standard coal per ton of steel higher than the advanced domestic level. Overall energy consumption is around 50% higher than the advanced international level, and the pollutant discharge is more serious.

Table 2.12
Proportion of main pollutants discharged by China's iron and steel industry out of China's total volume (years 2004-2006)

	2004			2005			2006		
	Iron and steel	National industrial	Proportion percent	Iron and steel	National industrial	Proportion percent	Iron and steel	National industrial	Proportion percent
Waste gas (100 million standard cubic meters)	*46628*	*237696*	*19.62*	*57134*	*268988*	*21.24*	--	*330992*	--
SO2 (10000 tons)	*119.1*	*1891*	*6.30*	*146.5*	*2168*	*6.76*	*154.7*	*2235*	*6.92*
Smoke dust (10000 tons)	*55.90*	*887*	*6.30*	*71*	*949*	*7.48*	*74.7*	*864*	*8.61*

Table 2.12
(continued)

Powder dust (10000 tons)	*125.1*	*905*	*13.82*	*129.6*	*911*	*14.23*	*117.4*	*808*	*14.53*
Wastewater (100 million tons)	*20.122*	*221*	*9.10*	*18.41*	*243*	*7.58*	*17.21*	*240*	*7.17*

The effect of energy saving and emission reduction on the large and medium iron and steel enterprises is obvious, but since the medium and small enterprises with backward technologies and equipment have a high energy consumption and high pollutant discharge, arduous tasks are still ahead for energy saving and emission reduction, as well as for the elimination of the backward iron and steel capacity. The development of the iron and steel industry must not only consider the pressures the state faces in such aspects as energy supply and environmental pollution but also be realized on the premises of constant improvement of energy utilization efficiency and reduction of energy consumption.

While the iron and steel industry is developing rapidly, the features of extensive development become extremely obvious because of the effect of the improper system and mechanism. During recent years, blind investment and low-level expansion have pushed more and more into the forefront, as have their consequences, such as the prominent contradictions of capacity surplus, the incapacity of the resource supply and the environment to keep up with production, the high proportion of low-level capacity, the appearance of harmful competition in the sector, and the further reduction of industrial concentration. The State declared that the control of the total volume, the elimination of the backward capacity and the adjustment of product structure must be realized currently and in the near future as the major tasks for the development of the iron and steel industry, and as an important measure for the implementing a scientific vision of development, the change of the growth mode and the realization of a 20% energy consumption reduction per GDP unit. All of this is vitally important for achieving an industrial upgrade and improving the comprehensive competitiveness of the iron and steel industry.

Policies and Targets for Eliminating Backward Capacity from the Iron and Steel Industry

Development Policies for the Iron and Steel Industry in 2005. It is clearly regulated in Article 17 that China "should accelerate the elimination and prohibition of such backward working techniques and equipment as newly-built sintering with indigenous methods, indigenous carbonization (including improved carbonization), melting iron and refining steel, hot agglomeration mines, blaster furnaces with a volume of 300 cubic meters or below (except for the special iron pipe casting factories), converters with the nominal capacity of 20 tons or below, electronic furnaces with the nominal capacity of 20 tons or below (except for mechanical casting or the production of high-alloy steel), tight rolling sheet mills, roughing mills for ordinary steel, blank medium-sized rolling mills, three-roller Lotus medium plate rolling mills, double due wire mills, row small-sized millers, hot narrow strip rolling mills, assembling units of hot rolling seamless pipes with diameters below 76 centimeters and intermediate frequency furnaces.

Enterprises in the iron and steel industry will strictly abide by the Catalog of Repetitive Construction as Prohibited in the Field of Industry and Commerce and the Catalog of Backward Production Capacity, Working Techniques and Products to Be Eliminated as amended by the State at the opportune moment, or eliminate backward working techniques, products and techniques according to the requirements of the provisions on environmental protection." In 2006, the State Council published the Circular of the State Council on Accelerating the Restructuring of the Sectors with Production Capacity Redundancy and Notice for Control of Total Volume, Elimination of the Backward and Acceleration of Structural Adjustment in Iron and Steel Industry.

It clearly ruled that furnaces with a volume of no more than 200 m^3, as well as converters and electronic furnaces with a nominal capacity of no more than 20 tons, would be rigorously eliminated before 2007, and that other backward equipments such as furnaces with a volume of no more than 300 m^3 would be eliminated before 2010.

In 2007, the State Council published Comprehensive Working Program for Energy Saving and Emission Reduction.

It clearly ruled that the pace for eliminating the backward capacity would be accelerated and the efforts would be increased to eliminate backward capacity in such sectors as electrical power, iron and steel, building materials, electrolytic aluminium, iron alloy, carbide, coke, coal and flat glass, etc.

The State Council Issued Responsibility Agreement for Closing, Stopping and Eliminating Backward Iron and Steel Capacity. The main contents of the Responsibility Agreement are: each province and municipality should set up a detailed implementation program in accordance with general State guidelines for closing, stopping and eliminating backward capacity and, in combination with actual local conditions, arrange modes and rates of progress, undersign the responsibility agreement with the relevant enterprises, supervise and urge them to close, and halt and eliminate backward capacity. The State Council asks the DRC (ETC) of each province (region, municipality) to rapidly detail the implementation programs and report them to the NDRC. The NDRC will form a joint work team with the relevant departments to supervise and check the implementation status in each region.

Objectives for Eliminating the Backward Capacity from the Iron and Steel Industry. The closing, stopping and elimination of backward capacity from the iron and steel industry must comprehensively implement the scientific vision of development, adhere to handling affairs in accordance with legal provisions, combine the market mechanism with macro-control and implement the national development plan and industrial policies; adhere to the control of total volume, the adjustment of structure and the improvement of industrial concentration; adhere to the transition of growth modes, improve the utilization efficiency of energies and resources, reduce environmental pollution; adhere to the improvement of technological and equipment level and product structure.

Great efforts need to be made to realize the following objectives in the Eleventh Five-year Plan. Before 2010, 100 million tons of backward iron-making capacity and 55 million tons of backward steel-making capacity had to be eliminated[U72]. In 2007, 30 million tons of backward iron-making capacity and 35 million tons of backward steel-making capacity were eliminated. By 2010, the comprehensive energy consumption per ton of steel in the whole iron and steel sector would be reduced from a 0.76 ton of standard coal in 2005 to a 0.73 ton of standard coal; freshwater consumption per ton of steel would be reduced from 12 tons in 2005 to 6 tons; the SO_2 discharge volume per ton of steel would be reduced to 2.64 kg. By 2010, two or three super-large iron and steel enterprise groups with a capacity of 30 million tons and several groups with a capacity of 10 million tons and with international competitiveness would be built by recombination so that the steel output of the ten foremost iron and steel enterprises would account for more than 50% of the total nationwide output.

Detailed Measures Adopted for Eliminating the Backward Capacities from the Iron and Steel Industry

The elimination of backward capacities and the adjustment of industrial structure would be combined. The structural contradictions are the striking features for the surplus of overall capacity of the iron and steel sector.

Use the Tax and Price Lever for Control. After the removal of tax refunds for ordinary and medium- and low-level steel materials in 2006, policies for further reductions of tax refund rates were released in April 2007 and the export tax refund rate for most steel products was reduced to zero, which was to be implemented earnestly; meanwhile, temporarily determined tariffs would be levied on primary products such as steel billets and cokes etc. and part of rolled steels with low added value, so as to further reduce the production and export of products with high energy consumption and high pollution. The export tax refund would be reserved for high-level steel products and special steel articles so as to encourage the structural adjustment. The leverage roles of price would be brought into full play, and stricter policies for differential pricing of electricity would be implemented for those backward capacities in the stopping, closing and elimination scope, so as to further compress the profit space of backward capacities.

Be Strict with Market Access Management. For iron and steel projects under construction or to be constructed, make a rigorous examination, verification and evaluation, and allow market access in accordance with the laws, rules and regulations for land use and environmental protection, as well as with the national development plan and industrial policies. As for iron and steel projects that have not been verified and approved, the relevant departments should not deal with such procedures for production certificates, industrial and commercial registration and tax registration, etc., financial department should not provide loans, design units should not provide drawings and manufacturing enterprises should not provide equipment.

Adhere to the Elimination of the Backward Capacities. The whole iron and steel industry is currently in oversupply, but part of this supply does not conform to energy saving and environmental protection standards. Space can be reserved for necessary modernized and large-sized iron and steel projects only after this part of backward capacity has been eliminated. If a province (municipality or region) actively closes, stops and eliminates the backward capacity and obvious effects have been obtained, the State can preferentially consider its proposed construction projects for verification and approval. If a province (municipality or region) fails to keep promises in the Responsibility Agreement and fails to close, stop and eliminate backward capacity in accordance with requirements, the State will no longer verify and approve its new projects. If a large iron and steel enterprise wants to build a structural adjustment project, it must first promise to eliminate its backward capacity and then initiate verification and approval procedures. After verification and approval of the project, the enterprise should gradually compress its backward capacity and completely close and stop it after the project goes into production. This whole process must comply with the national development plan and industrial policies.

Proper Economic Support. Small iron and steel enterprises have made contributions to local taxes and employment, so when they are eliminated in accordance with the laws, necessary economic support should be provided. When a project approved by a local government is eliminated, that government should provide necessary economic support. When a transfer payment is made by the central government to a local administration, the factors for closing, stopping and eliminating its backward capacities should be taken into account and the transfer payment should be addressed to local firms. All the revenue from price difference after the implementation of the differential electricity price for products with high energy consumption shall be reserved for the local government for elimination of backward capacities.

Enhance Supervision and Inspection in Accordance with the Provisions of the Laws. Elimination of backward capacity has been clearly stipulated in State laws, rules, regulations, programmes and policies. The relevant departments of each local government should make a comprehensive arrangement and implement it in accordance with the plan and procedures. As for those enterprises and projects listed in the elimination range, they must be closed in timely fashion in accordance with the requirements of the plan, the laws should be executed rigorously and inspections should be carried out in earnest. As for those enterprises and projects that should have been closed and stopped but are still operating, timely measures should be taken to close and stop them and the key responsibilities should be pursued. A list of enterprises with backward capacities should be released in sets so that the social forces can be called in to supervise the closing, stopping and elimination process.

Achievements of the Iron and Steel Industry in Eliminating the Backward Capacities

Key Distribution Regions of Backward Capacities of Iron and Steel Industry. In the capacity of 420 million tons of steel formed at the end of 2004, 100 million tons were forged in small blast furnaces with a volume below 300 m^3, accounting for 27% of the total; 55 million tons came from the small converters and electric furnaces with a volume of 20 tons, accounting for 13.1% of the total. Backward iron-making and steel-making capacities are mainly concentrated in Northern and Eastern China. Backward iron-making capacity in those regions accounts for 60% and 21% of the national total, respectively, and backward steel-making capacity accounts for 36.5% and 23.3% of the national total, respectively. Backward capacity of small electric furnaces in Eastern China accounts for 48% of the total in China. Backward iron-making capacities in Northern China are mainly distributed in two provinces, Hebei and Shanxi, where there are 248 enterprises having blast furnaces with an effective volume below 300 m^3, accounting for 68.7% of the same category of enterprises in China. The total backward iron-making capacity in these two provinces is 45.4 million tons, accounting for 64.8% of the total backward iron-making capacity in China.

Achievements of the Iron and Steel Industry in Eliminating Backward Capacities. In 2006, the NDRC signed the first set of Responsibility Agreements with ten provinces and municipalities: Hebei, Liaoning, Jiangsu, etc., for eliminating backward capacities. As a result, 39.826 million tons of backward iron-making capacity with blast furnaces and 41.668 million tons of backward steel-making capacity were cumulatively closed, stopped and eliminated. In 2007, 12.422 million tons of backward iron-making capacity with blast furnaces and 8.727 million tons of backward steel-making capacity were cumulatively closed, stopped and eliminated. Besides, 15 sets of blooming mills/cogging mills were reduced from the iron and steel sector over the year 2002 and its capacity was reduced by 78.71 million tons.

From April 27, 2007 to the end of November of 2007, phased achievements were made in closing, stopping and eliminating the backward capacities of the iron and steel industry. The first group of provinces that signed the Responsibility Agreements in April 2007 cumulatively closed, stopped and eliminated 29.4 million tons of backward iron-making capacity and 15.21 million tons of backward steel-making capacity. Zhejiang, Jiangxi, Henan and Shandong fulfilled the tasks and objectives in the Responsibility Agreement. As the province with the most onerous task in the first group, Shanxi province eliminated 9 million tons of backward iron-making capacity out of a targeted 10 million tons; meanwhile, it actively eliminated 11.95 million tons of backward iron-making capacity which was not listed in the Responsibility Agreement. The Shangang Group eliminated 4 million tons of backward capacity for iron-making and steel-making in accordance with the general requirements for removal and adjustment.

On December 27, 2007, the NDRC held a conference for the purpose of closing, stopping and eliminating the backward capacities of the iron and steel industry. During the conference, the NDRC signed the second set of Responsibility Agreements for closing, stopping and eliminating the backward iron-making and steel-making capacities with 18 provinces (regions and municipalities): Tianjin, Inner Mongolia, Jilin, Helongjiang, Anhui, Fujian, Hebei, Hunan, Guangdong, Guangxi, Chongqing, Sichuan, Huizhou, Yunnan, Shan'xi, Gansu, Qinghai, Ningxia, as well as Baoshan Iron and Steel Co., Ltd. The second set of Responsibility Agreements required that 49.31 million tons of iron-making capacity and 36.1 million tons of steel-making capacity had to be cumulatively closed, stopped and eliminated by 2010, involving 573 enterprises. Part of the total capacity to be eliminated, namely 14.51 million tons of iron-making capacity and 13.98 million tons of steel-making capacity, had to be accumulatively closed, stopped and eliminated in 2007. The 18 provinces (regions and municipalities) carried out the process to different extents for eliminating the backward iron-making and steel-making capacity in combination with the general objectives set by the local government for energy saving and emission reduction. Some of them signed with the enterprises responsibility agreements defining the elimination tasks and responsibilities, and some eliminated part of the backward capacity. Arduous efforts had to realize the objectives and tasks of closing, stopping and eliminating 89.17 million tons of backward iron-making capacity and 77.76 million tons of steel-making capacity by 2010.

Case-Study: Removal of 400 m^3 Iron-Making Blast Furnace by Tangshan Iron and Steel Co., Ltd. In March 2008, a 400 m^3 iron-making blast furnace in the southern area of Tangshan Iron and Steel Co., Ltd stopped its production. By April 2008, all its internal facilities had been moved away.

This type of iron-making blast furnace can yield 60000 tons of iron and earn a profit of more than 20 million yuan each year. It was once the main type of furnace for the iron and steel industry in Hebei. Its various economic and technological indices rank foremost among blast furnaces of the same categories in China. In 2008, Tangshan Iron and Steel Co., Ltd decided to eliminate three such iron-making furnaces. Their advance elimination meant great economic losses, but compared with the 400 m^3 blast furnace, a 1000 m^3 blast furnace can save 50 tons of standard coal for each ton of liquid iron. The elimination of the three blast furnaces meant an estimated annual reduction of 2700 tons of powder dust discharge and 2987 tons of SO_2 discharge from Tangshan Iron and Steel CO., Ltd.

Tangshan Iron and Steel Co., Ltd invested 1.798 billion yuan on environmental protection in the Tenth Five-year Plan period. In 2007, it invested 600 million yuan, of which 20 million yuan were allocated for the secondary smoke-dust deep processing project so as to solve the red smoke issue and 300 million yuan were allocated for reducing and eliminating more than 2000 tons of smoke dust discharge. In 2008, Tangshan Iron and Steel Co. Ltd invested 1 billion yuan to satisfy environmental protection indices and rigorously implemented 20 projects for energy saving and emission reduction. 585 million yuan is to be invested on energy saving and emission reduction projects and 443 million yuan on emission reduction projects. Through these treatments, Tangshan Iron and Steel Co., Ltd was expected to save 200,000 tons of standard coal and reduce more than 4000 tons of powder dust discharge in 2008.

Issues Observed During the Elimination of Backward Capacities from the Iron and Steel Sector

The process for closing, stopping and eliminating the backward capacities from the iron and steel industry has made some progress, but the work and tasks are still arduous, which is reflected in the following four aspects: 1) the overall market environment is erratic and market pressure is insufficient for eliminating backwardness; 2) a theoretical understanding is wanting and some local governments have not fully understood the need to eliminate backward capacities; 3) the ancillary measures are not perfect, and this has in some measure affected the progress of eliminating backward capacities; 4) driven by their interests, some enterprises take various measures to avoid being closed, stopped and eliminated.

The Japanese and American experiences in eliminating backward equipment from their iron and steel industries in the 1970s-1980s followed the process of establishing a set of large-sized superior enterprises with advanced technologies and strong competitiveness, relying on market forces for the purpose of preserving superior and eliminating inferior enterprises with backward technologies, high energy consumption, serious pollution and poor product quality. Undoubtedly, in the process of replacing the old with the new, phased capacity surplus will unavoidably occur, but this is the best time to eliminate the backward iron-making and steel-making capacity and bring about industrial upgrade.

In 2008, China's iron and steel industry in still faced such situations as constant increase of pressure for environmental protection and resource supply, surplus of capacity and further enhancement of market restrictions. It should change its development mode, accelerate the elimination of backward capacities and structural adjustment, focus on energy saving and emission reduction, and switch from a development mode relying on growth to one relying on scientific and technological innovation, improvement of economic benefits, reduction of resource consumption, optimization of industrial structure, improvement of ecological environment and proper distribution of development achievements.

Effects of the Policies for Eliminating Backward Capacities

Ever since 2006, when the NDRC signed in sets with each local government the responsibility agreements for eliminating backward capacity, obvious phased achievements have been made by the iron and steel industry all over China in implementing State industrial policies and eliminating backward capacity. The policies for eliminating backward capacity from the steel and iron sector in China have resulted in positive effects that will continue into the future.

Positive Effects

I. Energy and resource saving, and pollutant discharge reduction. By 2010, the energy consumption per GDP unit should have been reduced by around 20%, the total pollutant discharge should have been reduced by 10% and water consumption per unit of industrial added value should have been reduced by 30% as compared with the situation in 2005[U73]. The total energy consumption of the iron and steel industry accounted for more than 15% of the total in China, the SO_2 discharge for 6.9% and water consumption for around 14 %. Thus the iron and steel industry plays an important role in energy consumption, water consumption and waste discharge. Currently, there are approximately 100 million tons of backward iron-making capacity and 55 million tons of steel-making capacity that do not conform to industrial policies. These facilities are small-sized, inefficient and highly pollutant, and their unit energy consumption is usually 10-15% higher than large-scale facilities, their material consumption is 7-10% higher, their water consumption 100% higher and their SO2 discharge is 300% higher. In some medium and small iron and steel enterprises safe production cannot be guaranteed. By eliminating backward iron-making and steel-making capacity, more than 50 million tons of standard coal and 100 tons of water can be saved annually, and more than 400,000 tons of SO_2 discharge can be reduced. Furthermore, the conditions for safe production can be improved; therefore, these policies are very important for realizing sustainable development objectives in the Eleventh Five-year Plan.

II. Optimization of frame and product structure of the iron and steel industry. For historical reasons the iron and steel production frame in China is not really rational. More than 20 out of 75 national key iron and steel enterprises are located in provincial capitals or large cities, many in regions with dense populations and water scarcity, a practice which has greatly affected the living conditions of the inhabitants. Low-end products have accounted for a large portion of the total iron and steel output. Some products were prohibited by the State many years ago, such as ground strip steel and the hot-rolled silicon steel. Ordinary products such as wire rods and narrow steel strips still make up a large portion of the newly added iron and steel output, while products with high technological content and high added value, such as steel plates for cars, cold-rolled silicon steel slice and high-level steel plates for ships, etc., cannot satisfy domestic demand. The accelerated closing, stopping and elimination of backward capacity can optimize the frame of the iron and steel industry and urge enterprises with the necessary conditions to adjust to locations with convenient transportation and space facilities. Besides, it can leave market space for products with high added value and urge iron and steel enterprises to improve varieties and quality and increase benefits.

In 2007, the output of steel with high technological content and high added value was greatly increased. In annual outputs, cold-rolled thin and wide steel tape was 17.4027 million tons, an increase of 31.8% over 2006; cold-rolled thin steel plate was 15.6383 million tons, an increase of 25.2%; coated steel plate (belt) was 17.5458 million tons, an increase of 37.9%; clad steel plate (belt) was 3.1721 million tons, an increase of 36.1%; electric steel plate (belt) was 4.1557 million tons, an increase of 23.5%. In 2007, the total yield of the above-mentioned five kinds of steel was 57.9148 million tons, accounting for 10.26% of the total, an increase of 0.67% as compared with 2006.

III. Alleviation of the contradictions of oversupply of iron and steel capacity. In 2006, China's steel-making capacity exceeded 500 million tons, and the consumption volume of steel was less than 400 million tons, so iron and steel are generally in oversupply[U74]. Most of the newly added steel yield has to be digested by export. These enterprises apply low technologies and environmental protection levels, their products have low added value and their profits are small. Currently, the investment scale on iron and steel projects is still large. The accelerated elimination of backward capacity from the iron and steel sector can effectively control the total production output, maintain a supply-demand balance, prevent harmful competition and avoid abrupt changes, so as to favour a healthy development of the iron and steel sector.

IV. Improvement of international competitiveness of the iron and steel industry. The iron and steel industry has intensive funds and technologies and obvious scaled economic benefits, so the competitiveness of enterprises can be enhanced only by improving their infrastructures ; however, since there are many iron and steel enterprises in China and the medium and small enterprises make up a large portion of them, the modernized infrastructures have been decreasing rather than increasing in recent years. In 2006, the steel yield of China's leading iron and steel enterprises accounted for only 24.8% of the total national output, a decrease of 10.6% over that in 2000[U75]. There is much backward equipment - small coke ovens, small blast furnaces, small converters, small electric furnaces and backward mills which still make up a large portion. Currently, there are 1250 blast furnaces in China, of which, 1130 have a volume below 1000 m^3, accounting for 60% of total iron-making capacity. There is a big gap between China and the international level. Closing, stopping and eliminating these backward capacities can reduce the number of iron and steel enterprises, improve the quality of industrial infrastructures, favour the adjustment and modification of large enterprises, and improve the technical and equipment level so as to requalify the international competitiveness of China's iron and steel industries.

At present, the prices of some iron and steel products have risen, but the oversupply frame of the whole iron and steel sector has not changed.

Negative Effects

Small iron and steel enterprises have contributed to local tax bases and employment, so even though backward capacities have been eliminated in accordance with the law, this could have negative effects on local economies in the short term. To offset these negative effects nationwide rules and regulations need to be strictly obeyed; but at the same time emergency economic support should be provided to these regions.

I. Local employment. Despite the many problems posed by blast furnaces with less than 300 m^3 volume, as well as by converters and electric furnaces with a volume of less than 20 tons, they have in some measure guaranteed local employment and encouraged the development of useful industries. Therefore, their elimination will have temporary negative effects on local employment.

II. Local tax. Another contribution to local finance from the above-mentioned blast furnaces, converters and electric furnaces comes from taxes. In some regions with relatively underdeveloped economies, closing and stopping these small blast furnaces will temporarily reduce local tax revenues.

III. Interests of local governments. Based on the previous two aspects, the elimination of backward capacity will generate significantly negative effects on regions with underdeveloped economies , in particular when local government leaders face severe pressure for timely development. On the one hand, they are obliged to abide by the responsibility agreement signed with the State for eliminating backward capacity, while on the other such issues as employment, taxation and residential income may temporarily outweigh it. Finding the appropriate way to carry out coordinated development has become a thorny issue for local governments.

UPDATES

U1. In 2012 a new edition of the white paper on the country's energy policy was published. For the full text see CPG (2012).

U2. Energy consumption continued rising and reached 3.249 million tce in 2010 and 3.75 million tce in 2013 (see the indicator Total Energy Consumption at NBS (n.d.)).

U3. Between 2005 and 2010 China's energy consumption per GDP unit dropped by 19.1%. The new target of the 12th Five-Year Plan for 2015 is to achieve a 16% reduction of energy use per GDP unit from 2010 levels (CCCHINA, 2011).

U4. Those targets were almost completely met (energy consumption per GDP unit and pollutant emission dropped by 19.1% and 14%, respectively). In 2011 new guidelines were set in the 12th Five-Year Plan, concerning the 2011-2015 period:

- 16% reduction of energy use per GDP unit.
- 17% reduction of CO_2 emission per GDP unit.
- Reduction of major pollutant emissions: 8% for COD and SO_2 and 10% for ammonia nitrogen and NOX (KPMG, 2011a).

U5. The transition to an economy driven by domestic consumption is also one of the goals of the 12th Five-Year Plan (KPMG, 2011a).

U6. In 2010 the non-fossil fuels proportion of the primary energy mix was 8.3% and the intermediate target for 2015, set by the 12th Five-Year Plan, is an increase of non-fossil fuel use to 11.4% (China Water Risk, n.d. and KPMG, 2011a).

U7. In 2013 the renewable power share of total energy consumption was 9.8% (367.5 million tons of standard coal) (China's Statistical Yearbook, 2014).

U8. In 2010 the total annual utilization volume of renewable energies was 279.45 million tons of standard coal (8.6% of total energy consumption) (China's Statistical Yearbook, 2014).

U9. In 2012 the installed capacity of hydropower in China was 249 million kw, accounting for 21.20% of the installed capacity for power generation (EIA, n.d. d).

U10. In 2012 the annual hydropower output was 872.11 billion kw, accounting for 17.5% of the total electric output (NBS, n.d.).

U11. During the period 2006-2010 the hydropower installed capacity increased by 101 million kwh, reaching 219 million kwh in 2010 (EIA, n.d. d).

U12. In 2012 the installed capacity for solar power was 3.4 GW (EIA, n.d. g).

U13. In 2010 the installed capacity for solar power was 0.9 million kw. The solar water heater installation was 185 million square meters and it reached 258 million square meters in 2012 (EIA, n.d. g and CNREC, 2014).

U14. China's installed wind capacity, which has almost doubled each year since 2005, was 61 GW in 2012. In 2010 wind installed capacity was 31 GW (EIA, 2015 and EIA, n.d. f).

U15. By the end of 2011 39.96 million households had domestic biogas digesters (Zuzhang, 2013).

U16. At the end of 2012 the installed capacity for power generation from biomass and waste was 8 million kw (EIA, n.d. e).

U17. In 2012 the biomass power installed capacity was 8.04 million kw (EIA, n.d. e).

U18. "By the end of 2010, the installed capacity of all varieties of biomass power generation established nationwide amounted to about 6.7 million kW, exceeding the goal in the 11th Five-Year Plan for Renewable Energy of achieving 5.5 million kW. Among them, bagasse generated 1.7 million, stalk waste generated 2.26 million kW, municipal refuse generated 2.23 million kW, and methane and rubbish landfill gas generated 500,000 kW. By the end of 2010, there were 40 million rural households were using methane and 72,741 agricultural waste methane projects. The total annual methane output from household methane and large medium methane projects was about 14 billion m^3, equivalent to 10 million tons of standard coal. In 2010, the output of Chinese biomass solid fuel reached 3.5 million tons, an increase of 75% in comparison with that of 2009. The annual output of bio-ethanol reached 1.84 million tons and that of biodiesel reached 400,000 tons" (CNREC, 2012).

U19. In 2010 the consumption of renewable energies was 279 million tons of standard coal (NBS, n.d.).

U20. In 2009 China started building a strategic crude oil reserve facility at Lanzhou, in Gansu province, one of the sites for the second of three phases of crude oil reserves (Reuters, 2009). China made its first official announcement about the country's strategic petroleum reserve (SPR) in November 2014, stating that the first phase of the government emergency stockpile is storing about 91 million barrels of crude oil, or about nine days of oil use (Reuters, 2014).

U21. Natural gas dependency in the EU was 65.2% in 2013. The main countries of origin were: Norway (23.8%), Russia (17.5%), Qatar (7.1%) and Algeria (6%) (Eurostat, 2014b).

U22. The European Parliament resolution of June 9, 2011 on the EU-Russia summit included some updates about the regulation of the EU-Russia relationship.

U23. "On August 20, 2009 the Russian Federation officially informed the Depository that it did not intend to become a Contracting Party to the

ECT. In accordance with Article 45(3(a)) of the Treaty, such notification resulted in Russia's termination of its provisional application of the ECT upon expiration of 60 calendar days from the date on which the notification was received by the Depository" (Energy Charter Secretariat, 2013).

U24. In 2011 [COM(2011)539 final] defined a strategy of cooperation beyond the borders of the EU in order to ensure energy supply. This strategy was based on four main objectives:
- Building up the external dimension of the EU's internal energy market;
- Strengthening partnerships for secure, safe, sustainable, competitive energy;
- Improving access to sustainable energy for developing countries;
- Better promotion of EU policies beyond its borders.

U25. Repealed by Directive 2012/27/EU.

U26. Repealed by the Regulation (EU) No 305/2011.

U27. Repealed by Directive 2006/32/EC, later replaced by Directive 2012/27/EU.

U28. Repealed by Directive 2010/31/EU.

U29. Directives 92/42/EEC and 2000/55/EC were amended by the Commission Regulation (EC) No 643/2009. This regulation also repealed Directive 96/57/EC. Directive 2000/55/EC was repealed by the Commission Regulation (EC) No 245/2009. Directive 92/42/EEC was also amended by the Commission Regulation (EU) No 813/2013.

U30. Repealed by the Commission Delegated Regulation (EU) No 626/2011.

U31. Repealed by the Commission Delegated Regulation (EU) No 874/2012.

U32. Repealed by the Commission Delegated Regulation (EU) No 1059/2010.

U33. Repealed by the Commission Delegated Regulation (EU) No 392/2012.

U34. Repealed by the Commission Delegated Regulation (EU) No 1061/2010.

U35. Repealed by the Commission Delegated Regulation (EU) No 1060/2010.

U36. Repealed by Directive 2010/30/EU.

U37. Repealed by Directive 2012/27/EU.

U38. Repealed by Directive 2012/27/EU.

U39. Later relevant documents on energy efficiency are the Communication about Energy efficiency for the 2020 goal [COM(2008)772], the Energy Efficiency Plan 2011 [COM(2011)109] and [COM(2014)15] for the period from 2020 to 2030.

U40. Table 2.1 presents some results of the impact assessment for the Action Plan for Energy Efficiency (2006). The impact assessment for the Energy Efficiency Plan 2011 is now available. This assessment evaluates and compares policy options (section 6) and also provides a brief summary of the results of the 2006 Action Plan for Energy Efficiency (section 3.3.1). See [COM(2011)109 final].

U41. In 2013 the World Energy Council published a new study on energy efficiency policies. See World Energy Council (2013).

U42. Repealed by the Regulation (EU) No 994/2010.

U43. Other relevant documents on supply security are Directive 2009/119/EC and COM(2011)539 (see also note U6).

U44. These guidelines are contained in the Decision 1364/2006/EC on Trans European Networks, which was repealed by the Regulation (EU) No 347/2013.

U45. In 2010 EU met the 12% target set by the White Paper (Eurostat, 2014a).

U46. The Renewable Energy Directive 2009/28/EC, repealing Directives 2001/77/EC and 2003/30/EC, established new targets for 2020. According to this Directive the share of renewables must reach 20 % by 2020.

U47. The renewable share in the EU in 2012 was 14.1 % (Eurostat, News Release, 2014).

U48. Every two years, EU countries report on their progress toward meeting the EU's 2020 renewable energy goals. Based on the national reports, the European Commission produces a report. The latest available report was published in 2013 (EC, 2013a).

U49. The share of CHP in 2011 was 11.2% (Eurostat, 2015a).

U50. The 21% target was not achieved, since in 2010 the share of electricity from renewable sources was 19.6%. In 2013 it was 25.4% (Eurostat, 2015b).

U51. The proposal COM(2008)30 was followed by the Communication from the Commission – Energy efficiency: delivering the 20% target [COM(2008)772] and Directive 2009/28/EC on the promotion of the use of energy from renewable sources.

U52. Repealed by Directive 2003/55/EC, later replaced by Directive 2009/73/EC.

U53. Repealed by Directive 2009/72/EC.

U54. Repealed by Regulation (EC) No 714/2009.

U55. Updates about cross-border flows of electricity according to [COM(2014)634] on progress towards completing the internal energy market:

Cross-border trade in electricity between most EU countries has increased and so has the use of interconnectors – the share of imports in the total electricity available for final consumption has grown in 23 Member States between 2008 and 2012. However, it is nowhere near its full potential yet.

U56. In the matter of unbundling and competition, the cited report [COM(2014)634] states that:

Thanks to the rigorous application of the provisions in the Third energy package, including the unbundling rules and those mandating the establishment of ten-year-network development plans, an investment climate now exists that makes sure those lines are being built that are needed most. The Third package has reduced both the incentive and the ability for operators to revert to discriminatory behaviour or withhold the construction of important infrastructure. Today, 96 of approximately 100 transmission system operators in Europe have been certified as compliant with one of the Third energy package's unbundling models. The Commission will continue to monitor the situation and will also remain vigilant to ensure compliance with the EU competition rules.

U57. Repealed by Directive 2003/54/EC, later replaced by Directive 2009/72/EC.

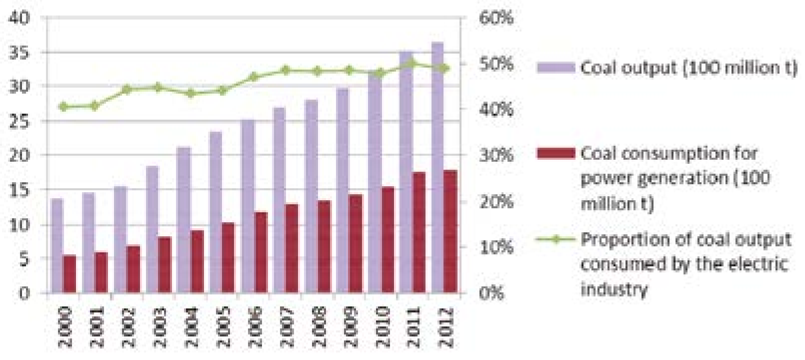
U58. [COM(2014)634] also states that:

Transparency has been improved substantially and in many ways. Regulatory oversight to ensure market integrity and avoid market abuses has been tightened thanks to the application of the rules laid down in the 2011 REMIT Regulation. A central information transparency platform for the publication of data in electricity markets will be established by ENTSO-E by early 2015.

U59. New data about market concentration (HHI) can be obtained from the latest country profiles at EC (2014). The data are summarized in the table below.

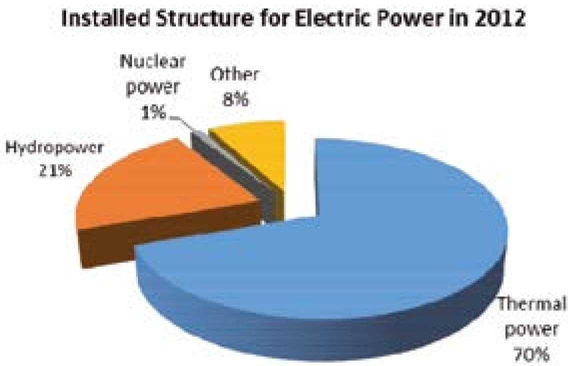
	Electricity generation	**Gas supply**
HHI above 5000	*HR, CY, CZ*, EE, FR, EL, LV, SK**	*BG, EE, FI*, LV, LT, LU*, NL, PL*, RO*, SK*, SI, SE*
HHI between 1800 and 5000	*BE, DE, HU, LU, PL, PT, RO, SI, SE*	*AT, BE, HR, CZ, FR, DE, PT, ES*
HHI below 1800	*FI, IE, IT, LT, MT, NL, ES, UK*	*HU, IT, UK**
N/A	*AT, BG, DK*	*CY, DK, EL, IE, MT*

LEGEND
*Gathered from the text because the HHI value was not available
☐ NORDIC in the previous table
☐ Not in the previous table
+ Higher than the previoud table
- Lower than the previous table
= No changes



U60. Further available NBS (n.d.) data are summarized in the chart below.

	2005	2006	2007	2008	2009	2010	2011	2012
Total installed capacity (GW)	*524,21*	*631,00*	*725,40*	*806,41*	*890,36*	*987,33*	*1084,73*	*1174,31*
Hydropower	*117,39*	*128,57*	*145,26*	*171,50*	*196,80*	*219,00*	*231,00*	*249,00*
Thermal power	*391,37*	*484,05*	*554,52*	*601,30*	*652,10*	*706,60*	*766,00*	*819,00*
Nuclear power	*6,59*	*7,57*	*8,44*	*8,44*	*8,44*	*10,06*	*11,82*	*12,86*
Other	*8,86*	*10,81*	*17,18*	*25,17*	*33,02*	*51,67*	*75,91*	*93,45*



U61. Further updated EIA data are shown in the table and chart below.

U62. The proportion of thermal power generating units with a generation capacity above 300,000 kw each in China's thermal power installed capacity increased from 47% in 2005 to 71% in 2010 (CCHINA, 2011).

U63. In 2009 (latest data available from CARMA) China was the country with the highest CO_2 power plant emissions, 2.8 billion tons, while the USA's CO_2 emissions decreased from 2.8 billion tons in 2006 to 2.3 billion tons in 2009. Per capita emissions in 2009 were 2.1[1] tons in China and 7.5[2] in the USA, while in 2006 it was 2.1 tons for China and 9.4 tons for the US.A. Per capita emissions are calculated as $\frac{\text{Annual } CO_2 \text{ Emission}}{\text{Total Population}}$. Data are retrieved from CARMA (n.d.) and the World Bank (n.d.).

U64. The Eleventh Five-Year Plan concerns the period 2006-2010, thus, China's current guidelines are those of the Twelfth Five-Year Plan (2011-2015).

The objectives concerning energy are summarized in the section "Energy Sector: Targets and Planned Investment" of KPMG (2011b).

U65. The first objective of the policy was achieved, in fact "China shut down small thermal power generating units with a total generating capacity of 76.82 million kw" and "The proportion of thermal power generating units with a generation capacity above 300,000 kw each in China's thermal power installed capacity increased from 47% in 2005 to 71% in 2010" (CCCHINA, 2011).

U66. During the 11th Five-Year Plan (2006-2010) small thermal power generation units with a total capacity of 76.82 million kw were shut down.

In 2011 China shut down small thermal power generating units with a total generating capacity of 8 million kw.

In 2013 China closed 4.47 GW of small thermal power units (CCCHINA 2011, 2012, 2014).

U67. The table below summarizes the results of the Plan for Development of Renewable Energies, according to CCHINA (2011).

Renewable Source	**2010 target installed capacity**	**2010 actual installed capacity**
Hydropower	*190 GW*	*213 GW*
Wind Power	*10 GW*	*31.07 GW*
Biomass Energy	*5.5 GW*	*5GW*
Solar Energy	*300 MW*	*600 MW*
Nuclear Power	*20 GW*	*10.82 GW*

U68. "From 2005 to 2010, coal consumption in thermal power supply dropped 10% from 370 to 333 g/kwh" (CCCHINA, 2011).

U69. According to the estimates in CCCHINA (2011), energy consumption per ton of steel decreased by 12.8%, from 694 kg of standard coal in 2005 to 605 kg of standard coal in 2010.

U70. Between 2005 and 2010 "the proportion of large iron production blast furnaces with a capacity above 1,000 cu m each increased from 48% to 61%" (CCCHINA, 2011).

U71. The tables below show updated data on pollutant discharge from the iron and steel industry in China (NBS, n.d. and China's Statistical Yearbooks).

	2007			2008		
	Iron and steel	National industrial	Proportion percent	Iron and steel	National industrial	Proportion percent
SO_2 (10000 tons)	*146,5*	*2168,4*	*6,76*	*154,7*	*2234,8*	*6,92*
Smoke Dust (10000 tons)	*71,0*	*948,9*	*7,48*	*74,4*	*864,5*	*8,61*
Powder Dust (10000 tons)	*129,6*	*911,2*	*14,22*	*117,4*	*808,4*	*14,52*
Wastewater (100 million tons)	*18,4*	*243,1*	*7,57*	*17,2*	*240,2*	*7,16*

	2009			2010		
	Iron and steel	National industrial	Proportion percent	Iron and steel	National industrial	Proportion percent
SO_2 (10000 tons)	*175,6*	*1866,1*	*9,41*	*181,9*	*1864,4*	*9,76*
Smoke Dust (10000 tons)	*53,7*	*603,9*	*8,89*	*58,2*	*603,2*	*9,65*
Powder Dust (10000 tons)	*87,9*	*523,6*	*16,79*	*98,8*	*448,7*	*22,02*
Wastewater (100 million tons)	*14,2*	*234,4*	*6,06*	*13,2*	*237,5*	*5,56*

U72. By the end of 2010, 120 million tons of backward iron production capacity and 72 million of backward steel production capacity were eliminated (CCCHINA, 2011).

U73. The table below compares these targets of the 11th Five-Year Plan and the results achieved by 2010 (CAAC, 2013 and China Water Risk, n.d.).

	Target reduction	Actual reduction
Energy consumption per GDP unit	*20%*	*19.1%*
SO_2 discharge	*10%*	*14.29%*
COD discharge	*10%*	*12.45%*
Water intensity	*30%*	*37%*

U74. "Total steel capacity in China estimated at 720-750 million tons per year. According to one estimate, around 100 million tons of steel capacity is unnecessary" (KPMG, 2011c).

U75. "China's top 10 steel producers are expected to expand through M&A, and will represent 60% of the country's total steel output by 2015, up from 48% in 2010" (KPMG, 2011c)

NOTES

1. Import dependency is calculated by using the following formula: net imports / (gross inland consumption + bunkers). Source: DG TREN (2005).
2. For more details see EC (2003b).
3. The bilateral relations between the EU and individual partner countries has been achieved through the negotiation of Partnership and Co-operation Agreements (PCAs), now in force with ten of the Eastern European and Central Asian countries. PCAs are legal frameworks, based on respect for democratic principles and human rights, for establishing political, economic and trade relationship between the EU and its partner countries. Each PCA is a ten-year bilateral treaty signed and ratified by the EU and the individual state.
4. The Energy Charter Treaty was signed in December 1994 and entered into legal force in April 1998. To date, the Treaty has been signed or acceded to by fifty-one states. The fundamental aim of the Energy Charter Treaty is to strengthen the rule of law on energy issues by creating a level playing field of rules to be observed by all participating governments, thereby mitigating risks associated with energy-related investment and trade.
5. Negotiations on an Energy Charter Transit Protocol aim at clarifying the operational meaning of 'freedom of transit' for the energy sector, on the basis of the existing Treaty provisions. The overall aim is to provide clear and transparent rules for international energy transit flows, rules which can encourage the efficient development and use of energy transportation infrastructure and reduce the risk of interruptions of supply.
6. Consolidated version following the Treaty of Nice, which entered into force on February 1, 2003.
7. A more detailed analysis of the principle can be found in Protocol 30 to the EC Treaty.
8. These are the Directive on energy performance of buildings, the Directive on the promotion of cogeneration, the Directive on the taxation of energy products and electricity, the Directives on efficiency requirements for boilers, refrigerators and ballasts for fluorescent lighting, the Directives on the labelling of electric ovens, air conditioners, refrigerators and other appliances, the Directive on eco-design requirements for energy-using products, the Directive on energy end-use efficiency and energy services, Regulation on Energy Star labelling for office equipment.
9. See World Energy Council (2008)
10. The so called "rebound effect" refers to an increase in demand that is caused by the introduction of more efficient technologies. For example, because of the lower consumption achieved by more efficient buildings, the consumers tend to increase their comfort through higher heating temperature or longer utilisation of lights.
11. Confindustria (2008).
12. The proposal of this Directive was published by the European Commission in December 2003 The text, agreed on by the European Parliament in July 2005, had to be transposed by the Member States by February 24, 2008.
13. With regard to the measures aimed at improving energy security, further research will be devoted to empirically assess the relationship between the objectives embedded in the policies and the energy security indicators considered in the current report.
14. F=Finalised; F/C=finalised/construction phase ; C=construction phase ; A=authorisation phase ; A/S=authorisation/study phase; S=study Phase; D=deleted; F/S = finalised/study phase
15. However, RES contribution varies widely across country: it ranges from 1% (U.K.) to 28.7% (Sweden).
16. Kyoto protocol fixes an 8% reduction of CO_2 emissions between 2008 and 2012 compared to 1990.
17. See [COM(2006) 105 final].
18. See [COM(97)599 final].
19. See Directive 2001/77/EC.
20. See [COM(2005)627 final].
21. See Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources, [COM(2008)30 final].
22. See [SEC(2008)57].
23. See OPTRES (2006).
24. The effectiveness indicator is defined as $E_i(t) = [G_i(t)-G_i(t-1)]/ADDPOT_i(t-1)$, where $E_i(t)$ is the effectiveness indicator for RES technology i at time t, $G_i(t)$ is the electricity generation potential of RES technology i at time t and $ADDPOT_i(t)$ is the additional electricity generation potential of RES technology i at time t.
25. The average expected profit or annuity of the renewable investment is calculated as the specific discounted average return of on every produced kWh by taking into account income and expenditure over the entire lifetime of a given RES-E technology.
26. See EWEA (2005).

27. The first phase of the stakeholder consultation consisted of a web-based questionnaire, whereas in the second phase in-depth interviews were held with selected stakeholders. In total 251 respondents filled in the web-based questionnaire, coming from all EU member states except the Slovak Republic. During the second phase 25 interviews were held.
28. According to many experts (see, inter alia, Vasconcelos (2005)), the direct impact of this Directive has been modest.
29. [SEC(2006)1724].
30. Prices are deflated by using the Consumer Price Index (CPI).
31. The source of data is Eurostat.
32. [COM(2008)192 final].
33. The Herfindahl-Hirschman Index is a measure of the concentration of an industry/sector. It is obtained by computing the sum of squared market shares of individual firms. Consequently, this index is equal to 10,000 in the case of a monopolist. On the contrary, in the case of a large number of firms with very small market shares, the HHI tends to be zero. If the values are higher than 1800, the market can be classified as highly concentrated.
34. See Council Directive 2003/96/EC.
35. See [COM(2006) 105 final].
36. See [COM(2007) 140 final].
37. Answers from CDRA officials to questions about how to reduce small-scale projects and develop large-scale ones in the electrical power industry for energy saving and emission reduction, February 1, 2007, web station for CDRA.
38. Mi (2007a).
39. See NDRC (n.d.) for details.
40. Mi (2007b).
41. China Electricity Newspaper (2008).
42. This value is obtained averagely from the CO2 discharge of coal calculated by six project groups, i.e., DOE/EIA (0.702), Japan Institute of Energy Economics (0.756), Chinese Academy of Engineering (0.68) SEPA Greenhouse Gas Control Project (0.748), Climate Change Project of the original SSTC (0.748) and Beijing project of SSTC (0.656).
43. Speech made by Ou Xinqian, Deputy director of NDRC, on International Forum for DSM of China's Electrical Power in 2007.
44. The energy-saving data for the iron and steel sector of our country for 1999 are not available. Because of institutional changes, the data for only large and medium iron and steel enterprises, the members of CISA, are available. Now, the large and medium iron and steel enterprises have the list for energies, but there is no list for iron and steel enterprises in China, and the proportion of enterprises without those detailed data is increasing. Except when indicated, all the data in this article come from the data and materials published in the past years on the official CISA website.
45. China Statistics Yearbooks, 2005-2007.

3. Environmental Protection

CHINA

3.1. Use of Traditional Fuels and Environmental Protection

General Situation of Energy Utilization and Environmental Protection

Much of the environmental pollution in countries all over the world is related to the processes for production, transport and use of energy. At present, the greenhouse gas issue that arouses world-wide attention is mainly caused by the large consumption of fossil energies. China is no exception.

Since reform and opening up, China has registered enormous growth in energy production and consumption, thereby adding tremendous pressure to the environment while lending strong support to sustained economic growth. The massive coal-dominated energy production and consumption is mainly to blame for the deterioration of China's atmospheric environment. It is estimated that coal is accountable for 85% of carbon dioxide emissions, 74% of sulphur dioxide emissions, 60% of nitrogen oxide emissions and 70% of flue gas in China's atmosphere. At present, power plant coal consumption accounts for approximately half of China's coal production; the water consumption of its thermal power plants accounts for 40% of industrial water usage; sulphur dioxide emissions account for over half of all the country's emissions; flue gas emissions account for 33% of industrial emissions and 20% of the national total; the clinker produced accounts for 70% of the national total. China's flue gas emissions reached 11.825 million metric tons in 2005, 19.7% up from 2002; sulphur dioxide emissions reached 25.49 million metric tons, 27.8% up from 2000, exceeding the targets set in the "Tenth Five-Year" Environmental Protection Plan. In the first half of 2006, the pollutant emission issue was still very severe. Statistics show that China generated 6.896 million metric tons of chemical oxygen demand (COD) emissions in the first half of 2006, representing a year-over-year growth rate of 3.7%; sulphur dioxide emissions reached 12.746 million metric tons, up 4.2% from a year earlier. Thus the emissions of two key pollutants: chemical oxygen demand and sulphur dioxide increased to varying extents (SEPA, 2006).

Table 3.1 shows that 70% of smoke dust and carbon dioxide, 90% of sulphur dioxide and 67% of hydrogen oxides came from coal combustion.

But during recent years, the concern for environment protection in China's energy sectors has been constantly increasing. The 11th Five-Year Plan set a specific objective of slashing pollutant emissions by 10% during the 2005-2010 period. Generally speaking, the environmental influence caused by energy sectors is steadily declining.

Table 3.1
Comparison of environmental influences from different fossil energies

	Natural gas	Petroleum	Coal	Remarks
Heat	*1000m³*	*1 ton*	*Industry: 2.2-3.2 tons* *Civilian: 3.5-5.3 tons*	
Discharge of sulfide	*1*	*400*	*700*	*Provide the same thermal heat equivalent. 1 for natural gas.*
Discharge of carbon Dioxide	*1.00*	*1.33*	*1.67*	
Discharge of nitrogen Dioxide	*1*	*5*	*10*	
Smoke dust	*1*	*14*	*148*	
Energy conservation by the use of natural gas			*Industry: 36-44%* *Civilian: 48-66%*	
Investment on facilities	*0.41*	*0.47*	*1*	

Notes: Author's' elaborations.

What follows is an explanation of the environmental influence from China's energy sectors from the discharge volumes of three wastes (waste water, waste gas and solid waste) in energy sector.

Waste Water Discharge from Energy Sectors

Waste Water Discharge from Electrical Power and Thermal Power Sectors[U1].The waste water discharge from electrical power and thermal power enterprises increased from 2.15785 billion tons in 1991 to 2.17145 billion tons in 2006, therefore remaining basically unchanged, but the volume of qualified waste water has been constantly increasing, and increased from 1.33769 billion tons in 1991 to 2.10066 billion tons in 2006 (see Table 3.2).

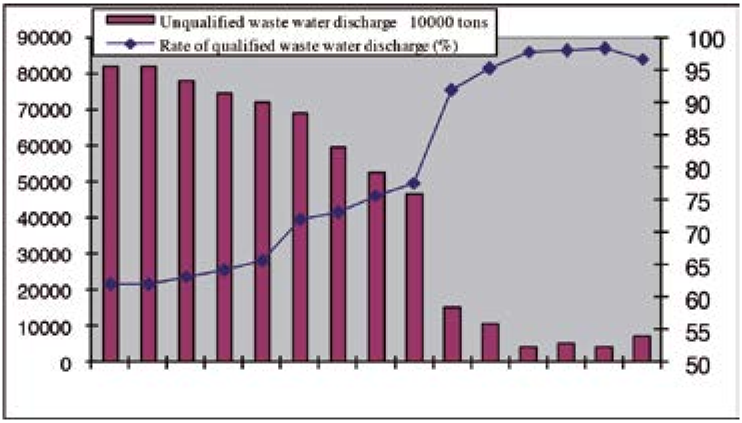
Table 3.2
Discharge of industrial waste water from electrical power and thermal power sectors in China (10,000 tons)

Year	Number of enterprises	Amount of discharge	Amount of qualified discharge	Number of waste water treatment facilities (set)	Rate of qualified discharge of waste water (percent)
1991	*932*	*215785*	*133769*	-	*61.99*
1992	*932*	*215785*	*133769*	-	*61.99*
1993	*996*	*212675*	*134586*	-	*63.28*
1994	*1054*	*208063*	*133535*	-	*64.18*
1995	*1105*	*209366*	*137252*	-	*65.56*
1996	*1173*	*245556*	*176653*	-	*71.94*
1997	*1498*	*221762*	*162219*	-	*73.15*
1998	*1623*	*215909*	*163431*	-	*75.69*
1999	*1661*	*207955*	*161533*	-	*77.68*
2000	*1756*	*186594*	*171364*	-	*91.84*
2001	*1659*	*222997*	*212553*	*2260*	*95.32*
2002	*1771*	*209107*	*204702*	*2341*	*97.89*
2004	*2072*	*251565*	*246456*	*2635*	*97.97*
2005	*2356*	*251145*	*246832*	*2793*	*98.28*
2006	*2648*	*217145*	*210066*	-	*96.74*

Notes: China's Statistical Yearbooks, 1992-2007.

Since more and more waste water from the electrical power and the thermal power sectors is discharged after being processed, the rate of qualified discharge steadily increasing and the waste water volume directly discharged without treatment decreased (as shown in Figure 3.1) from 820.16 million tons in 1991 to 70.79 million tons in 2006.

Figure 3.1
Rate of qualified waste water discharge from electrical power and thermal power sectors in China



Notes: The waste water discharge volume from the electrical power and thermal power sectors was constantly rising, but the unqualified waste water discharge volume was constantly decreasing and the rate of qualified waste water discharge was constantly rising. Taking the waste water discharge volume as the measurement index, the negative influence of this sector on the environment was being reduced.

Waste Water Discharge from Coal Sector[U2].The waste water discharge volume from coal enterprises in China grew from 506.44 million tons in 2001 to 540.23 million tons in 2006 and the qualified waste water volume grew from 425.29 million tons in 2001 to 480.15 billion tons in 2006 (see Table 3.3).

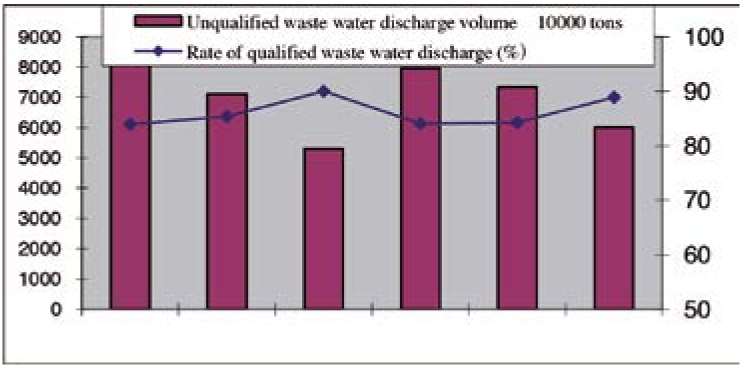
Table 3.3
Discharge of industrial waste water from coal sectors in China

Year	No. of enterprises	Amount of discharge	Amount of qualified discharge	Number ofwaste water treatment facilities (set)	Rate of qualified waste water discharge (percent)
2001	*2331*	*50644*	*42529*	*2277*	*83.98*
2002	*2300*	*48571*	*41463*	*2300*	*85.37*
2004	*2379*	*53168*	*47873*	*2317*	*90.04*
2003	*2828*	*49983*	*42019*	*2440*	*84.07*
2005	*2968*	*46650*	*39309*	*2517*	*84.26*
2006	*3108*	*54023*	*48015*	-	*88.88*

Notes: China's Statistical Yearbooks, 2002-2007.

The unqualified discharge of waste water in China's coal sector has been subject to constant fluctuation over the past several years, but there seems to be a general decrease trend. It decreased from 81.15 million tons in 2001 to 60.08 million tons in 2006, while the rate of qualified waste water discharge increased from 83.98% in 2001 to 88.86%. The fluctuation of the volume of waste water discharge from China's coal sector is related, to some extent, to the production situation of the country's small coal mines. In those years, since small coalmines produced large amounts of coal, the rate of unqualified waste water discharge from coal enterprises was high (see Figure 3.2).

Figure 3.2
Rate of qualified waste water discharge from coal sectors in China



Notes: The volume of waste water discharge from China's coal sectors was constantly increasing, but the volume of unqualified waste water discharge was constantly decreasing in the fluctuation, and the rate of fluctuation of qualified waste water discharge was constantly rising. If we take the waste water discharge volume as the measurement index, the negative influence of this sector on the environment was being reduced.

Waste Water Discharge from Petroleum and Natural Gas Exploitation Sector[U3]. China's waste water discharge from petroleum and natural gas sectors decreased from 187.78 million tons in 2001 to 111.77 million tons in 2006,and the qualified waste water volume decreased from 170.42 million tons in 2001 to 107 million tons in 2006 (see Table 3.4).

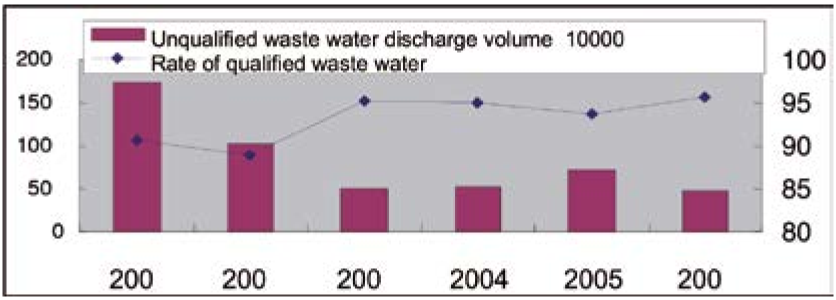
Table 3.4
Discharge of industrial waste water from petroleum and natural gas sectors in China (10,000 tons)

Year	Number of enter prises	Amount of discharge	Amount of qualified discharge	Number of waste water treatment facilities (set)	Rate of qualified waste water treatment (%)
2001	*180*	*18778*	*17042*	*647*	*90.76*
2002	*177*	*9226*	*8196*	*562*	*88.84*
2004	*186*	*10644*	*10145*	*676*	*95.31*
2003	*193*	*10372*	*9845*	*623*	*94.92*
2005	*211*	*11252*	*10545*	*662*	*93.72*
2006	*205*	*11177*	*10700*	-	*95.73*

Notes: China's Statistical Yearbooks, 2002-2007.

China's unqualified discharge of waste water from the petroleum and natural gas sectors has been subject to constant fluctuation over the past several years, but there is a general decrease trend. It decreased from 17.36 million tons in 2001 to 4.77 million tons in 2006, while the rate of qualified waste water discharge increased from 90.76% in 2001 to 95.73% in 2006 (see Figure 3.3).

Figure 3.3
Rate of qualified waste water discharge from petroleum and natural gas sectors in China



Notes: The volume of waste water discharge from the petroleum and natural gas sectors was constantly increasing, but the volume of unqualified waste water discharge was constantly decreasing in fluctuation, and the fluctuation rate of qualified waste water discharge was constantly rising. If we take the volume of waste water discharge as the measurement index, the negative influence of this sector on the environment was being reduced.

Waste Gas Discharge from Energy Sectors

Waste Gas Discharge from Electrical Power and Thermal Power Sectors[U4].The waste gas discharge from electrical power and thermal power enterprises grew from 2.6962 trillion standard cubic meters in 1991 to 8.8347 trillion standard cubic meters in 2005, and the discharge of industrial sulphur dioxide grew from 5.28million tons in 1991 to 12.041 million tons in 2006. Despite the rapidly increased discharge of sulphur dioxide, its removal volume also increased from 0.31 million tons in 1991 to 4.275 million tons in 2006 (see Table 3.5).

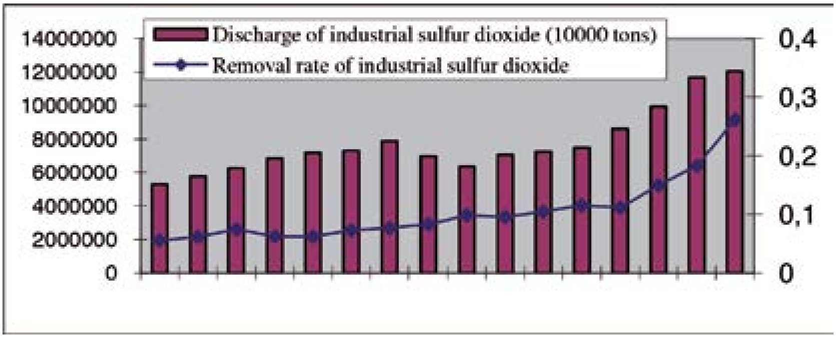
Table 3.5
Discharge of industrial waste gas from China's electrical power and thermal power sectors (10,000 tons)

year	Number of waste gas treatment facilities (set)	Amount of industrial waste gas discharge (100 million standard cubic meters)	Amount of industrial sulphur dioxide discharge (tons)	Removal volume of industrial sulphur dioxide (tons)	Amount of industrial smoke dust discharge (tons)	Removal volume of industrial smoke dust (tons)	Amount of industrial powder dust discharge) (tons)	Removal amount of industrial powder dust (tons)
1991	-	*26962*	*5280000*	*310000*	*4180000*	*53020000*	*40000*	*50000*
1992	-	*28531*	*5760000*	*380000*	*3880000*	*58690000*	*80000*	*30000*
1993	-	*32264*	*6283378*	*506340*	*4193399*	*67219630*	*47567*	*33972*
1994	-	*34854*	*6856677*	*453782*	*4303366*	*73746916*	*36310*	*69245*
1995	-	*38175*	*7178420*	*477783*	*4443756*	*81854959*	*36147*	*34271*
1996	-	*38651*	*7315727*	*575028*	*4164878*	*85566168*	*66964*	*841860*
1997	-	*41482*	*7894660*	*656815*	*3952957*	*87117616*	*71749*	*551974*
1998	-	*41239*	*6967926*	*626990*	*3419778*	*81054187*	*62491*	*178901*
1999	-	*43443*	*6374392*	*693131*	*3074608*	*79588791*	*35775*	*400780*
2000	-	*48028*	*7072292*	*745803*	*3013124*	*86876648*	*24577*	*211173*
2001	*6866*	*53647*	*7255415*	*846886*	*3231957*	*104789968*	*20590*	*139121*
2002	*9620*	*58322*	*7500892*	*971549*	*3284493*	*114458878*	*14923*	*66906*
2003	*8134*	*68008*	*8619462*	*1075885*	*127569284*	*3369721*	*70404*	*29090*
2004	*8703*	*79744*	*9948598*	*1744308*	*3485800*	*149546458*	*79660*	*74464*
2005	*10009*	*88347*	*11672000*	*2607000*	*4052000*	*167048000*	*108000*	*39000*
2006	-	-	*12041000*	*4275000*	*3467000*	*190477000*	*14000*	*26000*

Notes: China's Statistical Yearbooks, 1992-2007.

The removal of sulphur dioxide from China's electrical power and thermal power sectors has been steadily increasing, from 5.5% in 1991 to 26.2% in 2006 (see Figure 3.4).

Figure 3.4
Removal rate of sulphur dioxide from China's electrical power and thermal power sectors



Notes: The waste gas discharge volume from the electrical power and thermal power sectors showed a rise, as did the removal rate of sulphur dioxide. If we take the waste water discharge volume as the measurement index, the negative influence of these sectors on the environment was increasing.

Waste Gas Discharge from the Coal Sector[U5]. The waste gas discharge from coal enterprises grew from 154.3 billion standard cubic meters in 2001 to 193.5 billion standard cubic meters in 2005, the discharge of industrial sulphur dioxide decreased from 0.177 million tons in 2001 to 0.145 million tons in 2006, and the removal volume of sulphur dioxide rose from 40 thousand tons in 2001 to 89 thousand tons in 2006 (see Table 3.6).

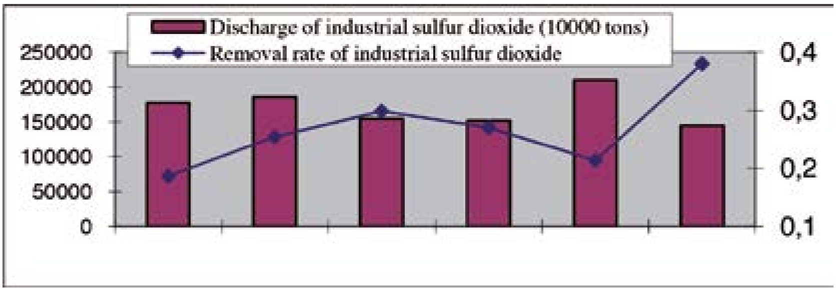
Table 3.6
Discharge of industrial waste gas from China's coal industry (10,000 tons)

year	Number of waste gas treatment facilities (set)	Amount of industrial waste gas discharge (100 million standard cubic meters)	Amount of industrial sulphur dioxide discharge (tons)	Removal volume of industrial sulphur dioxide (tons)	Amount of industrial smoke dust discharge (tons)	Removal volume of industrial smoke dust (tons)	Amount of industrial powder dust discharge) (tons)	Removal amount of industrial powder dust (tons)
2001	*5295*	*1543*	*177672*	*40663*	*168805*	*1335075*	*76328*	*228218*
2002	*4946*	*1407*	*185960*	*63519*	*127420*	*1087076*	*91503*	*134842*
2003	*4431*	*1782*	*155244*	*66213*	*1043837*	*133507*	*89206*	*52103*
2004	*4252*	*1826*	*152093*	*56403*	*134790*	*966846*	*137528*	*151198*
2005	*4427*	*1935*	*210000*	*57000*	*109000*	*1418000*	*246000*	*97000*
2006	-	-	*145000*	*89000*	*122000*	*923000*	*176000*	*79000*

Notes: China's Statistical Yearbooks, 2002-2007.

The removal rate of sulphur dioxide from China's coal sector has been steadily increasing, from 18.6% in 1991 to 38% in 2006 (see Figure 3.5).

Figure 3.5
Removal rate of sulphur dioxide from China's coal sector



Notes: The direct discharge of sulphur dioxide from China's coal sectors showed a decrease in fluctuation, and fluctuation in the removal rate of sulphur dioxide was constantly rising. If we take the waste gas discharge volume as the measurement index, the negative influence of the coal sector on the environment was decreasing.

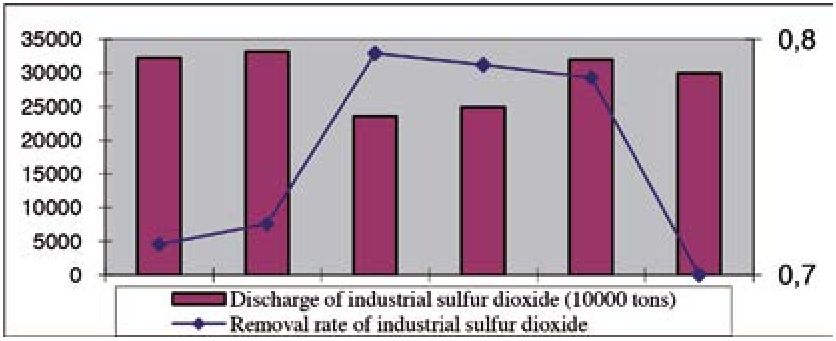
Waste Gas Discharge from Petroleum and Natural Gas Exploitation Sector[U6]. The waste gas discharge from the sectors of petroleum and natural gas exploitation decreased from 106.4 billion standard cubic meters in 2001 to 96.3 billion standard cubic meters in 2005, the discharge of industrial sulphur dioxide decreased from 32 thousand tons in 2001 to 30 thousand tons in 2006, and the removal volume of sulphur dioxide decreased from 80 thousand tons in 2001 to 70 thousand tons in 2006. Since 2001, the removal rate of sulphur dioxide from petroleum and natural gas sectors has remained basically stable (see Table 3.7 and Figure 3.6).

Table 3.7
Discharge of industrial waste gas from China's petroleum and natural gas sectors (10,000 tons)

Year	Number of waste gas treatment facilities (set)	Amount of industrial waste gas discharge (100 million standard cubic meters)	Amount of industrial sulphur dioxide discharge (tons)	Removal volume of industrial sulphur dioxide (tons)	Amount of industrial smoke dust discharge (tons)	Removal volume of industrial smoke dust (tons)	Amount of industrial powder dust discharge) (tons)	Removal amount of industrial powder dust (tons)
2001	*544*	*1064*	*32217*	*80013*	*18544*	*62834*	*1788*	*629*
2002	*329*	*829*	*33135*	*85907*	*20224*	*239002*	*1325*	*1670*
2003	*717*	*828*	*23538*	*90742*	*82460*	*13119*	*1748*	*1410*
2004	*476*	*791*	*24912*	*93246*	*12577*	*45726*	*1584*	*1752*
2005	*437*	*963*	*32000*	*116000*	*14000*	*99000*	*1000*	*1000*
2006	-	-	*30000*	*70000*	*10000*	*99000*	*3000*	*4000*

Notes: China's Statistical Yearbooks, 2002-2007.

Figure 3.6
Removal rate of sulphur dioxide from petroleum and natural gas sectors



Notes: The direct discharge of sulphur dioxide from the China's sectors of petroleum and natural gas exploitation have shown in recent years a decrease in fluctuation, as well as fluctuation in the removal rate of sulphur dioxide. If we take the waste gas discharge volume as the measurement index, the variation of influence on the environment of the sector of petroleum and natural gas exploitation has not been great.

Discharge of Industrial Solid Waste from Energy Sectors

Discharge of Industrial Solid Waste from Electrical and Thermal Power Sectors[U7]. The yield of industrial solid waste from electrical and thermal power enterprises grew from 149.25 million tons in 2001 to 291.35 million tons in 2006, but the discharge of industrial solid waste from these sectors decreased from 0.9 million tons to 0.55 million tons (see Table 3.8).

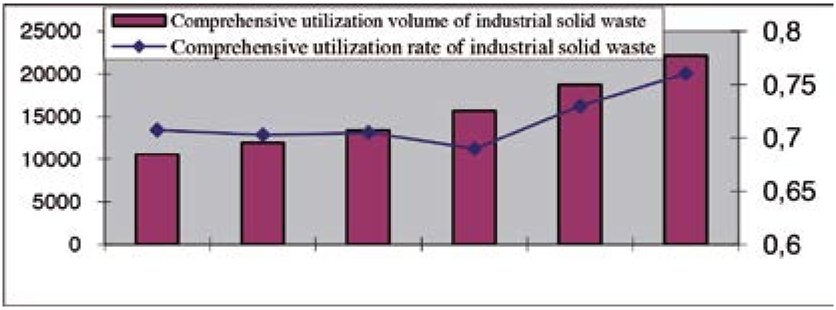
Table 3.8
Discharge of industrial solid waste from China's electrical and thermal power enterprises (10,000 tons)

Year	Yield of industrial solid waste	# Dangerous waste	Comprehensively utilized volume of industrial solid waste	Storage volume of industrial solid waste	Disposal volume of industrial solid waste	Discharge volume of industrial solid waste
2001	*14925*	*NA*	*10561*	*4587*	*1381*	*90*
2002	*16969*	*3.3*	*11931*	*4638*	*1484*	*56*
2003	*19026*	*1.46*	*13418*	*4823*	*1470*	*73*
2004	*22770*	*2.458*	*15710*	*5333.4*	*2603*	*53.4941*
2005	*25638*	*67.62*	*18721*	*5136*	*3041*	*49*
2006	*29135*	*21.23*	*22153*	*5229*	*2905*	*54.78*

Notes: China's Statistical Yearbooks, 2002-2007.

The reduction of the discharge of industrial solid waste from the electrical and thermal power sectors in China is mainly caused by the constant increase of its comprehensive utilization. The comprehensive utilization volume of industrial solid waste in this sector was 105.61 million tons in 2001 and increased to 221.53 million tons in 2006. The comprehensive utilization ratio also increased from 41% in 2001 to 43% in 2006 (see Figure 3.7).

Figure 3.7
Comprehensive utilization volume and rate of industrial solid waste in electrical and thermal power sector in China



Notes: The discharge volume of industrial solid waste in China's electrical and thermal power sector was in constant increase, but the discharge volume of industrial solid waste was in constant decrease. The main reason for this was the constant improvement of its comprehensive utilization level. If we take the discharge volume of solid waste as the measurement index, the negative influences from the electrical and thermal power sector on the environment were decreasing.

Discharge of Industrial Solid Waste from Coal Sector[U8]. The yield of industrial solid waste from coal enterprises grew from 127.28 million tons in 2001 to 193.52 million tons in 2006, but the discharge volume of industrial solid waste from this sector decreased from 6.19 million tons to 3.74 million tons (see Table 3.9).

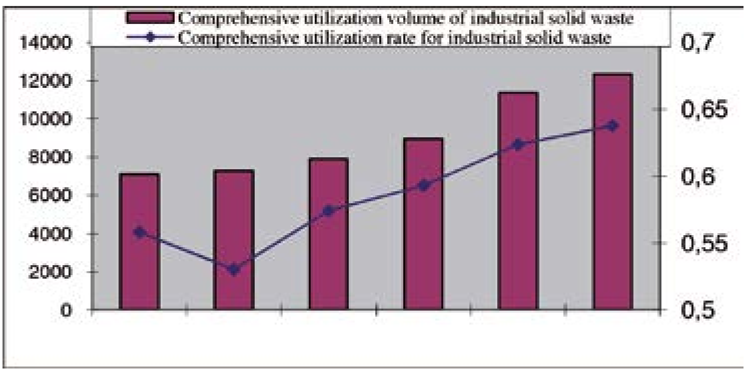
Table 3.9
Discharge of industrial solid waste from coal enterprises in China (10,000 tons)

Year	Yield of industrial solid waste	# Dangerous waste	Comprehensively utilized volume of industrial solid waste	Storage volume of industrial solid waste	Disposal volume of industrial solid waste	Discharge volume of industrial solid waste
2001	*12728*	*NA*	*7105*	*2973*	*2749*	*619*
2002	*13716*	*0.06*	*7277*	*2896*	*3458*	*562*
2003	*13746*	*2.69*	*7893*	*2440*	*3569*	*532*
2004	*15082*	*0.0497*	*8944*	*2131.8*	*4051*	*461.39*
2005	*18248*	*0.08*	*11379*	*2342*	*5016*	*444*
2006	*19352*	*18.29*	*12337*	*1886*	*5700*	*374.15*

Notes: China's Statistical Yearbooks, 2002-2007.

The reduction of discharge of industrial solid waste from the coal sector in China is mainly caused by the constant increase of its comprehensive utilization volume. The comprehensive utilization volume of industrial solid waste in this sector was 71.05 million tons in 2001 and increased to 123.37 million tons in 2006, and the comprehensive utilization ratio also increased from 56% in 2001 to 64% in 2006 (see Figure 3.8).

Figure 3.8
Comprehensive utilization volume and rate of industrial solid waste in China's coal sector



Notes: The yield of industrial solid waste in China's coal sector was in constant increase, but the discharge volume of industrial solid waste was in constant decrease. The main reason for this was the constant improvement of its comprehensive utilization level. If we take the discharge volume of solid waste as the measurement index, the negative influence from this sector on the environment was decreasing.

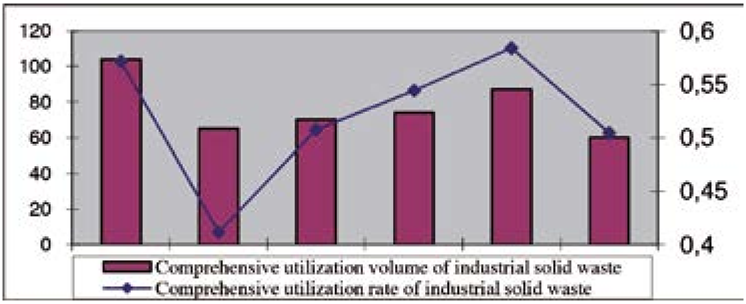
Discharge of Industrial Solid Waste from the Petroleum and Natural Gas Exploitation Sector[U9]. The yield of industrial solid waste from the petroleum and natural gas exploitation sector in China decreased from 1.82 million tons in 2001 to 1.19 million tons in 2006, its comprehensive utilization volume in this sector also decreased from 1.04 million tons in 2001 to 0.6 million tons in 2006, and its comprehensive utilization rate also decreased from 57% in 2001 to 50% in 2006 (see Table 3.10 and Figure 3.9).

Table 3.10
Discharge of industrial solid waste from petroleum and natural gas exploitation sector in China (10,000 tons)

Year	Yield of industrial solid waste	# Dangerous waste	Comprehensively utilized volume of industrial solid waste	Storage volume of industrial solid waste	Disposal volume of industrial solid waste	Discharge volume of industrial solid waste
2001	*182*	*12*	*104*	*7*	*73*	*NA*
2002	*158*	*11.77*	*65*	*31*	*60*	*2*
2003	*138*	*10.83*	*70*	*13*	*63*	*...*
2004	*136*	*17.34*	*74*	*8*	*52*	*2.1313*
2005	*149*	*19.11*	*87*	*5*	*56*	*1*
2006	*119*	*10.09*	*60*	*6*	*42.6*	*10.74*

Notes: China's Statistical Yearbooks, 2002-2007.

Figure 3.9
Comprehensive utilization volume and rate of industrial solid waste in petroleum and natural gas sector in China



Notes: The yield of industrial solid waste in China's petroleum and natural gas exploitation sector was in constant increase, as was the discharge volume of industrial solid waste. If we take the discharge volume of solid waste as the measurement index, the negative influence on the environment from this sector was increasing.

EUROPEAN UNION

3.2. The European Union Emission Trading Scheme

The European Union Emission Trading Scheme (EU ETS) is the world's largest multi-national emissions trading scheme, and is a major pillar of the EU's climate policy. "The EU ETS covers more than 11,000 power stations and manufacturing plants in the 28 EU member states as well as Iceland, Liechtenstein and Norway. Aviation operators flying within and between most of these countries are also covered. In total, around 45% of total EU emissions are limited by the EU ETS" (DG CLIMA, 2013).

Under the EU ETS, large emitters of carbon dioxide within the EU must monitor and annually report their CO_2 emissions, and they are obliged every year to surrender (give back) to the government an amount of emission allowances that is equivalent to their CO_2 emissions in that year. The installations may get the allowances free of charge from the government, or may purchase them from others (installations, traders, the government.) If an installation has received more free allowances than it needs, it may sell them to anybody. In January 2008, the European Commission proposed a number of changes to the scheme[U21], among which centralized allocation (no longer national allocation plans), auctioning a greater share (60%) of permits rather than allocating gratis, and inclusion of the greenhouse gases nitrous oxide and perfluorocarbons. Also, the proposed caps foresee an overall reduction of greenhouse gases of 21% in 2020, as compared to 2005 emissions.

Mechanism

The EU scheme is largely modeled on the mechanisms in the Marrakech Accords of the Kyoto Protocol, helped by the experience gained during the running of the voluntary UK Emissions Trading Scheme in the previous years.

Thus the governments of the EU Member States agree upon national emission caps, allocate allowances to their industrial operators, track and validate the actual emissions in accordance with the relevant assigned amount, and require the allowances to be retired after the end of each year.

The operators within the ETS may reassign or trade their allowances by several means: 1) privately, moving allowances among operators within a company and across national borders; 2) over the counter, using a broker to privately match buyers and sellers; 3) trading on the spot market of one of Europe's climate exchanges (the most liquid being the European Climate Exchange).

As with any other financial instrument, trading consists of matching buyers and sellers between members of the exchange and then settling by depositing an allowance in exchange for the agreed financial consideration. Much as with a stock market, companies and private individuals can trade through brokers who are listed on the exchange.

When each ownership change of an allowance is proposed, the national registry and the European Commission are informed in order for them to validate the transaction. During Phase II of the EU ETS the United Nations Framework Convention on Climate Change (UNFCCC) will also validate any change that alters the distribution within each national allocation plan.

Like the Kyoto trading scheme, the EU scheme allows a regulated operator to use carbon credits in the form of Emission Reduction Units (ERU) to comply with its obligations. A Kyoto Certified Emission Reduction unit (CER), produced by a carbon project that has been certified by the UNFCCC's Clean Development Mechanism Executive Board or the Joint Implementation project's host country, respectively, is accepted by the EU as equivalent.

Thus one EU Allowance Unit of one ton of CO_2, or "EUA", was designed to be identical ("fungible") to the equivalent "Assigned Amount Unit" (AAU) of CO_2 defined under Kyoto. Hence, because of the EU's decision to accept Kyoto-CERs as equivalent to EU-EAUs, it will be possible to trade EAUs and UNFCCC-validated CERs on a one-to-one basis within the same system. (However, the EU has announced that this facility would be delayed, possibly until 2009, until it could overcome its technical problems related to connecting to the UN systems.)

During Phase II of the EU ETS, the operators within each Member State must surrender their allowances for inspection by the EU before they can be "retired" by the UNFCCC.

Allocation

In order to make sure that real trading emerges (and that CO_2 emissions are reduced), EU governments must make sure that the total amount of allowances issued to installations is less than the amount that would have been emitted under a business-as-usual scenario. For each Phase, the total quantity to be allocated by each Member State is defined in the Member State National Allocation Plan (NAP) (equivalent to its UNFCCC-defined carbon account). The European Commission has oversight of the NAP process and decides if the NAP fulfills the 12 criteria set out in the Annex III of the Emission Trading Directive (EU Directive 2003/87/EC). The first and foremost criterion is that the proposed total quantity is in line with a Member State's Kyoto target. Of course, the Member State's plan can and should also take account of emission levels in other sectors not covered by the EU ETS, and address these within its own domestic policies. During Phase I, most allowances in all countries were given freely. This approach has been criticized as giving rise to windfall profits, being less efficient than auctioning, and providing too little incentive for innovative competition to provide clean, renewable energy. To address these problems, the European Commission proposed various changes in a January 2008 package, among which the abolition of NAPs from 2013 and auctioning a far greater share (40% in 2013, growing afterward) of emission permits.

Phase I

In the first phase (2005-2007), the EU ETS includes some 12,000 installations, representing approximately 40% of the EU's CO_2 emissions, and covering energy activities (combustion installations with a rated thermal input exceeding 20 MW, mineral oil refineries, coke ovens), production and processing of ferrous metals, mineral industry (cement clinker, glass and ceramic bricks) and pulp, paper and board activities.

The scheme, in which 15 Member States of the European Union participated, nominally commenced operation on January 1, 2005. In its first year, 362 million tons of CO_2 were traded on the market for a sum of €7.2 billion, and a large number of futures and options. The price of allowances increased more or less steadily to its peak level in April 2006 of about €30 per ton CO_2, but fell in May 2006 to under €10/ton on news that some countries were likely to give their industries such generous emission caps that there was no need for them to reduce emissions. Lack of scarcity under the first phase of the scheme continued through 2006, resulting in a trading price of €1.2 a ton in March 2007, and declining to €0.10 in September 2007.Consequently, observers and NGO's have accused national governments of abusing the system under industry pressure, and have urged for far stricter caps in the second phase (2008-2012).

Phase II

The second phase (2008-12) expands the scope significantly: 1) Clean Development Mechanism (CDM)[3] and Joint Implementation (JI) credits were expected to be introduced in the second phase through the EU's "Linking Directive"; 2) Aviation emissions were included from 2012; 3) Three non-EU members (Norway, Iceland and Liechtenstein) joined the scheme.

The inclusion of aviation is a move considered important because of the large and rapidly growing emissions of the sector. The inclusion of aviation is estimated to lead to an increase in allowance demand of about 10-12 million tons of CO_2 per year in phase two. This in turn is expected to lead to an increased use of JI credits from projects in Russia and the Ukraine, which would offset the increase in prices and eventually result in no discernible impact on average annual CO_2 prices.

The National Allocation Plans for Phase II, the first of which were announced on November 29, 2006, will result in an average cut of nearly 7% below the 2005 emission levels. The European Commission has started infringement proceedings against Austria, the Czech Republic, Denmark, Hungary, Italy and Spain, for failure to submit their proposed National Allocation Plans on time.[U22]

Overall Emission Reductions

The environmental effectiveness of the scheme rests on the tightness of the caps. Phase I was widely believed to be over allocated, implying that little, if any, additional overall emission reductions have been achieved.

Phase I. In 2004, Ecofys analysed the then available preliminary NAPs of all EU countries. The information suggested that the caps for Phase I were lenient; in most countries, the power sector would not need to reduce CO_2 emissions as much as the country as a whole; in other words, the other sectors must make more ambitious emission reductions than the power sector under the scheme. More strikingly, a few countries (such as the Netherlands) gave more allowances than Ecofys estimated to be needed under a business-as-usual scenario, implying that no 'real' efforts to reduce emissions would be required. In May 2006, when several countries revealed registries indicating that their industries had been allocated more allowances than they could use, trading prices crashed from about €30/ton to €10/ton, and have (after an initial slight recovery) declined further to €4 in January 2007 and below €1 in February 2007, reaching an all time low of €0.03 at the beginning of December 2007.

Phase II. In 2006, Ecofys performed an initial assessment of NAPs for phase II, using the proposed but not-yet-approved NAPs. They found that most Member States did not have sufficiently strict caps, and that they would be insufficient in assisting the members in meeting their Kyoto targets. They also compared caps with official business-as-usual (BAU) projections and with independent BAU projections to assess stringency of caps. They concluded that the caps were 7% under official BAU but (except for Portugal, Spain, and UK) the proposed cap was "higher" than the independently estimated BAU, suggesting over allocation.

Partly in response to this, the Commission cut eleven of the first twelve Phase II plans it reviewed (accepting only the U.K.'s plan without revision). The commission tightened the caps some 7%,which corresponds to 7% below the 2005 emissions.[U23]

The Inclusion of Sinks

Currently, the EU does not allow CO_2 credits under ETS to be obtained from sinks (e.g. reducing CO_2 by planting trees). However, some governments and industry representatives lobby for their inclusion, which is currently opposed by NGO's as well as by the EU Commission itself, who argue that sinks are surrounded by too many scientific uncertainties over their permanence and that they constitute an inferior long-term contribution to climate change, as compared to reducing emissions from industrial sources.

3.3. Other European Environmental Directives

Large Combustion Plant Directive (LCPD)[U24]

The revised Large Combustion Plant Directive (LCPD, 2001/80/EC) aimedat reducing acidification, ground level ozone and particles throughout Europe by controlling emissions of sulphur dioxide (SO_2), nitrogen oxides (NOx) and dust (particulate matter (PM)) from large combustion plants (LCPs) in power stations, petroleum refineries, steelworks and other industrial processes running on solid, liquid or gaseous fuel. It was applied to combustion plants with a thermal output of greater than 50 MW.

The revised LCPD took into account advances in combustion and abatement technologies. New combustion plants had to meet the emission limit values (ELVs) given in the LCPD. For "existing" plants (i.e. those in operation before 1987), Member States could choose to meet the obligations by either: 1) complying with ELVs for NOx, SO_2, and particles; 2) operating within a "National Plan".

This would set an annual national emission level calculated by applying the ELV approach to existing plants, on the basis of those plants' average actual operating hours, fuel used and thermal input, over the 5 years up to 2000.

Annex VIII (B) of the Large Combustion Plants Directive required Member States to establish, starting in 2004 and for each subsequent year, an inventory of SO_2, NOx and dust emissions for all combustion plants with a rated thermal input of 50MW or more.

Article 4(4) of the LCPD provided for operators of existing plants to be exempted from compliance with ELVs or a NERP if they made a written declaration by June 30, 2004 to the competent authority not to operate the plant for more than 20,000 operational hours starting from January 1, 2008 and ending no later than December 31, 2015.

The Directive on Integrated Pollution Prevention and Control (IPPC)

The Integrated Pollution Prevention and Control Directive (IPPC, 96/61/EC) provides an integrated approach to establishing pollution prevention from stationary "installations", as listed in the Directive, which gives a wide range of polluting activities included.

The objective is outlined in Article 1 as achieving a high level of protection of the environment through measures to prevent or, where that is not practicable, to reduce emissions to air, water and land from activities listed in Annex I. Member States must put into place a system requiring operators of certain industrial installations to prevent or reduce pollution from their operation.

The operator has to apply to the regulatory authority for a permit before operations can commence, and must demonstrate that they will use "best available techniques" (BAT) to prevent or reduce pollution.

There is a requirement to consult other Member States where the operation of an installation is likely to have significant negative effects on the environment of another Member State.

On December 21, 2007 the Commission adopted a Proposal for a Directive on industrial emissions[U25]. The Proposal recasts seven existing Directives related to industrial emissions into a single clear and coherent legislative instrument. The recast includes in particular the IPPC Directive.

The IPPC Directive has been in place for over 10 years and the Commission has undertaken a 2-year review with all stakeholders to examine how it and the related legislation on industrial emissions can be improved to offer the highest level of protection for the environment and human health, while simplifying the existing legislation and cutting unnecessary administrative costs. The results of this review have provided clear evidence of the need for actions to be taken at a Community level.

UPDATES

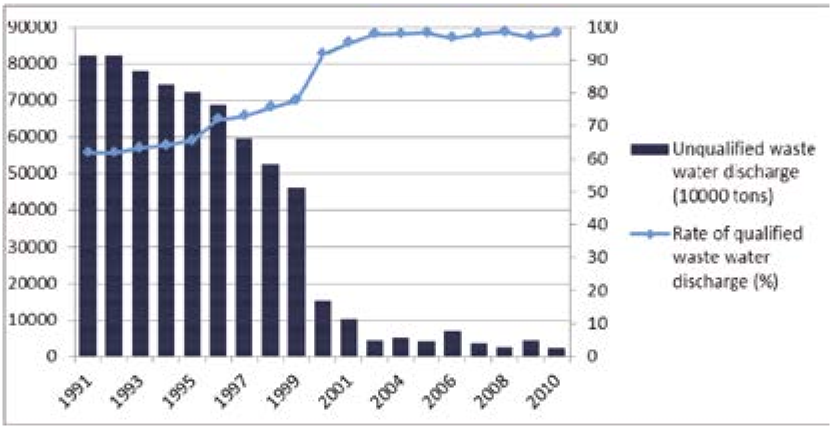
U1. In 2006 fluegas (soot) emissions started decreasing, reaching 8.291 million tons in 2010 (MEP, 2013a). The discharge of SO_2 dropped to 21.851 million tons in 2010 and 20.439 million tons in 2013 (see the indicator Main Pollutant Emission in Waste Gas at NBS (n.d.)).

U2. According to the Report on the State of the Environment in China 2010 (MEP, 2013a), COD discharge started decreasing in 2007, reaching 12.381 million tons in 2010, an 11% decrease from 14.282 million tons in 2006. Since 2011 SOE statistics for major pollutants take into consideration industrial sources, domestic sources, agricultural sources and collective pollution control facilities, while until 2010 they only included industrial sources and domestic sources. Therefore, in order to compare values from 2011 onward, relevant adjustment has been made for the 2010 data involved in 2011 SOE, which states that in 2011 the COD discharge was 24.999 million tons, 2.04% lower than that of the previous year (MEP, 2013b). Between 2012 and 2013, the COD discharge decreased by 2.9%, reaching 23.527 million tons.

U3. Table 3.2 and Figure 3.1 can be updated with data from the section Resources and Environment - Discharge and Treatment of Waste Water by Sector of China's Statistical Yearbooks 2008-2011.

Year	Number of enterprises	Amount of discharge*	Amount of qualified discharge*	Rate of qualified discharge of waste water (%)
2006	*2648*	*217145*	*210066*	*96,74*
2007	*3373*	*174796*	*171209*	*97,95*
2008	*3689*	*181627*	*178960*	*98,53*
2009	*4132*	*149010*	*144573*	*97,02*
2010	*4132*	*129624*	*127132*	*98,08*

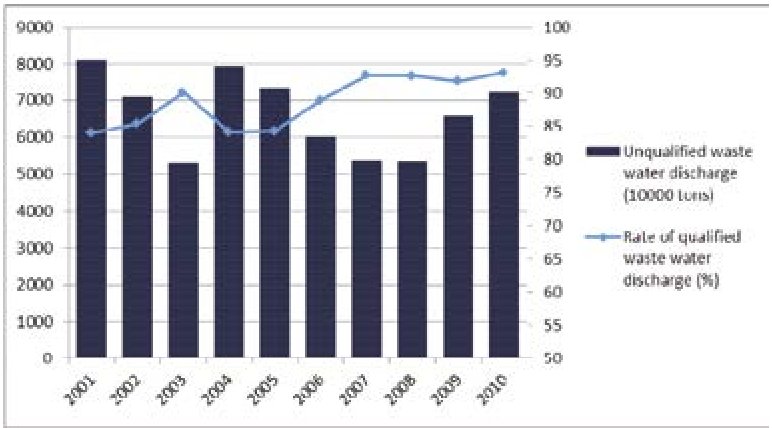
* 10000 tons



U4. Table 3.3 and Figure 3.2 can be updated with data from the section Resources and Environment - Discharge and Treatment of Waste Water by Sector of China's Statistical Yearbooks 2008-2011.

Year	Number of enterprises	Amount of discharge*	Amount of qualified discharge*	Rate of qualified discharge of waste water (%)
2006	*3108*	*54023*	*48015*	*88,88*
2007	*3610*	*73040*	*67680*	*92,66*
2008	*4103*	*72209*	*66868*	*92,60*
2009	*4261*	*80236*	*73665*	*91,81*
2010	*4623*	*104765*	*97542*	*93,11*

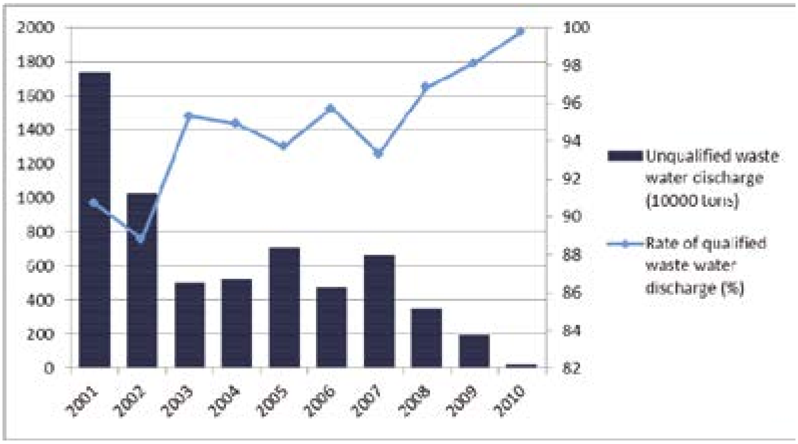
* 10000 tons



U5. Table 3.4 and Figure 3.3 can be updated with data from the section Resources and Environment - Discharge and Treatment of Waste Water by Sector of China's Statistical Yearbooks 2008-2011.

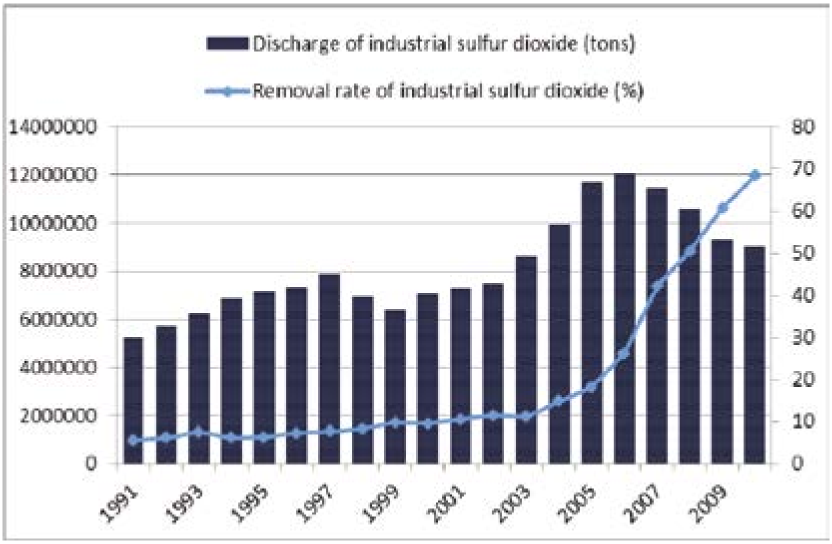
Year	Number of enterprises	Amount of discharge*	Amount of qualified discharge*	Rate of qualified discharge of waste water (%)
2006	*205*	*11177*	*10700*	*95,73*
2007	*224*	*9988*	*9321*	*93,32*
2008	*227*	*11209*	*10856*	*96,85*
2009	*233*	*10197*	*10005*	*98,12*
2010	*228*	*11555*	*11530*	*99,78*

* 10000 tons



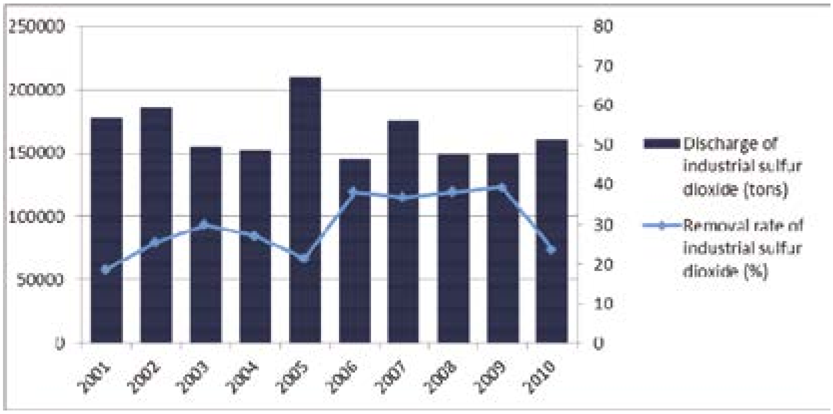
U6. Table 3.5 and Figure 3.4 can be updated with data from the section Resources and Environment - Emission and Treatment of Waste Gas by

Year	**Amount of industrial sulfur dioxide discharge (tons)**	**Removal volume of industrial sulfur dioxide (tons)**	**Amount of industrial smoke dust discharge (tons)**	**Removal volume of industrial smoke dust (tons)**	**Amount of industrial powder dust discharge (tons)**	**Removal amount of industrial powder dust (tons)**
2006	*12041000*	*4275000*	*3467000*	*190477000*	*14000*	*26000*
2007	*11471200*	*8382900*	*2973900*	*213047400*	*11900*	*28900*
2008	*10599400*	*10782200*	*2503600*	*254953600*	*6100*	*13700*
2009	*9329900*	*14379000*	*2221500*	*276655600*	*6700*	*17100*
2010	*8997900*	*19417400*	*1989500*	*316321500*	*6200*	*4700*



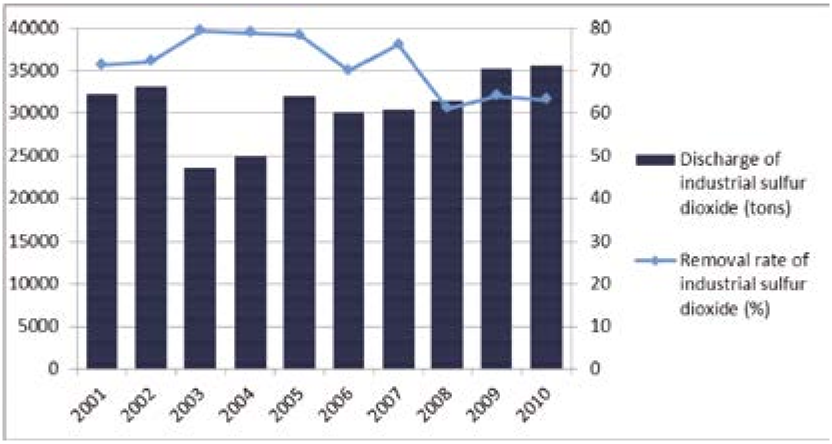
U7. Table 3.6 and Figure 3.5 can be updated with data from section Resources and Environment - Emission and Treatment of Waste Gas by Sector of China's Statistical Yearbooks 2008-2011.

Year	**Amount of industrial sulfur dioxide discharge (tons)**	**Removal volume of industrial sulfur dioxide (tons)**	**Amount of industrial smoke dust discharge (tons)**	**Removal volume of industrial smoke dust (tons)**	**Amount of industrial powder dust discharge (tons)**	**Removal amount of industrial powder dust (tons)**
2006	*145000*	*89000*	*122000*	*923000*	*176000*	*79000*
2007	*175300*	*102200*	*92000*	*1849400*	*139100*	*175900*
2008	*148700*	*91600*	*99900*	*1854800*	*136600*	*168700*
2009	*149900*	*97300*	*98300*	*1711800*	*187800*	*162200*
2010	*160300*	*49600*	*116200*	*1186500*	*149100*	*161700*



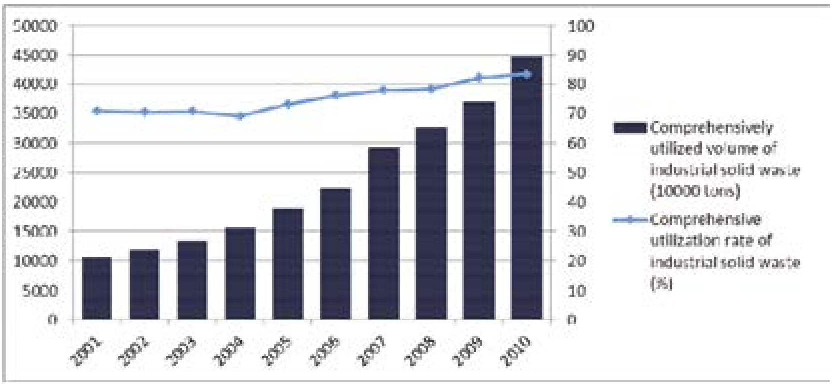
U8. Table 3.7 and Figure 3.6 can be updated with data from the section Resources and Environment - Emission and Treatment of Waste Gas by Sector of China's Statistical Yearbooks 2008-2011.

Year	**Amount of industrial sulfur dioxide discharge (tons)**	**Removal volume of industrial sulfur dioxide (tons)**	**Amount of industrial smoke dust discharge (tons)**	**Removal volume of industrial smoke dust (tons)**	**Amount of industrial powder dust discharge (tons)**	**Removal amount of industrial powder dust (tons)**
2006	*30000*	*70000*	*10000*	*99000*	*3000*	*4000*
2007	*30400*	*96700*	*10300*	*32100*	*3000*	*5600*
2008	*31400*	*49200*	*11400*	*47800*		
2009	*35300*	*62600*	*11100*	*46700*		
2010	*35600*	*60900*	*12800*	*83500*		



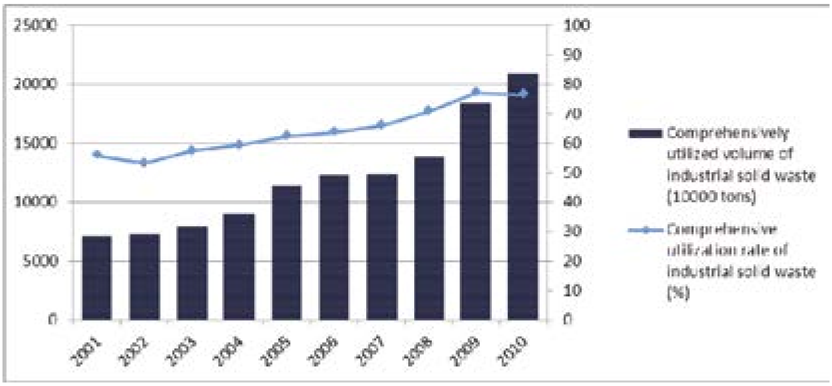
U9. Table 3.8 and Figure 3.7 can be updated with data from the section Resources and Environment - Production, Treatment and Utilization of Industrial Solid Wastes by Sector of China's Statistical Yearbooks 2008-2011.

Year	Yield of industrial solid waste (10000 tons)	# Dangerous waste	Comprehensively utilized volume of industrial solid waste (10000 tons)	Storage volume of industrial solid waste	Disposal volume of industrial solid waste	Discharge volume of industrial solid waste
2006	*29135,0*	*21,23*	*22153,0*	*5229,0*	*2905,0*	*54,78*
2007	*37585,5*	*21,60*	*29211,8*	*4987,2*	*4302,6*	*71,66*
2008	*41726,0*	*51,96*	*32590,0*	*5004,0*	*4802,0*	*95,00*
2009	*45131,2*	*15,67*	*36963,8*	*4975,6*	*3798,0*	*45,17*
2010	*53823,1*	*16,79*	*44819,5*	*5493,6*	*4040,3*	*44,86*



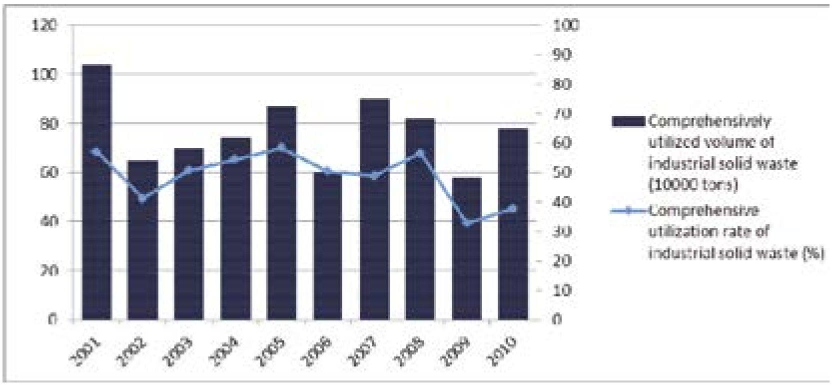
U10. Table 3.9 and Figure 3.8 can be updated with data from the section Resources and Environment - Production, Treatment and Utilization of Industrial Solid Wastes by Sector of China's Statistical Yearbooks 2008-2011.

Year	**Yield of industrial solid waste (10000 tons)**	**# Dangerous waste**	**Comprehensively utilized volume of industrial solid waste (10000 tons)**	**Storage volume of industrial solid waste**	**Disposal volume of industrial solid waste**	**Discharge volume of industrial solid waste**
2006	*19352,0*	*18,29*	*12337,0*	*1886,0*	*5700,0*	*374,15*
2007	*18751,6*	*1,56*	*12386,2*	*1266,8*	*5449,1*	*361,75*
2008	*19571,0*	*1,08*	*13880,0*	*1234,0*	*5127,0*	*247,00*
2009	*23868,6*	*0,06*	*18409,9*	*1490,3*	*5069,7*	*261,35*
2010	*27316,1*	*0,01*	*20906,1*	*1627,0*	*5327,0*	*187,73*



U11. Table 3.10 and Figure 3.9 can be updated with data from the section Resources and Environment - Production, Treatment and Utilization of Industrial Solid Wastes by Sector of China's Statistical Yearbooks 2008-2011.

Year	**Yield of industrial solid waste (10000 tons)**	**# Dangerous waste**	**Comprehensively utilized volume of industrial solid waste (10000 tons)**	**Storage volume of industrial solid waste**	**Disposal volume of industrial solid waste**	**Discharge volume of industrial solid waste**
2006	*119*	*10,09*	*60*	*6*	*42,6*	*10,74*
2007	*184,2*	*11,16*	*89,9*	*6,5*	*90,4*	*0,08*
2008	*145*	*9,19*	*82*	*6*	*58*	
2009	*175,5*	*12,31*	*57,6*	*11,2*	*106,7*	*0,03*
2010	*206,6*	*17,5*	*78*	*6,7*	*122,7*	*0,04*



U12. The changes approved in 2009 established that, whereas the vast majority of emission allowances was previously given away gratis by governments, since 2013 auctioning has been the main method of allocating allowances. This means that businesses have to buy an increasing proportion of their allowances at auction (40% in 2013). The EU legislation sets the goal of phasing out free allocation completely by 2027 (DG CLIMA, 2013).

U13. *Phase III*

"Work on implementation has led to the successful start of phase 3 under the EU ETS (period 2013-2020). In terms of scope, the ETS now covers, in addition to CO_2 from most industrial installations, nitrous oxide (N20) from the production of nitric and other acids, and PFCs from the production of aluminium.

The EU ETS phase 3 no longer provides an individual cap for every Member State, but a single cap for the EU, Iceland, Liechtenstein and Norway. As of 2013, around 43% (excluding NER 30022) of the emission allowances were auctioned, and this share is expected to increase over time.

Since 2009, a growing surplus of allowances and international credits has been available on the carbon market, leading to a fall of the carbon price. To address this imbalance, the Commission proposed postponing ('back-loading') the auctioning of 900 million allowances from the early years of phase 3 of the EU ETS till the end of the trading period. The 'back-loading' was adopted by amending the Auctioning Regulation on February 25, 2014.

On January 22, 2014 the Commission furthermore adopted a legislative proposal to establish a market stability reserve at the beginning of the fourth trading period in 2021. The proposed reserve will complement the existing rules. Allowances are placed in the market stability reserve – i.e. deducted from future auction volumes – according to the "total number of allowances in circulation". The flow of allowances into and out of the reserve would occur on the basis of an automatic, fully rule-based process.

In the aviation sector, the International Civil Aviation Organization (ICAO) Assembly agreed in the autumn of 2013 to adopt a definitive agenda leading to a global agreement to tackle aviation emissions. Pending the possible adoption of international rules, the Council and the European Parliament limited in March 2014 the coverage of the EU ETS to flights within the European Economic Area for the 2013-2016period [COM(2014)689 final].

U14. *Phase III*

"Emissions of greenhouse gases from installations participating in the EU ETS are estimated to have decreased by at least 3% in 2013" (EC, n.d. c).

"The 2013 cap for emissions from power stations and other fixed installations in the 28 EU Member States and the three EEA-EFTA states was set at 2,084,301,856 allowances.

During phase 3 of the EU ETS (2013-2020), this cap decreases each year by 1.74% of the average total quantity of allowances issued annually in 2008-2012. In absolute terms this means the number of general allowances will be reduced annually by 38,264,246.

Thanks to the decreasing cap, in 2020 emissions from fixed installations will be 21% lower than in 2005.

The annual reduction in the cap will continue beyond 2020. To achieve the target of a 40% reduction in EU greenhouse gas emissions below 1990 levels by 2030, set out in the 2030 framework for climate and energy policy, the cap will need to be lowered by 2.2% per year from 2021, as compared with the current 1.74%. This would reduce emissions from fixed installations to around 43% below 2005 levels by 2030."

"Unlike the cap for fixed installations, the aviation sector cap remains the same in each year of the 2013-2020 trading period.

The cap has been provisionally set at 210,349,264 aviation allowances per year, which is 5% below the average annual level of aviation emissions in the 2004-2006 base period. The cap will be adjusted to include additional aviation activities arising from Croatia's full integration into the aviation part of the EU ETS on 1 January 2014" (EC, n.d. b).

U15. Repealed by Directive 2010/75/EU.

U16. The new Directive was 2008/1/EC, later replaced by Directive 2010/75/EU.

NOTES

1. Source: REEP (2007) and European Commission official EU ETS website (EC, n.d. c).
2. The UK Emissions Trading Scheme was a voluntary emissions trading system created as a pilot prior to the mandatory European Union Emissions Trading Scheme. It ran from 2002 and closed in 2006. At the time, the scheme was a novel economic approach, as the first multi-industry carbon trading system in the world.
3. The Clean Development Mechanism is an arrangement under the Kyoto Protocol, allowing industrialised countries with a greenhouse gas reduction commitment (called Annex 1 countries) to invest in projects that reduce emissions in developing countries as an alternative to more expensive emission reductions in their own countries.
4. The Joint implementation is one of three flexibility mechanisms set forth in the Kyoto Protocol to help countries with binding greenhouse gas emission targets (so-called Annex I countries) meet their obligations. Any Annex I country can invest in emission reduction projects (referred to as "Joint Implementation Projects") in any other Annex I country as an alternative to reducing emissions domestically. In this way countries can lower the costs of complying with their Kyoto targets by investing in greenhouse gas reductions in an Annex I country where reductions are cheaper, and then applying the credit for those reductions towards their commitment goal. The JI, unlike the CDM, takes place in countries which have an emission reduction requirement.

PART II

Comparative Case Studies

4. Methodological Aspects

CHINA

4.1. Energy Policy Assessment and Methods

Energy Policy Evaluation

Energy policy evaluation, centred on value, assesses the usefulness or value of energy policies/plans. Evaluation demands rely not only on "values" but also on "facts"; evaluation should not only collect information about operational results of energy policies, but also evaluate goals and objectives. Evaluation demands should be based on present and historical consequences rather than future conditions.

There are two definitions of public policy evaluation. First, positivism, as advocated by Harold Lasswell (1998), etc. They strictly separate facts from values, try to avoid policy issue conflicts between the goals and values of parties, tend to adopt technical analyses of facts, and advocate identifying correspondences between policy targets and policy results, consequently determining the actual policy effects. Second, post-positivism, as advocated by John Rawls (2004), William Dunn (2002), etc. They emphasize the combination of facts and values-first of all, understanding issues about values, legitimacy, fairness and sociality; then evaluating policy effectiveness. As positivism emphasizes value orientation, which separates facts from values, it may easily lead to misunderstanding and distortion of the real world, and for this reason is widely criticized.

Models and Methods for Energy Policy Evaluation

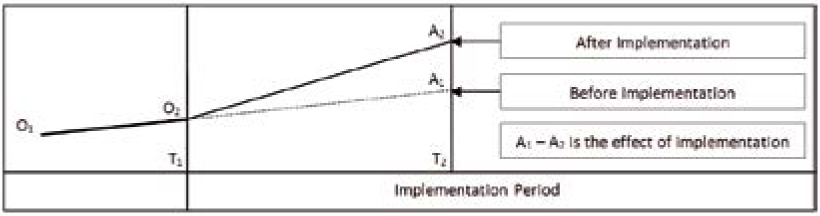
Energy Economic Models. Energy economic models, if we take economic models as a starting point, show marked relationships with energy consumption and production, and links between the economy, energy and environment sectors in the overall framework of the macro-economy, enabling analyses of changes in energy consumption and environmental emissions under different policies, and the definition of policy methods and approaches that can realize a harmonious development of energy, the economy and the environment. They are also called "top-down models". Energy economic models can better reflect interactions at the macro level. They are more closely attuned to interconnections between economic sectors, and are able to reflect trade and feedback relationships between different economic sectors under different market conditions. However, these models are based on abstract descriptions of energy technologies and lack sufficient details, i.e. advanced technological factors, costs of alternative technologies, technology-related resources and environmental constraint costs cannot be reflected in these models.

Energy Technical Models. Energy technical models, based on technology processes adopted by human activities that reflect energy consumption and production, predict energy consumption and production modes in order to evaluate the influence of different policies on energy technology selection and environmental emissions, and consequently seek policies, technological methods and means for realizing a harmonious development of energy, the economy and the environment. They are also called "bottom-up models". Energy technical models have the great advantage of reflecting on technical details: subject to data availability, information on economic efficiency, utilization efficiency and environmental emission levels can be fed into these models to fully reflect the structure of production and the technical type of each sector of production. However, these models lack and overlook feedback relations in the economic system. Some important factors, such as the sectors' output volume and energy prices, are exogenous to those models.

Methods of Energy Policy Evaluation. Methods of energy policy evaluation mainly include before-after comparison analysis, cost-benefit analysis, and qualitative analysis.

Before-After Comparison Analysis. The main steps of before-after comparison analysis evaluation are as follows. Employ the simple "projection-implementation" comparison analysis to project the tendency line before the implementation of energy policy to some point after the implementation of energy policy, then compare the projection with actual conditions after the implementation to determine the effect of the energy policy. In the diagram below, O1O2 is the tendency line established according to various conditions before the implementation of the energy policy; A1 is the projection of O1O2 at a certain point T2 after the policy implementation in T1 by extrapolating the tendency line; A2 is the actual condition after the implementation; (A1-A2) is the effect of the energy policy. By projection, this method can filter the influence of some non-policy factors.

Figure 4.1
"Projection-implementation" scheme of a given energy policy



Cost-Benefit Analysis. Cost-benefit analysis is based on the accurate definition of total costs and total benefits, expressed in monetary units, and associated with the implementation of a given energy policy.

Costs involved in implementing an energy policy may include government expenditure, supervision cost, etc. Therefore, the total costs associated with a specific energy policy can be formulated as follows:

$$TC = \sum_{i=1}^{n} C_i$$

where C_1 refers to the i-th cost to be held in order to implement the energy policy, while TC indicates total costs.

Benefits by implementing the energy policy include reduction of energy expenditure, improvement of residents' living standard, etc. Therefore, benefits of the energy policy can be formulated as follows:

$$TB = \sum_{j=1}^{m} B_j$$

where B_1 refers to the j-th benefit achieved by implementing the energy policy, while TB indicates total benefits achieved by implementing the energy policy.

If the benefit-cost ratio:

$$\beta = TB / TC$$

is larger than1, the energy policy is profitable to improving social welfare; otherwise it is profitless.

In general, cost-benefit analysis requires calculating direct costs and indirect costs during the process of policy formulation and implementation, which to some extent is difficult for energy policy.

4.2. Qualitative Assessment of Energy Policies

We choose energy policies for evaluation according to the core objectives of China's energy policy. The scope of China's energy policy is to increase domestic supply, save energy, reduce dependence on imports, and use clean energy on a large scale. The main objectives of China's energy policy are security, efficiency, environmental protection and universality. It is then natural to concentrate on those aspects in order to evaluate China's energy policies

4.3. Cost-Benefit Analysis

Different energy policies have different types of costs and benefits. Chinese energy policies can be categorized into four types according to their target orientations:

Type I: policies to promote energy conservation and improve energy efficiency, abbreviated as energy efficiency policies. The direct benefit of energy efficiency policies is that energy consumption per unit output is reduced, and its indirect benefit includes improvement of environmental quality and energy security. Costs of energy-saving policies are different when different measures are adopted. There are three measures promoting energy conservation: (1) enhancing energy efficiency through improving management; (2) enhancing energy efficiency through adjusting structure; (3) enhancing energy efficiency through technical progress. The first approach will raise management cost, the second will result in structural unemployment and social instability, and the third requires businesses and the society at large to increase input in energy efficient technologies and equipment.

Type II: policies to enlarge the energy base. Such policies include two sub-types, one to discover recoverable non-renewable energy, and the other to develop renewable energy. The cost of the former is to increase investment in exploration, and its benefit is to enhance security and help to stabilize prices. The latter has benefits similar to those of the former, but it also helps to increase employment or increase the income of stakeholders. The cost of the latter mainly consists of increasing input in R&D.

Type III: energy security policies, among which increasing petroleum reserves and implementing diversified import channels. The benefit of such policies is that they can ensure stable energy prices and supply, but investment cost and diplomatic cost are increased.

Type IV: environmental policies. The direct benefit of such policies is that environmental quality is improved, and their cost is increase in investments.

Type V: universal service policies. Such policies are good for promoting social fairness and social stability, but they demand more governmental investments or subsidies.

Different energy policies produce different benefits and costs. Based on a comparison of costs and benefits, there are three categories of energy policies: (1) benefits that outweigh costs, (2) costs that outweigh benefits, and (3) benefits that are equal to costs. If we subdivide them according to the categories of benefits, energy policies can be further broken down into various sub-types.

As for economic, social and environmental dimensions, the costs and benefits of energy policies can be classified into three types: (1) economic costs and benefits, (2) social costs and benefits, and (3) environmental costs and benefits. Measured via direct and indirect impacts, the costs of energy policies can be divided into direct costs and indirect costs, as do the benefits. In addition, energy policies can also be further classified based on different cost types. Those with benefits greater than costs can be categorized into policies with net economic benefits greater than social and environmental costs, policies with net social and environmental benefits greater than net economic costs; those with costs greater than benefits can be divided into policies with net economic benefits smaller than net social and environmental costs, and policies with net social and environmental benefits smaller than net economic costs.

The degrees of difficulty and the modes of policy execution not only depend on the relationship between total costs and total benefits, but also rely on the types of costs and benefits. Those policies with net economic benefits that outweigh net social and environmental costs are easier to implement, while those policies with net social and environmental benefits that outweigh net economic costs are more difficult to execute, although their total benefits are greater than total costs. In addition, it is not enough just to consider total costs and total benefits when making and executing policies; the structure of costs and benefits must also be taken into consideration in planning implementation.

We have selected 34 energy policies from 500 specific energy policies, among which 6 energy security policies (17.65%), 10 energy conservation policies (29.41%), 11 environmental policies (32.35%) and 7 universal energy service policies (20.59%). The evaluation of each group of policies is presented in the following chapters.

Comments

The comprehensive evaluation on China's energy policy is summarized in Table 4.1. The comprehensive benefit/cost ratio is 1.27; composite benefits of implementation of various energy policies are 27% higher than composite costs. Among various energy policies, universal energy service policies have the highest benefit/cost ratio (i.e. 1.42); followed by environmental policies and energy conservation policies, with a benefit/cost ratio of 1.28 and 1.23, respectively; the last is energy security policies, with a benefit/cost ratio of 1.16.

Table 4.1.
Comprehensive cost-benefit analysis of China's energy policies

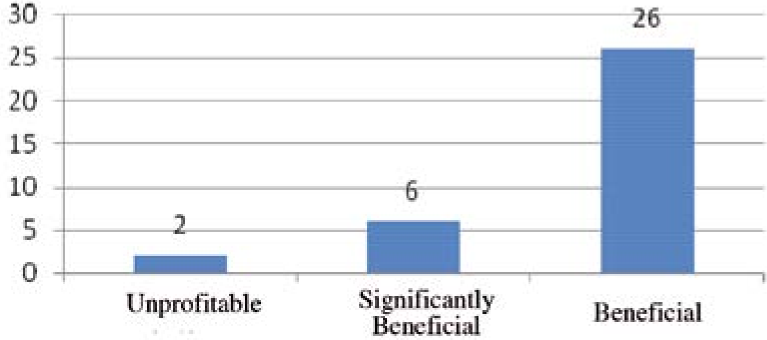
Comprehensive Evaluation	**Policy Benefits**	**Policy Costs**	**β=Benefit/ Cost**	**Benefit-cost**	**Policy Evaluation**
Comprehensive Evaluation on Energy Security Policies	*72.59*	*62.59*	*1.16*	*10*	*High Benefit*
Comprehensive Evaluation on Energy Efficiency Policies	*78.95*	*63.98*	*1.23*	*14.97*	*High Benefit*
Comprehensive Evaluation on Environmental Policies	*80.30*	*62.54*	*1.28*	*17.76*	*High Benefit*
Comprehensive Evaluation on Universal energy service Policies	*84.66*	*59.79*	*1.42*	*24.87*	*High Benefit*
Comprehensive Evaluation	*79.13*	*62.23*	*1.27*	*16.9*	

Among the 34 energy policies evaluated, unprofitable policies account for 5.88%, highly beneficial policies account for 76.47%, and significantly beneficial policies account for 17.65% (see Figure 4.2).

Figure 4.2.
Overall evaluation of China's energy policies

Policies Evaluation	**Policy Number**	**Proportion percent**
Unprofitable	*2*	*5.88*
Significantly Beneficial	*6*	*17.65*
Beneficial	*26*	*76.47*
Total	*34*	

Figure 4.2
(continued)



Policies with benefit-cost ratio above 1.5, namely with benefits 50% higher than costs of policy implementation, include "Same Quality and Same Price of Electricity for Rural and Urban Areas" and "Developing Small Hydropower Stations" among rural energy supply policies, "Power Rate Protection of Clean Energy Generating Industry" and "Commercial Fuel Cleaning" among clean energy policies, "Set Up the Large Thermal Power Generating Units and Shut Down the Small Thermal Power Generating Units" and "Coal Compensation Fund" among industrial energy conservation policies, environmental education policy and "Limit Commercial Electricity Price" policy (see Table 4.2). On the contrary, "Postpone Imposition of Fuel Duty" policy and "Encouraging Foreign Investment to Enter Energy Exploration Sector" policy have resulted in a low benefit-cost ratio, namely, the costs of policy implementation are higher than the benefits.

Table 4.2
China's energy policies with benefit/cost ratio larger than one

Energy Security Policies	Specific Policies	Policy Benefits	Policy Costs	Benefit/Cost	Policy Evaluation
Rural Energy Supply	*Same Quality and Same Price of Electricity for Rural and Urban Areas*	*100*	*44.44*	*2.25*	*Significant Effect*
Rural Energy Supply	*Developing Small Hydropower Stations*	*88.89*	*48.15*	*1.85*	*Significant Effect*

Table 4.2
(continued)

Energy Security Policies	Specific Policies	Policy Benefits	Policy Costs	Benefit/Cost	Policy Evaluation
Clean Energy	*Power Rate Protection of Clean Energy Generating Industry*	*85.19*	*47.22*	*1.8*	*Significant Effect*
Environmental Education	*Environmental Education*	*77.78*	*44.44*	*1.75*	*Significant Effect*
Clean Energy	*Commercial Fuel Cleaning*	*86.11*	*51.85*	*1.66*	*Significant Effect*
Industrial Energy Conservation	*Set up Large Thermal Power Generating Units & Shut down Small Thermal Power Generating Units*	*100*	*61.11*	*1.64*	*Significant Effect*
Stabilize Energy Price	*Coal Compensation Fund*	*66.67*	*44.44*	*1.5*	*Effective*
	Limit Commercial Electricity Price	*88.89*	*59.26*	*1.5*	*Effective*

EUROPEAN UNION

4.4. Methodology for Analyzing Energy Security Policies

The cost-benefit analysis of any measure aimed at improving energy security in a given nation is not a straightforward exercise. On the cost side, one needs to evaluate the specific costs of a given policy which, depending on the specific policy under scrutiny, may be more or less transparent. The benefits, on the other hand, require an assessment of the advantage for the society of avoiding or mitigating the impacts of typical supply disruptions.

There are two sources of complication there. First, a supply disruption is an uncertain event; hence its impacts can be evaluated only in expected terms, provided that a probability distribution for supply disruptions can be estimated.

Second, the benefits from an avoided supply disruption, particularly in the case of oil, amount to a whole range of avoided negative macroeconomic effects, precisely because oil is such a widespread commodity and a vital factor for many a sector. These benefits can only be assessed trough a macroeconomic model.

Designing a specific macroeconomic model to assess the impacts of energy disruptions and/or of the measures to curb them is a complex exercise that goes beyond the scope of this project.

The literature has been prolific on the cost side. Arnold et al (2008) point out that

> a number of general equilibrium macro-economic models have been developed to simulate the impact of energy price increases and/or supply disruptions on the macro-economy, and these have largely focused on the impacts of oil supply shocks that last for a year or more.

The outputs of such models are helpful in isolating these impacts from other macro-economic trends – something that a reliance on untreated observational data is unable to do. This section therefore briefly reviews the outputs of a number of these models in terms of their EU-wide macroeconomic costs of energy price rises. Hunt and Markandya (2004) reviewed the published results produced by these models up to 2004, shown in Table 4.3.

Roeger (2005) used the DSGE model to estimate the effects of a 50% oil price rise on the euro area macro-economy. The paper does not give the baseline price. After a year, GDP is 0.5% lower than the baseline case, and falls further to 0.6% after 2 years and 0.9% after 5 years. Other studies that have presented results of this kind include the World Bank's (2005).

The summary results do not reflect the complexity of the models and the variety of their outputs for world regions. Nevertheless, despite model differences there is some consistency in the pattern and extent of GDP changes. The models show that even when the oil price increase is assumed to be permanent, GDP impacts are likely to be greatest in the first four years of the price increase, and decline subsequently, suggesting that economic agents adapt to the new price level so that factor and product markets move to new equilibriums over this time period.

There is also a degree of consistency in the scale of annual GDP losses associated with specific oil price increases. Thus for the industrialised countries a $10 price increase per barrel gives rise to a 0.5% loss of GDP (EC, 2002) or a proportionate linear scaling of that, on average (IMF, 2000). For the Euro Zone countries there is a similar consistency in the results, though here it appears that GDP is more sensitive to oil price increases than it is for industrialised countries as a whole. For Euro Zone countries, as presented in Table 4.4, a 50% increase in oil prices results in a 0.4% decline in annual GDP for the first year, simply by taking the arithmetic mean of these results, with a range of 0.1% to 0.8%.

Table 4.3
Macroeconomic cost estimates of oil price increases

Source	Driver	Estimate	Units	Country / Region
EC 2002	*Sustained $10 increase in price of crude oil (per barrel)*	*- 0.5%*	*GDP growth rate*	*Industrialised countries*
IEA 2004	*Sustained increase $25-$35 i.e. $10 per barrel crude oil*	*- 0.5%*	*GDP growth rate*	*Euro Zone*
		0.5%	*Inflation*	*Euro Zone*
IMF 2000	*Sustained increase of $5 per barrel of crude oil (20% increase)*	*- 0.25% (over first four years, then fades to negligible)*	*GDP growth rate*	*World*
		- 0.4% (%age deviation from baseline after one year)	*GDP growth rate*	*Euro Area*
		0.5% (percentage deviation from baseline after one year)	*Inflation*	*Euro Area*
		- 7.8 ($ billion)	*Trade balance*	*Euro Area*
IMF 2004	*Sustained increase of $5 per barrel of crude oil (20% increase)*	*- 0.4% (after one year)*	*GDP growth rate*	*Euro Zone*
Jones et al 2002	*Price change exceeding a three year high*	*- 0.05 to – 0.06*	*Elasticity GDP to oil price shocks*	*USA*
Sauter and Awerbuch 2003	*Sustained 10% rise in oil price*	*- 1.5% (for 3-6 months)*	*GDP growth rate*	*Euro Zone*
		- EURO 35 to 70 billion	*GDP*	*Euro Zone*
World Bank 2000 in IMF 2000	*50% increase in price in first year, then decline back to original level by the third year.*	*- 0.25% (over first two years)*	*GDP growth rate*	*Industrial countries*
		0. %	*Inflation*	*Industrial countries*
Huntington 2004	*Doubling of oil price*	*-3.7%*	*GDP*	*USA and Euro Zone*

Table 4.3
(continued)

Source	Driver	Estimate	Units	Country / Region
IEA 2001	*Price level: 1% increase*	*0.44%*	*percent change in Investment*	*IEA member countries*
	Price volatility: 1% increase	*- 0.11%*	*percent change in Investment*	*IEA member countries*

Source: Hunt end Markandya, 2004.

Table 4.4
Impacts on Euro Zone GDP of 50 percent increase in oil prices (deviation from baseline GDP after 1 year)

Source	Year	Driver	Estimate (percent)	Country / Region
Barell and Pomerantz	*2004*	*50% increase in oil prices*	*-0.8*	*Euro Zone*
EU Commission	*2004*	*50% increase in oil prices*	*-0.5*	*Euro Zone*
Dalsgaard et al	*2001*	*50% increase in oil prices*	*-0.4*	*Euro Zone*
World Bank	*2000*	*50% increase in oil prices*	*-0.3*	*World*
Hunt et al	*2001*	*50% increase of oil prices*	*-0.1*	*Euro Zone*
Dieppe and Henry	*2004*	*50% increase of oil prices*	*-0.1*	*Euro Zone*

Besides these studies on the evaluation of negative impacts in the literature, there are, fortunately, a few cost-benefit studies which have attempted to evaluate precisely the policies under scrutiny in this section.

De Joode et al (2004) perform cost-benefit analyses of both policy options (support to biofuels and increased strategic stockholdings for oil) within a more general assessment of energy security policies for the Netherlands. The options chosen vary from government investments in strategic oil stocks to financial incentives for consumers to reduce their consumption of electricity. The set of options comprises several types of governmental action, among which subsidies, regulation and government investments. Moreover, the selection includes measures meant to address risks on all three major energy markets: oil, natural gas and electricity. The general picture that ensues from the cases studied is that security of supply measures are hardly ever beneficial to welfare: benefits of policy measures do generally not outweigh costs. Note, however, that these conclusions are specific to the Netherlands, where virtually all biomass has to be imported.

Subsidizing biomass, given the scenarios conceivable at the time the study was completed, turned out to be a highly expensive policy measure. In the framework of De Joode et al (2004), replacing crude oil with biomass increases production costs significantly. Direct welfare costs occur as an increase in the import bill, since the required biomass has to be imported. Financing this biomass policy by raising taxes leads to an additional, indirect, welfare cost. The direct welfare gains of the biomass policy, which arise in the case of a crisis, appear to be small. Comparing the costs and benefits of the biomass option shows that the costs outweigh the benefits to a large extent. Even if the crisis should occur permanently, the policy measure is unprofitable. It must be noted that this study excludes CO_2 reduction from the potential benefits of increased biomass use.

As to increasing strategic oil stockpiling, findings by De Joode et al (2004) are less clear-cut: "the efficiency of additional investments in strategic oil stocks depends heavily on frequency, duration and magnitude of disruptions in the supply of oil. In particular political unrest in major Middle East countries could result in a large and sudden decline in oil production. Our conclusion is, therefore, that additional investments in strategic oil stocks are not efficient unless one views the risk of a long-lasting, severe disruption as a relatively large one." These conclusions refer to the comparison of the following policy alternatives.

> The base alternative is the situation where the Dutch government and the other IEA-countries have the current emergency stocks at their disposal. The policy option is the extension of these strategic stocks by 33% following the proposal put forward recently by the Commission of the European Union (COM, 2002).

4.5. Methodology for Energy Conservation Policies Analysis

Case A: Premature Phase Out of Small Power Generation Units in OECD Countries

Large thermal power plants are usually more efficient than small generation units, and therefore they are suitable for energy conservation policies. As a result of a lower consumption of fuel, large thermal power plants are also more likely to produce electricity at a lower generation cost.

In 2005 a report published by OECD and undertaken jointly by the Nuclear Energy Agency (NEA) for the Committee for Technical and Economic Studies on Nuclear Energy Development and the Fuel Cycle (NDC) and by the International

Energy Agency (IEA) conducted a study related to the costs of generating electricity. This study provides a large quantity of data for more than 130 power plants in different countries, by different technologies.

In order to provide a cost-benefit analysis of the setup of large thermal power generating units and phase-outof the small, we adopt the methodology proposed by ZEW in the report

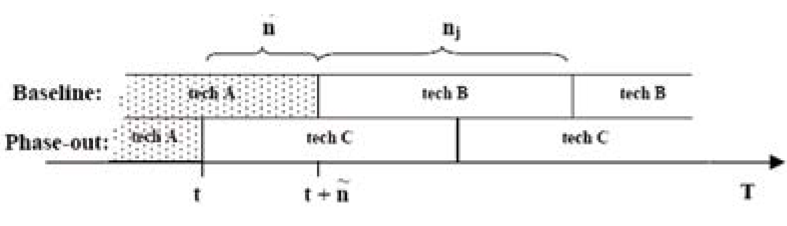
> The cost of phasing out nuclear power, a quantitative assessment of alternative scenarios for Germany" (Böhringer, Hoffmann and Vögele, 2000).

Given this methodology, we present a cost-benefit analysis for two coal based power plants: an existing small power plant and a new large power plant (with a more efficient thermal rate), using the data provided by the AEN NEA Report.

Each existing power plant is explicitly characterized by its remaining technical lifetime, which sets the upper bound for its economic lifetime. According to ZEW, phasing out a competitive power plant requires an earlier replacement investment, as would be the case for the unconstrained use of existing power plants.

Given the phase-out date t for a small power plant (Tech A), this plant would operate for another ñ years (remaining technical lifetime) in the baseline scenario, and then be replaced by another power plant (Tech B).Consequently, at any given time, the vintage structure of the installed power plant in the phase-out scenario differs from the baseline vintage structure without a premature phase out, as illustrated in Figure 4.3.

Figure 4.3
Vintage effect of phase-out policies



In the phase out scenario, replacement of the small thermal plant must already occur in t with a large power plant (Tech C), which is not necessarily of the same type as the back-up technology in the baseline (Tech B). For the sake of simplicity in our cost benefit analysis we assumed Tech C = Tech B.

We employ standard dynamic calculus (Stelzer, 1992; VDEW, 1993; Betge, 1998) in order to calculate the cost of phasing out a small power plant: all revenues and expenditures are discounted to a base year yielding the net present value of the corresponding investment or combination of investment.

A cost-benefit analysis for alternative investment schemes with a finite horizon model poses the problem of a consistent comparison between payment streams differing in their duration beyond the model horizon. One common approach (Blohm and Lüder, 1995) is to assume that the replacement of an existing power plant takes place through an endless series of the chosen replacement technology.

$$C_0^J(t) = \underbrace{\sum_{j=1}^{m} \tilde{C}_0^j(t)}_{\text{NPV small plants}} + \underbrace{\sum_{j=1}^{m} \left((1+i)^{-\tilde{n}_j} \, C_0^j\left(t+\tilde{n}_j\right) . \overset{\infty}{F}_j . \frac{\tilde{L}^j}{L^j} \right)}_{\text{NPV new plants}}$$

where:

m	=	Number of existing power plants (with j as the running index)
$\tilde{C}_0^j(t)$	=	Present Value of the existing small plant j in period t,
i	=	Interest rate
$\tilde{n}_j$	=	Remaining lifetime years for the existing small power plant j
n_j	=	Lifetime of the replacement power plant j
$C_0^j(t+\tilde{n}_j)$	=	Present Value in the period of new large power plant j replacing the existing small plant j in period
$\tilde{L}^j$	=	Capacity of existing small power plant j
L^j	=	Capacity of large power plant j

The factor $\overset{\infty}{F}_j$ is used for calculating the present value of an infinite investment stream for the new large replacement power plant j where:

$$\overset{\infty}{F}_j = \frac{(1+i)^{n_j} \cdot i}{(1+i)^{n_j} - 1} \cdot \frac{1}{i} = \frac{(1+i)^{n_j}}{(1+i)^{n_j} - 1}$$

The present value of the Tech A of the (small) power plant j in period t is:

$$\tilde{C}_0^j(t) = \sum_{tt=1}^{\tilde{n}_j} \left(\left(\underbrace{p(z+tt) \cdot h(t+tt)}_{\text{Electricity sold}} - \left(\underbrace{fc_j(z+tt) + vc_j(z+tt) \cdot h(t+tt) + sc_j(z+tt)}_{\text{Cost of generating electricity}} \right) \right) \cdot \tilde{L}_j \cdot (1+i)^{-tt} \right)$$

where:

$p(t+tt)$	=	Electricity price in USD/kWh in period (t+tt)
$h(t+tt)$	=	Hours plant j is operated in period (t+tt)
$fc_j(t+tt)$	=	Fixed payments in period (t+tt) in USD/kWh
$vc_j(t+tt)$	=	Variable payments as a function of plant utilization in period(t+tt) in USD/kWh
$sc_j(t+tt)$	=	Fixed repayments and interests payments in period(t+tt) in USD/kWh

Fixed payments are made up of personnel expenses and other fixed payments (such asmaintenance costs). Variable payments consist of payments for fuels (incl. fuel taxes) and other variable expenses (e.g. factory supplies). The present value of the Tech Bis calculated as:

$$C_0^j(z)=\sum_{tt=1}^{n_j}\left(\left(\underbrace{p(z+tt)\cdot h(t+tt)}_{\text{Electricity sold}}-\left(\underbrace{fc_j(z+tt)+vc_j(z+tt)\cdot h(t+tt)+sc_j(z+tt)}_{\text{Cost of generating electricity}}\right)\right)\cdot L_j\cdot(1+i)^{-tt}\right)$$

The present value of the premature phase-out investment stream is given as:

$$C_0^{tt}(t)=\underbrace{\sum_{j=1}^{m}\left(C_0^j(t)\cdot\frac{\tilde{L}^j}{L^j}\cdot\overset{\infty}{F}_j\right)}_{\text{NPV (new power plants)}}-\underbrace{\sum_{j=1}^{m}\sum_{tt=1}^{\tilde{n}_j}\left(sc_j(t+tt)\cdot\tilde{L}^j\cdot(1+i)^{-tt}\right)}_{\text{Sunk costs (small power plants)}}$$

The factor $\frac{\tilde{L}^j}{L^j}$ normalizes the profit of the large power plants with the size of the capacity installed of the small power plants. In fact, the large power plants provide an additional capacity (MW) of electricity supply in the market. However, in the premature phase out, the additional supply that the large power plants can provide is not required by the market.

Therefore the factor $\frac{\tilde{L}^j}{L^j}$ assures that the total electricity output is the same in the baseline scenario (small power plant in operation) and in the premature phase out scenario (large power plant in operation).

Finally:

$$C_0^{\text{Phase-out}}(t) = C_0^I(t) - C_0^{II}(t)$$

It is also important to remark that:

1) if the residual life of the small power plant tends to zero, then the value of the Baseline scenario tends to be equal to that of the phase out scenario (this means that $C_0^{\text{Phase-out}}$ tends to be equal to 0).

2) if the large power plant has the same specific cost (*fc, vc, sc*) of the existing small power plants, the strategy of premature phase out is never advantageous. Moreover, if the residual life of the small power plants is equal to its economic lifetime the cost of the premature phase out strategy is exactly equal to the investment cost of the new power plants.

Case B: Construction of New Buildings in the State of California

Sustainable buildings are characterized by a lower consumption of key resources than that of conventional buildings. Therefore, green buildings provide some financial benefits that conventional buildings do not.

The benefits of new green buildings range from being fairly predictable (such as energy and water savings) to relatively uncertain (health benefits, increase in productivity). Most green buildings are high-quality buildings, in that they cost less to operate and maintain and provide greater comfort to their occupants. However, there is no universally accepted way to compare these diverse green attributes, such as improved human health, reduced air and water pollution and increased productivity. Therefore, in our analysis we focus on the financial benefits related only to energy savings and reduced emissions from energy.

The LCC (life cycle costing) approach can be used to evaluate and integrate the benefits and costs associated with sustainable buildings. Projected future costs and benefits must be discounted to give a fair value in today's dollars. The present value of benefits and costs is calculated using a constant discount real (5%) rate, according to the usual formula:

$$NPV = \sum_{i=1}^{n} \frac{values_i}{(1+rate)^i}$$

A detailed review of 60 LEED (Leadership in Energy and Environmental Design) related buildings clearly demonstrates that green buildings, when compared to conventional buildings, are: 25-30% more efficient; characterized by lower electricity peak consumption; more likely to generate renewable energy on site or to purchase grid power generated from renewable energy.

The total 20-year present value of financial energy benefits from a typical green building was estimated in \$5.79/ft^2 (\$62.32/m^2), while the present value of a 36% pollution reduction for California Buildings ranges from 1.18\$ (if we assume 5\$/ton for CO_2 price) to 1.25\$ (if we assume a value for CO_2 price equal to 10\$/ton). On the other hand the cost increase to make these projects green was \$4/ft^2 (\$43/m^2). Thus the net benefit is between \$2.97/ft^2 (\$31.97/m^2) and \$3.04/ft^2 (\$32.7/m^2).

On the basis of these estimates, sustainable buildings appear to be cost effective.

In the literature we can find many studies related to the cost-benefit analysis of sustainable buildings. In summary, green buildings offer numerous unique benefits when compared to conventional buildings, and there are strong indications that these benefits significantly outweigh the relatively small increase in construction costs.

4.6. Methodologies for Cost-Benefit Analysis of Clean Coal Technologies

Clean Coal Technologies (CCTs) refer to all those technologies intended to reduce pollution from coal utilisation. They can be classified into two broad categories: (1) Technologies which improve burning efficiency and reduce emissions, among which integrated gasification, higher efficiency Pulverised Fuel (PF) combustion, fluidised bed combustion, and coal washing. (2) Technologies which fundamentally change the way coal is used to create energy, among which various gasification and liquefaction technologies.

We exploited the methodology of a FEEM-coordinated project called CASES to propose a cost-benefit analysis framework for CCTs. The CASES project is a Coordination Action on "Cost Assessment of Sustainable Energy Systems" funded by the European Commission under the Sixth Framework Programme, Sustainable Energy Systems. The project, which ended in September 2008, has involved twenty-six partners, most of them universities and research institutions, from twenty countries. The aim of the project was to assess different policies for the efficient use of energy and to evaluate the social cost of different electricity generation technologies, among which CCTs, under different energy scenarios to 2030.[1]

Within the CASES project the social cost of electricity production from the *i*-th technology at time *t*, denoted as SC_t^i, is given by the sum of private cost (PC_t^i) plus the external cost (EC_t^i). As for private costs, the CASES project takes into consideration the long-term development of heat and electricity generating costs based on present best predictions about the evolution of the considered technologies. External costs of electricity generation (in EuroCents/kWh) are calculated by multiplying the average height of release values of unit of emission for classical air pollutants (2000 Eurocent/kg) times the quantity of emission for unit of electricity generated (kg/kWh). The cost estimates produced by CASES can be used to carry out a cost-benefit analysis of CCT as follows: let SCtB be the social cost of a benchmark technology. Then we can define the benefit of technology i over the benchmark as: $B_t^{i,B} = SC_t^B - SC_t^i$.

NOTES

1. See Bigano, Markandya and Porchia (2010).

5. Energy Security Policies

CHINA

5.1. Evaluation of Energy Security Policies

Energy security means the degree of stability of energy supply to meet the general demand for national survival and development. It has two meanings: first, supply security; second, security of development, transport and utilization technology, namely, security of short-term and long-term nonstop energy supply, and security of safety. As energy has a leading position in economic activities and a direct impact on the national economy and on people's lives, and in view of the pressure of petrol price increases on the international market, changes on the international political scene, and threat of terrorist activities against energy transport, the guarantee of a sufficient energy supply is generally regarded as the primary objective of economic security. As a result, energy security is regarded as the first objective of energy policy. Energy security policy (especially a petrol security policy) mainly includes: actively carrying out energy diplomacy; diversifying petrol supply channels, reducing the impact of energy price fluctuation, reserving petrol, and optimizing energy consumption structure, etc.

Background of Energy Security Policies

Since enacting its reforms and opening up, the situation of China's energy security has undergone two major changes. During the decade 1980-1990, the energy factor curbing China's economic development was insufficient energy consumption. Except for two special periods of overheated economy in 1987-1988 and economic adjustment in 1989-1990, China' s total energy production was higher than the total energy consumed, and its export volume was far greater than its import volume. Generally speaking, China's energy situation was basically safe during those ten years.

From 1990 onwards, while China's GDP was increasing at an average annual rate of 9%, China's total energy consumption approached its total energy production. In 1992, its total production was slightly lower than its total consumption demand. Since 1993 onwards, the gap between China's energy production and consumption has widened from 19.14 million tons to

190 million tons; its energy import expanded from 13.1 million tons in 1990 to 143.31 million tons in 2000, increasing by 992.4%; its energy export expanded from 58.75 million tons in 1990 to 90.26 million tons in 2000, increasing by 53.6%. In particular, petrol imports increased year by year. In 2005, its net petrol imports were about 136 million tons, with an import dependence higher than 40%. According to estimates, China's petrol consumption is rising consistently, such that by 2010 its import dependence was close to 50%, and by 2020 it will be close to 60%[U1]. China's total energy consumption has surpassed its total supply, and the import dependence of its energy demands will continue to rise, creating an energy security situation that is anything but optimistic.

Energy security, especially petrol supply security, has become an important part of China's national security.

One of the major factors contributing to the high risks of China's petroleum imports is the fact that currently it relies mainly on a single channel. In fact, 90%of its imports rely on petrol tanker transport, and 80% of its petroleum imports must pass through the Strait of Malacca, which, although governed jointly by Malaysia, Indonesia and Singapore, also serves as a naval base for the United States, Japan and other countries, therefore, constituting a potentially serious threat to China's petrol supply security.

Petrol Reserve Policy

China has established a petrol reserve system at both the national and enterprise level, first in order to curb the increase of petrol prices by releasing petrol reserves onto the market, and second, in order to supplement domestic petrol demands when the supply is interrupted temporarily. On June 22, 2002, China unveiled the specific implementation plan of its petrol reserve system: the setup of a petroleum reserve base in Guangdong and other coastal regions starting from 2003,and the establishment of 12 million tons of strategic petrol reserves before 2010[U2], equivalent to 30 days of petrol imports. With respect to IEA member countries, China has just begun to build its national petrol reserves. The IEA stipulates that its member countries should have petrol reserves on hand equivalent to at least 90 days of the country's petrol imports. Currently, nearly 60% of US petrol comes from imports, and its reserve requirement is 90 days of crude oil imports, so that the actual number at present is 249 days. Germany relies 100% on petroleum imports; its reserve requirement is 120 days of crude oil imports, and the actual number at present is 140 days. Japan is one of the world largest importers of crude oil, with a reserve requirement of 160 days, and its actual number at present is 161 days. The South Korean government has established a strategic petrol reserve equivalent to approximately 90 days of petrol imports, which contains an oil equivalent of 237 days (IEA, 2014).

Energy Import Policy

In order to ensure a smooth implementation of crude and refined oil imports, and strengthen its macro-control on the importation of crude and refined oil, its policy foresees: establishing a comprehensive coordination mechanism at the national strategic level; fighting for petrol rights by promoting joint ventures, equity participation, mergers and acquisitions, and other modes; examining international practices to encourage domestic petrol companies to realize upstream and downstream supply and marketing, and domestic and overseas integrated transnational operations, to reduce transaction costs, share profits and risks, complement advantages and achieve economies of scale, and actively participate in international market competition. China's "going out" strategy has scored achievements in Sudan, Venezuela, Kazakhstan and other countries. PetroChina, Sinopec and CNOOC, and other large domestic petrol companies are investing heavily in Kazakhstan, Venezuela, Sudan, Iraq, Iran, Peru, Azerbaijan and other countries, and accelerating the process of exploiting and producing petrol with local petrol and natural gas companies. However, investments are not smooth in the United States. The three companies have about 60 petrol and natural gas projects overseas.

Main Problems

China's oil import channels remain relatively concentrated. In 2006 China mainly imported crude oil from Saudi Arabia, Angola, Russia, Iran and Oman, with over 10 million tons from each. The total volume was 93.24 million tons, increasing by 20.3%as compared with 2005.This accounted for 64.2% of its total crude oil imports in 2006, an increase of 3.1%as compared with 2005. China imported 23.87 million tons from Saudi Arabia, increasing by 7.6%; 23.45 million tons from Angola, 34.3% higher than the previous year; 16.77 million tons from Iran, an increase of 17.5%; 15.97 million tons from Russia, an increase of 24.9%; and 13.18 million tons from Oman, an increase of 21.7%. Therefore, China's crude oil import channels are still relatively concentrated. In 2006 China imported crude oil mainly from the Middle East, totalling 60.73 million tons, an increase of 1.5%as compared with 2005; accounting for 41.8% of its total crude oil imports in 2006, a decrease of 5.3%as compared with 2005. This was followed by the Africa, from which: China imported 43.51 million tons of crude oil in 2006, increasing by 13.5%as compared with 2005; accounting for 30.0% of its total crude oil imports, basically the same percentage as the previous year. Its crude oil imports from the former Soviet Union grew most rapidly: 18.65 million tons in 2006, an increase of 32.6%as compared with the previous year; accounting for 12.8% of the country's total crude oil imports, increasing by 1.7%as compared with 2005[U3].

Cost-Benefit Evaluation of Energy Security Policies

Policy Selection. China's energy security policies mainly include: a "Going-out Strategy for Enterprises," an energy import policy for addressing energy import channels; a "Policy Adjustment for Energy Export Duty Rebates" to discourage energy exports; an Oil Reserve Strategy; a "Policy on Encouraging the Development of Biomass Energy," which promotes the development of clean energy; a "Policy on Encouraging Nuclear Power" and "Encouraging Foreign Investment to Enter Energy Exploration Sector" for strengthening energy cooperation. See Table 5.1.

Cost-Benefit Analysis. Experts have scored and calculated benefits, costs and the benefit-cost ratio of various policies. The results are shown in Table 5.1. Generally speaking, benefit-cost ratio of energy security policies is above 1. This indicates that the benefit of implementing these energy security policies is greater than the cost, and China's energy security policies are efficient. Among these policies, the benefit-cost ratio of "Policy Adjustment for Energy Export Duty Rebates" is the highest, followed by "Going-out Strategy for Enterprises". This shows that the benefit of energy import policies is relatively higher than that of other energy security policies.

Table 5.1
Cost-benefit analysis of energy security policies

Energy Security Policies	Specific Policies	Benefit	Cost	β=Benefit/ Cost	Evaluation
Energy Import Policies	*Going-out Strategy for Enterprises*	*81.48*	*66.67*	*1.22*	*High Benefit*
	Policy Adjustment for Energy Export Duty Rebates	*72.22*	*55.56*	*1.30*	*High Benefit*
Oil Reserve Strategy	*Oil Reserve Strategy*	*66.67*	*61.11*	*1.09*	*High Benefit*
Clean Energy Policies	*Policy on Encouraging the Development of Biomass Energy*	*62.96*	*51.85*	*1.21*	*High Benefit*
	Policy on Encouraging Nuclear Power	*83.33*	*66.67*	*1.25*	*High Benefit*
Energy Cooperation	*Encouraging Foreign Investment to Enter Energy Exploration Sector*	*77.78*	*77.78*	*1.00*	*Benefit Offsets Cost*
Comprehensive Evaluation on Energy Security Policies		*72.59*	*62.59*	*1.16*	*High Benefit*

5.2. Costs and Benefits of China's National Crude Oil Reserve Policy

China is a large crude oil producing, consuming and importing nation. Chinese domestic oil production reached 187 million tons in 2007, ranking as the 5th largest in the world, after Russia, Saudi Arabia, the USA and Iran. China consumed 346 million tons of crude oil in the same year, ranking 2nd in the world after the USA. In 2007, China imported 163 million tons of crude oil and 33.80 million tons of refined oil, ranking 3rd after the USA and Japan[U4]. As import volume and consumption increase, crude supply will seriously fall short of demand if imports are interrupted. In view of this situation, in the 1990's the Chinese government began to discuss building a crude oil reserve system jointly managed by the government and private enterprise, so as to accelerate the construction of crude oil reserve infrastructures with a rational sharing of costs and investments, and build as soon as possible a strategic crude oil reserve equivalent to 60 days of net import volume.

According to the definition given by the International Energy Agency (IEA), petrol reserves refer to the total inventory of all the crude oil and major refined oil stored by governments, non-governmental organizations and petrol enterprises of member countries, with the inclusion of reserves in pipelines and terminals (minus 10% non-usable reserves).

China's petroleum reserves consist of governmental and commercial reserves. Governmental reserves take a dominant position, while commercial reserves are secondary. Before 2003, China's crude oil reserves were mainly a turnover reserve for production and refining owned by petrol and petrochemical companies. Such reserves were primarily stored in oilfields and refineries. There were no governmental crude oil reserves. The Chinese government began to conceive a governmental petrol reserve plan in 2003. Building national strategic petrol reserve bases was formally planned in 2004: the Mid- to Long-Term Energy Development Plan (2004-2020) passed by the State Council in June 2004 explicitly proposed building national strategic petrol reserves. According to the preliminary plan made by the National Development and Reform Commission (NDRC) and other departments, crude oil reserves equivalent to 90 days of import volume will be built in China by 2020. To reach this goal, construction of infrastructures for the national petrol reserve will be accomplished in three stages, with a total investment to exceed CNY100 billion. The reserve arrangement roughly establishes: 100 million barrels in the first stage, 300 million barrels in the second stage, and 500 million barrels in the third stage.

China has started to invest in building four national petrol reserve bases in Zhenhai and Daishan, Zhejiang Province, Qingdao, Shandong Province, and Dalian, Liaoning Province. Zhenhai National Petroleum Reserve Base was inspected and approved after completion, and now it stores petrol in full capacity. The Zhenhai reserve base has 52 oil tanks with 520 m^3 total storage volume. Basic construction and water test of tanks have been completed in the 3 remaining bases, which were planned to be filled with crude oil in 2009. Currently, the second set of petrol reserve bases are in the location selection stage. Caofeidian of Tangshan, Nansha of Guangzhou, Baoan of Shenzhen, Yangpu of Hainan Province and Lanzhou of Gansu Provinces are location candidates for the petroleum bases[U5].

China's national petrol reservesare managed on three levels by NDRC, the National Petroleum Reserve Center (NPRC) and petrol reserve bases, among which, the NDRC is the investor, the NPRC is the manager, and each petrol reserve base is a specific executor.

When the four petrol bases of the first stage are completed, a government petrol reserve capacity exceeding 10 day's import volume can be formed. If the commercial petrol reserve capacity within China's petroleum sector is incorporated, China's total strategic petrol reserve will exceed 30 days' crude oil import volume.

The benefits of national petrol reserves lie mainly in reducing the loss resulting from the interruption of crude oil imports and the negative impacts of the international price fluctuations of crude oil.

First of all, when the supply of crude oil is interrupted (for instance, because of local wars in the Middle East, or riots or turmoil in the Strait of Malacca or Indonesia), national petrol reserves can ensure a short-term stable supply of oil products. The supply of oil from the Middle East has been interrupted many times since 1951. In 2013, 52% of China's imported crude oil came from the Middle East (EIA, 2015). Therefore, the volatile situation in the Middle East and the crowded Strait of Malacca may negatively impact China's crude oil imports from the Middle East.

Second, the national petroleum reserve helps stabilize oil prices in China. In recent years, the frequency as well as the amplitude of international oil price fluctuations have accelerated. Under such circumstances, in order to maintain crude oil security, it is increasingly important to improve the ability to respond to abrupt rises in international oil prices.

Third, national petrol reserves can weaken the impact of petrol embargos, thus relieving possible international political and economic pressures.

Fourth, the national petroleum reserve can enhance China's influence on the international crude oil market and the OPEC countries, thus giving China greater leeway in implementing appropriate policies.

The direct costs of the national petrol reserve primarily regard the land acquisition, construction, management and maintenance of storage facilities, as well as the cost of procuring crude oil and the volatilization cost of reserved oil.

Let us first consider the costs of land acquisition for constructing storage facilities. There are various ways of reserving crude oil, such as ground oil storage, semi-underground oil storage, underground oil storage, water sealed cavern storage, underwater storage, and so on. The first stage oil storage facilities are all built above ground. Storage facilities with 1 million cubic meters of storage capacity cover 450mu (1mu=666.67m^2) land, and oil gravity is generally 0.75-1. Therefore, 11.43million m^3 – 13.71 million m^3 of storage facilities are needed to reserve 10 million – 12 million tons of crude oil, if an average gravity of 0.875 is assumed for the sake of computation. If 12 million m^3 of the storage facilities are built, then, 5,400mu (3.6 million m^2) land is covered. The 4 petroleum reserve bases in the first stage are all built in coastal areas with a developed economy and proximity to ports. The land price in these regions is above CNY1,000,000/mu (CNY1, 500/m^2). Hence the land cost is about CNY5.4 billion, if the land price is CNY1,000,000/mu. The construction of underground storage tanks can dramatically reduce land occupation, and land cost accordingly.

Second, the costs of constructing storage facilities mainly depend on the storage methods used. As described earlier, crude oil can be stored in underground carbonate caves, in above-ground oil tanks, semi-underground oil tanks and underground oil tanks. At present, China, because of its limited manufacturing ability, can only build oil tanks with a volume of 100,000m^3 or 125,000m^3. To build one oil tank with a volume of 100,000m^3, investments valued at about CNY70 million to CNY100 million are needed. Since 120 oil tanks, each with a volume of 100,000m^3, are needed to store 12 million m^3 of crude oil, an investment of about CNY8.4 billion – CNY12 billion is required. In the long run, oil tanks tend to be built larger, and various ways, such as above-ground storage, semi-underground storage and underground carbonate cave storage can be used for China's petroleum reserves. If crude oil is stored in underground carbonate caves, or exploited salt mines, hematite mines, limestone mines, granitic mines or coal mines, the cost of storage facilities construction will be further reduced.

Third, the costs of management and maintenance reflect the measures required to prevent the quality of crude oil from declining, to reduce the loss of crude oil, and to ensure security. The cost of management and maintenance includes expenses for surveillance, monitoring and repairing storage facilities, as well as expenditures on fire fighting and labor. The annual cost of management and maintenance is about CNY140 million – CNY160 million, if deemed as 2% of the construction cost.

Fourth, the costs of crude oil procurement are related to the crude oil price. 1 ton of crude oil is equivalent to 7.3 barrels. If the price of crude oil is USD70/barrel,12 million tons of crude oil cost USD6.132 billion, or CNY41.88 billion, based on the USD/CNY bid/ask spread of 6.8297 as of October 20, 2008. Clearly, the cost of purchasing crude oil is much greater than the other two costs. Therefore, it is of critical importance to try to reduce the purchase costs for implementing national petroleum reserves. If crude oil is purchased when there is abundant oil supply and the oil price is low on the international market, the cost of procurement can be reduced.

Fifth, the costs of crude oil volatilization are determined by the fact that some of the hydrocarbons contained in crude oil (e.g. methane) are lighter than air and hence subject to evaporation. Generally, about 1-2% of reserves are volatilized each year, with an overall loss of 12 million tons of petrol reserves in the first stage of about CNY 419 million, computed on the basis ofa 1% volatilization rate.

In addition, there are also the costs of risks which include price risk in procurement, natural risks in construction and maintenance, and transport risks. To prevent and reduce losses, measures must be taken against all the risks in every phase.

5.3. Costs and Benefits of the Biomass Energy Policy

Biomass energy, derived from solar energy, is stored in such biomass "containers" as crop stalks, agricultural processing residues, fuel wood, and forestry processing residues, animal feces, industrial organic wastewater and waste residues, municipal domestic waste and energy crops. It can be converted into a wide variety of energies, such as electricity, gas fuel, solid fuel and liquid fuel. Characterized by low pollution and wide distribution, biomass energy is the only kind that is renewable and that can be directly stored and transported. Globally, it ranks as the fourth largest energy source after coal, petroleum and natural gas, accounting for 14% of the world's total energy consumption. In the developing world, it even accounts for 35% of total energy consumption. Biomass energy is predicted to reach, by 2050, 38% of the total direct fuel consumption and 17% of the total power consumption worldwide. According to China's mid-term and long-term objectives for replacing petroleum with biomass energy, by 2020 the consumption of biomass energy will reach 20% of total petroleum consumption, and the production of biological liquid fuel will reach 20 million tons, which include 15 million tons of fuel ethanol and 5 million tons of biodiesel. If everything goes well, the annual output of biological liquid fuel may well exceed 30 million tons by that time. If we consider growing consumption, this alternative energy can be expected to account for 20% of petroleum consumption by 2020, limiting dependency on petroleum to below 50%.

Prospect of Biomass Energy

China has 4.14 billion hectares of forest, grassland and farmland, which theoretically provide over 6.5 billion tons of biomass energy per year. If the calorific value is 15,000KJ /kg, that amount is equivalent to 3.3 billion TCE of theoretical resources, more than three times the country's current total annual energy consumption. According to a survey, the amount of stalk resources available in the country exceeds 720 million tons, corresponding to 360 million TCE. Besides the 120 million tons that are used for such purposes as feed, papermaking, textile and building materials, the remaining 600 million tons can be used as energy. The survey also shows that China produces an annual average of 127 million tons of fuel wood, equivalent to 74 million TCE, 130 million tons of feces resources, and 120 million tons of municipal waste, all of which grows at an annual rate of 8-10%. It is estimated that the aggregate of biomass resources in the country reaches 700 million tons.

If we assume that 30%, 50% and 70% of energy crops (with market demand, tech-economic efficiency and policies and other factors taken into account) and 20%, 40% and 60% of other resources are available for biomass power production in 2020, 2030 and 2050, respectively, and generating efficiency reaches 20%, then by 2050, there will be nearly 1 billion TCE of biomass energy in the country, which includes 360 million TCE of energy crops (for making biofuel), that is more than 30% of the total.

It is estimated that by 2050 the biomass power output will hit 590 billion KWH, which, if calculated on the basis of equivalent value, is equivalent to 72 million TCE, and if calculated on the basis of equal value, is equivalent to 200 million TCE (accounting for 4.4% of the total energy demand that year) Biofuel will contribute to 6.8 %, 14.2 % and 30.2 % of China's petroleum demand by 2020, 2030 and 2050 respectively, providing strong support for the country's petroleum security. On top of that, it will also greatly favour the development of the rural economy.

Impacts of Biomass Energy Development

The development and application of biomass energy will go far to solving the energy, environmental and ecological problems facing China in the 21st century.

Better Energy Structure and Lower Pressure on the Environment. Fully tapping China's its 700 million available tons of biomass resources will make a difference in improving the country's energy structure and reducing its dependency on petrochemical fuel, thus reducing its CO_2 and SO_2 emissions, and eventually alleviating the environmental pressures due to energy consumption.

Adequate Energy Supply and Higher Standard of Living in Rural Areas. The development and use of the rich biomass resources in the rural areas can ease the tight energy supply and improve the standard of living there.

Less Pollution and Better Living Conditions. A common objective shared by organic sewage treatment, municipal waste energy utilization, stalk pyrolys is and biomass utilization is to reduce environmental pollution. A wider application of biomass energy will contribute to a better environment with improved living conditions.

Better Use of Marginal Land and Increased Rural Income. In China there are 100 million hectares of land that are unsuitable for grain crops but suitable for energy crops, and 3.11 million hectares of land available for forest plantation. Such land is largely distributed in China's outlying border regions, consisting of old industrial bases inhabited by backward ethnic minority groups. Proper utilization of alkaline land, wasteland, winter fallow fields and other land resources that are left fallow or not fully utilized in these regions to grow sugarcane, sweet sorghum, potatoes and rape will open up new paths for developing the economy and increasing rural income.

Decrease in Biodiversity. Like agricultural production, the plantation of biomass energy crops will cause damage to the eco-environment as well. A major cause for the decrease in biodiversity is artificial introduction. The overdevelopment and over-cultivation of biomass energy crops in forests, wetlands, grasslands, mountainous regions, mudflat areas and deserts will result in damage to the vegetation in its original habitats. Once the original equilibrium of the ecosystem is disrupted, the species will consequently decrease in number or go extinct.

Environmental Pollution and Disruption of the Biological Chain Due to Plant Protection. The development of biomass energy crops, like any other crops, requires effective protection, but the application of pesticides and herbicides has an adverse effect on fish and mammals, including human beings. It will also affect the air and water environment, and cause deterioration of the eco-environment and output decrease or even crop failure.

Case-study: Cost Analysis for Biodiesel

The study and development of biodiesel in China started rather late yet developed rapidly, with some study outputs reaching the international level. The study covers oil crop distribution, selection, cultivation, genetic improvement and processing techniques and equipment. So far, initial success has been made in every aspect of the study, contributing to further study and development. In its Outline of the 10th Five-year Plan, China proposed to develop petroleum substitutes and identified biological liquid fuel as the development direction for the nation's industry. The dual pressure to maintain rapid economic development and protect the environment has made it all more urgent to accelerate the commercial availability of effective and clean biodiesel. In response, the Chinese government and businesses have given more weight to biodiesel in recent years and some private businesses have taken the lead in production. How to satisfy the demand of the biodiesel sector for raw materials poses a huge challenge for the entire world. In China, such oil plants as jatropha curcas and pistacia chinensis bunge are able to provide 5 million tons of raw materials per year. In order to obtain adequate raw materials, some foreign businesses choose to set up shop in China and sell products to other countries. But if foreign businesses invest in China only to make the country their supply source of raw materials, they are likely to bring on a shortage of raw materials to the disadvantage of the country's own efforts to develop biodiesel.

The prices and supplies of raw materials are the key factors restricting China's biodiesel development. There are two ways to calculate the price of biodiesel: the net production-end price and the comprehensive price which takes into consideration the consumption end and environmental factors.

Let us take a look at the net production-end price. Hainan Zhenghe Bio-energy Co., Ltd. produces 1 ton of biodiesel together with 50-80 kg of glycerol from 1.2 tons of cooking oil residues. Biodiesel is sold at a price of 2,300-2,500 Yuan/ton, with a profit of 300-500 Yuan. The company's product is competitive compared to the European or the US product, which has a price many times that of petroleum or diesel oil. In Yugoslavia, 1 ton of rapeseed can produce 360 kg of biodiesel and 16 kg of glycerol as a by product. Based on grade and purity, the price of biodiesel ranges from 250 to 750 US dollars/ton, with an average of 500 US dollars/ton. This price cannot compete with that of petroleum or diesel oil. But the price of glycerol with a purity of 99.7% reaches 2,000 US dollars/ton. In Yugoslavia, each hectare of rape land produces 3 tons of rapeseeds with a total output value of 336 US dollars. In terms of comprehensive price which takes into consideration environmental factors and facility investment, biodiesel is highly competitive. In Europe, the retail price of biodiesel is lower than that of ordinary diesel because governments provide tax incentives for the production of biodiesel on account of its environmental friendliness. In Germany, for example, tax exemptions are granted for biodiesel, whose pump price is 1.45 mark/ liter, compared favorably to 1.60 mark/ liter for diesel oil.

How to meet the raw materials demand of the biodiesel sector is an enormous challenge for the whole world. For instance, the use of soybeans will be restricted because of the amount of bean pulp produced. The increased crush of the soybean, which is low in oil content, will result in a glut of bean pulp which is hard to store. In comparison, other oilseeds, the high-oil rapeseeds for example, have greater potential to meet the demand of the biodiesel sector. Globally, rapeseed oil accounts for a dominant 84% of the total raw materials for biodiesel, followed by sunflower seed oil. Other materials take a small share.

In China, biodiesel is primarily produced from waste oil, leaving a lot of room for large-scale development of plant oils as raw materials. In view of the insufficient supply of raw materials, China should in the short term make use of the existing waste oils and oil-bearing leftover bits and pieces from restaurants and leather and rubber sectors. These raw materials, however, do not provide much room for development. Statistics show that in 2005 the total cooking oil supply in the country stood at 20.959 million tons, of which, 10.14 million tons were produced domestically, accounting for 48.4% of the total. If calculated at 20% of cooking oil, then the amount of waste oil produced from that total amount of cooking oil is 4 million tons. If calculated at 15% of the cooking oil, then the amount of oil residues produced during crushing is 3.14 million tons, from which 150,000 tons of waste oil can be produced if calculated at a rate of 10%. The country's leather sector produces an aggregate of 40,000-60,000 tons of waste oil annually. If 50% of the above waste oil can be converted into biodiesel, the output will in theory reach 2 million tons. The supply and price of raw materials have become the thorniest problems. On the one hand, the prices of raw materials have skyrocketed. Consider for instance the palm oil recovered from fast-food restaurants. The price jumped from 2,800yuan/ton in 2006 to 3,500yuan/ton in 2008, approaching the import price. Whereas biodiesel No. 10 is sold at 5,000 Yuan/ton, offering a limited profit margin. Biodiesel is losing its cost advantage compared to the 5,700 Yuan/ton standard for petroleum diesel oil. On the other hand, the sources of raw materials have put a strain on biodiesel projects that are in operation. China has only a few biodiesel projects and all of them use waste oils as raw materials, a large proportion of which comes from the limited amount of leftovers. Longyan Zhuoyue New Energy Sources Development Company Limited is one of China's largest biodiesel production bases, collecting waste oil nationwide as raw material and generating an output of 20,000 tons annually (refer to Table 5.2 for the costs of biodiesel from different raw materials).

Table 5.2
Cost comparison for biodiesel from different raw materials

Raw Material	Price of Raw Material	Full Cost	Price of Biodiesel	Profit Margin
Cottonseed Oil	*4800*	*5100*	*4450*	*-650*
Rapeseed Oil	*5100*	*5200*	*4450*	*-750*
Animal Oil	*2791*	*3798*	*4450*	*652*
Hogwash Oil	*2200*	*3650*	*4450*	*800*
Palm Oil	*3175*	*4650*	*4450*	*-200*
Leftover Bits and Pieces	*600-800*	*4750*	*4450*	*-300*

Notes: Yuan is the unit of measurement

Cost-Benefit Analysis of Rural Biogas Development

Background[1]. In the 1970s, the acute conflict between energy supply and demand in rural areas gave rise to a peak period of biogas development. However, since biogas projects were primarily built under administrative orders, in the absence of mature technologies and professional construction teams, most biogas digesters had serious quality problems and short service lives. Although the number of households having access to biogas increased from 6,000 in 1970 to 7.23 million in 1980, and by the mid-1980s all the biogas digesters built with the indigenous method were abandoned. In 1986 alone, 350,000 household biogas digesters were added, yet 400,000 were abandoned, and by the end of the year, only 4.53 million were in use. For a long period before the 1990s biogas development was characterized by large swings and slow overall progress.

The major technological and organizational breakthroughs made in the 1990s led to an annual average increase of 360,000 household biogas digesters during the 8th Five-year Plan period and an annual average increase of 750,000 in the following five-year period. By the end of 2000, biogas digesters had been provided for 9.8 million rural households nationwide. Starting in 2001, the State Council has devoted greater efforts to accelerating the development of biogas in the countryside. During the period 2001-2005, the central government invested a cumulative 3.530 billion Yuan, of which, 3.450 billion were used to construct biogas digesters for 3.576 million households and 81.15 million went to 120 biogas projects. As of the end of 2005, 18 million households had biogas digesters, which combined to produce 6.9 billion m^3 of biogas. In addition, 3,500 biogas projects for animal farms were developed, which could treat 87 million tons of feces and other waste every year (see Table 5.3).

Table 5.3
Central investment in rural biogas development (years 2001-2005)

	Total Central Investment	**Rural Households**		**Large and Medium Biogas Projects for Animal Farms**	
Year	*10,000 Yuan*	*Households*	*10,000 Yuan*	*Number*	*10,000 Yuan*
Total	*353270*	*3575665*	*345155*	*120*	*8115*
2001	*13050*	*165424*	*12370*	*17*	*680*
2002	*30990*	*286333*	*28645*	*49*	*2345*
2003	*103000*	*1033248*	*101640*	*24*	*1360*
2004	*103250*	*1044279*	*101250*	*20*	*2000*
2005	*102980*	*1046381*	*101250*	*10*	*1730*

Source: National Rural Biogas Development Plan (2006-2010), Ministry of Agriculture, March 2007.

Planned Costs. China plans to give investment priority to the development of rural household biogas for the 11th Five-year Plan period, with greater support for biogas technologies and service systems. A total of 40.065 billion Yuan is planned to be invested in rural household biogas over the period 2006-1010, among which 12.5 billion from the central government[U6]. Refer to Table 5.4 for the investment structure of the national rural biogas development in period 2006-1010.

Table 5.4
Investment structure of national rural household biogas development (years 2006-2010; unit: 10,000 households, 100 million Yuan)

Region		Construction under Central Support		Total Planned Investment			Including Central Subsidy Investment		
		2006-2010	*Annual Construction Scale*	*2006-2010*	*Share in Total Investment (percent)*	*Total Annual Investment*	*2006-2010*	*Share in Central Subsidy (percent)*	*Annual Investment*
Total		*1317.50*	*263.50*	*400.65*	*100.00*	*80.13*	*125.00*	*100.00*	*25*
West China	*Subtotal*	*640.00*	*128.00*	*196.00*	*48.92*	*39.20*	*68.00*	*54.40*	*13.60*
	Southwest Region	*375.00*	*75.00*	*112.50*	*28.08*	*22.50*	*37.50*	*30.00*	*7.50*
	Northwest Region	*200.00*	*40.00*	*64.00*	*15.97*	*12.80*	*24.00*	*19.20*	*4.80*
	Three Prefectures and Eight Counties	*65.00*	*13.00*	*19.50*	*4.87*	*3.90*	*6.50*	*5.20*	*1.30*
Central and North-east China	*Subtotal*	*540.00*	*108.00*	*163.40*	*40.78*	*32.68*	*46.00*	*36.80*	*9.20*
	Hilly Areas in Southeast Region	*175.00*	*35.00*	*52.50*	*13.10*	*10.50*	*14.00*	*11.20*	*2.80*
	Huanghuaihai Plain	*295.00*	*59.00*	*88.50*	*22.09*	*17.70*	*23.60*	*18.88*	*4.72*
	Northeast Region	*70.00*	*14.00*	*22.4*	*5.59*	*4.48*	*8.40*	*6.72*	*1.68*
East China	*Subtotal*	*137.50*	*27.50*	*41.25*	*10.30*	*8.25*	*11.00*	*8.80*	*2.20*

Source: National Rural Biogas Development Plan (2006-2010), Ministry of Agriculture, March 2007.

The average total investment per household is 3,200 Yuan in the northwest and northeast regions, and 3,000 Yuan in other parts of the country. The support standards vary according to different construction costs and economic conditions in different regions. The central support per household is 1,200 Yuan in the northwest and northeast regions, 1,000 Yuan in the southwest regions and 800 Yuan in other regions. The 243 counties in the six central provinces, where policies are implemented with reference to the policies for western China's development campaign, receive a subsidy of 1000 Yuan for each household.

A household biogas digester is composed of a digester, a cooker, a light and such accessories as a desulphurizer, pipes and switches. Construction of an 8 m^3 biogas digester needs 1 ton of cement, 600 bricks, 2m^3 of sand, 0.6m^3 of gravel and reinforcement. If built entirely with concrete blocks instead of bricks, a digester needs 1.5 tons of cement, 3 tons of sand, 3 tons of gravel and reinforcement. The construction also requires four days of work of a skilled laborer and eight days of work of a handyman. A complete concrete structure also requires a mould. The construction contents and standards, building materials and labor used vary from region to region. The investment also varies depending on the prices of materials, cookers, accessories and labor. In Table 5.5 representative counties are selected nationwide to give an idea of the actual investment in different regions in 2002.

Table 5.5
Statistics of actual investment in rural household biogas in different regions (year 2002; unit: 10,000 Yuan)

Region	Weinan, Shaanxi	Yanchi, Ningxia	Fenggang, Guizhou	Fuxin, Liaoning	Huailai, Hebei	Songzi, Hubei	Qidong, Hunan
Total Investment	*3356*	*3535*	*2867*	*3452*	*3590*	*2929*	*3152*

Source: National Rural Biogas Development Plan (2006-2010), Ministry of Agriculture, March 2007.

Analysis of Planned Benefits. Upon fulfillment of the plan, 23 million rural households using biogas and 4,000 large and medium biogas projects will be added[U7]. Nationally, there will be 40 million households with access to biogas and 4,700 large and medium biogas projects for animal farms, generating significant social, ecological and economic benefits.

Less Energy Consumption and Better Rural Living Conditions. The 40 million rural household biogas digesters can provide 15.4 billion m^3 of biogas annually, which can replace 24.20 million TCE of energy consumption. The amount of biogas provided by the newly added 23 million household biogas digesters can replace

13.92 million TCE of energy consumption. The 1.16 billion m^3 of biogas from large and medium biogas projects can meet the annual domestic gas demands of 3 million households, replacing 1.8 million TCE of energy consumption.

Consolidated Grain-to-green Results and Improved Eco-environment. It was estimated that by 2010, the biogas output from the 40 million rural household biogas digesters would have been equivalent to 140 million mu of annual growing stock. The output of the newly added 23 million will be equivalent to 80.5 million annual growing stocks. The application of biogas sludge and slurry will not only reduce the consumption of pesticide and fertilizers by over 20%, with pesticide residue on agricultural products down by more than one percentage point, but also improve the conditions of 50 million mu of land. The reclamation of animal feces and the discharge of wastewater within the limits will benefit the protection of water sources.

Faster Agricultural Restructuring and Higher Rural income. By 2010, the 40 million rural households using biogas saved 20 billion Yuan of direct expenditures on fuel, power, fertilizers and pesticide every year (save 500 Yuan every year). The 23 million newly added households saved expenditures up to 11.5 billion Yuan. Further, the biogas development in rural areas has boosted the growth of animal husbandry and the restructuring of plant production. Development of pollution-free and green agricultural programs is also facilitated, and the households covered in the programs gain more from higher quality agricultural products.

Biogas development also provides a source of labor absorption. If the proportion of skilled laborer and biogas digester is 1:50, and each skilled laborer is provided with three supporting laborers, then every 10,000 digesters can absorb 800 rural laborers and 368,000 job opportunities are generated across the country every year.

Case-study: Cost-Benefit Analysis of Biogas Development in Gongcheng County

Benefits. The development of biogas is closely related to the drive to build a new socialist countryside. This is so because biogas application has economic, social and environmental benefits which are manifested in such aspects as proper and full use of agricultural and natural resources, provision of fuel and quality organic fertilizers, improved ecological conditions and a clean environment.

Direct Economic Benefits. Biogas is sound fuel gas and biogas sludge is a good organic fertilizer. Thus the application of biogas in rural areas brings about ideal economic benefits by reducing both fuel expenditure and use of fertilizer.

Estimates by prominent research institutes show that a farmer spends 800-900 Yuan less after he begins to use biogas. Generally, a family of four needs 10 honeycomb briquets every day, and if the price is 0.2 Yuan each, its annual expenditure on coal will amount to 730 Yuan. If using stalks, a rural household will have an annual opportunity cost of no less than 400 Yuan. But the construction of a biogas digester can save a household more than 700 Yuan of expenditure on honeycomb briquets or even over 800 Yuan for a larger family.

Biogas sludge and slurry is rich in organic matter, humic acid, ammonium nitrogen, crude protein, crude fiber, starch, trace element, zinc, copper and iron. Biogas slurry with 10%concentration contains 6.2% protein. Biogas sludge has a crude protein content of as high as 18.5%. Since few nutrients in raw materials are lost when biogas is produced through fermentation in closed conditions, biogas fertilizer contains many more nutrients than compost. Calculations show that, compared with compost, biogas fertilizer contains 40-60% more total nitrogen, 40-50% more total phosphorus and 80-90% more total potassium, and has a 10-20% higher crop utilization rate. The development of biogas reduces a rural household's fertilizer expenditure by half. A biogas digester generally produces nearly 1,000 Yuan of direct economic benefits every year.

Indirect Economic Benefits. The biogas industrial chain is long, so apart from the reduction in direct investment, the development of biogas also drives forward a rapid growth of the associated sectors. The production of biogas needs adequate raw materials, which can be green grass, stalks, and human and animal feces. To produce adequate biogas it is advisable for a household to feed livestock with stalks and then use the feces to make biogas. Actually, it is an interaction process whereby livestock raising produces biogas, which in turn facilitates the development of family or group livestock raising. In the industrial process from biogas to livestock raising, the former becomes a by product of the latter.

Biogas sludge is a high-quality pollution-free organic fertilizer which helps cut down the use of fertilizers, contributes to the development of organic agriculture and allows farmers to obtain a value added that is higher than the price of general agricultural products.

The development of biogas as a clean energy suitable for both cooking and lighting can substantially improve sanitary conditions in the countryside. First, in the process of producing biogas through anaerobic fermentation in closed conditions, eggs of parasites are killed, and this raises epidemic prevention levels. Second, fermentation in closed conditions prevents sewage spillage when it rains. Third, the use of biogas does away with the use of fuel wood.

Eco-environmental Benefits. The development of biogas as a sound alternative to fuel wood helps forest protection, improves regional vegetation and thus reduces eco-environmental problems caused by deforestation, problems such as soil loss, desertification and reduction of biodiversity.

Cost Analysis. Biogas technology is developed for the public welfare, without market access threshold and franchise protection. If its economic and environmental benefits and easy application are taken into consideration, it is generally believed that farmers will be ready to embrace the technology. The fact, however, is that since the 1970s, when China began to extend biogas into the countryside, the extension has been less than satisfactory except in a small number of places, such as Gongcheng County, Yanbian County, Enshi Prefecture and Guangxi Zhuang Autonomous Region. There are underlying reasons for this low penetration rate and lack of enthusiasm.

Development of Professional Workforce. Biogas technology is not easy to extend, despite being an open, public welfare technology without patent protection and franchise restriction. Restricted by their education levels, farmers, and even some skilled workers, do not have the necessary skills to build qualified biogas digesters as required by the national technical standards. In Gongcheng County, county officials made careful plans and set up a technical team of 1,000 members in the early stage of their biogas extension program. This technical team was able to timely and effectively tackle any technical problem that might arise in the process of constructing and maintaining biogas digesters. The county even sent technical staff to assist other provinces in solving leaking problems that they could not solve on their own or some problems that had caused deaths.

Direct Investment. Insufficient direct income is the primary reason why farmers are reluctant to invest in constructing biogas digesters. To build "a digester, a kitchen and a bathroom" as required by the state, a rural household needs more than 3,000 Yuan. Although the government provides 800-1,000 Yuan of subsidy[U8], the remainder in excess of 2,000 Yuan is still a considerable amount for a many farmers.

Boosting Farmer Enthusiasm Through Pilot Activities. Although the market economy does not exclude administrative intervention by the government, nevertheless it is impossible to make the intervention mandatory since the government cannot take upon itself the part of the bargain that lies with the farmers. The market is in constant flux, so that any plan, no matter how carefully made, may conceal oversights and flaws. If farmers suffer any loss as a result of a mandatory government program, they will develop distrust of or even opposition to the government.

But if the government can demonstrate to farmers the market prospect of using this technology through pilot activities in which technical personnel or specialized households take part, farmers will become willing to use the technology. In Gongcheng, while adjusting its agricultural structure, the county demonstrated to farmers the benefits of building biogas digesters by providing technical guidance and support to specialized households. Consequently, farmers became confident of the government's decisions.

Investment in the Pig-Biogas-Fruit Tree Base. Gongcheng mode features a pig-biogas-fruit circular economy. Because of the increase in fruit tree areas and decrease in crop areas in the county, farmers have been forced to buy pig feed from the market. Along with rising feed prices and falling pork prices, there have been fewer and fewer households raising pigs. The reduced availability of raw materials for biogas has in turn reduced the number of households using biogas. In a move to address this situation, Gongcheng has begun to encourage large-scale pig raising. In 2003, the county allocated 600,000 Yuan from its revenues to support large pig farms. In 2005, the county had five farms with 100 pigs and 15 farms with 50 pigs.

EUROPEAN UNION

5.4. Policies Encouraging the Development of Biomass Energy

For the production of biodiesel, the biomass feedstock is processed at specialised sites. The final product is sold to oil companies, which distribute it via their automobile service station network. For the production of ethanol, several small production companies obtain their feedstock (corn, wheat, beets or barley) from farmers. Sugar is then extracted and processed into ethanol.

Although biofuels have long been a familiar option for automotive engines, in Europe the production and use of these fuels has significantly increased in the past five to ten years. During the last century other fuels, namely petrol and diesel derived from crude oil, developed to such an extent, and have been so cheap and abundant, that biofuels were only used on a very small scale in the transport sector. Petrol and diesel are still the most common fuels used in road transport but biofuels have been expanding, partly because of European and national environmental policies.

Until now biofuels have been produced in the EU by processing primarily food crops using available technologies. These so-called first-generation biofuels can be used in low percentage blends with conventional fuels in most vehicles and can be distributed through existing infrastructure. Advanced conversion technologies are needed for a second generation of biofuels. The second generation will use a wider range of biomass resources-agriculture, forestry and waste materials- and promise to achieve higher reductions in greenhouse gas emissions and fuel production costs (Smeets et al, 2006 and Hoogwijk et al, 2005).

Biofuels are likely to play a key role in the world's energy future. Rising fuel prices, growing energy demand, concerns over global warming from GHG emissions, increased openness to renewable energy resources, domestic energy security, and the push for expansion into new markets for crops in the face of world trade outlooks are all factors stimulating interest in the use of bioenergy.

As recently as January 23, 2008, the EU Parliament published a Directive on the promotion of the use of energy from renewable sources and set an explicit 10% binding minimum target for biofuel use in transport to be achieved by each EU Member State by the year 2020.

In 2007, President Bush called for U.S. production of ethanol to reach 35 billion gallons per year by 2017, which would displace 15% of U.S. projected annual gasoline use. By 2030, the U.S. administration aims to increase that production to 60 billion gallons per year. The policies cited above are examples of the latest government decisions to promote biofuel energy use. Therefore, it is becoming increasingly likely that in the future agriculture will become a significant supplier of energy along with food.

Increases in oil prices in conjunction with subsidy policies have led to a dramatic expansion in corn ethanol production and high interest in further expansion over the next decade. Yet, there are currently few players in this field: in 2005, Brazil and the United States together accounted for 99% of global ethanol production[U9], whereas Germany and France accounted for 69% of global biodiesel production.

The recent boom in biofuel production, and the support it has gathered among policy makers, has, however, spurred some concern about the possible negative impacts of a sustained expansion of first generation biofuels, and about the real extent of their positive effects in terms of GHG emission reductions.

Given the current policy developments and the availability of exclusively first generation biofuels, an increase in biofuel production either due to 'pure' market and/or 'policy' forces might have significant impacts on agricultural markets, among which world prices, production, trade flow, and land use. Linkages between food, forestry and energy production include competition for land, but also for other production inputs. The effect of an increasing supply of biofuel production by products such as oil cake and gluten feed also affect animal production.

Furthermore, the biofuel boom raised concerns such as whether biofuels would hurt the economically disadvantaged by increasing food prices, whether it would lead to loss in biodiversity due to increased land use, or whether it would have a negative effect on water resources. All these implications are not well understood and need further scientific investigation .

A particularly interesting interaction was triggered by the direct or indirect land use competition between crops for biofuels, food production and forests. There are two main reasons for concern. If the boost in biofuel demand translates into increased deforestation, this can result in a direct loss of biodiversity particularly in tropical areas. On the other hand, increased deforestation will imply increased GHG emissions, since deforestation is considered the second largest source of greenhouse gas emissions (IPCC 2007) and is expected to remain a major emission source. This potential negative effect on GHG mitigation is at odds with one of the main rationales for policy support of biofuels, namely its GHG mitigation potential. However, second generation biofuels are likely to be produced from inputs unsuitable for agriculture and forestry.

Finally, another field in which biofuels can play an important role is that of energy security, particularly in the EU, where the issue of energy security has gained increasing importance on account of the continuous increase of EU energy needs coupled with the increased scarcity of domestic energy resources, and the growing competition for access to global energy sources from other consuming regions such as Asia.

As a matter of fact, the EU domestic energy system is widely considered as not reliable enough to support sustained and stable economic growth over the next decades. The energy consumption of OECD European countries is steadily increasing while domestic sources are becoming exhausted, leading to growing import dependence, especially for oil and gas.

In this perspective, the potential of biofuels to reduce dependence on fossil fuels and increase the diversification of energy supply may enhance their appeal among policy makers, particularly in Europe. This is the aspect of biofuel policy that is investigated in this section.

EU Biofuel Policy

The European Commission has been very favourable to biofuels in the last decade; only very recently, mounting concern over the undesirable side effects of the diffusion of biofuels and their questionable GHG mitigation potential have urged the EC towards a more cautious approach.

The official position remains favourable, as exemplified by José Manuel Barroso's speech during the International Biofuels Conference in Brussels, on 05 July 2007: "Properly managed, biofuels have the potential to offer important benefits", namely:

i) Reinforce the EU's security of supply through diversification of energy sources.
ii) One of the few practical ways – alongside more efficient vehicles and hybrids – to significantly reduce greenhouse gas emissions.
iii) Biofuels also provide important opportunities for industrial development, innovation and high quality jobs - important factors when moving towards the knowledge economy of the future.
iv) Biofuels can be used without major changes to vehicle fleets and fuel distribution systems.
v) Support the EU in remaining in a frontrunner position in the field of renewable energy, and improve international trade relations and advancement of ongoing free trade negotiations.

Mr. Barroso also stated that

> Our aim must be to develop an EU biofuels policy which meets our objectives on security of supply and climate change, while ensuring sustainable oil reserve strategy.

On January 23, 2008 the European parliament published the Directive[U10] "On the promotion of the use of energy from renewable sources" [COM(2008) 19]. This has been the final step of a policy process initiated in 2003. The main steps in the EU policy towards biofuels have been the following:

i) May 2003: The European Union (EU) Biofuels Directive was adopted. It aims to promote the use in transport of fuels made from biomass, as well as other renewable fuels. The directive sets a reference value of 5.75% for the market share of biofuels in 2010 (petrol and diesel market).

ii) March 2007: EU leaders committed to 20% renewable sources in the EU's energy mix and 10% biofuels in vehicle fuel by 2020.

iii) January 2008: The Commission finally presented its review of the 2003 Biofuels Directive, as part of a broader Directive on renewable energies. The Directive stated that EU Member States should ensure that biofuels and other renewable fuels attain a minimum share of their total consumption of transport fuel, which is responsible for almost 25% of all greenhouse gas emissions in the EU. The share should reach, measured in terms of energy content, 5,75% by the end of 2010[U11] and 10% by the end of 2020. The Directive establishes an overall binding target of a 20% share of renewable energy sources in energy consumption and a 10% binding minimum target for biofuels in transport to be achieved by each Member State, as well as binding national targets by 2020. The Directive now counterbalances these requirements with "sustainability criteria" to prevent mass investment in cheaper but environmentally harmful biofuels:

- Biofuels must deliver GHG savings of at least 35%as compared to fossil fuels
- Biofuels planted after January 1, 2008, in protected areas, "highly biodiverse" grasslands, forests and wetlands will not be considered as counting towards the 10% target.
- The origin of imported biofuels must be checked to ensure that no raw materials from undisturbed forests, biodiverse grasslandsor nature protection areas was used for biofuel production (unless compatible with nature protection).

The Biofuels Directive stems from the overall drive of the EC towards a unified European energy policy, to be built around the three pillars of sustainability, competitiveness and security of supply, as stated in the green paper "A European strategy for competitive, sustainable and secure energy" (COM(2006) 105 final).This green paper points explicitly to the linkages between the support of renewable energy and the security of supply, particularly in the perspective of

> a detailed short, medium and long-term plan to stabilise and gradually reduce the EU's dependence on imported oil. This should build on the existing Biomass Action Plan and the Strategy for Biofuels.

The EU Biofuel Market

This paragraph is largely based on the GAIN Annual Report on "EU-27 Biofuels" prepared by the USDA Foreign Agricultural Service (USDA, 2007).

Biodiesel[U12]. The European Union is the largest producer of biodiesel in the world, and biodiesel is the most important biofuel in the EU, representing about 80% of the total biofuels market.

Table 5.6
Biodiesel statistics in EU-27 (1,000 liters)

	2005	2006	2007	2008
Production	*3,360,610*	*6,015,885*	*9,452,700*	*14,467,299*
Imports	*26,459*	*121,368*	*501,810*	*534,486*
Consumption	*3,540,344*	*6,350,814*	*8,053,467*	*13,466,013*
Exports	*78,258*	*5,835*	*38,511*	*175,050*

Estimates presented in Table 5.6are partly based on announced industry intentions to expand biodiesel production capacity in the EU. In 2007, EU biodiesel production is expected to exceed EU demand. This may suggest that current plans to further expand biodiesel production capacity may be potentially overestimating actual demand. Given the traditional shortage of biodiesel in the EU, good profit margins have encouraged many companies to produce not only for domestic demand in their own Member State, but also for consumers in other EU Member States. In 2005 and in 2006, EU biodiesel companies and traders were very profitable. The German market in particular benefited from not only high mineral oil prices, but also from large tax benefits. These conditions generally encouraged an expansion of production capacity throughout the EU. In some EU Member States the anticipation of new incentives (for instance in Bulgaria) or the desire to create jobs in rural areas (Greece) added to the investment boom. At the end of 2006, production capacity in the EU-27 was estimated to be around 8.7 million MT.

EU-27 biodiesel production amounted to 5.1 million MT in 2006. The largest producers were Germany, Italy, France, and the UK, accounting for 46, 14, 10, and 10% of EU-27 production, respectively[U13]. Biodiesel consumption in 2006 amounted to 5.4 million MT. In 2006, the largest consumers were

Germany, the U.K., France, and Austria, accounting for 53, 18, 10, and 6% of EU-27 consumption, respectively[U14].

Bioethanol.[U15] Bioethanol is the second largest biofuel in the European Union, representing almost 20% of the biofuel production[U16]. Bioethanol is normally used as a blend with normal gasoline in any proportion up to 5%. This blend can be used in modern spark-ignition engines without modification. Modified engines, such as flexi-fuel vehicles, can run on E85 as well as on pure bioethanol and conventional petrol.

Table 5.7
Ethanol statistics in EU-27 (1,000 liters)

	2006	2007	2008
Production	*1707552*	*2927988*	*4649589*
Imports	*578340*	*831600*	*1159200*
Consumption	*1569355*	*2473758*	*5406660*
Exports	*127479*	*233478*	*271656*

Current estimates for production and production capacity indicate that the EU bioethanol industry is growing. While much of the focus and investment has traditionally been on biodiesel (a majority of EU vehicles run on diesel), bioethanol offers many opportunities for using a large variety of different feedstock, mainly from crops rich in starch and sugar such as cereals and sugar beets, sugar cane and wine alcohol (USDA, 2007).

Import competition remains a very important concern for the EU bioethanol industry. It is often argued that cheap imports will make it very difficult for the industry to grow and manage without subsidies. Prior to 2006 there was a loophole which allowed a large amount of bioethanol to come into Sweden. The loophole was closed in January 2006.

Nevertheless, imports of bioethanol to the EU continue to increase, and were expected to double between 2006 and 2008[U17]. A large part of these imports came through the Benelux, but also Sweden, France and the UK saw increasing imports (see Table 5.7).

Currently the most important EU bioethanol producer is Germany, with an annual production of 450,000 MT in 2006. It is estimated that Spain had an annual production of 420,000 MT, which reached 800,000 MT in 2008. France was also expected to significantly increase production from about 200,000 MT in 2006 to an estimated 800,000 MT in 2008[U18].

The most important feedstock for the production of bioethanol in the EU are cereals, mainly wheat, rye and sugar beets. There is also one plant that is reportedly using corn. In 2006, an estimated 39% of bioethanol was made from wheat, followed by 17% from rye and 6% from barley. A considerable amount, roughly 16%, was produced from wine alcohol sold at the Commission's auctions[U19]. According to some analysts, wheat alcohol production will benefit from the EU's structural production surplus, while corn, rye and barley will remain minor elements in the feedstock mix.

5.5. Oil Reserve Strategy in the EU

This section is largely based on the Annex to the consultation document on the revision of the emergency oil stocks regime in the EU (European Commission 2008b) and on Arnold et al (2008).

The origins of emergency oil stockpiling go back to early 20th century Europe. Already in 1917 the United Kingdom introduced specific requirements on the stockpiling of energy fuels. France introduced similar provisions in 1925. At that time, this obligation was justified by military needs, since coal and oil stocks helped maintain the war effort.

In the second half of the 20th century, oil became the most important fuel in the European energy mix, making the economy crucially dependent on its continuous, reliable and affordable supply. Moreover, most of the oil was imported from other regions. After Egypt's blockade of the Suez Canal in the 1950s, European politicians became aware of the necessity to maintain oil reserves in order to mitigate the economy's exposure to a disruption of its oil supply. Oil emergency stocks emerged as the best protection to cope with supply disruption as they could swiftly and effectively replace missing barrels. Consequently, in 1968 (well before the oil price shocks of 1973-74 and 1979-80) the European Community adopted legislation obliging Member States to maintain minimum oil and/or oil product stocks. Originally, the obligation was equivalent to 65 days of domestic consumption of three distinct product categories (gasoline, middle distillates and fuel oil). In 1972 this was raised to 90 days. The oil price shock of 1973 seriously damaged the world economy and created a period of high inflation and stagnation.

European versus IEA Stockpiling Systems

Against this background, and with a mission to protect oil consuming countries, the International Energy Agency (IEA) was created in 1974. It assembled the most developed economies of the world. The IEA took over the 90-day stockpiling obligation from the European Community, but changed the base from consumption to net imports of oil and oil products in order to make allowance for the oil production of some of its member countries, particularly the United States. Accordingly, the IEA obligation is not related to specific product categories and member countries are free to determine the composition of stocks.

EU Member States with IEA membership thus have to ensure that their stocks comply with two different obligations, one set by the EU, another by the IEA. The IEA system is geared toward an effective response to disruptions having a global effect, while the EU legislation merely foresees a consultation between Member States in case of a supply disruption. The International Energy Program, the founding document of the IEA, establishes specific tasks for member countries and the Secretariat in an actual oil emergency.

A primary mission of the IEA was the creation of a mechanism to mitigate the negative effects of oil disruptions. The mechanism of emergency response was set up under the 1974 agreement on an International Energy Programme (IEP). The IEP Agreement requires IEA countries to hold oil stocks equivalent of at least 90 days of net imports of the previous calendar year and to increase supply (by releasing oil stocks and increasing domestic production) and reduce demand (by means of demand restraints and fuel switching) in the event of an oil supply disruption of 7% or more to the IEA or individual countries (IEA, 2007a). The IEA emergency measures are kept in constant readiness through periodic tests involving administrations and the oil industry. They have been mobilised on several occasions over the years, making a significant contribution to restoring market stability in times of uncertainty.

There are two different categories of stocks, depending on the holder: public stocks, held exclusively for emergency purposes, are oil reserves held by agencies or owned directly by governments; industry stocks include stocks held to meet government stockholding obligations and stocks held for commercial purposes. In June 2007, total oil stocks in IEA member countries totaled some 4.1 billion barrels (about 150 days of net imports), of which 1.5 billion barrels were public stocks and 2.6 billion barrels were industry stocks[U20] (IEA, 2007b). IEA stocks seem adequate for a medium-scale disruption of short- to medium-term duration, while for larger disruptions the instrument is sufficient only for short periods of time.

Policies of stock draw and demand restraint are the most feasible and effective measures in the IEA context, because of high oil stock capacity, great dependence on oil (high demand), reduced spare capacity and reduced fuel-switching capacity. A recent example of their effectiveness was the 2005 IEA Collective Action in response to the hurricanes in the Gulf of Mexico, which resulted in 57.5 million barrels made available by the IEA's 26 Member States from all forms of stock release and increased indigenous production, in addition to 1.7 million barrels made available from demand restraint (IEA, 2007b).

Demand restraint as a policy approach refers to the short-term oil saving that can be achieved during a period of crisis. The measures to achieve demand restraint fall into three main categories: persuasion and public information, administrative and compulsory measures, and allocation and rationing schemes. Demand-restraint programmes reflect local demand patterns and economic structures, legislation and emergency-response policies.

In general, IEA countries must have a ready programme of demand restraint measures equal to 7% of oil consumption if supplies are cut by 7% (approximately equivalent to 3.4 mb/d, see BP, 2007), and 10% of oil consumption (approximately equivalent to 4.9 mb/d, see BP, 2007) if supplies are cut by more than 12%. Restraint measures are designed mainly for the road transport sector, which is the biggest oil-consuming sector in OECD countries (> 50%), but price elasticity of the sector remains very low in the short term and is decreasing. (Arnold et al, 2008)

Characteristics of the EU Stockholding System. The legal framework for emergency stocks in the EU and rules related to their use are currently dispersed among three distinct pieces of EU legislation[5][U21].

EU legislation puts the stockholding obligation on the Member States, which are free to choose their specific stockholding arrangements. As a result, the transposition of the stock directive in different Member States has brought about very diverse stockholding systems across the EU. Some Member States have set up government-owned stocks, while others have established government-supervised agencies responsible for holding emergency stocks. In a number of Member States stocks are entirely kept by the oil companies, while yet others have opted for a mixed system (with an agency plus an obligation of a different extent on the industry). Today, eight EU Member States rely entirely on mandatory industry stocks[U22] while in the other Member States all or part of the emergency stocks are held directly by the government or an agency. Management and ownership of stocks may be separated. For example, stocks held by agencies are often owned by the oil companies.

The directive allows holding stocks in the form of crude oil or intermediate products; however on average, 56% of European emergency stocks are held in the form of finished products, ranging from 20% to 100% of reserves in individual Member States[U23]. Emergency oil stocks can be held on the territory of another Member State, on the basis of a bilateral intergovernmental agreement that exists between the Member States. At present, there are about 40 bilateral agreements in force and another 10 or so are under consideration or in the process of being agreed on. Several Member States, especially in Northwest Europe, have a number of such agreements in force. However, seven Member States have refrained from concluding bilateral agreements and some of them expressly prescribe that all their stocks are located on the national territory.

Most of the stocks are owned by the entity which has the stockholding obligation. However, 11% of the emergency stocks are held through so-called “ticket” arrangements. Such stocks are owned and physically stored by another, typically commercial entity for a pre-determined fee. The “ticket” is in fact an option to buy the stock at the price set out in the agreement.

“Ticket” agreements are usually concluded for a short period. This form of stockholding is used in several Member States, primarily for cost reasons. It may also give a certain flexibility to exchange oil products for reasons of aging/

degradation or changing specifications.

Member States have to report their stock levels to the Commission (DG TREN[U24]) on a monthly basis. According to the data reported, emergency stocks held by EU Member States amounted in late 2007 to 143 million tons, which is equivalent to 114 days of internal consumption. For Member States with a 90-day obligation (EU-15 plus Hungary, the Czech Republic, Slovenia, Cyprus and Malta) the coverage was 116 days, while for countries with a transitional period it was 90 days. The situation (referred to the first semester of 2008) is summarised in Table 5.8[U25]:

Table 5.8
Oil stockholding situation in Europe (year 2008)

COUNTRY	SITUATION as to	CATEGORY I*		CATEGORY II*		CATEGORY III*		TOTAL*	
consump.	1000 t	Days of consump.	1000 t	Days of consump.	1000 t	Days of consump.	1000 t	Days of consump.	1000 t
COUNTRIES WITH A 90-DAY CONSUMPTION OBLIGATION									
BELGIUM	*31/03/2008*	*140*	*644*	*44*	*1592*	*305*	*645*	*67*	*2881*
DENMARK	*30/06/2008*	*164*	*614*	*108*	*1122*	*947*	*710*	*164*	*2446*
GERMANY	*30/06/2008*	*124*	*7026*	*123*	*18041*	*179*	*2904*	*127*	*27971*
GREECE	*30/06/2008*	*115*	*1302*	*107*	*2425*	*147*	*1111*	*116*	*4838*
SPAIN	*31/07/2008*	*130*	*2384*	*98*	*10933*	*230*	*2653*	*113*	*15970*
FRANCE	*30/06/2008*	*141*	*3776*	*106*	*15136*	*274*	*1998*	*118*	*20910*
IRELAND	*30/06/2008*	*93*	*441*	*81*	*1227*	*130*	*360*	*89*	*2028*
ITALY	*31/07/2008*	*112*	*3352*	*96*	*8543*	*366*	*5268*	*129*	*17163*
LUXEMBOURG	*30/06/2008*	*85*	*101*	*93*	*619*	*90*	*1*	*92*	*721*
THE NETHERLANDS	*30/06/2008*	*211*	*2495*	*154*	*5022*	*14020*	*1402*	*200*	*8919*
PORTOUGAL	*31/07/2008*	*148*	*647*	*100*	*1744*	*187*	*860*	*123*	*3251*
UNITED KINGDOM	*30/06/2008*	*107*	*3877*	*98*	*8250*	*427*	*1171*	*108*	*13298*
AUSTRIA	*30/06/2008*	*140*	*698*	*104*	*2071*	*401*	*802*	*132*	*3571*
SWEDEN	*30/06/2008*	*111*	*1205*	*118*	*1787*	*336*	*1231*	*142*	*4223*
FINLAND	*30/06/2008*	*105*	*539*	*146*	*1898*	*172*	*642*	*141*	*3079*
HUNGARY	*30/06/2008*	*96*	*412*	*92*	*742*	*261*	*209*	*103*	*1363*
EUR-15 + HU		*126*	*29513*	*105*	*81152*	*274*	*21967*	*122*	*132632*

Table 5.8
(continued)

MEMBER STATES IN A TRANSITIONAL PERIOD									
LATVIA	*31/07/2008*	*57*	*56*	*62*	*129*	*164*	*23*	*65*	*208*
POLAND	*30/06/2008*	*114*	*1246*	*113*	*3310*	*200*	*410*	*117*	*4966*
SLOVAK REP.	*31/07/2008*	*85*	*175*	*85*	*334*	*92*	*29*	*85*	*538*
LITHUANIA	*31/07/2008*	*77*	*83*	*76*	*234*	*148*	*108*	*87*	*425*
ESTONIA	*30/06/2008*	*59*	*52*	*51*	*95*	*50*	*1*	*54*	*148*
ROMANIA	*31/08/2008*	*83*	*278*	*56*	*475*	*284*	*376*	*86*	*1129*
BULGARIA	*30/06/2008*	*50*	*79*	*46*	*216*	*88*	*39*	*50*	*334*
TOTAL-EUR-7		*94*	*1969*	*90*	*4793*	*196*	*986*	*98*	*7748*
CZECH Rep.°°	*31/08/2008*	*89*	*482*	*91*	*1044*	*124*	*120*	*92*	*1646*
SLOVENIA°°	*30/06/2008*	*104*	*171*	*90*	*399*	*182*	*4*	*94*	*574*
MALTA°°°	*31/05/2008*	*90*	*17*	*120*	*75*	*119*	*203*	*117*	*295*
CYPRUS°°°°	*31/07/2008*	*92*	*89*	*106*	*235*	*103*	*352*	*102*	*676*
TOTAL-EUR-11		*94*	*2728*	*91*	*6546*	*149*	*1665*	*97*	*10939*

Notes: Reserves held for the following categories, on the basis of 2007 consumption:
CATEGORY I - Motor spirit and aviation fuel of gasoline type;
CATEGORY II - Gasoil, diesel oil, kerosene and jet-fuel;
CATEGORY III - Fuel oils.

* among which crude oil and intermediate products stocks converted into finished products (per category), in according to Article 5 of Council Directive 2006/67 EC.
°° CZ-SI: 90-day obligation since 31.12.2005.
°°° MT: 90-day obligation since 31.12.2006.
°°°° CY: 90-day obligation since 31.12.2007.

In March 2007 the European Council launched a public consultation to underline the need to enhance the security of supply for the EU as a whole and for each Member State also by developing more effective crisis response mechanisms. It highlighted in this context the need to review EU oil stock mechanisms, complementary to the crisis mechanism of the International Energy Agency (IEA), especially with respect to the availability of oil in the event of a crisis. In this spirit, in April 2008 the European Commission launched a public consultation about reforming Europe's oil stockholding legislation.

The main aspects of the arrangements which according to the EC called for improvement are: a fragmented legislation that should be consolidated; the real availability of stocks; the effectiveness of the stock system; the need for closer coordination with the IEA; the need for transparency of stockholding information.

To bring about significant improvements in these areas, the EC's proposal entails the following legislation amendments:

i) 90-day obligation characteristics brought closer to IEA practices. The EC notes that

> an approximation of the actual calculation to the IEA practice can bring about benefits.

ii) This approximation would mainly involve a switch from a consumption-based calculation method to the net import-based method used by the IEA and the introduction of the 10% deduction to take account of unavailable stocks. This change would make the level of the overall obligation under EU rules identical to the one mandated by the IEA, bringing about important practical simplifications in compliance.

iii) Strengthened government control for part of the stocks. The EC notes that while a full government-based system in which all emergency stocks were held by a government/agency could considerably improve the capability and effectiveness of the whole EU emergency response system, ensuring that 90 days of stocks would be available in all Member States at all times, the costs would outbalance the benefits associated with the incremental security. Instead, the Commission suggests strengthening the emergency system by using a combination of both stockholding systems, following the successful examples of countries in other parts of the world. Under this option the Member States could be obliged to maintain a minimum proportion, for example at least a third, of their obligation as dedicated stocks under stricter control of government authorities.

iv) Reinforced verification and control. Reinforcement of the monitoring activities on the part of the Commission on the compliance of Member States may be necessary to assure oil markets that European emergency oil stocks and related policies are effectively functioning. The EC deems that, on the basis of its current experience, reinforcing the related procedures appears necessary and it may be necessary to allow the Commission to appoint auditors in order to verify the emergency stocks of the Member States.

v) Coherent emergency procedures.

The Commission services consider it necessary to develop and implement clear and transparent rules for the EU on how to act in a supply crisis in a coordinated manner. In crisis circumstances it is essential to collect the necessary information, to evaluate the situation, in particular from a European perspective, to provide effective consultation with Member States and, if necessary, to make swift decisions on the best course of action for the EU". Coordination with the IEA is considered necessary, as it remains the principal authority for coordinating international responses to oil crises.

vi) Improved reporting and data availability.

Currently the Commission (DG TREN) collects data on the emergency oil stocks via a dedicated questionnaire, as provided under Council Directive 2006/67/EC. If the obligations under EU rules are approximated to those of the IEA, the Monthly Oil and Natural Gas Statistics (MOS) could substitute the current special questionnaire of the Commission that has to be filled out regularly by the Member States. It should be investigated whether the submission deadlines of MOS could be shortened and to what extent the JODI (Joint Oil Data Initiative) reporting could replace it. Both MOS and JODI are included in the proposed "Energy Statistics Regulation" and are already collected by the Commission (Eurostat), so their use would not increase the administrative burden on Member States.

vii) Updated rules for Biofuels.

The Commission services consider that biocomponents blended into motor fuels should entail a stockholding obligation, while pure biofuels should be exempt. Blended products could count towards meeting the stockholding obligation. The IEA methodology embraces the same logic - the biofuel content of imported fuels is taken into account when calculating the stockholding obligation, but pure biofuels do not qualify as emergency stocks and their imports do not give rise to a stockholding obligation.

5.6. Case-Study: Cost-Benefit Analysis of EU Biofuel Policies

Azar, Johansson and Hedenus (2008) look at the role biofuels can play in the EU's energy policy, in particular given their poor potential for mitigating CO_2 emissions. The research question investigated is whether it could make sense to use biofuels in a security of supply perspective, as a means to reduce the impact of supply disruptions of traditional fuels. In particular, the paper compares the impact of using domestic ethanol and imported ethanol. Only the latter turns out to be (cost) effective against supply disruptions. The authors mention that damages to the EU resulting from oil supply disruptions may also be reduced by insurances and release of stockpiled oil, although these policy options are not considered in their analysis.

Azar et al (2008) start by analyzing how domestic energy policies can reduce the Expected economic Cost of oil Disruptions, *ECD*. The expected cost of an oil disruption in a base scenario is given by *ECD*, and in a policy scenario by *ECD'*. The expected reduced economic loss of an oil disruption due to a policy, ΔECD, may then be computed as.

$$\Delta ECD = ECD - ECD'$$

Energy policies affecting the oil market can also reduce the oil price, and the EU may thereby obtain a monopsony power gain, *MP*. Thus, the GrossExpected Economic Gain, *GEG*, of a policy is

$$GEG = \Delta ECD + MP$$

Proper cost/benefit analysis is performed by computing the Net Expected Economic Gain of a policy, NEG:

$$NEG = \Delta ECD + MP - Z$$

where *Z* represents the policy costs. Azar et al(2008) note that the economic damage of an oil shock is usually divided into three parts: wealth transfer, social surplus loss, and macroeconomic adjustment cost.

Wealth is transferred to oil exporters as long as the oil price is higher than the extraction cost. Still, an increased price due to an oil disruption implies an additional wealth transfer to oil exporters. This transfer is a pecuniary externality, and hence it does not bring about an efficiency loss for the global economy. Therefore, from the global perspective, there are no efficiency reasons for introducing policy instruments in order to reduce the wealth transfer. From the perspective of an individual oil-importing country, however, wealth transfer is a cost; therefore wealth transfer is often part of discussions about oil imports (Leiby, 1997; Parry and Damstadter, 2003).

Econometric studies have found that the GDP growth often slows down when there is a sudden oil price increase. One part of this cost consists of a deadweight loss due to increased prices (the so-called social surplus loss). Azar et al (2008) note that the total economic damage found in the econometric studies is significantly higher. These additional costs are attributed to macroeconomic adjustment costs. The macroeconomic adjustment cost occurs in conjunction with sudden oil price increases, and stems from factors such as shifted demand, decreased productivity in energy capital, balance of trade effects, and sticky wages.

Macroeconomic adjustment costs depend on the total use of oil in the economy rather than the amount of imported oil (Jones et al, 2004). The macroeconomic adjustment cost is transitory, and seems to be independent of how long the oil price remains high. Also, the oil price has an asymmetrical impact on GDP: increased oil prices hamper GDP growth, but reduced oil prices do not boost the economy (Lardic and Mignon, 2006) . Finally, the macroeconomic adjustment cost depends both on the oil price increase and on the macroeconomic conditions, see Barsky and Kilian (2004) and Huntington (2004).

Azar et al (2008) point out that whether the expected costs of an oil disruption are externalities or not is still debated. If the market anticipates the oil disruption it adjusts its investment decisions so as to be less vulnerable to the oil price increase. On the other hand, macroeconomic adjustment costs tend to increase the more oil-intensive the economy is as a whole. This effect is rather economy-wide than firm-specific and is therefore to a large degree an externality.

Scenarios

Azar et al (2008) simulate four policy scenarios, and compare these to the actual situation in 2004. The four policy scenarios studied are:

i) Imported ethanol: 1.6 EJ[7] gasoline (corresponding to 10% of the energy in the road transport sector) is replaced by imported ethanol.
ii) Domestic ethanol: 1.6 EJ gasoline is replaced by domestic ethanol.
iii) More efficient cars: 1.6 EJ less oil is used in the road transport sector.
iv) Biomass in households: 1.6 EJ oil is replaced by domestic solid biomass in the household sector.

These scenarios have been chosen because they represent policies that are ongoing or under scrutiny in the EU, and because they represent different mechanisms by which EU-25 can gain energy security benefits.

The first two scenarios increase the supply to the liquid fuels market. Efficient cars on the other hand reduce the demand for liquid fuels. Biomass in the household sector scenario also reduces demand for liquid fuels, since oil is replaced by solid biomass, whose price is not currently linked to the prices in the liquid fuel markets. Azar et al (2008) label the last two scenarios as demand reduction scenarios, whereas the first two are called ethanol scenarios.

Risk of disruption and oil parameters

Azar et al (2008) estimate the risk and size of disruptions from historical data between 1960 and2003, compiled in Beccue and Huntington (2005). They divide the probability into three categories (see Table 5.9). In the first one they place large disruptions that are dependent on OPEC's production share, such as disruptions due to wars and internal unrests in OPEC countries. In the second one there are smaller disruptions of the same kind. In the third category are included accidents and deliberate disruptions, such as the Saudi embargo during the Yom-Kippur war in 1973.

Table 5.9
Probability, size and duration of oil supply disruptions

	Probability per year δ_k	Size n_k	Duration (months)
1	*11%*	*13% of OPEC*[a]	*7*
2	*23%*	*2.7% of OPEC*[b]	*5*
3	*18%*	*0.7million bbl/day*	*4*

Notes: a) In the base scenario this corresponds to a disruption of 3.8 bbl/day; b) In the base scenario this corresponds to a disruption of 0.8 bbl/day.

The oil price GDP elasticity for the EU is set to -0.04 in the base case, but it is varied in the sensitivity analysis. This is within the range of -0.02 to -0.06 reported in an overview by Leiby et al (1997). Jones et al (2004) report - 0.055 as a best estimate of the oil price-GDP elasticity in a later overview.

The energy use, import, domestic supply and import prices for the EU-25 are obtained from IEA (2007a) and the global demand and supply data from BP (2004).

Long-run demand and supply elasticities have been estimated to about -0.65 and 0.46, respectively, while short-run demand and supply elasticities have been estimated to -0.07 and 0.07, respectively (Greene and Leiby, 2006). For 2004, a medium-run elasticity is suitable since 2004 falls in the middle of an oil price increase. Azar et al (2008) set the supply and demand elasticities to 0.3 and -0.33, respectively, claiming that these values give a good fit with the actual production and price for 2004.

Scenario costs and greenhouse gas emissions

Azar et al (2008) estimate the cost of the four different policies by calculating the annualized investment cost and fuel costs for consumers without taxes. In the ethanol scenarios the ethanol is blended into the gasoline; therefore there are no extra costs for the vehicles. In the efficiency scenario they assume that hybrid cars are introduced on a large scale, which reduces fuel consumption. For the fourth scenario, they assume pellets instead of oil are used for residential heating. For all cost calculations, a discount rate of 5%/year is used. Greenhouse gas emissions are based on life-cycle emissions and converted into CO_2 equivalents by using Global Warming Potentials calculated over a 100-year time horizon. The basis for the cost estimates and greenhouse gas emissions is found in Table 5.10.

Table 5.10
Cost estimates and greenhouse gas emissions for energy technologies used in selected policy scenarios

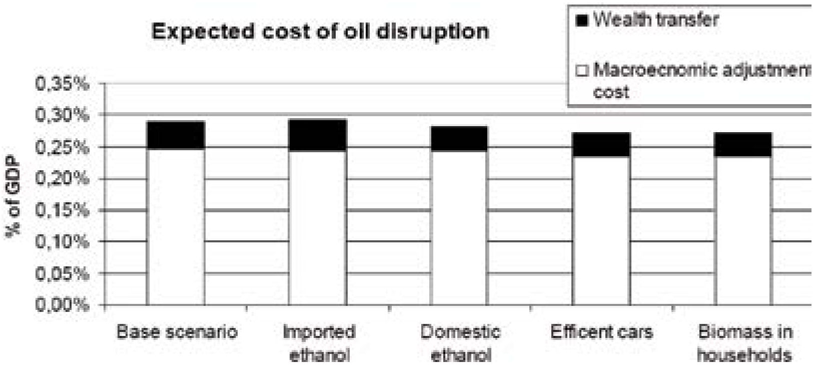
Cost estimate based on	Vehicle cost (€)	Inv. Cost (€/kW)	Fuel price (€/GJ)	Total cost	GHG emissions (kg CO_2eq/GJ)
Gasoline	*21500*		*9.3*[a]	*0.14 €/km*	*95*[b]
Sugar cane	*21500*		*13.3*[c]	*0.15 €/km*	*20*[b]
Wheat	*21500*		*30.8*[c]	*0.19 €/km*	*50*[b]
Hybrid car	*25400*[d]		*9.3*[a]	*0.16 €/km*	*95*[b]
Oil heater		*15*[f]	*7.0*[a]	*7.9 €/GJ*	*90*[e]
Pellet boiler		*50*[f]	*10*[g]	*14.4 €/GJ*	*12*[e]

Notes: a) EUROSTAT (2007); b) Concawe (2006); c) Hammerlink (2004); d) OECD/IEA (2006); e) Dones et al. (2003); f) STEM/KO (2006); g) European Pellets Center (2007).

Results

The expected cost of oil disruption in Azar et al (2008) base and policy scenarios is 0.27-0.29% of GDP or between 29.5 and 31.6 billion Euros a year, as shown in Figure 5.1. The largest cost is the macroeconomic adjustment cost, which constitutes around 85% of the expected economic cost of oil disruption. In the imported ethanol scenario, the expected cost of oil disruption is slightly higher, whereas the opposite holds true in the other policy scenarios. Efficient cars and biomass in households have the largest reduction in the expected cost among the policy scenarios.

Figure 5.1
Expected economic costs of oil disruption for selected policy scenarios



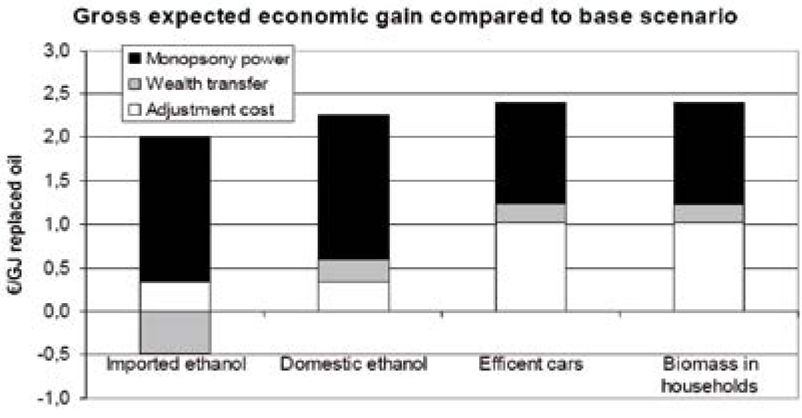
Source: Azar et al. (2008).

Figure 5.2 shows that in the imported ethanol scenario there is an increased wealth transfer compared to the base scenario, from the fact that the price of ethanol increases even more and remains high for a longer period of time than the oil price (according to their analysis). Since ethanol is imported, wealth is transferred to the ethanol exporter instead of to the oil exporter. The post-disruption oil price is in this scenario lower than in the base scenario (this tends to reduce the additional wealth transfer but not enough to compensate for the increased ethanol price). The lower oil price increase (in relative terms) reduces the macroeconomic adjustment cost. In addition, the macroeconomic adjustment cost is lowered since the oil price GDP elasticity is reduced. The latter effect is small, however, since the ethanol price is closely linked to the oil price.

In addition to changes in the expected cost of oil disruption, energy policies yield a monopsony power gain for the EU 25 in all scenarios. The monopsony gain is largest in the ethanol scenarios, since OPEC's market share is reduced more in the scenarios in which liquid fuel is added to the market as compared to scenarios which reduce demand. This is in line with the study by Hoftyzer et al (1989), who analyze how the market share of the dominant firm is affected by changes in base demand.

The lower the market share, the more difficult it is for OPEC to maintain a high price. Therefore, the monopsony power gain is higher in the ethanol scenarios.

Figure 5.2
Gross expected economic gains for selected policy scenarios



Source: Azar et al. (2008).

In the domestic ethanol scenario the gross benefit is larger than in the imported ethanol scenario, since the wealth transfer is reduced as compared to the base scenario. The reason for this is that the wealth is transferred to domestic producers and therefore not considered a cost.

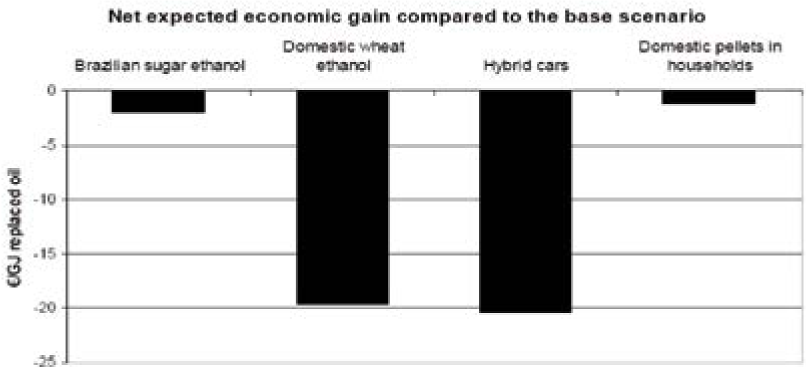
In the biomass in households scenario there is an increased use of pellets. Since pellets do not have a price correlation to the oil price in the short term, there is a reduced wealth transfer in this scenario. In the more efficient cars scenario the same holds true, since less oil is imported.

In the demand reduction scenarios the relative price increase after a disruption is slightly higher than in the base scenario. This would have led to a slightly higher macroeconomic adjustment cost if it was not taken into account that the liquid fuel intensity is reduced because of this policy measures. The combined effects of these two changes result in a reduction in the macroeconomic costs; hence the reduction in the liquid fuel intensity more than offsets the relatively higher price increase.

Azar et al (2008) calculate the net expected economic benefits in the policy scenarios, according to equation (3). In all scenarios, the cost of the policy outweighs the expected economic benefits (See Figure 5.3). The pellets scenario is the closest to being cost-efficient. Pellet prices in the EU vary significantly between countries; therefore, this policy may be cost-efficient in some EU countries where the pellet price is low.

The cost of implementing a scenario with imported sugarcane based ethanol is significantly lower than the cost of all other transportation scenarios. Therefore, among the transportation scenarios, the imported ethanol scenario gains the largest net benefits even if the gross benefit was the lowest among all the scenarios. The more efficient cars scenario showed quite high gross expected economic gain. But when implemented with hybrid cars, the cost by far exceeds the benefits. More efficient cars may, however, be obtained to a lower cost if consumer preferences regarding passenger vehicles change. In addition, important cost reductions for hybrid systems can be expected in the future if these are deployed on a largescale, because of economiesof scale and learning-by-doing.

Figure 5.3
Net expected economic gains for selected policy scenarios



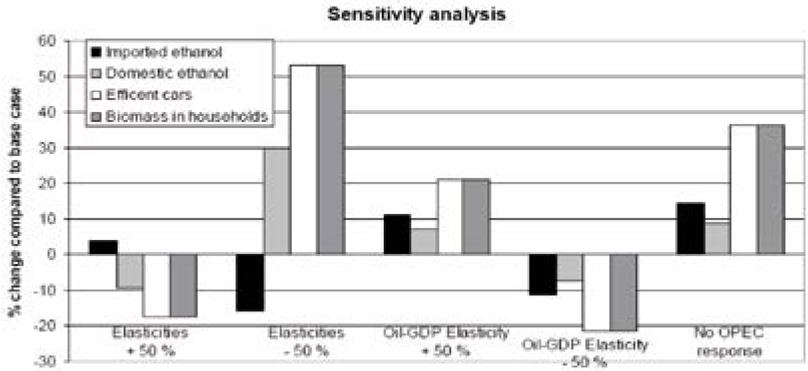
Source: Azar et al. (2008).

Azar et al. (2008) perform a sensitivity analysis of the gross expected economic gain with respect to the short run supply and demand elasticities, the oil-GDP elasticity, and the OPEC response to the EU energy policy.

Increasing short-term supply and demand elasticities by 50 % results in lower post disruption oil price. This reduces the benefit of energy policies in all scenarios except the imported ethanol scenario. The opposite result holds true if the elasticities are lowered by 50% (see Figure 5.4). The reason why imported ethanol stands out is that a higher post-disruption oil price increases the wealth transfer, which is a negative term in this scenario. Therefore the gross economic gain is reduced as compared to the base case, and vice versa when the elasticities were 50% higher.

If oil GDP elasticity increases, the benefits of energy policies increase in all scenarios (and vice versa).

Figure 5.4
Sensitivity analysis of the gross expected economic gains due to selected energy policies

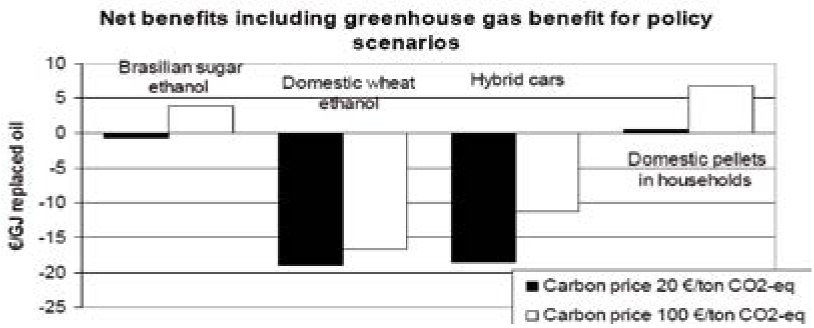


Source: Azar et al. (2008).

In the non-OPEC response case, OPEC does not adjust production when the EU implements its energy policy; rather, the oil supply is kept constant at its original level,

This affects the demand reduction scenarios the most. In the demand reduction scenario OPEC's market power was less reduced because of the policy than in the ethanol scenarios. If OPEC is not using its market power, the benefits of this will be higher in the demand reduction scenarios than in the ethanol scenarios. Even though there are some changes in gross economic gain in the sensitivity analysis, none of the policies become cost-efficient. All the policy scenarios studied also reduce greenhouse gas emissions. Azar et al (2008) therefore also add a greenhouse gas benefit to the gross economic gain. They consider two alternative carbon prices: (a) 20 and (b) 100 €/ton CO_2-eq. In this case they find that pellets in households and imports of Brazilian ethanol reach break-even at a carbon price of ca 20 €/ton CO_2-eq, whereas for a carbon price of 100 €/ton CO_2-eq both scenarios are clearly cost-efficient. Hybrid cars and domestic wheat ethanol do not yield net benefits even in these cases (Figure 5.5).

Figure 5.5
Net benefits, including greenhouse gas benefits



Source: Azar et al. (2008).

The results on macroeconomic costs are based on the assumption that oil price-GDP elasticity is proportionate to liquid fuel expenditure per GDP. Azar et al (2008) stress that, while there are theoretical reasons for this assumption and some empirical support, the exact relation is of course unknown; moreover, they note that it is unclear how to incorporate ethanol use in this framework: if only the instant price correlation is considered, the effect on macroeconomic adjustment cost is roughly the same as for the demand reduction scenarios, but if on the other hand we compare the crude oil expenditure (instead of gasoline) in the base scenario to the crude oil and ethanol expenditure in the ethanol scenarios, this increases macroeconomic adjustment costs. Domestic ethanol is not cost-efficient either way, whereas the question of cost efficiency remains ambiguous for the imported ethanol scenario.

The ethanol scenarios and the demand reduction scenarios act mainly through different mechanisms.

Increased liquid fuel supply has a stronger effect on OPEC's market power, and thereby the pre-disruption oil price, than a corresponding reduction in demand for liquid fuels. This means that the monopsony power gain is larger in the ethanol scenarios than in the demand reduction scenarios. Furthermore, the relative price increase after the oil shock is smaller when there is more liquid fuel supply on the market. This means reduced macroeconomic adjustment cost and wealth transfer if the new fuel is produced domestically.

In the demand reduction scenarios the relative price increase is larger than in the base scenario. Still, the macro economic adjustment cost is lower in the demand reduction scenarios than in the ethanol scenarios, since oil price-GDP elasticity is reduced because of lower oil expenditure. The ethanol price is strongly linked to the oil price, therefore there is only a small reduction in oil price-GDP elasticity in the ethanol scenarios.

The ethanol scenarios mainly yield benefits through reduced pre- and post-disruption oil price, whereas the demand reduction scenarios mainly gain benefits through reduced oil price-GDP elasticity. Their analysis shows that the gross benefits are larger if demand is reduced rather than if additional supply is added.

UPDATES

U1. The NBS collected data on energy and petroleum import-export in China between 2000 and 2012 (Table 1 and Table 2). The chart compares the import dependency rate of total energy and petroleum.

Table 1
Total energy import–export

Year	Total Energy Import (10000tce)	Total Energy Export (10000tce)	Total Energy Consuption (10000tce)	Energy Import Dependency (%)
2000	*14334*	*9633*	*145531*	*9,85*
2001	*13471*	*11145*	*150406*	*8,96*
2002	*15769*	*11695*	*159431*	*9,89*
2003	*20048*	*12989*	*183792*	*10,91*
2004	*26593*	*11646*	*213456*	*12,46*
2005	*26952*	*11448*	*235997*	*11,42*
2006	*31171*	*10925*	*258676*	*12,05*
2007	*35062*	*9995*	*280508*	*12,50*
2008	*36764*	*9955*	*291448*	*12,61*
2009	*47313*	*8440*	*306647*	*15,43*
2010	*55737*	*8846*	*324939*	*17,15*
2011	*62262*	*8447*	*348002*	*17,89*
2012	*66598*	*7375*	*361732*	*18,41*

Table 2
Petroleum import-export

Year	Total Energy Import (10000tce)	Total Energy Export (10000tce)	Total Energy Consuption (10000tce)	Energy Import Dependency (%)
2000	*9748,5*	*2172,1*	*22495,9*	*43,33*
2001	*9118,2*	*2046,7*	*22888,4*	*39,84*
2002	*10269,3*	*2139,2*	*24789,2*	*41,43*
2003	*13189,6*	*2540,8*	*27125,8*	*48,62*
2004	*17291,3*	*2240,6*	*31700,5*	*54,55*
2005	*17163,2*	*2888,1*	*32537,7*	*52,75*
2006	*19453,0*	*2626,2*	*34876,2*	*55,78*
2007	*21139,4*	*2664,3*	*36658,7*	*57,67*
2008	*23015,5*	*2945,7*	*37302,9*	*61,70*
2009	*25642,4*	*3916,6*	*38384,5*	*66,80*
2010	*29437,2*	*4079,0*	*43245,2*	*68,07*
2011	*31593,6*	*4117,0*	*45378,5*	*69,62*
2012	*33088,8*	*3884,3*	*47650,5*	*69,44*

U2. In November 2014 the statistics bureau said that "the oil bases are storing a total of 12.43 million tons of crude, or 91 million barrels, just under 90% of the total storage capacity of 103 million barrels" (Reuters, 2014).

U3. China's average net total oil imports reached 6.1 million bbl/d in 2014. Crude imports now outweigh domestic supply, and they made up over half of total oil consumption in 2013. The government's current Five-Year plan targets oil imports reaching no more than 61% of its demand by the end of 2015. EIA expects China to import over 66% of its total oil by 2020 and 72% by 2040, as demand is expected to grow faster than domestic crude supply.

The Middle East remains the largest source of China's crude oil imports, although African countries, particularly Angola, have begun contributing more to China's imports in recent years. As part of China's energy supply security policy, the country's NOCs are attempting to diversify supply sources in various regions through overseas investments and long-term contracts. In 2013, Saudi Arabia supplied 19% of crude oil imports, Angola 14%, Russia 9%, Oman 9%, Iran 8% and Iraq 8%. The Middle East supplied 2.9 million bbl/d (52%). Other regions that export to China include Africa with 1.3 million bbl/d (23%), the Americas with 562,000 bbl/d (10%), the Asia-Pacific region with 129,000 bbl/d (2%), and 736,000 bbl/d (13%)

from other countries (EIA, 2015).

U4. Chinese domestic oil production reached 207 million tons in 2012, ranking as the 4th largest, after Russia, Saudi Arabia and the USA. China consumed 467 million tons of crude oil in the same year, ranking 2nd in the world after the USA. In 2012, China imported 271 million tons of crude oil, ranking 2nd after the USA (IEA, n.d. f and NBS, n.d.).

U5. On December 2, 2014 the Ministry of Commerce published some news about phase I of China's National Oil Reserve Project.
The first phase of China's national oil reserve project has been put into use. The project contains four national oil reserve bases in Zhoushan, Zhenhai, Dalian and Huangdao, with a total reserve capacity of 16.4 million cubic meters and a reserve of 12.43 million tons of crude oil. The Zhoushan national oil reserve base has a reserve capacity of five million cubic meters with 3.98 million tons of crude oil reserve. The Zhenhai national oil reserve base has a reserve capacity of 5.2 million cubic meters with 3.78 million tons of crude oil reserve. The Dalian national oil reserve base has a reserve capacity of three million cubic meters with 2.17 million tons of crude oil reserve. The Huangdao national oil reserve base has a reserve capacity of 3.2 million cubic meters with 2.5 million tons of crude oil reserve. (MOFCOM, 2014).

U6. During the Eleventh Five-Year Plan period, a total of 21.2 billion yuan from the central government was spent on the development of biogas in rural areas. By the end of 2010, the number of household biogas users amounted to over 40 million or 33.3% of the national total, with proper conditions for biogas use benefiting 155 million people.
In the past five years, more than 22 million biogas projects for individual household use were finished (among which 20 thousand small-scale ones and 3192 large-scale ones).
During the Eleventh Five-Year Plan period, with funds from the central government budget, 77.6 thousand rural service sites and 50 county service stations were set up for 30 million rural households or 75% of the rural total, playing an important role in supporting biogas use.
By the end of 2010, it was expected that biogas production would reach over 16 billion cubic meters (about 13% of the national annual consumption of natural gas), which would equal over 25 million tons of standard coal, reducing carbon dioxide by more than 50 million tons; and nearly 400 million tons of biogas manure could be produced annually, allowing a more than 20% reduction in the use of pesticides and fertilizers and improving 80 million mu (5.33 million ha) of farmland. (Zhang & Lin, 2011).
In 2011 the central government invested 4.3 billion yuan to subsidize the development of rural biogas projects. The government's effort has resulted in 2.8 million additional biogas household users and an average subsidy

increase of 32.5%. The standard subsidy was increased to 1300 yuan, 1600 yuan and 2000 yuan for the eastern, central and western regions, respectively, 3500 yuan for the Tibet Autonomous Region, and 3000 yuan for the Tibetan areas in Sichuan, Yunnan, Gansu and Qinghai provinces, and for three other prefectures in south Xinjiang Autonomous Region (MOA, 2013).

U7. By the end of 2011 39.96 million households had domestic biogas digesters (Zuzhang, 2013).

U8. In 2011 the standard subsidy was increased to 1300 yuan, 1600 yuan and 2000 yuan for the eastern, central and western regions, respectively, 3500 yuan for the Tibet Autonomous Region, and 3000 yuan for the Tibetan areas in Sichuan, Yunnan, Gansu and Qinghai provinces, and for three other prefectures in south Xinjiang Autonomous Region (MOA, 2013).

U9. In 2014 Brazil and the United States together accounted for 83% of global ethanol production (RFA, 2015).

U10. [COM (2008)19] was a proposal for a Directive, adopted on April 23, 2009 as Directive 2009/28/EC.

U11. In 2010 the share of renewable fuels used in transport was 4.7% (EC, 2013a).

U12. In theUSDA reports (2013 and 2014) some values were revised:

	2008	**2009**	**2010**	**2011**	**2012**	**2013[e]**	**2014[f]**	**2015[f]**
Production	*9550*	*9860*	*10710*	*11040*	*10475*	*10890*	*10890*	*11000*
Imports	*2020*	*2190*	*2400*	*3160*	*3290*	*1415*	*1740*	*1400*
Consumption	*10400*	*12270*	*13270*	*14070*	*13390*	*12220*	*12280*	*12280*
Exports	*70*	*75*	*115*	*100*	*115*	*415*	*230*	*230*

e: estimate
f: forescast

U13. In 2012 the largest producers were Germany (28%), France (18%), Benelux (13%) and Poland (6%) (USDA, 2014).

U14. In 2012 the largest consumers were Germany (21%), France (19%), Italy (12%) and Spain (12%) USDA, 2014).

U15. In the USDA reports (2013 and 2014) some values were revised:

	2008	**2009**	**2010**	**2011**	**2012**	**2013[e]**	**2014[f]**	**2015[f]**
Production	*3466*	*4203*	*4918*	*5042*	*5460*	*5840*	*5900*	*5960*
Imports	*1451*	*1249*	*1230*	*1637*	*1176*	*945*	*830*	*855*
Consumption	*4459*	*5553*	*6203*	*6653*	*6626*	*6520*	*6585*	*6650*
Exports	*112*	*150*	*126*	*149*	*145*	*132*	*240*	*175*

e: estimate

f: forescast

U16. According to EIA data, in 2012 bioethanol represented 28% of total biofuel production.
U17. Imports of bioethanol to the EU increased by 165% in 2006 and 2008. Imports started decreasing in 2012 (USDA, 2014).
U18. In 2012 the most important EU bioethanol producers were France (24%), Benelux (19%) and Germany (16%) (USDA, 2014).
U19. “In the EU, bioethanol is mainly produced from wheat, corn, barley, rye, and sugar beet derivatives. Wheat is mainly used in northwestern Europe, while corn is predominantly used in Central Europe and Spain. When the EU domestic wheat supply is tight, producers in northwestern Europe commonly switch to imported corn. Rye is used for bioethanol production in Poland, the Baltic Region and Germany, while barley is mainly used in Germany and Spain. In Italy, about 30% of bioethanol is produced from wine byproducts and about 10% directly from wine” (USDA, 2014).
U20. In June 2014 total oil stocks in IEA member countries totaled a number of barrels equivalent to 221 days of net imports, of which 93 in public reserves and 128 in industry reserves (IEA, 2014).
U21. Directive 2006/67/EC, Council Decision 68/416/EEC and Council Directive 73/238/EEC were repealed by Directive 2009/119/EC.
U22. In 2013, five Member States (Greece, Italy, Luxembourg, Sweden and the United Kingdom) relied entirely on mandatory industry stocks (IEA, 2014).
U23. IEA countries that also belong to the European Union typically hold product stocks based on EU regulations, which require that at least one third of the obligation be covered by product stocks.
In 2013 nearly 60% of the stocks in IEA Europe were held in the form of petroleum products (IEA, 2014).
U24. DG TREN is currently DG Energy.
U25. Data for Table 5.8 until 2012 are available at EC, (2013b).

APPENDIX A

China's Energy Security Policies - Experts' Evaluation

Table A.1
Experts' evaluation of China's energy security policies

Panel 1 Energy Security Policy-Going-out Strategy for Enterprises					
Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Increased energy supply channels,	*6*	*0*	*Increased investment*	*2*	*4*
Increased energy supply	*4*	*2*	*Increased diplomatic costs*	*4*	*2*
Profits of overseas energy exploitation	*3*	*3*			
Total Scores	*39*	*5*		*18*	*6*
Policy Benefits	*44*		***Policy Costs***	*24*	
Conversion Factor	*81.48*			*66.67*	

Panel 2 Energy Security Policy-Policy Adjustment for Energy Export Duty Rebates					
Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Reduced energy exports	*5*	*1*	*Reduced profits of exporting enterprises*	*1*	*5*
Reduced government subsidies	*2*	*4*	*Declined volume of energy exports*	*3*	*3*
Total Scores	*21*	*5*		*12*	*8*
Policy Benefits	*26*		***Policy Costs***	*20*	
Conversion Factor	*72.22*			*55.56*	

Table A.1
(continued)

Panel 3 Energy Security Policy -Oil Reserve Strategy

Benefits	High Benefits	Low Benefits	Costs	High Costs	Low Costs
Improved energy security	*5*	*1*	*Increased government expenditure*	*3*	*3*
Stable prices	*1*	*5*	*Increased enterprises' expenses*	*2*	*4*
Total Scores	*18*	*6*		*15*	*7*
Policy Benefits	*24*		***Policy Costs***	*22*	
Conversion Factor	*66.67*			*61.11*	
Conversion Factor	*81.48*			*66.67*	

Panel 4 Energy Security Policy -Policy on Encouraging the Development of Biomass Energy

Benefits	High Benefits	Low Benefits	Costs	High Costs	Low Costs
Guaranteeing energy supply	*2*	*4*	*Increased grain and oil prices*	*3*	*3*
Development and reservation of new energy technologies	*3*	*3*	*Reduced edible grain and oil supply*	*2*	*4*
Reducing carbon dioxide emissions	*3*	*3*	*Influence on fossil energy application*	*0*	*6*
Total Scores	*24*	*10*		*15*	*13*
Policy Benefits	*34*		***Policy Costs***	*28*	
Conversion Factor	*62.96*			*51.85*	

Table A.1
(continued)

Panel 5 Energy Security Policy -Policy on Encouraging Nuclear Power

Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Increased energy supply	*5*	*1*	*Higher cost of power generation*	*2*	*4*
Reduced pollution in coal use	*4*	*2*	*Disposal cost of nuclear waste*	*4*	*2*
			Potential safety risks	*3*	*3*
Total Scorse	*27*	*3*		*27*	*9*
Policy Benefits	*30*		***Policy Costs***	*36*	
Conversion Factor	*83.33*			*66.67*	

Panel 6 Energy Security Policy -Encouraging Foreign Investment to Enter Energy Exploration Sector

Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Application of overseas exploration technology	*5*	*1*	*Sharing domestic resource profits with foreign capital*	*4*	*2*
Employment of foreign capital	*4*	*2*			
Increased proven reserves	*3*	*3*			
Total Scores	*36*	*6*		*12*	*2*
Policy Benefits	*42*		***Policy Costs***	*14*	
Conversion Factor	*77.78*			*77.78*	

Notes: i) Each policy is evaluated by a pool of 6 experts with respect to a given set of benefits and costs. To each benefit (or cost) each expert assigns a score, according to whether he/she evaluates that benefit (or cost) to be high or low. If the benefit (or cost) is evaluated to be high, the score is equal to 3, whereas if the benefit (or cost) is evaluated to be low, the score is equal to 1; ii) Columns entitled "High Benefits" and "Low benefits" report, for each benefit, the number of experts who have evaluated that specific benefit to be high or low; iii)Columns entitled "High Costs" and "Low Costs" report, for each cost, the number of experts who have evaluated that specific cost to be high or low; iv) The row entitled "Total Scores" reports the sum of scores assigned to the benefits and the costs of a given policy, which the experts evaluateas high or low; v) The row entitled "Policy Benefits" reports the sum of high and low total scores recorded by the benefits associated with a given policy; vi) The row entitled "Policy Costs" reports the sum of high and low total scores recorded by the costs associated with a given policy; vii) The row entitled "Conversion Factor" reports the factor by which entries "Policy Benefits" and "Policy Costs" have to be divided in order to be converted into percentages.

NOTES

1 The main reference for this part is the National Rural Biogas Development Plan (2006-2010),Ministry of Agriculture, March 2007.

2 To produce enough biofuel to fill an SUV needs as much corn as would feed a poor family z

3 The urgent need to improve our knowledge in this field is vividly felt both in the scientific community and in the international policy arena. For instance, the final declaration of the Heads of State gathered at the FAO High-Level Conference on World Food Security: The Challenges of Climate Change and Bioenergy, of June 5, 2008 acknowledges that

(...) it is essential to address the challenges and opportunities posed by biofuels, in the view of world's food security, energy and sustainable development needs. We are convinced that in-depth studies are necessary to ensure that production and use of biofuels is sustainable in accordance with the three pillars of sustainable development and takes into account the need to achieve and maintain global food security. We are further convinced of the desirability of exchanging experiences on biofuels technologies, norms and regulations

4 E85 is a fuel mix of 85% ethanol and 15% gasoline (Slaski, 2008)

5 Council Directive 2006/67/EC of July 24, 2006, which imposes an obligation on Member States to maintain minimum stocks of crude oil and/or petroleum products, 0J L 217, 8.8.2006, p. 8; Council Decision 68/416/EEC of December 20, 1968 on the conclusion and implementation of individual agreements between Governments, relating to the obligation of Member States to maintain minimum stocks of crude oil and/or petroleum products, OJ L 308, 23.12.1968, p. 19; Council Directive 73/238/EEC of July 24, 1973 on measures to mitigate the effects of difficulties in the supply of crude oil and petroleum products, OJ L 228, 16.8.1973, p. 1.

6 Azar et al (2008) point to Huntington (1998) and Brown and Yücel (2002) for discussions of the reason for this asymmetry.

7 Exajoules

6. Energy Conservation Policies

CHINA

6.1. Evaluation of Energy Conservation Policies

Energy conservation means improving energy efficiency, reducing energy consumption as far as possible, and producing the same amount of products with the same quality; or producing more or the same amount of products with better quality by consuming the same quantity of energy.

Background of Energy Conservation Policies

The key points by which the Chinese government identifies its energy conservation policies are: its guideline "Focusing on Economic Construction" of 1978; rapid development of the Chinese economy; severe supply shortages; adoption of a "3-day shutdown, 4-day operation" production scheme; perception of energy as the "bottleneck" for the development of the national economy.

Along with its severe energy shortage of energy, a pattern of extensive economic growth has emerged. China's consumption of energy per unit of output value is at about twice the world's average level, 7 times that of Japan, 6 times that of the United States, and 2.8 times that of India. China's energy utilization efficiency is only 33%, about 10% lower than that of developed countries. Unit energy consumption of main products in the electrical, iron and steel, nonferrous metals, petrochemical, building materials, chemicals, light industry and textiles sectors, is 40 % higher than the advance international average; the energy consumption of these eight industries accounts for about 73% of the total consumption of the industrial sector. 80% of newly constructed buildings every year belong to high energy-consuming buildings; the per unit energy consumption for heating buildings is about three times that of developed countries. As for energy consumed for transportation, for example, the equivalent of 1.6 tons of oil is consumed in China's automobile production, while the United States consumes only 0.9 tons of oil equivalent for the same process.

Reducing energy consumption and improving energy efficiency is not only the goal of enterprises and institutions, but also of the government, which has adopted policy instruments for intervening to prevent excessive energy consumption by industrial and residential use. International experience also shows that no country in the world is promoting energy conservation simply by market forces; the visible hand of the government should play a leading role; besides improving relevant laws, the government should also formulate corresponding fiscal and tax policies to support these laws.

China's Major Energy Conservation Policies

China started to launch large-scale energy conservation campaigns in 1979. In 1980, the former State Planning Commission and State Economic Commission compiled the Five-Year Energy Conservation Plan and the Annual Energy Conservation Plan, and brought energy conservation into national economic planning. In 1978 China formulated its "Focusing on Economic Construction" guidelines; the Chinese economy has been developing rapidly and faced severely short energy supplies. Energy consumption by private industry was distributed according to quotas. Objectively speaking, the energy shortages were the biggest driving force of energy conservation. To this end, the government formulated its "Giving the Same Priority to Development and Conservation, Focusing on Conservation in the Recent Period" guidelines, which its strategy for developing energy conservation.

In 1997, the promulgation and implementation of the Energy Conservation Law set up the important position of energy conservation in Chinese economic and social construction, set forth the legal basis for "energy conservation as a long-term strategic guideline of national economic development", and provided legal guarantees for China's energy conservation campaigns. After the Energy Conservation Law was promulgated and implemented, China put reinforced the concept of energy conservation. In order to support the implementation of Energy Conservation Law, the Chinese government enacted associated regulations and policies, such as the China Energy Conservation Technology Policy Outline, Guidelines for the Establishment and Assessment of the Chapter "Energy Conservation" of Fixed Asset Investment, Measures of Management of Key Energy Consumption Units, Measures of Management of Electricity Conservation, Regulations on Management of Energy Conservation of Civil Architecture, Measures of China's Energy Conservation Product Certification Management, Measures of Energy Efficiency Label Management, National Standard Catalog of Energy Foundation and Management, etc.

With the gradual deepening of market structural reform, the Chinese government began to attempt market-based energy management policies, and constituted policies related to the promotion and dissemination of energy conservation technologies under market economy. These policies contributed to the improvement of Chinese energy conservation regulations, norms, and system standards.

To address the energy crisis during the "Tenth Five-Year Plan" period, the Chinese government highlighted the importance of strategic energy conservation, planning and industrial policy (for example, in June 2004, the State Council approved the Outline of Long-term and Mid-term Energy Development Planning (Draft), which went far to "form nationwide production and consumption modes beneficial to energy conservation, to develop an energy-efficient economy and to build an energy-saving society." In November 2004, the first long-term and mid-term plan in energy conservation field was promulgated; since 2004, Chinese government has instituted a series of policies for strengthening industrial structural adjustments in the coke, steel, cement and electrolytic aluminum sectors); and has further intensified standard labeling and certification of energy conservation.

During this period, energy efficiency standards for dozens of products, such as refrigerators, air conditioners, washing machines and lighting, were introduced; a series of standards and specifications relating to the energy conservation design of buildings, such as Standard of Energy Conservation Design of Residential Buildings in Regions with Hot Summers and Cold Winters, were introduced; Limits of Fuel Consumption for Passenger Cars (GB19578-2004) and the Catalogue of the People's Republic of China on Products on Which to Attach Energy Efficiency Labels (First List) was released in October and December of 2004, respectively. The promulgation and implementation of the above policies have alleviated China's energy supply and demand situation at the end of "Tenth Five-Year Plan" period, and will play a more important role in energy conservation and consumption reduction for well into the future. Table 1 in the Appendix lists China's major energy conservation policies.

Key Sectors and Effect of Energy Conservation

During the 30 years since reform and opening up, China's energy conservation efforts have made great achievements: In the early 1980s, the government formulated its energy development guidelines "Giving the Same Priority to Development and Conservation, Focusing on Conservation in the Recent Period"; in the mid 1980s, it established benefit-centered energy development and a utilization strategy and an electricity-centered energy consumption structure adjustment strategy; in the 1990s, the Chinese government set up various guidelines which further emphasized the general guidelines of energy development, promoting conservation and development concurrently while giving top priority to conservation. In the new century, energy conservation and emission reduction have become increasingly widespread; the new Energy Conservation Law has set resource conservation as China's basic national policy; energy conservation and the reduction of industrial emissions have become a major national campaign in which the entire society participates.

At the beginning of China's reform and opening up, the country's energy consumption per RMB10,000 GDP was 16 tons of standard coal; in 2005, the figure dropped to 1.22 tons of standard coal, a dramatic decrease. China's energy consumption per RMB10,000 GDP dropped 45% in 2004 as compared with 1990[U1], with accumulated energy conservation of 700 million tons of standard coal; coal consumed for thermal power generation decreased by 11%, comparable energy consumption per ton of steel production decreased by 29%, and comprehensive energy consumption for cement production decreased by 21.9%. From 1991 to 1995 gross investment in energy-saving infrastructure of the whole society was RMB25.32 billion, forming an annual energy conservation capacity of 14.96 million tce; 3,750MW of thermoelectricity units had been built up; 4 million m^3/d of town gas and released gas had been reclaimed; annual production capacity of commercial coal reached 5.4 million tons; annual coal washing capacity reached 6 million tons; cement production increased by 3 million tons; electricity saved by reforming blowers and pumps reached 400 million kWh; overall investment in energy-saving technological renovation of the whole society was RMB27.64 billion, forming an annual energy conservation capacity of 46 million tce.

Industrial Energy Conservation. To tackle issues of relatively backward industrial technology equipment and management, high energy conservation and low economic benefit, the Chinese government released five energy conservation orders: saving burning oil of all kinds of industrial boilers and industrial furnaces, saving electricity, saving refined oil, saving coal for industrial boilers, and developing reasonable energy consumption of coal washing and dressing.

The existing Coal-burning industrial boilers in China feature small volume, large quantity, scattered distribution and difficult governance. There are over 500,000 industrial boilers in use, with about 1.8 million steam tons/hour. Among these 500,000 industrial boilers, 480,000 are coal-burning boilers, accounting for about 85% of total industrial boilers; with an average capacity of 3.4 steam tons/hour, they consume about 400 million tons of raw coal every year. Chinese coal-burning industrial boilers have an average operating efficiency of 60-65%, 15-20% lower than the overseas advanced level; they release about 2 million tons of smoke dust, 7 million tons of sulphur dioxide, and nearly 1 billion tons of carbon dioxide every year; it is the largest coal soot type pollution source, second to that of thermal power plants.

The Chinese government amended its Catalogue for the Guidance of Industrial Structure Adjustment to encourage the development of advanced production capacity with lower energy consumption and low pollution; amended and promulgated the Catalogue for the Guidance of Foreign Investment Industries to encourage foreign capital to invest in energy-saving and environment-friendly sectors and severely restrict foreign projects with high energy consumption and high pollution, and promote industrial structure upgrading of foreign investment; modified the Prohibited Commodities Catalogue for the Processing Trade to improve access threshold of processing trade and promote renovation and upgrading of processing trade.

The Chinese government set high thresholds for land purchase, credit loans, and entry into energy-saving and environment-friendly markets; established a mechanism for integrating new projects to counter high energy-consuming and high-polluting industries, and local targets for energy conservation and emission reduction and backward capacity elimination; carried out various policies to restrict the import of high energy-consuming and high-polluting products.

Measures taken to control imports of high energy-consuming and high-polluting products included adjusting export rebates, increasing export tariffs, reducing export quotas, and listing some products in the prohibited commodities catalogue for the processing trades, etc.

Achievements were made in eliminating backward production capacity and improving the utilization of energy technology. Some reductions of energy consumption per unit of industrial added-value were observed in major energy-consuming industries: in the first quarter of 2008, the coal industry's dropped 3.79%, the steel industry's 3.84%, the building materials industry's 12.04%, the chemical industry's 5.29%, the textile industry's 7.69%, the power industry's 3.12%, the petroleum and petrochemical industries' 2.88%, and the non-ferrous metals industry's 2.51%[U2] .In the same period, coal consumption for thermal power generation dropped 2.23%and there were drops in comprehensive energy consumption for the production of coal (11.53% per ton produced), petroleum and natural gas (3.02% per unit), blister copper (5.05% per unit alumina (3.90% per unit), pure caustic soda (6.35% per unit), ethylene (4.08% per unit), synthetic ammonia (2.95% per unit), cement (7.31% per ton), and machine-made paper and cardboard (4.71% per unit).The comprehensive energy consumption for crude oil processing also dropped 4.01%.

Main Problems

The main problem in energy conservation is the low enthusiasm of consumers and enterprises due to the fact that energy conservation cannot save money. Therefore, forceful policies need to be made to mobilize consumers and enterprises. An efficient approach for the government would be to establish an incentive mechanism to promote energy-saving products and at the same time launch reasonable tax, operational, technological and market management incentives, and set up a subsidy mechanism for buying energy-saving products.

Cost-Benefit Evaluation of Energy Conservation Policies

Policy Selection. Selected Chinese energy conservation policies for evaluation mainly include: (1) Industrial energy conservation policies, among which "Set Up the Large Thermal Power Generating Units and Shut Down the Small Thermal Power Generating Units", "Energy Conservation and Emission Reduction Responsibility System", "Industrial Energy Consumption Technical Standard", "Cancel Differential Electricity Price in Energy-Intensive Industries", "Cancel Export Rebates in Energy-Intensive Industries", etc.; (2) Building energy conservation policies, among which "Building Energy Conservation Standard", and policies advocating "Office Energy Conservation" and promoting the utilization of "High Efficient Lighting" Lamp, etc.; (3) Transport energy conservation policies: Removing the ban on "Small-engine Cars"; and (4) Commercial energy conservation policies: Implementing the system of "Energy Efficiency Labeling of Home Appliances". Please refer to Table 6.1.

Cost-Benefit Analysis. Experts have scored and calculated the benefits, costs and benefit-cost ratios of various energy conservation policies. The results are shown in Table 6.1. Generally speaking, the benefit-cost ratio of energy conservation policies is above 1. This indicates that the benefits derived from implementing these energy security policies outweigh the costs. Among these policies, the benefit-cost ratio of "Set Up the Large Thermal Power Generating Units and Shut Down the Small Thermal Power Generating Units" is the highest, followed by "Cancel Differential Electricity Price in Energy-Intensive Industries". This shows that the benefits of energy conservation policies in the industrial sector are relatively higher than those of other energy conservation policies, with a benefit-cost ratio of 1.35; followed by energy conservation policies in the commercial sector, with a benefit-cost ratio of 1.33; the third group regards energy conservation policies in the building sector, with a benefit-cost ratio of 1.24; the fourth regards energy conservation policies in the transport sector, with a benefit-cost ratio of 1.06.

Table 6.1
Cost-benefit analysis of energy efficiency policies

Energy Conservation Policies	Specific Policies	Benefit	Cost	β=Benefit/ Cost	Evaluation policies
Energy conservation policies in the industrial sector	*Set up the Large Thermal Power Generating Units & Shut down the Small Thermal Power Generating Units*	*100.00*	*61.11*	*1.64*	*Extremely High Benefit*
	Energy Conservation & Emission Reduction Responsibility System	*91.67*	*69.44*	*1.32*	*High Benefit*
	Industrial Energy Consumption Technical Standard	*92.59*	*74.07*	*1.25*	*High Benefit*
	Cancel Differential Electricity Price in Energy-intensive Industries	*70.37*	*50.00*	*1.41*	*High Benefit*
	Cancel Export Rebates in Energy-intensive Industries	*77.78*	*66.67*	*1.17*	*High Benefit*

Table 6.1
(continued)

Energy conservation policies in the building sector	*Building Energy Conservation Standard*	*81.48*	*62.96*	*1.29*	*High Benefit*
	Office Energy Conservation	*58.33*	*51.85*	*1.12*	*High Benefit*
	High Efficient Lighting	*81.48*	*63.89*	*1.28*	*High Benefit*
Energy conservation policies in the transport sector	*Small-engine Cars*	*86.67*	*81.48*	*1.06*	*High Benefit*
Energy conservation policies in the commercial sector	*Energy Efficiency Labeling of Home Appliances*	*96.30*	*72.22*	*1.33*	*High Benefit*
Comprehensive Evaluation of Energy Efficiency Policies	*78.95*	*63.98*	*1.23*	*High Benefit*	

6.2. Case-Study: Cost-Benefit Analysis of Shutting Down Small Thermal Power Generation Units in Hubei Province

In the 11th five year plan period, Hubei Province's quota of small thermal power generation units to be shut down was 1.302 million kilowatts. The NDRC ordered it to shut down 17 units with a generation capacity of 353,000 kilowatts in 2007. The Hubei provincial government set the goal of ensuring the shutdown of at least 500,000 kilowatts, and of making an effort to shut down 600,000 kilowatts, in line with the need to improve energy efficiency and reduce emissions. It turned out that Hubei Province accomplished the greater task of shutting down 600,000 kilowatts 3 months earlier than planned without affecting the power supply. Therefore, Hubei Province finished within one year 46.3% of the five year task of shutting down small thermal power generation units.

The Hubei Provincial Economic Commission's inspection shows that 19 small thermal power generation units (with a capacity of 503,000 kilowatts) were dismantled in seven power plants (Hubei Guodian Qingshan Thermal Power Co., Ltd., Wuchang Power Plant, Huangshi Power Plant, Huangshi Xinyegang Company's self owned power plant, Jingzhou Jinneng Power Co., Ltd., Jingzhou

Chengnan Thermal Power Plant and Enshilichuan Shiba Thermal Power Plant). A small thermal power generation unit with a capacity of 100,000 kilowatts was shut down in the Guodian Jingmen Jiangshan Power Co., Ltd. To sum up, 20 small thermal power generation units (with a capacity of 603,000 kilowatts) were shut down in the above 8 companies and plants. After the shutdown of these small units, the average capacity of thermal power generation units increased to 267,000 kilowatts in Hubei, 70,000 kilowatts higher than the previous year; the number of large thermal power generation units with a capacity of at least 300,000 kilowatts adds up to 52% of the total thermal power generation units in Hubei, 10 percentage points more than the previous year.

The shutdown of small thermal generating units involves both direct and indirect costs.

Direct Costs

Direct costs include staff resettlement costs, local government expenditures and repayment of company debts.

Staff resettlement costs: according to the Hubei Economic Commission data, small thermal generating units with a combined capacity of 603,000KW were shut down in 2007, involving 5,342 staff, 2,865 of whom were in active employment. With funds pooled from various sources and through rotation and transfer within companies and placement by local labor authorities, all of them were adequately deployed elsewhere. For instance, the Wuchang Power Plant transferred 216 staff members to the neighboring provinces of Henan, Anhui and Hunan.

The shutdown of companies entails expenditures for resettlement of both retired and active staff -no matter in what ways they are resettled. In the absence of detailed data, we base our calculation of staff resettlement costs on the average salaries of Hubei's power sector. In 2006, the average salary of the province's power, gas and water supply sectors was 21,272 Yuan, so the expenditures for deploying the 5,342 staff members came to 113.64 million Yuan.

Local government subsidies: subsidies were provided by the Hubei Provincial Government in an attempt to move forward the decommissioning efforts. The government stipulated that a central company in the province was entitled to a subsidy of 300,000 Yuan for the shutdown of every 10,000KW capacity, and the subsidy for a local company was 600,000 Yuan. If calculated at an average level of 450,000 Yuan, then 27.14 million Yuan were needed for the 603,000 KW capacity shutdown in 2007.

Repayment of company debts: small thermal power companies have to deal with their debts when shutting down. They may satisfy their debts with the incomes that they are allowed to derive from the transfer of their generation rights within three years after the shutdown. The shortfalls need to be addressed according to the relevant government policies.

Indirect Costs

Indirect costs consist of substantial power investments, such as those in power sources and grids.

Investment in power sources: an important component of the policies regarding the shutdown of small thermal generating units is to build large capacity units to replace small capacity ones. According to this policy, if Hubei decommissions small units with a capacity of 600,000KW, it will be given a quota for units of 1 million KW. But in fact, this proportion is not respected. The new projects are still approved on the basis of their merits, without directly considering the call for shutting down small capacity units. The portion of investments related to this policy is, therefore, less than anticipated. As things stand now, only about 20% of the new units are built as a result of the shutdown of small capacity ones.

The year 2007 saw an addition of 13.0448 million KW of thermal generating capacity, therefore, if calculated at 20%, 2.6 million KW were built upon the shutdown of small capacity units. Our calculation of the investment cost is based on the 300,000 KW units. In 2006, the construction cost of such units was 3,850yuan/KW (final account) , so the investment cost of power sources was 10.01 billion Yuan.

Investment in power grids: the Hubei Electrical Power Company has planned a host of power transmission and distribution projects in light of the need to increase power consumption in order to ensure power transmission and supply following the shutdown. These projects include: the 500KV Wudong power transmission and distribution project with 2×1 million KVA transformers and 72km long power lines; building or expanding nine 220KV projects to add 1.71 million KVA transformers, and 226.3km long lines; building or expanding three 110KV projects to add 190,000KVA transformers and 36.9m long lines; and upgrading the 10KV distribution network. The total investment was expected to reach 2.6 billion Yuan.

The above investments were planned on the basis of Hubei's 11th Five-year Plan, according to which small thermal generating units with a total capacity of 1.302 million KW had to be shut down over that period. In 2007, the shutdown of 603,000 KW capacity required 1.2 billion Yuan in grid investment.

Benefits accruing from the shutdown of small thermal generating units were both direct (incomes from transferring generation rights) and indirect (environmental improvement).

Benefits From Generation Rights Transfer

This benefit is directly related to the policies regarding the shutdown of small thermal generating units. In order to ensure the smooth shutdown of small units, the NDRC and the State Power Regulatory Commission jointly introduced policies allowing small capacity plants that were shut down to transfer their generation rights to important large capacity ones so as to obtain incomes which can be used for staff resettlement and debt repayment. According to the Implementation Measures for the Transfer of Generation Quota by Small Thermal Generating Units to Efficient Units jointly issued by the Economic Commission and Price Bureau of Hubei, the 2 billion KWH power quotas of closed companies remaining for 2007 were transferred to the large capacity generating units. By doing so, the companies that had been shut down generated 180 million Yuan for dismantling units and staff resettlement.

Benefits of Environmental Improvement

The 603,000 KW capacity of small thermal generating units shut down by Hubei in 2007 reduced annual energy consumption by 1.5 million TCE and SO_2 emissions by 24,000 tons, or 3.2 percentage points, for the entire province.

EUROPEAN UNION

6.3. Case-Study: Cost-Benefit Analysis of Setting Uplarge Thermal Power Plants and Shutting Down Small Thermal Generation Units

Background

In this section we assess a cost benefit analysis in order to quantify the financial benefits of setting up large thermal power plants and shutting down small thermal generation units. The idea is that large thermal power plants are generally more efficient than the small generation units, and therefore they are suitable for energy conservation policies. As a result of a lower consumption of fuel, large thermal power plants are also more likely to produce electricity at a lower generation cost. Hence the first step is to collect data related to the power plant characteristics and to verify if small power plants are generally less efficient than large ones.

Power Plant Data. In 2005 a report published by OECD and undertaken jointly by the Nuclear Energy Agency (NEA) for the Committee for Technical and Economic Studies on Nuclear Energy Development and the Fuel Cycle (NDC) and by the International Energy Agency (IEA) conducted a study related to the costs of generating electricity[U3]. This study provides a large quantity of data for more than 130 power plants in different countries, by different technologies, among which:

i) Coal – fired power plants
ii) Gas – fired power plants
iii) Nuclear power plants

iv) CHP plants
v) Other renewables (wind, hydro, solar power plants)

The overall objective of the AEN-NEA study is to provide reliable information on key factors affecting the economics of electricity generation using a range of technologies.

The LCE (levelised cost of electricity) approach was used in order to calculate the cost of generating electricity. The expression for the Average Lifetime LCE (ALLCE) is:

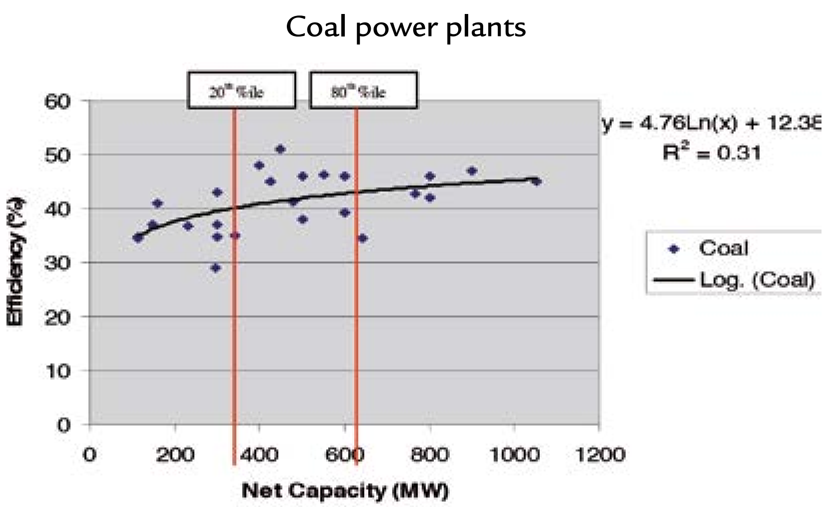
$$\text{ALLCE} = \sum_{t=0}^{T} \frac{[I_t + M_t + F_t]}{(1+r)^t} / \sum_{t=0}^{T} \frac{[E_t]}{(1+r)^t}$$

where It is the investment expenditures in year t;Mt is the operation and maintenance expenditures in year t; Ft is the fuel expenditures in year t; Et is the electricity generation in year t; and r is the discount rate.

According to AEN-NEA,this approach provides a robust, transparent and coherent set of cost estimates for the power plants considered.

In our cost-benefit analysis we focus on coal-based power plants. Using the AEN-NEA data, we found a relationship between the size of the power plants and thermal efficiency. Figure 6.1[U4] shows the relationship between the net thermal efficiency and the net installed capacity of a single turbine for each coal-based power plant .

Figure 6.1
Thermal efficiency and installed capacity, coal-based power plants

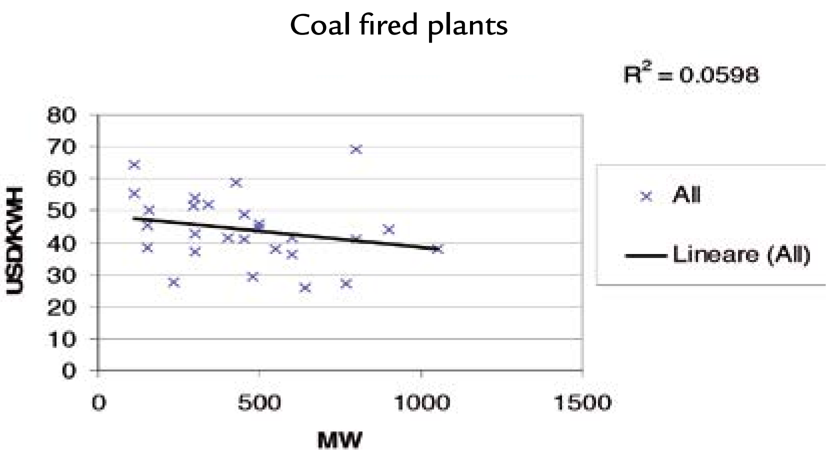


Source: AEN – NEA 2005.

We can notice that an increase of the turbine size generally is associated with an increase in thermal efficiency. Given these data, we should define what the threshold is for defining a large thermal plant and a small thermal plant. Therefore we assume as small all turbines that are below the 20th percentile (246 MW), while the thermal plants over the 80th percentile (634 MW) were assumed to be large. The empirical relationship shown in Figure 6.1 seems to support the idea that big turbines are more efficient than small ones.

However, in order to assess the benefits and costs of setting up large thermal plants and phasing out small plants ones, it is important to verify if turbine size also affects the levelised cost of generating electricity (LCE). Electricity generation costs are calculated at an interest rate of 5% and with an economic lifetime of 40 years and a load factor equal to 85% for all the thermal plants considered.

Figure 6.2
Projected costs of generating electricity and installed capacity (all countries)



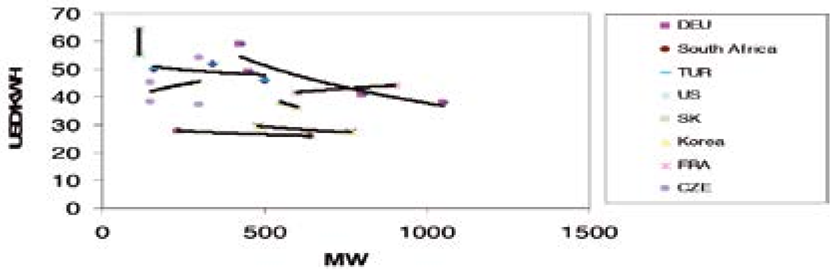
Source: AEN – NEA 2005.

As shown in Figure 6.2[U5], the empirical relationship between LCE and turbine size is not so strong. However, it should also be pointed out that the power plants considered in the graph are located in different countries and the costs of electricity calculated above are in US Dollars . As a result, the LCE is influenced by the international exchange rate.

Therefore a more appropriate analysis is to consider the thermal plants related to a specific country, as summarized in Figure 6.3[U6]:

Figure 6.3
Projected costs of generating electricity and installed capacity (selected countries)

Coal fired plants



Source: AEN – NEA 2005.

We can note that only France and the Czech Republic registered an increase of LCE associated with an increase of power plant capacity. In the Czech Republic the increasing cost of LCE associated with large size can be explained by a lower level of CO_2 emission as compared with other small coal-based power plants.

Cost-Benefit Analysis

In this section, a cost-benefit analysis for two coal-based power plants is presented, namely an existing small power plant and a new large power plant (with higher thermal rate efficiency).

In our example we considered two thermal power plants using the costs data provided by AEN – NEA2005 report. Therefore we assumed the same hypotheses as in the AEN – NEA report:

i) interest rate = 5%
ii) economic lifetime = 40 years
iii) load factor = 85%

The electricity price we used in our calculation is 0.0744 USD (2003) / kWh, which is the retail price of electricity on the U.S market . However, it should be pointed out that this value is purely illustrative; in fact, given our assumption , a change in the retail price does not affect the net present value of the premature phase-out strategy (C0Phase out). Indeed,the factor influencing the cost-benefit analysis is the electricity generation cost of the power plants considered.

In the phase-out scenario a small thermal plant is substituted before its expectedeconomic lifetime with a large thermal plant (with a higher thermal efficiency and a lower levelised cost of generating electricity). Tables 6.2 and 6.3 show the characteristics of the small and the new thermal power plants:

Table 6.2
Existing (small) power plant characteristics

SMALL THERMAL POWER PLANT	Figures	Unit
Net Capacity	*114*	*MW*
Efficiency	*34,5*	*Percent*
Fixed payments	*71,33*	*USD 2003 / KW*
Variable payments	*26,6*	*USD 2003 / MWh*
Fixed repayments and interest payments	*11,5*	*USD 2003 / MWh*

Table 6.3
New (large) thermal power plant characteristics

LARGE THERMAL POWER PLANT	Figures	Unit
Net Capacity	*1050*	*MW*
Efficiency	*45*	*Percent*
Fixed payments	*49,54*	*USD 2003 / KW*
Variable payments	*12*	*USD 2003 / MWh*
Fixed repayments and interest payments	*10,8*	*USD 2003 / MWh*

Fixed repayments and interest payments are related to the investment cost of the power plants.

The investment cost of the small power plant is equal to 390 M USD (2003) , while according to AEN –NEA, the overnight construction cost is equal to 308 MUSD (2003). Therefore we assumed the refurbishment and interest payments are equal to 62 MUSD (2003) (20% of total cost), and the cost of decommissioning is equal to 20 MUSD (2003).

As far as investment cost is concerned, we assumed the following amortization schedule, taking into account that, according to the AEN-NEA, construction expenses "are spread over a period of 4 to 6 years with, in most cases, 90% or more of the expenses incurred within four years or less" (see Table 6.4):

Table 6.4
Investment costs, for given amortization schedule assumption

Year	Residual Investment Cost (2003 USD)	Yearly Expenditures (2003 USD)	% paid
0	*390.468.244*	*228.649.668*	*59%*
1	*161.818.576*	*57.162.417*	*73%*
2	*104.656.159*	*25.405.519*	*80%*
3	*79.250.641*	*14.290.604*	*83%*
4	*64.960.036*	*9.145.987*	*86%*
5	*55.814.050*	*6.351.380*	*87%*
10	*36.114.367*	*1.889.667*	*91%*
15	*29.101.098*	*893.163*	*93%*
20	*25.506.048*	*518.480*	*94%*
25	*23.320.121*	*338.239*	*94%*
30	*21.850.655*	*237.929*	*94%*
35	*20.795.026*	*176.427*	*95%*
39	*20.142.906*	*20.142.906*	*100%*

Given this data, we provide a cost-benefit analysis related to phasing out an existing small power plant and replacing it with a new large power plant. Table 6.5 provides the net present value of the phase-out strategy, assuming a residual life of 10 years for the small plant:

Table 6.5
Cost-benefit analysis of a premature phase-out strategy

Residual life = 10 years	Present value (2003 USD)
- Baseline scenario (CI)	*746.896.015*
+ Phase out scenario (CII)	*804.118.087*
= Net Present Value (C0Phase out)	*57.222.072*
Cost Benefit ratio (CII/ CI)	*1,08*

The table above shows that a premature phase-out of the small thermal power plant is cost effective.

Comments

In order to provide the cost-benefit analysis of gradually replacing small power plants with large (and more efficient) generation units, we made the following assumptions:

i) the two thermal plants sold electricity at the same price (constant over time)
ii) Economic lifetime = 40 years
iii) same load factor for both power plants (85%)

Given these assumptions, we found that a premature replacement of a small power plant with a large one appears to be cost effective.

However, it is important to stress that in the real world a large thermal plant is more likely to generate electricity during base load hours, while a small thermal plant usually generates electricity during peak hours. This is due to the different merit order (given by the dissimilar electricity cost generation) of the different power plants. Therefore a large thermal plant usually works with a higher load factor than a small one. However we (conservatively) assumed the same load factor for both power plants considered.

Conversely the electricity price is higher during the peak hours, while is lower during the base load hours. Therefore a more appropriate modelling approach is needed in order to take into account these issues.

It should also be pointed out that this analysis does not take into consideration the financial benefits of CO_2 emissions and pollution reduction associated with power generation. These are additional benefits, which the large (and more efficient) thermal plant provides and which should be included in a more accurate analysis. In fact the large thermal power plant has a lower rate of CO_2 emissions if compared with the small power plant (0.797 and 0.865 t of CO_2/MWh, respectively) . Therefore the external cost of the small thermal power plant is higher if compared with the external cost of the large power plant. If we also take into consideration these benefits, the cost-benefit ratio of phasing out small thermal power plants and replacing them with large power generation units will be even higher.

FOCUS: CHINA'S ENERGY USE IN BUILDINGS

6.4. China's Energy Efficiency in Buildings

The concept of Energy Efficiency in Buildings (EEB) has undergone a constant elaboration. In developed countries it has passed through three stages: in the first stage it was called Energy Saving in Buildings (ESB), which I show it is normally call at present. ESB can be understood as low energy consumption in buildings, or the use of less energy; in the second stage it was called Energy Conservation in Buildings (ECB) which can be understood as energy being conserved in buildings, or reducing energy loss; in the third stage (the current one) it is called Energy Efficiency in Buildings (EEB), which means raising the efficiency of energy use in buildings. EEB stresses a scientific use of energy on condition that the degree of comfort provided by buildings will be guaranteed and enhanced. In China, when we talk about energy saving in buildings, we refer to EEB.

There are two definitions of ECB: one is energy consumption in buildings, in a broad sense which refers to the energy consumed in the whole process from producing building materials to constructing building using buildings, inclusive of its possible demolition; the other is energy consumption in buildings in a narrow sense, or energy consumption in the process of using buildings, which refers to the energy consumed when the buildings are used, inclusive of the energy consumed by illumination, heating, air-conditioning, cooling, elevators, supply of hot water, cooking, household appliances and office devices, etc. Energy consumption in a broad sense crosses different fields, inclusive of the industrial production sector and the domestic sector. Obviously, the range is too wide. In China, as well as in the developed countries, ECB normally refers to energy consumption in buildings in the narrow sense, which is in parallel with energy consumption for industry, agriculture, communication and transport. Energy consumption in buildings in the narrow sense is also called domestic energy consumption.

There is a huge potential for EEB in China, and EEB is of great significance. The reasons are:(1) The great number of newly built residential buildings. The Chinese construction industry has been rapidly developing since 1990s, growing on average over the past five years at an annual total output value rate of 11%. The floor area of newly constructed buildings in urban and rural regions each year is about 1.6 billion m^2, among which newly built residential buildings cover about 500 million m^2[U7]. (2) The energy consumption of buildings has a big share in the total energy consumption structure. In developed countries, the energy consumption of buildings is about 35%-40% of total energy consumption, while in China it is above 25%. According to incomplete statistics, the energy consumption of buildings accounted for 27.8% of the total energy consumption in China in 2000. (3) The thickness of external walls of buildings in China is about 2.6-3.6times that of developed countries, the thickness of roofs is about 3.2-4.2times that of developed countries, and the thickness of external windows is about 1.4-2.0times that of developed countries. All these factors make the energy consumption per unit area for heating residential buildings in China 3-5times that in developed countries. (4) The energy consumption of buildings has dramatic impacts on the environment. It is estimated that greenhouse gas emissions caused by the energy consumption of buildings account for about 1/3 of China's total greenhouse gas emissions[U8], which have had very negative impacts on air quality. In the long run, if no measures are taken in order to promote EEB to reduce the energy consumption of buildings, the sustainable development of China's economy will definitely be hindered, and the pressure to reduce the country's CO_2 emissions will be increasingly heavy. (5) The energy-saving potential in manufacturing building materials is huge. According to incomplete statistics, 70% of new Chinese buildings are built primarily with clay bricks. More than 70 million tons of standard coal are consumed annually to make clay bricks, and over 1 billion cubic meters of clay are consumed, equivalent to the destruction of 500,000mu of agricultural land. Therefore, construction will consume the most energy, surpassing industry, transport and agriculture, and EEB will be the top priority for energy saving in the whole society.

6.5. China's Policies and Measures to Promote Energy Efficiency in Buildings

Development of Technical Standards and New Technologies

Design Standards for Energy Efficiency of Residential Buildings (Section of Heating Residential Buildings) were enacted in 1986, marking the commencement of efforts to promote EEB in China. The standards classified the whole country into three zones: a cold zone in North China, a hot summer and cold winter zone, and a hot summer and warm winter zone. Different standards for energy conservation design of buildings were worked out. The design standard[U9] for the cold zone proposed saving 30%of energy based on the level of local general energy consumption design in 1980-1981. The 30%target was to be achieved by saving 20%of energy by working on structure maintenance and 10%by working on heating systems.

After the implementation of Design Standards for Civil Architecture Energy Conservation (New Heating Residential Buildings), various provincial authorities attached importance to energy conservation in civil architecture. North China, Northeast China, West China and Jiangsu Province formulated local enforcement regulations for Design Standards for Civil Architecture Energy Conservation (New Heating for Residential Buildings), and constructed a group of energy-saving buildings with an energy conservation ratio of 30%. Meanwhile, Beijing, Harbin, Xi'an and some other regions constructed trial residential districts and trial projects with a 50%energy conservation ratio, which promoted the application and development of various new composite wall-insulating materials, energy-saving plastic windows and heating technologies, improved local community awareness of architectural energy conservation, and achieved significant economic, social and environmental benefits.

The standard for the cold zone was amended in 1995, setting a target of 50% energy saving. Design Standard for Energy Efficiency of Residential Buildings in Hot Summer and Cold Winter Zone was issued in July 2001 and took effect on October 1, 2001. Design Standard for Energy Efficiency of Residential Buildings in Hot Summer and Warm Winter Zone is now being formulated. Besides the above standards, Design Standard for Heat Engineering and Air Conditioning of Hotels was also launched in 1993.

In 2005, the Ministry of Construction issued a series of documents to intensify architecture energy conservation efforts, among which Notice on Further

Promoting Wall Material Innovation and Energy-saving Buildings (General Office of the State Council [2005] No. 33), Notice on Further Strengthening Architecture Energy Conservation Standard and Implementing Supervision Work, Notice on Organization and Development of Special Inspection of Architecture Energy Conservation, and Notice on Organizing Investigation Relating to Architecture Energy Conservation. In 2006, Administrative Provisions on Energy Conservation of Civil Architecture, formulated by the Ministry of Construction, went into effect.

Utilization of Solar Energy in Buildings[U10]

To further promote utilization of solar energy in buildings, the Ministry of Construction (MOC) drafted the preliminary project plan of China's Residential Sunshine Plan, which consists of targets, tasks and 10 action measures.

The Enforcement Regulations of Urban Energy Efficiency in Construction was enacted in China in January 1988. It stipulated the energy saving policies in fields such as urban thermal energy, thermal power, heating, water supply, waste water treatment, urban road illumination, and so on.

To promote EEB and various fixed asset investment projects, the National Development and Reform Commission (NDRC) (the former State Planning Commission), which governs investment, the State Economy and Trade Commission (SETC), which governs technical transformation and MOC, which governs construction, jointly formulated the Interim Regulations for Adding "the Chapter on Energy Efficiency" to Feasibility Study Reports on Infrastructure Construction and Technical Innovation Projects, which stipulated explicitly: energy efficiency must be investigated, designed, examined and approved in all the processes when fixed asset investment projects are proposed, investigated, examined and approved.

The Energy Conservation Law of the People's Republic of China was launched in November 1997. The Law, enacted by the Standing Committee of the National People's Congress, operates at the national level to direct energy conservation work across China. It is also the legal ground for conducting the EEB's work, thus being of major significance in managing energy efficiency in buildings. NDRC, SETC and MOC amended the above-said interim regulations in December 1997, pursuant to the Energy Conservation Law of the People's Republic of China. The amendment stipulated the Regulations for Compiling and Evaluating "the Chapter of Energy Efficiency" in Feasibility Study Reports on Infrastructure Construction and Technical Innovation Projects, which specifies the requirements for energy efficiency and evaluation standards.

To implement the Energy Conservation Law of the People's Republic of China and the new standard for saving 50% energy, MOC issued in February of 2000 the Administrative Provisions of Energy Efficiency of Residential Buildings, which took effect as of October 2000[U11].

Relevant Fiscal Policies

The State Planning Commission and the State Administration of Taxation launched the Interim Provisions on Fixed Asset Investment Direction Regulating Tax in 1992, which specifies a zero% tax rate for residential buildings meeting energy efficiency design standards in North China, exempting them from the normal 5% tax rate on new buildings.

In 2002 the Ministry of Finance (MOF) and the State Economic and Trade Commission (SETC) issued administrative measures on collection and use of a special fund for the adoption of new materials in the construction industry. Those measures require construction firms to contribute to the special fund by paying no more than CNY8 per square meter of floor area for those projects which fail to use innovative materials. The total floor area is based on the construction budgetary estimate.

6.6. Cost-Benefit Analysis of Energy Efficiency in Buildings

The EEB involves the government, real-estate developers, homeowners and materials manufacturers.

The government advocates and promotes energy efficient buildings. The government benefits by: (1) saving energy effectively; (2) improving the environment, whereas traditional residential buildings consume large amounts of energy and emit CO_2 and SO_2 in the process of manufacturing building materials, constructing, using and tearing down buildings. The ultimate purpose of building energy efficient buildings is not just to save conventional energy, but also to find a balance between climate, energy and ecology so as to realize a sustainable development of the environment, ecology and energy; and (3) improving the social energy distribution structure and optimizing social energy allocation. The reduction of energy consumption of buildings plays a big role in optimizing social energy allocation. Energy efficient buildings consume less energy, reducing the amount of energy used in the construction industry, which is equivalent to increasing social disposable energy. The government's costs for promoting energy efficient buildings include: (1) expenses on publicity, (2) favorable policies, and (3) subsidies.

Real-estate developers are the suppliers of energy-efficient residential buildings. Generally speaking, the costs of the real-estate developers include: (1) cost of containment structures with good heat preservation performance; and (2) windows. The benefits they can normally obtain include: (1) saving in groundwork and framework. The containment structure of energy-efficient buildings is light in weight, thus helping to save expenses on groundwork and framework. (2) Saving in heating devices. Since the containment structure has a good heat preservation performance, the dispersion of indoor heat is small. Thus, the number of heaters can be reduced. Accordingly, investment in heating boilers and facilities is reduced. (3) High house-selling rate. The walls of energy-efficient buildings are thinner. As a result, if an energy efficient building has the same floor area as a traditional building, its net area is larger. Therefore, energy-efficient buildings are more popular with house buyers. (4) Support from national energy saving policies. Pilot projects of energy-efficient buildings are supported by the government both economically and through policies. (5) Improving developers' social image. The development of energy-efficient buildings by real-estate developers is encouraged by favorable national policies and made obligatory by mandate policies. It is critical to determine whether developers have mature technical support and whether developing energy-efficient buildings is profitable.

Home owners are the users of energy-efficient buildings, which normally provide them with the following benefits: (1) A comfortable, healthy living environment, which is the ultimate purpose of energy efficiency, in terms of indoor temperature, humidity and airflow speed. There is no condensation in energy-efficient buildings in winter, and they are comfortable to live in; (2) Low maintenance cost.

Theoretically, energy-efficient buildings cost less in maintenance. However, under the current social and political system, energy-efficient buildings are not very attractive in this respect, because policies and regulations, especially the regulations concerning energy consumption charges and the corresponding technologies have not been launched or developed. Home owners are only passive participants. The development of energy-efficient buildings can be greatly enhanced only when the owner's economic interest is closely linked with their energy consumption.

Building material manufacturers supply materials for energy-efficient buildings. As long as there is market demand there are profits. Generally, the benefit that energy-efficient buildings can provide for building material manufacturers is the additional profits they can obtain. Meanwhile, as energy-efficient buildings are popularized, demand for new building materials will increase, and manufacturers' costs will also decline. This is in both their interest. The consequence, however, is that traditional building material manufacturers will continually shrink as the market for energy-efficient building materials expands. Tables 6.6-6.8 summarize the results of the cost-benefit analysis of energy-efficient residential buildings with $100m^2$ floor area.

Table 6.6
Analysis of energy savings

	Materials Used to Build a 6-storey Residential Building with the Floor Area of 3,730m²	Energy Consumed in Manufacturing Building Materials (ton standard coal)	Energy Consumption Ratio in Manufacturing Building Materials	Coefficient of Thermal Conductionv W/(m ²K)	Thermal Resistance (m ²K/W)	Energy Consumption Ratio in Heating
Concrete Building Blocks	*760m³*	*1.8*	*3.4%*	*2.033*	*0.492*	*64.2%*
KP Porous Brick Concrete	*364,000*	*36.8*	*70%*	*2.262*	*0.442*	*71.4%*
Solid ClayBricks	*618,800*	*52.5*	*100%*	*3.165*	*0.316*	*100%*

Source: Lei Hongpeng (2003).Theory of Energy Efficiency in Buildings.Thesis of Master's Degree. Tianjin University.

Table 6.7
Comparison of per-square-meter construction costs of different types of energy efficient buildings (CNY/m²)

Building Types	Wall Material Types	Pile Types	Piling	Wall Works	Beams and Pillars	Reinforced Steel	Total Construction Cost
Energy Efficient Building Type I	*Concrete Building Blocks*	*Prefabricated Concrete Square Piles*	*23.34*	*125.85*	*23.64*	*73.60*	*533.51*
Energy Efficient Building Type II	*KP Porous Brick Concrete*	*Prefabricated Square Piles*	*24.07*	*123.8*	*32.99*	*73.77*	*541.71*
Non-Energy Efficient Buildings	*Solid Clay Bricks*	*Prefabricated Concrete Square Piles*	*24.87*	*122.85*	*32.99*	*75.50*	*543.37*

Source: Lei Hongpeng (2003).Theory of Energy Efficiency in Buildings. Thesis of Master's Degree. Tianjin University.

Table 6.8
Cost-benefit analysis of energy efficient residential buildings (100 m^2 floor areas)

Forms of Benefits	Lump Sum Quantitative Benefits ($CNY/100m^2$)	Beneficiaries	Forms of Costs	Lump Sum Quantitative Costs ($CNY/100m^2$)	Cost Bearers
Energy savings in heating	*1,074*	*Government, Heating companies*	*Incremental cost of energy efficient buildings*	*20,000*	*Real estate developers, home owners*
Energy savings in building material manufacturing	*1,360*	*Building material manufacturers, Government*			
Reduction of expenses on earthworks	*986*	*Real estate developers*			
Value of house selling	*10,697.63*	*Home owners*			

Source: Lei Hongpeng (2003).Theory of Energy Efficiency in Buildings.Thesis of Master's Degree. Tianjin University.
Notes: i)Energy consumption ratio in heating is 64.2% (see Table 6.6), which corresponds to a 35.8% saving. If energy consumption costs in a heating season amount to CNY 3, 000/$100m^2$, the earnings obtained through energy savings in heating are CNY 1, 074; ii) Energy savings in the manufacturing process are (52.5-1.8)/37.3=1.36 tons of standard coal/$100m^2$ (see Table 6.6). The price of 1 ton of standard coal is set as CNY 1, 000; iii)Reduction of expenses on earthworks is calculated as (543.37-533.51)×100=CNY986/$100m^2$(see Table 6.7).

The net area of an energy-efficient residential building with a floor area of $100m^2$ is $2.67m^2$ larger than that of an ordinary residential building with the same floor area. One square meter of net area is priced at CNY4,000 in the analysis (Table 6.9).

Table 6.9
Area-saving analysis

	Materials Used to Build a 6-storey Residential Building with the Floor Area of 3,730m^2	Earth Consumption (mu)	Ratio of Net Area to Floor Area
Concrete Building Blocks	*760m^3*	-	*78.67%*
KP Porous Brick Concrete	*364,000*	*0.78*	*75.99%*
Solid ClayBricks	*618,800*	*1.02*	*75.99%*

Source: Lei Hongpeng (2003).Theory of Energy Efficiency in Buildings. Thesis of Master's Degree. Tianjin University.

6.7. Goals and Implementation Effects of China's Policies for Energy Efficiency in Buildings

The General Office of the State Council issued the "Notice on Further Stimulating Innovation in Wall Materials and Promoting Energy Efficiency in Buildings"(hereafter referred to as the Notice) in 2005. The Notice stated that by the end of 2010 it would be forbidden to use solid concrete bricks in all cities; new buildings in both urban and rural areas would meet design standards for saving 50%of energy by 2010, and new buildings in the four municipalities directly under the central government (Beijing, Shanghai, Tianjin and Chongqing), and other cities with specific conditions, would save 65%of energy[U12]; energy efficiency transformation of existing buildings would undergo a breakthrough: by 2010 25% of the total planned energy efficiency transformation area would be completed in large cities, 15% in middle-sized cities and 10% in small cities.

On this basis, by 2020, the energy conservation reform on most existing buildings would have been accomplished; in newly built buildings, East China would have achieved the objective of 70% energy conservation, and Central China and West China would also have accomplished the objective of 65% energy conservation. As for newly built urban buildings, if an additional 50%of energy is conserved, based on the current standard, 68 million tons of standard coal would be saved every year, and the emission of 143 million tons of CO_2 would be avoided. If national public buildings are reformed according to the 50%standard for energy conservation, the total energy conservation potential would be 135 million tons of standard coal. According to a scientific budget analysis, energy conservation would reduce China's GDP energy consumption per RMB10,000 from 2.33 tons of standard coal in 1995 to 1.25 tons in 2010, 0.45 tons in 2030, and 0.25 tons in 2050. As for different energy conservation approaches, energy conserved by adjusting industrial and product structure accounts for about 70-80%of the energy conservation potential of the industrial sector, and energy conserved by reducing energy consumption per unit of product with advanced technology accounts for 20-30%.

However, the implementation effects of Chinese EEB policies have not been very successful. The major reasons are: (1) The administrative institutions are not well established, and the administrative system is not very functional. The Ministry of Construction oversees the Office of Energy Conservation, the Center of Energy Efficiency in Buildings and the Office of Wall Transformation to Improve Energy Efficiency in Buildings. However, the functions and responsibilities of these departments are not clearly defined, making it difficult to coordinate the work. For instance, EEB and wall material innovation are separate. In addition, the assessment system for technical products to improve EEB has not yet been established, there is no inspection system for examining energy efficiency, and the index system for rating the energy efficiency of residential buildings has not been set up either[U13].

(2) EEB policies and EEB measures do not match appropriately. Although legislation work has commenced, enforcement is far from adequate to reach the strategic goal of saving 50%of energy. Since the construction cost of energy-efficient buildings is higher than that of traditional buildings, their prices are higher too. However, energy efficiency is mainly shown in the process of using the buildings. Therefore, energy-efficient buildings often donot sell as well as traditional buildings. Real-estate developers thus are reluctant to build energy-efficient buildings. Plus, government regulations and inspections are not stringent. As a result, the regulations and laws enacted are more than not a dead letter.

(3) EEB policies lack incentive mechanisms. Incentive policies promoting the market mechanism of energy-efficient buildings are very few. The available EEP policies are not perfect. The enacted Energy Conservation Law of the People's Republic of China is not operational, and it does not actually assume a regulatory role. In contrast, the Administrative Provisions of Energy Efficiency of Residential Buildings is only a departmental regulation, hence not powerful enough to promote energy efficient buildings.

(4) The goals of EEP policies and the goals of local governments are not consistent. The EEB work in China is conducted from top level to lower levels. Such channels makes the policies more and more detailed as they reach the lower levels, and local authorities are responsible for executing the policies. Nevertheless, the economy is not developed in most regions of China, thus local government officials as well as the local masses are hardly aware of energy efficiency. Against such a background it is not surprising that EEP policies are distorted and even neglected. In the undeveloped regions, government officials

tend to encourage the construction of buildings to show their achievements, while more investments are needed to meet the standards of energy efficiency. Therefore, EEB policies are often regarded as a resistance to investing in construction, and are ignored.

(5) Heat metering and heating charges go against the development of energy-efficient buildings. Heat consumption is covered by public welfare programs. The heating charges are shared by households and heating companies. The share paid by households is very small, and is not linked to the actual heat they consumed. Under the current charge system, heating fees are computed based on floor area, and borne by the government and the companies. Thus, the amount of energy consumed has nothing to do with the users' interest. Plus, indoor heating networks are single vertical pipes connected in series in users' houses. Users are unable to adjust the temperature. What's more, neither do external networks have a regulatory function. This situation leads to a huge waste of energy, for heating companies are not motivated to meet users' comfort preferences, and users are not motivated to save heating energy. The reform of the urban heating system involves redistributing the interest of the users and the heating enterprises, and it also faces many tough issues, such as that heating fees are unaffordable for low income users, heat metering is difficult to realize, and it is difficult to control heat consumption separately for each household, therefore, heating reform is hard to get under way, and consequently the improvement of EEB is seriously impeded.

Financial deficit is also an important factor hindering the development of energy-efficient buildings. 500 million m^2 of floor area are added in China every year, requiring an increase of CNY100 billion in investments. If the proceeds are deducted, the financial deficit is still CNY34.78 billion.

The marketization of energy prices is low. The prices of electricity and heat are far from marketization. Energy prices do not truly reflect market demand and supply, and thus cannot regulate the market.

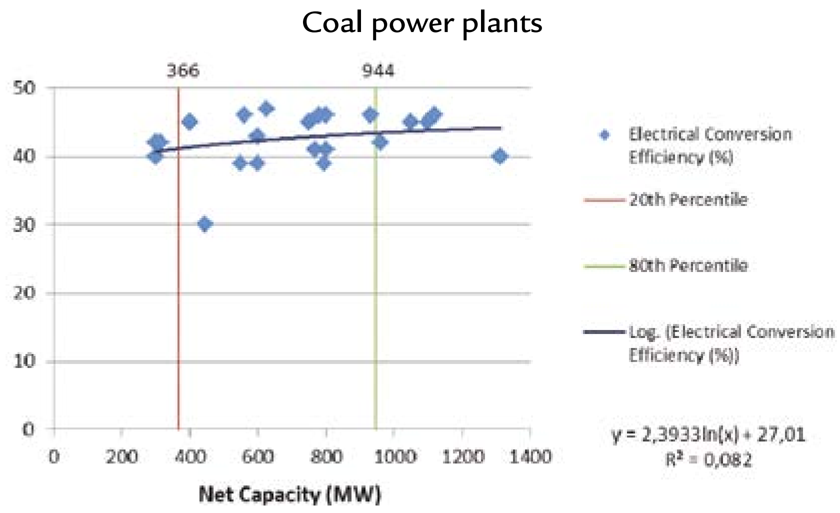
UPDATES

U1. Between 2005 and 2010 China's energy consumption per GDP unit dropped by 19.1%. The new target of the 12th Five-Year Plan for 2015 is to achieve a 16% reduction of energy use per GDP unit from 2010 levels (CCCHINA, 2011).

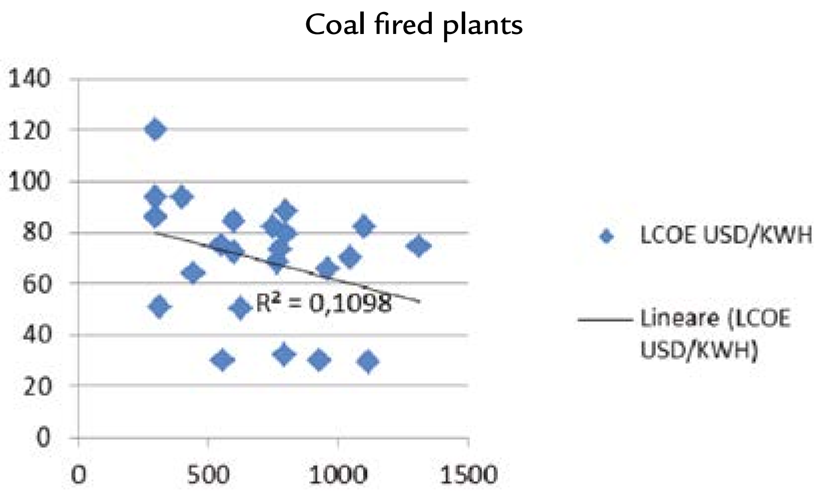
U2. In the first half of 2010, the coal industry dropped 2.69%, the steel industry 1.64%, the building materials industry 7.61%, the chemical industry 4.28%, and the textile industry 2.42%, while the power industry increased by 4.19 %, the petroleum and petrochemical industries 11.35%, and the non-ferrous metals industry 8.11% (NBS, 2010).

U3. The 2010 edition of "Projected Costs of generating Electricity" is available (AEN – NEA, 2010).

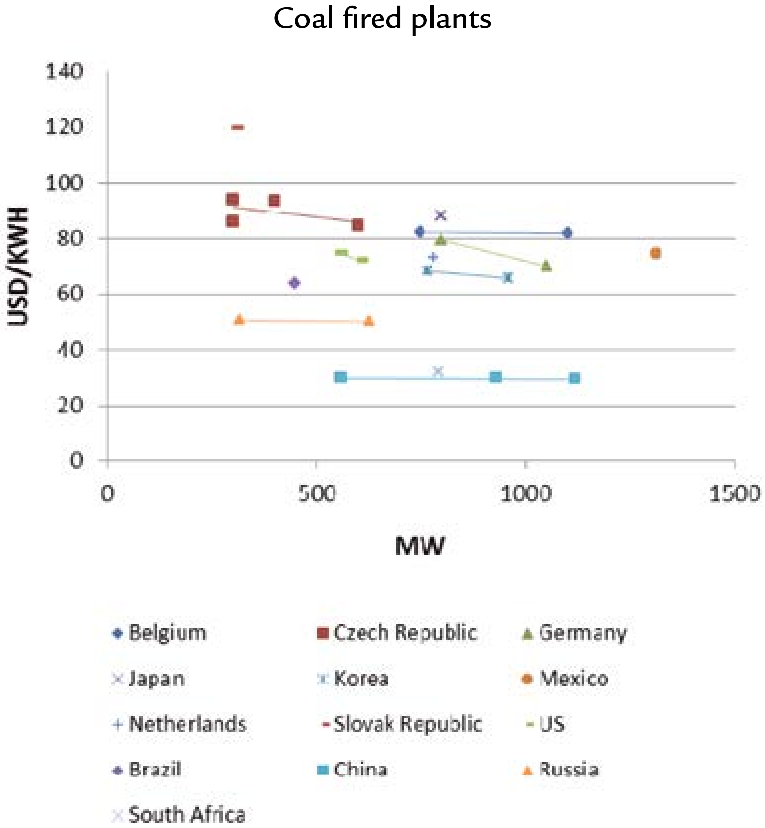
U4. Figure 6.1 can be updated with data from AEN – NEA (2010).



U5. Figure 6.2 can be updated with data from AEN – NEA (2010).



U6. Figure 6.3 can be updated with data from AEN – NEA (2010).



U7. "The construction industry has been a pillar industry in China's rapid economic development, accounting for 6.6% of China's gross domestic product in 2009(CSSB 2012). Between 2000 and 2010, China added some 1.7 billion square meters of new floor space on an annual basis (in both urban and rural areas). In 2010, China completed the construction of 2.8 billion square meters of new buildings, which was roughly 3.44 times the total area built in 2000. It is estimated that China will add another 10 to 15 billion square meters of residential buildings in urban areas, and an additional 10 billion square meters of public buildings by 2020" (Shui & Li, 2012).

U8. In 2008 CO_2 emissions associated with energy consumption in the Chinese building sector was 1,260 million tons, accounting for nearly one fifth of China's total CO_2 emissions that year (Shui & Li, 2012).

U9. Updates about targets for new buildings (Shui & Li, 2012):

a. The Design Standard for Energy Efficiency of Residential Buildings in

Hot Summer and Cold Winter Zone, introduced in 2001, was amended in 2010, proposing a 50% energy saving.

b. The Design Standard for Energy Efficiency of Residential Buildings in Hot Summer and Warm Winter Zone was introduced in 2003 and established a 50% energy saving.
c. The Design Standard for Energy Efficiency of Residential Buildings in Severe Cold and Cold Zone, introduced in 1986, was amended in 1995, setting a 50% standard, and in 2010, bringing energy saving to 65%.
d. In 2005 the Design Standard for Public Buildings was introduced. Public buildings must achieve a 50% energy saving target.

U10. The fundamental legal basis related to the use and management of renewable energy in China is the Renewable Energy Law of the People's Republic of China, promulgated in 2005.

Under this framework, in order to coordinate national energy and economic policy for energy conservation and emissions reduction, since the Eleventh Five-Year Plan (2006-2010), the National Development and Reform Commission, MOHURD, Ministry of Finance, Electricity Regulatory Commission, National Standards Commission and relevant departments have successively issued a series of relevant supporting policies to promote the application of renewable energy in the building sector, such as Implementation Opinions on Promoting the Application of Renewable Energy in Buildings and Notification on Accelerating the Application and Scale- up of Solar Water Heating Systems. (Shui & Li, 2012).

U11. The Energy Conservation Law was revised in 2007. The implementation of this law was supported by regulations, such as the Regulations of Energy Conservation in Civil Buildings and the Regulation of Energy Conservation of Public Organizations.
In 2010 the State Council issued the Comprehensive Working Scheme for Energy Conservation and Emissions Reduction in the 12th Five-Year Plan, stating that China will conduct residential retrofit of 400 million square meters in the northern heating zone, and 50 million square meters in the hot-summer and cold-winter zones.

China also began to establish its system of energy efficiency labeling and evaluation for buildings in 2006. There are two types of energy efficiency labels for buildings in place: an energy efficiency label for buildings that relies on theoretical values of energy efficiency for buildings evaluated during the acceptance stage, and an energy efficiency label for buildings that relies on actual values of energy efficiency for buildings evaluated

during normal operation.
Since 2009, the Ministry of Housing and Urban-Rural Development (MOHURD) has promoted energy efficiency labeling for buildings in newly constructed government office buildings and large public buildings through pilot projects in selected provinces and cities (Shui & Li, 2012).

U12. By the end of 2010, the implementation rate of mandatory energy efficiency standards for new urban buildings reached 99.5% in the design stage and 95.4% in the construction stage. During the 11th Five-Year Plan period, the accumulated total energy-efficient floor space constructed was 4.857 billion sq m, with an energy-saving capacity of 46 million tons of standard coal (CCCHINA, 2011).

In 2011, the implementation rate of mandatory energy efficiency standards for new urban buildings, which require a 50% energy-saving, reached almost 100% in the design stage and 95.5% in the construction stage (CCCHINA, 2012.)

By the end of 2012, the country had completed heat metering and energy efficiency renovations on 590 million square meters of existing residential buildings in northern China, saving energy equivalent to 4 million tons of standard coal and reducing about 10 million tons of CO_2 emissions. All new buildings in cities and towns, or a total of 6.9 billion square meters of floor space, have reached the new energy saving standard, saving energy equivalent to 65 million tons of standard coal, or 150 million tons of CO_2 emissions. (CCCHINA, 2013).

By the end of 2013, all newly constructed buildings had adopted mandatory energy-saving standards. Improved energy-saving design standards have been applied in northern regions covered by central heating, regions with hot summers and cold winters, and regions with hot summers and warm winters.

In total, 8.8 billion square meters of energy-saving structures have been built in cities and towns across the nation, equivalent to an annual saving of 80 million tons of coal equivalent and 210 million tons of carbon dioxide emissions. (CCCHINA, 2014).

U13. China began to establish its system of energy efficiency labeling and evaluation for buildings in 2006. There are two types of energy efficiency labels for buildings in place: one that relies on theoretical values of energy efficiency for buildings evaluated during the acceptance stage, and one that relies on actual values of energy efficiency for buildings evaluated during normal operation. (Shui & Li, 2012)

APPENDIX B

China's Energy Conservation Policies - Experts' Evaluation

Table B.1
Experts' evaluation of energy conservation policies

Panel 1 Energy Conservation Policy-Set up the Large Thermal Power Generating Units & Shut down the Small Thermal Power Generating Units

Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Improved productivity	6		*Employment cost*	3	3
Benefiting environmental protection	6		*Degree of decreased market competition*	1	5
Reduced unit coal consumption	6		*Losses of local interests*	2	4
			Decreased flexibility of power supply	4	2
Total Scores	*54*	*0*		*30*	*14*
Policy Benefits	*54*		*Policy Costs*	*44*	

Panel 2 Energy Conservation Policy-Energy Conservation & Emission Reduction policies

Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Saving energy	6	0	*Increased equipment inputs*	6	0
Reducing emissions	6	0	*Increased new technology investment*	3	3
Reducing energy consumption expenses	0	6	*Capacity losses of small and medium-sized enterprises*	2	4
Decreased treatment costs	0	6	*Impact on employment*	2	4
Enhancing awareness of energy conservation and emission reduction	6	0			
Total Scores	*54*	*12*		*39*	*11*
Policy Benefits	*66*		*Policy Costs*	*50*	

Table B.1
(continued)

Panel 3 Energy Conservation Policy-Industrial Energy Consumption Technical Standard					
Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Encouraging the application of energy-saving technology and equipment	*6*	*0*	*Increasing production cost*	*3*	*3*
Saving energy	*6*	*0*	*Eliminating backward production capacity, increasing social sunk costs*	*3*	*3*
Reducing pollution	*4*	*2*	*Reducing employment*	*5*	*1*
Total Scores	*48*	*2*		*33*	*7*
Policy Benefits	*50*		***Policy Costs***	*40*	
Conversion Factor	*92.59*			*74.07*	

Panel 4 Energy Conservation Policy-Cancel Differential Electricity Price in Energy-intensive Industries					
Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Saving energy	*2*	*4*	*Reduced profits of power enterprises*	*2*	*4*
Optimizing industrial structure	*5*	*1*	*Equipment operating costs of power enterprises*	*1*	*5*
Promoting industrial upgrading	*3*	*3*			
Total Scores	*30*	*8*		*9.00*	*9*
Policy Benefits	*38*		***Policy Costs***	*18*	
Conversion Factor	*70.37*			*50.00*	

Table B.1
(continued)

Panel 5 Energy Conservation Policy-Cancel Export Rebates in Energy-intensive Industries					
Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Guiding adjustment of industrial structure	*5*	*1*	*Increased export cost*	*3*	*3*
Reducing indirect energy output	*6*	*0*	*Reduced corporate profits*	*4*	*2*
Reducing export trade friction	*1*	*6*	*Reduced exports*	*2*	*4*
	2	*4*	*Impact on employment*	*2*	*4*
Total Scores	*18*	*12*		*27*	*9*
Policy Benefits	*30*		***Policy Costs***	*36*	
Conversion Factor	*77.78*			*66.67*	

Panel 6 Energy Conservation Policy-Building Energy Conservation Standard					
Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Energy conservation of the society	*6*	*0*	*Increased construction cost*	*5*	*1*
Increased demands for new materials	*6*	*0*	*Increased government expenditure*	*1*	*5*
	0	*6*	*Capacity losses of small and medium-sized enterprises*	*2*	*4*
	0	*6*	*Impact on employment*	*2*	*4*
Daily household energy expenses saved	*1*	*5*	***Demanding for traditional industries***	*2*	*4*
Total Scores	*39*	*5*		*24*	*10*
Policy Benefits	*44*		*Policy Costs*	*34*	
Conversion Factor	*81.48*			*62.96*	

Table B.1
(continued)

Panel 7 Energy Conservation Policy-Office Energy Conservation

Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Energy conservation	*4*	*2*	*Increasing one-off investment*	*3*	*3*
Demonstration effect	*1*	*5*	*Reducing environmental comfort*	*2*	*4*
Operating expenses saved	*1*	*5*	*Increased supervision costs*	*0*	*6*
Increased energy conservation awareness	*3*	*3*			
Total Scores	*27*	*15*		*15*	*13*
Policy Benefits	*42*		*Policy Costs*	*28*	
Conversion Factor	*58.33*			*51.85*	

Panel 8 Energy Conservation Policy-High Efficient Lighting

Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Saving electricity	*6*	*0*	*Big investment of energy-saving light bulbs*	*5*	*1*
Saving electricity costs	*6*	*0*	*Reducing comfort*	*2*	*4*
Increasing application of new materials	*1*	*5*	*Government subsidies for producers*	*2*	*4*
			Increasing conversion cost	*2*	*4*
Total Scores	*39*	*5*		*33*	*13*
Policy Benefits	*44*		*Policy Costs*	*46*	
Conversion Factor	*81.48*			*63.89*	

Table B.1
(continued)

Panel 9 Energy Conservation Policy-Small-engine Cars					
Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Saving oil	*5*	*1*	*Insufficient power, affecting traffic*	*2*	*4*
Saving parking space	*4*	*2*	*Lack of security*	*5*	*1*
Saving car purchase cost	*6*	*0*	*Increased use of family cars*	*6*	*0*
Saving daily expenses	*3*	*3*			
Saving raw materials	*6*	*0*			
Total Scores	*72*	*6*		*39*	*5*
Policy Benefits	*78*		*Policy Costs*	*44*	
Conversion Factor	*86.67*			*81.48*	

Panel 10 Energy Conservation Policy-Energy Efficiency Labeling of Home Appliances					
Benefiting the promotion of energy-saving products	**6**	**0**	**Increasing production cost**	**4**	**2**
Benefiting consumers' identification of energy-saving products	*6*	*0*	*Increasing product prices*	*3*	*3*
Benefiting household appliances to enter the market of developed countries	*5*	*1*			
Total Scores	*51*	*1*		*21*	*5*
Policy Benefits	*52*		*Policy Costs*	*26*	
Conversion Factor	*96.30*			*72.22*	

Notes: see Table A.1.

China's Major Energy Conservation Policies in 1978-2007

Table B.2
China's major energy conservation policies (years 1978-2007)

Year	Policy Name	Policy Objective	Main Content	Significance
1979	*Notice on Several Problems Concerning Improvement of Chinese Energy Utilization Efficiency*	*To alleviate energy shortage*	*Energy conservation has been included in the state's macroeconomic management as a specialized work*	*Administrative Regulation*
1980	*Report on Intensifying Energy Conservation Efforts and Notice on Working up Evaluation System of Comprehensive Energy Consumption*	*Energy shortage has become the "bottleneck" of the development of national economy; energy conservation has been paid necessary attention to.*	-	*Administrative Regulation*
1981	*A number of Specific Requirements on Energy Conservation for Industrial and Mining Enterprises and Municipalities (Trial)*	*To measure energy consumption; requiring the whole society to conserve energy, featuring strong operability*	-	*Administrative Regulation*
	Implementation Measures of Surcharge on Over-standard Fuel Consumption	-	-	
1982	*Provisional Management Measures of the Implementation of Quota Power Consumption According to Provinces, Cities and Autonomous Regions*	*To ensure reasonable allocation and utilization of power, and improve economic benefit of power utilization*	-	

Table B.2
(continued)

Year	Policy Name	Policy Objective	Main Content	Significance
1984	*Policy Outline of Energy Conservation Technology*	*To guidethe work of China's energy conservation and consumption reduction, guide the development of all trades, demonstrate and promote energy conservation technology, and promote the advancement of energy conservation technology*	-	
1985	*Interim Provisions of State Economic Commission on Several Issues Concerning Comprehensive Resources Utilization*	*The save energy and protect environment*	*Main contents of construction and renovation include cycling utilization of coke oven gas using waste heat, differential pressure and blast furnace, and cycling utilization of water. Provide identified energy conservation projects that have been built up with favorable terms of returning interest based on a 50% discount of commercial loan rate.*	
1986	*Provisional Regulations on Energy Conservation Management*	*To carry out the country's guidelinesfor giving the same priority to development and conservation, to use energy reasonably, to reduce energy consumption, to improve economic benefit, and to guarantee sustainable, stable and harmonious development of the national economy*	*Insufficient energy, especially tense power supply, remained a relatively prominent weak link of national economy and social development at that time*	*Administrative Regulation*

Table B.2
(continued)

Year	Policy Name	Policy Objective	Main Content	Significance
1987	*Notice on the Implementation of Design Standard for Civil Architecture Energy Conservation (New Heating Residential Buildings)*	*Buildings with an energy conservation ratio of 30-50%*	*Promoted the application and development of various new insulation composite wall materials, energy-saving construction plastic windows and heating technologies, improved local community awareness of architectural energy conservation, and achieved significant economic, social and environmental benefits.*	
	Interim Regulations on Upgrading (Rating) of Enterprises' Energy Management	*To arouse enthusiasm of enterprises for energy conservation work*		*Administrative Regulation*
1994	*Arrangement Opinions on "1994 National Energy Conservation Publicity Week"*	*To further carry out the energy guidelines of giving the same priority to development and conservation, and enhance people's awareness of energy conservation*	*Recommending 500 quality energy-saving products and 500 excellent energy-saving scientific and technological achievements*	
1995	*Report on the Development of New and Renewable Energy, Program of the Development of New and Renewable Energy in 1996-2010*	-	*Actively developing new and renewable energy resource, such as wind, solar and geothermal*	
	Electricity Law of the Peoples Republic of China	-	-	

Table B.2
(continued)

Year	Policy Name	Policy Objective	Main Content	Significance
1997	*Energy Conservation Law of the People's Republic of China*	*To emcourage the whole society to save energy, improve energy utilization energy, protect and improve environment, and advance overall harmonious sustainable development of the economic society*	*Reasonably adjusting industrial structure, corporate structure, product structure and energy consumption structure, promoting the advancement of energy conservation technology, reducing energy consumption of unit output value and unit product, improving the development, processing, transmission and supply of energy, gradually improving energy utilization efficiency, and movingthe national economy toward an energy-saving type*	*Providing legal protection for China's energy conservation efforts*
1999	*Measures of China Energy Conservation Product Certification Management*	*To save energy and protect environment, carry out certification work of energy conservation products effectively, safeguard healthy development and fair market competition of energy conservation products, and promote international trade of energy conservation products*	*Energy conservation productsare those that comply with product standards and requirements in terms of quality and safety, whose efficiency or energy consumption index is equal to that of the international advanced level, or reaches an advanced domestic level close to the international level with similar products or products with the same functions in social use.*	

Table B.2
(continued)

Year	Policy Name	Policy Objective	Main Content	Significance
	Measures of Management of Key Energy Consumption Units		*Key Energy Consumption Units refer to energy consumption units with an annual comprehensive energy consumption volume of and above 10,000 tons (of standard coal.*	
2000	*Measures of Management of Electricity Conservation*	*To strengthen energy conservation management, improve energy efficiency, promote reasonable utilization of electricity, and improve energy structure*	*Adopting feasible electricity conservation measures, formulating an electricity conservation plan and consumption reduction objective.*	
	Regulations on Management of Energy Conservation of Civil Architecture			
2001	*Standard of Energy Conservation Design of Residential Buildings in Regions with Hot Summer and Cold Winter*	*To tackle the problem of dramatic energy consumption,to increase of construction heating in winter and construction of air-conditioning in summer*	*Regions with hot summer and cold winter refer to the Yangtze River valley and its surrounding areas, covering 16 provinces, autonomous regions and municipalities.*	
2003	*Arrangement Opinions on "2003 National Energy Conservation Publicity Week"*	*To enhance people's awareness of energy conservation*	*Saving energy and enhancing the general well-being of society.*	
2004	*Outline of Long-term and Mid-term Energy Development Planning (Draft)*	*To formulate a nationwide production and consumption mode beneficial to energy conservation, to develop an energy-efficient economy and to build an energy-saving society.*		*Planning*

Table B.2
(continued)

Year	Policy Name	Policy Objective	Main Content	Significance
2005	*Guiding Opinions on Development of Energy-saving and Land-saving Residential and Public Buildings*	*Conditions for building energy conservation are not optimistic. Construction projects designed according to energy conservation standards account for 58.53%; construction projects built according to energy conservation standards account for only 23.25%.*	*By 2010, new urban buildings throughout the country should have achieved the goal of energy conservation of 50%; energy conservation renovation of existing buildings should be carried out step by step; large, middle and small cities should have completed a renovation area of 25%, 15% and 10%, respectively; the water conservation rate during construction and utilization should have improved 20% based on the current level; the total consumption ratio of unrenewable resources of new buildings should have decreased by 10%.*	
2006	*Regulations on Management of Energy Conservation of Civil Architecture (Revision)*	*To save energy*	*Improving operating efficiency of heating, cooling, lighting, ventilation, water supply and drainage, and drainage and channel system*	
	The Decision of the State Council on Strengthening Energy Conservation Efforts	*Energy has become an important factor curbing Chinese economic and social development. We shall, from a strategic and overall perspective, fully recognize the importance of doing a better job in energy conservation, and paying more attention to energy security.*	*To solve China's energy problem, the fundamental way is to promote conservation and development concurrently while giving top priority to conservation, greatly advancing energy conservation and decreased consumption, and improving energy utilization efficiency*	

Table B.2
(continued)

Year	Policy Name	Policy Objective	Main Content	Significance
2007	*Guiding Opinions on Comprehensive Utilization of Resources during the "Eleventh Five-Year Plan"*	*To save energy*	*Advancing the goal of a comprehensive utlilization of resources, key sectors, key projects and safeguards in 2010*	*Establishing a statistical system fora comprehensive utilization of resources*
	Planning of Energy Development during "Eleventh Five-Year Plan"	*To save energy* *To adjust energy structure*	*By 2010, total one-off energy consumption in China, which should control around 2.7 billion tons of standard coal. Coal, petroleum, natural gas, nuclear power, hydropower and other renewable energy, which should account for 66.1%, 20.5%, 5.3%, 0.9%, 6.8% and 0.4% of total one-off energy consumption respectively.*	
	Notice of the State Council on Printing and Distributing the Comprehensive Work Scheme of Energy Conservation and Reducing the Discharge of Pollutants	*Energy conservation & emission reduction*	*Curb high energy-consuming and high-polluting industries from growing too fast, speed up the elimination of backward production capacity; Acceleration of energy consumption restructuring will become an important work content of energy conservation and emission reduction*	

Table B.2
(continued)

Year	Policy Name	Policy Objective	Main Content	Significance
	Implementation Plan of the Ministry of Construction on Notice of the State Council on Printing and Distributing the Comprehensive Work Scheme of Energy Conservation and Reducing the Discharge of Pollutants	*Energy conservation & emission reduction*		
	Byelaws of Management of Energy Conservation of Civil Architecture (Draft)	*Energy conservation & emission reduction*		*Administrative Regulation*
	Energy Conservation Law of the People's Republic of China	*Energy conservation & emission reduction*	*The new Energy Conservation Law further defines a main law enforcement body, and intensifies corresponding legal responsibility*	*Making energy conservation a basic state policy of China*

NOTES

1 Enterprises operate for 4 days and shut down for 3 days during a week due to energy shortage.
2 State Power Regulatory Commission (2007).
3 AEN – NEA (2005)
4 Lower Heating Value (LHV)
5 For instance, if a thermal plant is made up of 2 turbines with a net capacity of 114 MW each , the net capacity reported in the graph is 114 MW instead of 228 MW
6 The load factor of an energy technology is the ratio of the net amount of electricity generated by a power plant to the net amount which it could generate if it were operating at its net output capacity (maximum capacity). Therefore an increase of the load factor tends to decrease the levelised cost of generating electricity.
7 Constant USD of 1° July 2003
8 Source of data: EIA (n.d. j).
9 We assumed the two power plants worked with the same load factor and sold the electricity at the same price. Moreover, the gains are normalised with respect to the net output of the power plants. Therefore the yearly gains are the same for both power plants considered.
10 The data presented in this table are referred to the "SVK C-1" power plant in the AEN – NEA 2005 report
11 The data presented in this table are referred to the "DEU C-4" power plant in the AEN – NEA 2005 report
12 Investment cost = 10,8 / 1000 * hours/y * economic lifetime (years)
13 Source: AEN – NEA (2005).
14 Source of data AEN - NEA (2005).

7. Environmental Policies

CHINA

7.1. Evaluation of Environmental Policies

Environmental protection means a conscious and reasonable use of natural resources, and preventing the natural environment from being polluted and destroyed. At the same time an environment that has been polluted and destroyed must be treated comprehensively, so as to create an environment suitable for human living and working.

Background

As the Chinese socialist economy develops at a high speed and the productivity level improves, the situation of industrial pollution and environmental deterioration is worsening, and environmental protection has become a major task in order for China to conduct sustainable development. Therefore, prevention and control of environmental pollution and ecological damage has become a very urgent task. In the 1990s, one basic national policy of China was to protect and improve the production environment and the ecological environment, and prevent and control pollution and other public hazards.

Major Environmental Policies

In 1978, for the first time the Chinese Constitution formulated provisions on environmental issues in the form of a fundamental law. The promulgation of the Environmental Protection Law marked the beginning of law governance for Chinese environmental management. The country realized the importance of protecting water resources and controlling water pollution, and in 1988 granted special funds for pollution control.

On July 12, 1989, the State Bureau of Environmental Protection issued Rules for Implementation of the Law of the People's Republic of China on the Prevention and Control of Water Pollution in its first order. Enterprises and institutions that need to discharge pollutants into waters must submit a Pollutant Discharge Declaration & Registration Form to the local environmental protection department. After receiving the Pollutant Discharge Declaration &

Registration Form, the environmental protection department investigates and verifies, and issues pollutant discharge permits to enterprises and institutions on condition that they meet national and local pollutant discharge standards, and the total pollutant discharge limit for enterprises and institutions stipulated by the country. As for those exceeding the limits, the department in charge sets a prescribed time limit by which they must treat the pollution. During the time limit, a temporary waste discharge permit will be issued. Total pollutant discharge targets of new, rebuilt and expanded enterprises and institutions should be determined according to the environmental impact report.

In the 1990s, many laws and regulations on environmental protection were formulated; some environmental laws or administrative rules previously promulgated were modified. Environmental legislation covers various aspects of social life, and has multi-layer and multi-directional regulations on issues that have emerged or will emerge.

In order to prevent construction projects from generating new pollution and damaging the environment, on November 18, 1998, the State Council passed Regulations on Environmental Management of Construction Project at its tenth executive meeting elaborated its Regulations, according to which,

> State standards and local standards for the discharge of pollutants must be complied with respecting construction projects that generate pollution; requirements for aggregate control of discharge of major pollutants must be met in areas subject to aggregate control of discharge of major pollutants.
>
> Measures must be taken in reconstruction projects, expansion projects and technological transformation projects to treat original environmental pollution and ecological damage related to the said projects.

Another important environmental policy focuses on the acceleration of construction and renovation of pipe networks for urban sewage treatment. Conservation and utilization of water resources is the key to develop a circular economy; water resources area lifeline for petroleum and chemical enterprises. China is accelerating its water conservation reform of major industries among which petroleum and chemical industries. Major industries should save 3.1 billion cubic meters of water during the "Eleventh Five-Year Plan" period. Utilization of trash has also been put on the agenda. The Comprehensive Working Program on Energy Conservation and Emission Reduction demands that cities at and above the county-level establish and improve a trash collection system, fully reclaim waste resources in trash, and actively promote urban and rural hazard-free trash disposal. Furthermore, China aims at improving present pollutant discharge standards related to energy production and consumption, guiding enterprises to adopt advanced equipment and production technology, and eliminating small thermal power plants and other production capacity and energy equipment with outdated technologies and low efficiency. The new Management Ordinances for Enforcement and Use of Pollution Discharge Fee issued in 2002 rule that all polluting enterprises must pay a pollution discharge fee. In the past, this fee was only collected to offset the actual cost of waste treatment without counting in the cost of the external environment. As China's environmental situation worsens, the trading of pollution discharge rights has gradually aroused wide concern in industry.

Other targets of China's environmental policies are improving the proportion of natural gas, hydropower and other clean, efficient and quality energy, and reducing the end consumption of coal; developing clean technologies, restricting and eliminating the production of high-ash and high-sulphur coal, preventing and reducing environmental pollution caused by energy development and utilization.

Water pollution control is China's key environmental protection project. The State Environmental Protection Administration, during its "Eleventh Five-Year Plan," added 45 million tons of urban sewage treatment capacity and 6.8 million tons of daily utilization capacity of renewable water, for the purpose of avoiding the emission of 3 million tons of COD; intensified industrial wastewater treatment, and achieved 1.4 million tons of COD reduction.

The Guiding Opinions on Comprehensive Utilization of Resources during the "Eleventh Five-Year Plan" accelerated the comprehensive development and utilization of paragenetic and accompanying mineral resources, and the comprehensive utilization of coalbed methane, coal slack, bulk industrial waste, and agricultural waste such as straw. During the "Eleventh Five-Year Plan," China intended to build a coal slack comprehensive utilization power plant with 20 million kilowatts installed capacity.

Main Problems

The punishment standard for environment violation is too mild. As for the punishment for over-standard discharge, China only prescribes in Law of the People's Republic of China on the Prevention and Control of Atmospheric Pollution,

> Any unit or individual that, in violation of this law, emits air pollutants in excess of the state or local emission standards shall be requested to undertake treatment within a certain time period and be imposed a fine of more than 10,000 but not exceeding 100,000 RMB by the environmental protection administrative department of the local people's government above county level.

According to provisions of Article 24 of the Law of the People's Republic of China on Administrative Penalty,

> For the same illegal act committed by a party, the party shall not be given an administrative fine penalty more than once,

thus enterprises discharging pollutants into the atmosphere in excess of the national or local discharge standards will only receive a maximum fine of RMB100,000. When the cost of pollution treatment exceeds the penalty, enterprises would prefer to accept the penalty rather than taking measures to prevent and control pollution.

Another problem is the free or low-cost environment use system. The environment is used without paying or at low cost because of free pollutant discharge permit or low pollutant fee imposition standard. Therefore, China should promote the reform of an environment pay for use system, and strive to establish a new environmental protection mechanism.

Cost-Benefit Evaluation of Environmental Policies

Policy Selection. Selected Chinese environmental policies for evaluation include: (1) Comprehensive environmental policies, among which the "Circular Economy" and "Environmental Impact Assessment System"; (2) Clean energy policies, among which the "Power Rate Protection of Clean Energy Generating Industry" policy, and the promotion measures of the "Commercial Fuel Cleaning"; (3) Policies for the prevention and control of environmental pollution, among which "Shut Down Small Coal Mines", "Coal Compensation Fund", and "Policy of Treatment of Coal Mine Subsidence Area", and (4) Environmental education.

Cost-Benefit Analysis. Experts have scored and calculated the benefits, costs and benefit-cost ratios of various policies. The results are shown in Table 7.1. Generally speaking, the benefit-cost ratios of Environmental Policies are greater than 1. Among these policies, the "Power Rate Protection of Clean Energy Generating Industry" policy has the highest benefit-cost ratio, 1.80, followed by the "Environmental Education", "Commercial Fuel Cleaning", and "Coal Compensation Fund" policies, with benefit-cost ratios, respectively, of 1.75, 1.66 and 1.50. This shows that policies related to the development of clean energy have higher benefits.

Table 7.1
Cost-benefit analysis of environmental policies

Environmental Policies	Specific Policies	Benefit	Cost	β=Benefit/ Cost	Evaluation
Comprehensive Policies	*Circular Economy*	*83.33*	*81.48*	*1.02*	*High Benefit*
	Environmental Impact Assessment System	*74.07*	*61.11*	*1.21*	*High Benefit*
Clean Energy Policies,	*Power Rate Protection of Clean Energy Generating Industry*	*85.19*	*47.22*	*1.80*	*Significant Benefit*
	Commercial Fuel Cleaning	*86.11*	*51.85*	*1.66*	*Significant Benefit*
Comprehensive Utilization Policies	*Encouraging Combined Heat and Power Generation*	*75.00*	*72.22*	*1.04*	*High Benefit*
Cleaning Technology Policies	*Coal Cleaning Technology*	*81.48*	*74.07*	*1.10*	*High Benefit*
	Clean Coal-burning Power Generation	*94.44*	*70.37*	*1.34*	*High Benefit*
Policies of Prevention and Control of Environmental Pollution	*Shut down Small Coal Mines*	*85.19*	*66.67*	*1.28*	*High Benefit*
	Coal Compensation Fund	*66.67*	*44.44*	*1.50*	*Significant Benefit*
	Policy of Treatment of Coal Mine Subsidence Area	*88.89*	*66.67*	*1.33*	*High Benefit*
Environmental Education	*Environmental Education*	*77.78*	*44.44*	*1.75*	*Significant Benefit*
Comprehensive Evaluation on Environmental Policies		*80.30*	*62.54*	*1.28*	*High Benefit*

7.2. Case-Study: Cost-Benefit Analysis for Non-Water and Renewable Energy Power

Background

The major obstacle to the current development of non-water and renewable energy power is its higher direct cost compared to traditional energy. Power production from wind, solar and other renewable energies involves a much higher cost (without considering the social and environmental benefits) than from coal, and this causes renewable power plants to compare unfavorably with thermal power plants in regard to price. If we consider the above, it is hard to develop renewable energy purely through market means.

This section tries to evaluate the full costs and benefits (among which environmental benefits) of renewable energy with a view to providing a complete picture of the costs and benefits of using such energy. It focuses on the costs and benefits associated with wind power generation, which at present is widely adopted. By means of the incremental analysis method, which is typically used for project evaluation, we estimate the increase in costs and benefits of renewable power generation as compared to traditional thermal power generation, which is used as the base scheme.

Cost Analysis for Renewable Energy Development

Relevant data indicate a falling trend in the construction and operating costs of Chinese wind farms: the initial investment slid from 12,000 Yuan/KWH in 1994 to 10,000 Yuan/KWH in 2008 and the operating cost dropped to 0.5-0.6 Yuan/KWH as compared to 0.2-0.4 Yuan/KWH for thermal power plants. The data suggest a much higher production cost of renewable energy.

The on-grid price of renewable power is higher than that of thermal power. According to the data published on the website of the NDRC in August 2008, the price of such wind power projects as Heilongjiang Ma'anshan, Liaoning Fuxin Phase I and Hebei Manjing Phase III is 0.61 Yuan/KWH, and the tax-inclusive on-grid price of the 205 KW concentrator photovoltaics power station developed by the Inner Mongolia Yitai Group and solar photovoltaic power station developed by Shanghai Chongming Qianwei Village is 4 Yuan/KWH.

The on-grid price of thermal power plants varies from place to place, but it is generally lower than that of renewable power. In 2007, the on-grid price of power plants in south China averaged 0.368 Yuan/KWH as compared to 0.3 Yuan/KWH for those in the northern part of the country.

The price per KWH of wind power is 0.242-0.305 Yuan higher than that of thermal power. According to the data released by Zhou Xi'an, chief of the comprehensive group under the Office of the National Energy Leading Group, China's wind power installed capacity was expected to surpass 10 GW by the end of 2008[U1]. If the annual utilization hours reach 2,000, then 11.2 billion KWH wind power was expected to be produced in that year, leading to an additional payment of 2.7104 billion to 3.416 billion Yuan. The above data are exclusive of the fixed asset depreciation of the grids added for wind power grid connection.

Benefit Analysis for Renewable Energy Development

In comparison to the traditional thermal power generation, renewable power generation produces enormous environmental benefits besides profits for the power plants. The environmental benefits are largely manifested in the reduced amount of pollutants and greenhouse gases such as CO_2.

Benefits from Environmental Pollutant Reduction. One environmental benefit of using renewable energy to generate power is that fewer pollutants (among which water pollutants, atmospheric pollutants and industrial solid waste) are produced. We adopt the treatment cost method in calculating the virtual environmental cost, which refers to the cost required for treating according to the current treatment technique, and levelling all the pollutants discharged into the environment. It should be noted that we are of the opinion that the cost that thermal power plants paid for pollutant treatment should not be included in the calculation of environmental benefits of renewable energy, since this cost was already included in the on-grid price of these plants. We calculated that in 2006, thermal power plants paid a total of 28.460 billion Yuan in virtual treatment cost and produced an aggregate of 2.3696 trillion KWH power, and the environmental cost was 0.012 Yuan/KWH.

In 2008, the total wind power generation reached 11.2 billion KWH, and if based on 0.012 Yuan/KWH, then the environmental benefits in terms of the reduction of pollutant discharges reached 134 million Yuan.

Benefits from Greenhouse Gas Reduction. We calculated the benefit accruing from greenhouse gas reduction by using the market price method. The prevailing price in the international carbon emission rights market is 220 Yuan/ton, or 0.22 Yuan/kg. It has been calculated that in 2007 the CO_2 emission performance of China's power industry was 1.021kg/KWH, which, based on the above price, represented an opportunity cost of 0.22yuan/KWH for CO_2 emissions from thermal power generation.

In 2008, the total wind power generation reached 11.2 billion KWH, so, based on the opportunity cost of 0.22 Yuan/KWH, the environmental benefit in terms of greenhouse gas reduction reached 2.464 billion Yuan.

On the basis of the above calculations, we have derived that the external benefits produced by wind power generation for 2008 total 2.598 billion Yuan.

Net Benefit Estimation for Renewable Energy

We have estimated above that a cost to the tune of 2.710 billion to 3.416 billion Yuan is needed to extend renewable energy (wind power generation of 11.2 billion KWH, the same below). Based on an average cost of 3.063 billion Yuan and total external benefits of 2.598 billion Yuan, the net cost is calculated at 465 million Yuan, or 4.15cent/KWH. In view of the accuracy of our data, we consider that the cost of extending renewable energy in China is negligible and that benefits basically equal expenditures.

7.3. *Cost-Benefit Analysis of Wind Power Generation in the Changdao County*

Introduction

Power production from clean and renewable wind energy provides an important solution to the problems of energy supply, CO_2 emissions, global climate change and sustainable development. The world's developed economies all provide incentives for developing wind power generation as a priority.

Current Status and Prospect of Wind Power Technology Development and Application in Changdao County

Changdao County has ideal natural conditions for the development of the wind power sector. Data from the county weather station show an average wind speed of 5.13m/s and a wind energy density of 162w/m^2 at an elevation of 10m. In addition, meteorological data from several wind measurement stations also indicate a bright development prospect for wind power, considering such factors as long hours of effective wind speeds, absence of destructive wind speeds and good wind quality. For instance, according to data from the measurement point at the county weather station, the county has 7,892 hours of effective wind speeds (3-25m/s) per year, accounting for 90% of the annual total.

Current Development Status of the Wind Power Sector. Changdao kicked off its wind power project in 1992 and since then several 40m anemometer towers have been installed at Nanchangshan, Beichangshan and Tuoji islands. Operation started in 1995, following years of wind measurement and expert study. In March 1998, the county government, the Changdao Power Industry Corporation and the Shandong Luneng Development Group Co., Ltd. set up a joint venture. The new company invested a total of 50.16 million Yuan in the initial phase to install on Nanchangshan Island nine 600KW German Nordex wind generating sets with a total installed capacity of 5,400KW, which were connected to the grid and began production in September 1999. This project, the first commercial wind farm in Shandong, has filled a vacancy in green energy development in the province's power industry. In view of the satisfactory benefits derived from the first phase, the Luneng Wind Power Co., Ltd. invested 59.30 million Yuan and 5 million Yuan in 2003 and 2005, respectively, to complete the extension of the first phase and technological upgrade in the second phase. So far, Luneng Wind Power has invested a cumulative 185 million Yuan into 30 wind generating sets with an installed capacity of 21,500KW, 54% of which are produced domestically. In 2004, the China Huaneng Group and China Light & Power Co., Ltd. jointly launched the Huaneng Zhongdian Changdao Wind Power Co., Ltd., which invested 268 million Yuan in 2005 to install thirty-two 850KW wind generating sets with a total installed capacity of 27,200KW on Nanchangshan and Beichangshan islands for commissioning in early 2006.

The Changdao Liankai Wind power Development Co., Ltd., which was jointly established by Changdao Wind Power Development Co., Ltd. and Wilson Energy Limited, invested 100 million Yuan to develop on Tuoji Island a wind power project with a total installed capacity of 12,000 KW, whose foundation engineering was completed for production in October 2006. Before 2006, the 62 wind generating sets with a total installed capacity of 4,8700 KW in Changdao combined to generate an annual output of 100 million KWH, which represented 84 million Yuan in revenues, among which 36 million Yuan in profits and taxes. As of the end of 2006, the 70 generating sets with a total installed capacity of 60,000 KW in the county attained an annual output of 130 million KWH, which translated into 110 million Yuan in revenues, among which 47 million Yuan in profits and taxes. The swift expansion of the wind power sector in Changdao has upgraded the industrial structure of the county, increased local government revenues, and furthermore set a good example for improving power source structure and developing alternative energy sectors for the entire Shandong Province.

Future Development Plan for the Wind Power Sector. Changdao County planned to develop 40,000KW wind farms on Tuoji, Daqin and Dazhushan Islands to bring the county's total wind power installed capacity on land to 10,000 KW over the 11th Five-Year Plan period. The country also intended to turn offshore wind power into one of its leading sectors during that period by tapping its geographical advantage of vast sea areas and expediting the implementation of a development strategy. Benefits of developing offshore wind farms include less use of land resources, reduced impact on the landscape, and longer service life of generating sets, higher power output and better economic benefits.

It has been calculated that the sea area south of Miaodao Island and west of Daheishan Island can accommodate 220 1500-5000KW generating sets with a total installed capacity of 1 million KW. Changdao planned to complete the offshore wind power project phase 1 with a total installed capacity of 300,000 KW by 2010 and complete a total installed capacity of 1 million KW by 2020. This large offshore wind farm is expected to produce an output of 3 billion KWH, 2.2 billion Yuan of revenues and 700 million Yuan of profits and taxes every year.

Benefits of Wind Power Generation

Significant Contributions of Wind Power Technology Application to the Development of Local Economy. Contributions of wind power technology application to the development of local economy are embodied in three aspects: faster and better economic development, improved economic structure, higher local government revenues and lesser burdens on fishermen.

The development of the wind power sector in Changdao has led to faster economic growth. For instance, during the period 2003-2005, the county's GDP increased at an annual average rate of 22.3%, led by the industrial value-added, which jumped by 49.8% in 2003 and 41.7% in 2005. These remarkable growths would not have been possible without the wind power sector. Before the sector was developed or when it was at the startup stage, the county's industry grew at a slow pace. In 2002, the industrial value-added and GDP climbed by a mere 5.3% and 9.4%, respectively. These figures clearly demonstrate the role of the wind power sector in promoting the growth of the local economy.

The development of the wind power sector has helped improve Changdao's industrial structure. The county saw the value-added ratio to GDP of its primary, secondary and tertiary industries stand at 56%, 11% and 33%, respectively, in 2005, with the primary industry taking a much larger share than the secondary industry, and this was not conducive to a coordinated development of the local economy. But the development of the wind power sector has helped improve this situation. The ratio became 53%, 12%, and 35% for 2006, and according to the county's 11th Five-year Plan, was expected to be adjusted to 44%, 16% and 40% by 2010. This means that, thanks to wind power development, the share of the secondary industry in GDP will increase by one percentage point every year over this period.

The most direct contribution of wind power development is the increase in local government revenues. The gradual phase-out of the agricultural tax over the years has become a test for Changdao, which relies on an agricultural economy. The reduction in agricultural tax collection has, however, been compensated by the increase in tax collection from the wind power sector. Thanks to wind power development, government revenues increased rapidly instead of decreasing (investigation shows that the wind power generated 36 million Yuan of profits and taxes in 2005, and the figure grew to 47 million Yuan in the following year). Data show that government revenues rose by an annual average rate of 19% (on comparable basis) during the period 2003-2005, to reach 37.88 million Yuan in 2005, and grew by 26-28% to reach 48 million Yuan in 2006. In its 11th Five-year Plan, Changdao set the objective of increasing government revenues by an annual average of 21.4%, to 100 million Yuan in 2010. The wind power sector contributes to the local government revenues via two channels. First, local government or companies may have shareholdings in the wind power projects. For example, the county government and county power company each hold 20% of the shares in Luneng wind power project phase 1. The Changdao Wind Power Development Co., Ltd. holds shares in the Changdao Liankai Wind Power Co., Ltd. Second, the local government may retain part of value-added taxes and income taxes contributed by the wind power sector.

The Positive Role of Wind Power Technology Application to Local Social Development. The application of wind power technology influences the local social development in two ways: by alleviating the difficulty of getting adequate power and potable water, a difficulty that had long plagued the development of islands, and by promoting the development of the tourist industry.

Before 2003, the power of the entire county had been supplied from Penglai through 35KVsubmarine cables, with just a few diesel generators as standby. The power transformation capacity and maximum power load amounted to 16.3MVA and 10MW, respectively. If the load grew by 10% annually, then without the wind power projects, the county would soon reach a bottleneck in its power supply. But the successful development of wind power projects has not only alleviated the tight power supply but also greatly improved the power facilities and systems. It can well be expected that with the successful development of the planned 110KV or 220KV transformers and submarine cables, the problems in power use and transmission will be solved satisfactorily. Furthermore, the sufficient power supply has expedited the construction of a seawater desalination project, which will further increase the availability of adequate potable water.

Wind generating sets are generating wide interest as a novelty. Therefore, the development of wind power projects can attract tourists to Changdao, which is also an important tourist island county. In fact, wind power development has graced the landscape of Changdao with its enchanting brilliance.

Impacts of the Application of Wind Power Technology on the Local Eco-environment. The development of wind power projects has generated both positive and negative impacts on Changdao's eco-environment. But all in all, the positive impacts far outweigh the negative ones. Compared to power generation from coal or any other traditional energy, wind power projects have such positive impacts as less coal and water consumption and elimination of emissions of CO_2 and SO_2 and other gases that have deleterious effects on the environment. As of the end of 2006, Changdao had built 62 wind generating sets with a total installed capacity of 48,700KW, which combined to produce a total output of 100 million KWH. In comparison with thermal power facilities, these facilities can save 36,500 TCE and 300,000 tons of water, and reduce emissions of CO_2, SO_2, ash and nitrogen oxide by 96,300 tons, 8,931tons and 18,000 tons, respectively, every year. The planned 1 million KW offshore wind farm, if successfully developed, will provide remarkable environmental benefits by saving 1.2 million TCE and 9 million tons of cooling water, and reducing emissions of 108,000 tons of SO_2, 2.889 million tons of CO_2 and 3.51 million tons of ashes and waste, as compared with a comparable thermal power plant. Significantly, wind power development in Changdao has not only contributed to a better local environment, but also to the surrounding regions, Shandong Province and even the whole country. This is because the developments of wind power as a green power reduce greenhouse gas emissions. It can be said that wind power development in Changdao is an important contribution to the sustainable development of the human society.

Costs of Wind Power Production

Investment Costs. Although providing enormous economic and social benefits, wind power development requires substantial investment costs and a long payback period. For example, the 12,000 KW project on Tuoji Island required a total statistic and dynamic investment of 100.98 million and 103.05 million Yuan, respectively (compiled in 2003), and the investment per unit KW reached 85.88 million Yuan. Huge investmentsare a pandemic feature of wind power projects not only in Changdao but throughout China. The investment cost per KW of wind power generation averages 8,000-10,000 Yuan compared to an average of 3,500 Yuan for thermal power generation. Because of the natural change in the wind, the annual effective operation period for wind power generating sets amounts to 2,000 hours, significantly less than the 6,000 hours for thermal generating sets. Further, the high cost is a problem shared by all the renewable power generation projects in China. Power generation from biogas, wind energy, small hydropower and photovoltaic requires a cost of 1.5 times, 1.7 times, 1.2 times and 11-18 times that of thermal power generation respectively.

If Changdao develops offshore wind power projects, a far greater investment will be required. According to experts, 67% of the total investment will be used as a basic investment, 19% will go to the transmission and distribution systems, and 14% for others. The overall investment will be 30% higher than that of wind power projects on land, with the cost per KW reaching 13,000-15,000 Yuan.

Government Support Regarding Power Price. In Shandong Province, the on-grid price and average user price of thermal power is 0.35 Yuan/KWH and 0.55 Yuan/KWH, respectively, whereas in Changdao, the operating cost of wind farms exceeds 0.5 Yuan/KWH. Since wind power is not in a position economically to compete with thermal power, it is unfeasible to put it to direct commercial use or put it in price competition for supplying power to grids. Government incentive support is necessary.

The on-grid price of wind farms in Changdao built before 2004 is 0.9 Yuan/KWH and that of those built thereafter is lower. The provincial government has promised to maintain the price at 0.76 Yuan/KWH during the eight-year loan repayment period and further reduce the price by 0.50 Yuan/KWH upon expiration of that period.

China has a higher wind power cost and price than other countries. In the northwestern, northern and northeastern parts of the country, where there are rich wind resources, the on-grid price of wind power is twice as high asthat of thermal power. In Xinjiang for example, the on-grid price of wind power is 0.7 Yuan/KWH compared to 0.32 Yuan/KWH for thermal power. In Guangdong, a province that is in dire shortage of coal resources, even the on-grid price of thermal power is as high as 0.7 Yuan/KWH, which is still lower than that of wind power. China lags behind such developed economies as the US, Germany and Britain in grid-connected wind power generation. On average, China's power price is twice that of the US and at the same level as that of Germany. But if external costs of thermal power are taken into account (thermal power plants are not responsible for expenses associated with pollution treatment and environmental disruption), wind farms are in a position to compete with clean thermal power plants.

Land and Environmental Implications. The negative impacts produced by wind power projects include substantial land use; noise, dust, water and soil loss caused by construction; and noise, radio disturbance, impact on birds and on the visual landscape during operation. Environmental impacts during construction will disappear upon completion of works. To address the operational impacts, considerations should be made in the construction stage to arrange generating sets in places that are far away from residential areas. The impacts on bird activities, however, may be longlasting.

Changdao is an island county with a limited land area of only 56 km^2, spread over 32 islands, with a per capita level of 1,240m^2. A weakness of wind power generation is that it requires a large land area. Wind power generation in Changdao thus puts a further strain on its already limited land resources. The solution to this problem is to develop offshore wind power projects, which, however, involve a much higher cost.

Transmission and Distribution Systems. Transmission and distribution systems serve as the basis for the wind power sector, and thus, if not properly developed, they will seriously hinder the development of the sector in Changdao. Changdao has already laid a 110KV submarine cable from Penglai to the county and built a 110KV transformer station. But the continuing wind power development has seen them only able to meet the needs of wind power on land but not the needs of offshore wind power. It has become imperative to build a new 220KV transformer station and to lay a submarine cable or add another 110KV transformer station and submarine cable to realize a double loop power supply between Penglai and Changdao in a bid to break the bottleneck in power use and transmission. Separately, a survey finds that there is only a 220KV grid between Yantai and Penglai, so a 500KV grid between the two will be required if Changdao is to transmit power generated by its new 1 million KV wind farm to other regions beyond Penglai. But the investment in power grid and cable will be beyond the financial capability of Changdao County or the power company.

7.4. Case-Study: Cost-Benefit Analysis of the Clean Coal Program in Chongqing

Background

Coal is one of the most important as well as one of the most polluting energy sources. As such, the European Commission (EC) has been financing research related to the production and use of coal ever since the European Coal and Steel Community Treaty of 1952. Nowadays the EC's efforts are focused on Clean Coal Technologies (CCTs) that are meant to enable coal to maintain its important contribution toward improving Europe's energy security.

Loosely speaking, CCT refers to all those technologies intended to reduce pollution due to coal utilisation. According to a recent study prepared by Energy Edge Ltd (UK) for the Institute for Energy of the European Union's Joint Research Centre CCTs can be classified into two broad categories:

- Technologies which improve burning efficiency and reduce emissions, among which integrated gasification, higher efficiency Pulverised Fuel (PF) combustion, fluidised bed combustion, and coal washing.
- Technologies which fundamentally change the way coal is used to create energy, among which various gasification and liquefaction technologies.

CCTs can be further classified into the following categories :

- Coal washing and beneficiation;
- Pulverised Fuel (PF);
- Fluidised bed combustion (FBC);
- Integrated gasification;
- Gasification and liquefaction;
- Carbon Capture and Storage (CCS).

Coal washing – also known as coal preparation, beneficiation or coal cleaning – is the cleaning process in which mineral matter is removed from mined coal to produce a cleaner product.

Coal can be made less polluting also by improving its efficiency levels; in fact, this increases the amount of energy that can be extracted from a single unit of coal. Increases in the efficiency of electricity generation are essential in tackling climate change. Not only do higher efficiency coal-fired power plants emit less CO_2 per megawatt, but they are also more suited to retrofitting with CO_2 capture systems. As the World Coal Institute points out,

> (...) a one percentage point improvement in the efficiency of a conventional pulverised coal combustion plant results in a 2-3% reduction in CO_2 emissions, depending on the level of efficiency prior to the change.

Efficiency improvements can also be achieved with the deployment of new technologies, such as Fluidised Bed Combustion Integrated Gasification Combined Cycle.

Fluidised Bed Combustion (FBC) is a very flexible method of electricity production which can improve the environmental impact of coal-based electricity, reducing SOx and NOx emissions by 90%. By using this method, coal is burned in a reactor comprising a bed through which gas is fed to keep the fuel in a turbulent state. This improves combustion, heat transfer and recovery of waste products. The higher heat exchanger efficiencies and better mixing of FBC systems allows them to operate at lower temperatures than conventional pulverised coal combustion systems.

An Integrated Gasification Combined Cycle, or IGCC, is a technology that turns coal into gas - synthesis gas (syngas). It then removes impurities from the coal gas before it is combusted. This results in lower emissions of sulphur dioxide, particulates and mercury. It also results in improved efficiency compared to conventional pulverized coal. The plant is called "integrated" because its syngas is produced in a plant-located gasification unit that has been optimized for the plant's combined cycle.

Another option in the portfolio of mitigation actions for stabilization of atmospheric greenhouse gas concentrations is Carbon dioxide (CO_2) Capture and Storage (CCS) which is a process consisting of the separation of CO_2 from industrial and energy-related sources, transport to a storage location and long-term isolation from the atmosphere.

The Clean Coal Program in Chongqing

Chongqing's industrial output value accounts for over 70% of its total output value. The primary energy consumed in the city is coal, 90% of which contains high levels of sulphur and ash, with its sulphur content exceeding 3%. The direct combustion of raw coal has seriously deteriorated the air quality and eco-environment of all southwest China. Incomplete statistics indicate that Chongqing consumes 18 million tons of coal annually, with emissions of SO_2 and soot reaching 900,000 tons and 300,000 tons, respectively.

In 2000, Chongqing invested 870 million Yuan to implement a coal-to-gas based clean energy program in its urban areas to upgrade coal-fired boilers below 100,000 tons and all the hot water boilers to gas-fired ones. Under the program, users had to spend an additional 436 million Yuan on fuel. In comparison, the application of clean coal technology only required an investment of 26.10 million Yuan and an additional operating cost of 27.20 million Yuan, but could reduce over 80% as much SO_2 as the coal-to-gas program. In addition, this technology could fundamentally curb the revival of small coal mines. Actually, SO_2 and soot was still discharged in large volume without any control. In the areas beyond the main urban center, many companies still bought raw coal from coal mines because of its low price. The dust-removing equipment was bought from the environmental authorities only for show. The filthy air in the surrounding districts and counties constantly affected the environment of the urban areas as well. Improvement of the environmental quality still remained a challenge.

In the period 2001-2005, the Chongqing Municipal Government implemented a clean energy action plan in an effort to improve the city's air quality- a city known as "city of fog". As a result, the emissions of SO_2 and soot was limited to below 690,000 tons and 170,000 tons, respectively, the deterioration trend of acid rain was curbed, clean power pilot districts and coal-free districts were developed, and the air quality remained at the state standard II. These have enabled the city to reach the standards for the state model cities in environmental protection. Considering that air pollution in the city was mainly blamed on high-sulphur coal combustion and automobile exhaust fumes, the city focused its energy action on desulphurization, clean coal, renewable energy, mobile pollution source control and industrial restructuring projects.

We will focus on the clean coal project for boilers of above 10 steam tons/hour.

Project background. Coal burning by boilers with a capacity above 10 steam tons/hour was a major contributor to the serious pollution in the urban areas of Chongqing. The economic unsoundness of upgrading such boilers to gas-fired ones increased the difficulty of extending the clean energy.

Project content. The project covered 23 boilers of 11 companies in four urban areas, with a combined capacity of 565 steam tons. The emission standard of air pollutants for coal-burning and oil-burning gas-fired boilers, namely GB13271-2001, was adopted for these boilers. That meant their soot and SO_2 emission concentration should reach 200mg/m^3 and 900mg/m^3, respectively.

Project investments. The investment totaled 50 million Yuan, with 8,500-9,000 Yuan per steam ton, and was provided by the owners. The Chongqing government provided 11 million Yuan in subsidies.

Project benefits. The project, upon completion, can reduce coal consumption by 180,000 tons and slag discharge by 40,000 tons, lower emissions of SO_2 and soot by 30,800 tons and 14,000 tons and save fuel costs of up to 30 million Yuan on an annual basis. The internal rate of return surpasses 20%.

EUROPEAN UNION

7.5. Case-Study: A Framework for the Cost-Benefit Analysis of Clean Coal Technologies in the EU

Background

Before analysing how to exploit these estimates to perform cost-benefit analyses of CCTs, it is useful to introduce the methodologies employed within the CASES project.

Estimate of the Private Cost of Electricity Generation

As for private costs, the CASES project takes into consideration the long-term development of heat and electricity generating costs based on present best predictions about the evolution of the technologies considered.

The methodology used to measure private costs is known as the Average Levelised Lifetime Generating Costs (ALLGC`s). The methodology calculates the generation costs on the basis of net power supplied to the station busbar (e.g. the point where electricity is fed to the grid). The cost estimate methodology discounts the time series of expenditures to their present values in a specified base year by applying a discount rate. The levelised lifetime cost per MWh of electricity generated can be expressed as the present value equivalent of ratio of total lifetime expenses versus total expected outputs. This cost is equivalent to the average price that would have to be paid by consumers to repay exactly the investor/operator for the capital, fuel expenses and Operation and Maintenance (O&M) expenses, inclusive of the rate of return equal to discount rate. The date selected as base year is for the following calculations the Euro in the year 2005. Hence, normal inflation is excluded from the calculations. However, the escalation of fuel prices and increased O&M costs, e.g. due to higher staff and materials costs, are considered.

The investment expenditures in each year include construction, refurbishment and decommissioning expenses. Investment expenditures are measured by defining the specific overnight construction cost, defined as the total costs incurred for the plant's immediate construction, and measured for instance in €/kW, and the expense schedule from the construction period. O&M costs include fixed O&M costs [€/kWa], such as the cost of the operational staff, insurance, taxes etc., and variable O&M costs [€/MWh], such as the cost for maintenance, contract personnel, material consumed (i.e. operating materials, operating fluids) and cost for disposal of normal operational waste (exclusive of radioactive waste).

Although the discount rate may differ from plant to plant, the CASES project used two interest rates: 5% and 10%.

Projections of fuel prices up to 2030 are based upon assumptions that differ among energy carriers. For nuclear power plants any cost figures include all costs of the front (uranium, conversion, enrichment) and back end (intermediate storage, final disposal) of the fuel cycle.

The fuel prices of lignite and biomass (straw, wood chips, biogas) take into account inflation and are assumed to be constant. As for electricity power plants with combined heat and power (CHP`s), the value of heat recovery can be measured by the cost avoided in using recovered thermal energy for a specific purpose, as opposed to using another source of energy. Usually recovered heat replaces thermal energy output from some type of fuel-burning-equipment, usually a boiler. In this case, the value of recovered thermal energy is equivalent to the cost of fuel energy that would have otherwise been consumed. The displayed energy is commonly referred to as an energy credit or fuel credit. The amount of energy displaced by recovered heat is a function of the efficiency of the displaced boiler (or other heating equipment). The alternative heat generation technology in this report is given by a gas boiler with 88% efficiency.

In the case of intermittent renewable energies, such as wind and solar power, their inflexibility, variability, and relative unpredictability should be taken into account. This is accomplished by using a back-up technology. The back-up cost measures the uncertain generating intermittent renewable energies and can be calculated as:

$$C_{BU} = \frac{A_k}{h_v} - \frac{A_k \cdot P}{h_w} = A_k \cdot \left(\frac{1}{h_v} - \frac{P}{h_w} \right)$$

where the cost of the back-up technology, C_{BU}, depends upon:

h_v ≡ Full loading hours, supply
h_w ≡ Full loading hours of the renewable power station
P ≡ Power credit of the renewable energy plant
A_k ≡ Annuity, inclusive of the annual fixed costs of the Back-Up technology.

In this equation, the provision of the back-up power is reduced by a capacity factor (P) for the renewable technologies. Back-up technologies here are a hard coal condensing power plant for minimum back-up costs and a gas-fired combined cycle gas turbine (CCGT) plant for maximum back-up costs.

The CASES project takes into account technologies that reflect the current and the future stage of the commercial heat and electricity industry. Let us focus on coal-fired power plants.

In the case of Hard Coal and Lignite fired power plants, one of the oldest and most common technologies for electricity production is pulverized coal combustion (PCC), which can be used also for lignite combustion, even though with lower efficiency levels because of the lower heat content of lignite. State-of-the-art technologies include the application of supercritical pulverised coal combustion with supercritical steam conditions; these technologies deliver an overall efficiency of 44.5% for lignite and 46% for hard coal. Lignite fuelled IGCC power plants have an efficiency of 44%, hard coal based IGCC plants reach 45%.

Although for the PCC-technology no major technical innovations are expected, elevated steam parameters, installation of superheating steps, and application of lower condenser pressures, further increases in power plant efficiency, up to 52% for the supercritical case, can be achieved. In 2030 an efficiency of the IGCC power plants of up to 55% can be expected. In the long term, the IGCC technology could potentially increase its efficiency considerably above 52%.

A power plant with CCS technologies (pre-combustion, post-combustion and oxyfuel combustion) requires additional individual components which have an impact on cost (about 1370 €/kW in 2020) and efficiency. The CASES project forecasts the IGCC technology with CCS to be available after 2010. Additional energy is required for the compression and liquefaction of the captured CO_2. The efficiency penalty due to CCS was assumed to be 6%. The specific total cost for transport and storage depends on many factors (e.g. accessibility to the storage area, topography and technical feasibility). The costs are assumed to be 3 €/t CO_2 and 15 €/t CO_2 in lesser case and greater case respectively.

Estimation of the External Cost of Electricity Generation

We recall that within the CASES project the social costs of electricity generation is the sum of two components: the private generation costs that we examined above, and the external costs due to impacts on human health, environment, crops and materials, as well as climate change impacts.

External costs of electricity generation (in EuroCents/kWh) are calculated by multiplying the average height of release values of unit of emission for classical air pollutants (2000 Eurocent/kg) times the quantity of emission per unit of electricity generated (kg/kWh).

The impact categories, addressed using the Extern Emethodology, are the environmental impacts, the damage to materials and the global warming impact. The costs of emission are calculated with respect to the impact of pollutants on human health, crops, damage to materials, and loss of biodiversity caused by acidification and eutrophication. For all these categories of impact the principal air pollutants, formaldehyde and a set of heavy metals are considered.

An important component of the total external cost of electricity production is the cost of greenhouse gases. To calculate the full cost of electricity generation the marginal abatement costs to reach the Kyoto objectives are used. The results are obtained by interpooling 26 models "observations" of MACs for different future years, 61 observations for the years 2000, 2025 and 2050. The abatement cost per unit of emission is calculated for CO_2, CH_4 and N_2O.

EcoSense calculates all types of external costs in Euro2000. Then these values are actualised to 2005 by using the Harmonised Indices of Consumer Prices (HICPs). Hence the external costs used to calculate full costs are homogeneous with the private costs, which are calculated in Euro 2005. All results reflect the Willingness To Pay in the year of release, which is respectively 2010, 2020 and 2030.

To calculate the external cost of each kWh of electricity produced, the marginal value per unit of emission is multiplied by the quantity of pollutants emitted at each production stage per unit of electricity. The methodology adopted to estimate the emissions of pollutants for energy generation subdivides the process of electricity generation into four sub-processes representing the life cycle stages: power plant construction, fuel supply, power plant operation, power plant dismantling.

To ensure homogeneity of cost components the assumptions about technical lifetime, installed capacity, power efficiency etc., which are used to estimate the emissions database, are the same used to estimate private costs of electricity and power generation.

Cost-Benefit Analysis of CCTs Based on CASES' Cost Estimates

We recall that the aim of the CASES project is to estimate the social cost of electricity production from the *i*-th technology, which can be written as;

$$SC_t^i = EC_t^i + PC_t^i$$

where SC_t^i is the social cost of technology i at time t, PC_t^i is its private cost and EC_t^i represents its external cost. CASES delivered estimates of the SC_t^i of a wide range of electricity production technologies for three different years t = 2005, 2020, 2030. A summary of the CASES results is provided in Table 7.2, which shows the ranking of technologies.

Table 7.2
External, private and social costs of electricity in Europe: ranking of technologies

									t
			2005			**2020**			**2030**
***i*-th technology**	EC_t^i	PC_t^i	SC_t^i	EC_t^i	PC_t^i	SC_t^i	EC_t^i	PC_t^i	SC_t^i
biomass (woodchips) CHP with an extraction condensing turbine	*10*	*2*	*1*	*12*	*2*	*1*	*13*	*1*	*1*
nuclear power plant	*9*	*9*	*2*	*9*	*6*	*2*	*9*	*6*	*2*
hard coal CHP with backpressure turbine	*31*	*1*	*3*	*31*	*1*	*4*	*32*	*2*	*7*
hard coal CHP with extraction condensing turbine without CCS	*28*	*3*	*4*	*29*	*3*	*6*	*29*	*3*	*6*
hard coal CHP with extraction condensing turbine with CCS	*29*	*4*	*5*	*17*	*8*	*5*	*17*	*8*	*4*
biomass (straw) CHP with an extraction condensing turbine	*20*	*5*	*6*	*23*	*4*	*7*	*22*	*5*	*5*
lignite IGCC without CCS	*22*	*7*	*7*	*22*	*7*	*8*	*24*	*7*	*8*
lignite IGCC with CCS	*23*	*8*	*8*	*10*	*10*	*3*	*12*	*10*	*3*
natural gas CHP with extraction condensing turbine without CCS	*14*	*13*	*9*	*18*	*14*	*11*	*18*	*14*	*13*

Table 7.2
(continued)

natural gas CHP with extraction condensing turbine with CCS	15	14	10	14	19	20	14	19	20
lignite condensing power plant	30	6	11	28	5	9	30	4	12
natural gas combined cycle CHP with backpressure turbine	16	15	12	21	13	12	21	13	14
natural gas combined cycle without CCS	17	16	13	19	15	14	20	15	15
natural gas combined cycle with CCS	18	17	14	15	16	19	15	17	18
wind, on-shore	7	18	15	4	17	15	4	18	11
wind, off-shore	6	19	16	3	18	16	3	16	9
hard coal condensing power plant	32	10	17	32	9	17	31	9	19
hard coal IGCC without CCS	26	11	18	26	11	13	26	11	16
hard coal IGCC with CCS	27	12	19	20	12	10	19	12	10
hydropower, run of river >100MW	1	22	20	1	21	18	1	22	17
hydropower, run of river 10MW	3	23	21	5	23	21	5	26	21
hydropower, run of river <100MW	2	24	22	2	24	22	2	27	22
natural gas, gas turbine	21	21	23	24	20	23	25	21	24
heavy oil condensing power plant	24	20	24	30	22	24	27	25	28
hydropower, pump storage	4	26	25	6	27	26	6	30	29
hydropower, dam (reservoir)	5	27	26	7	28	27	8	31	30
light oil gas turbine	25	25	27	27	25	29	28	29	31
solar thermal, parabolic trough	8	28	28	8	26	25	7	28	25
MCFC (biogas)	33	29	29	33	30	31	33	20	27
MCFC (natural gas)	19	30	30	25	31	30	23	24	26
solar PV, open space	12	31	31	13	32	32	11	32	32
solar PV, roof	11	32	32	11	33	33	10	33	33
SOFC (natural gas)	13	33	33	16	29	28	16	23	23

As we can see, the table shows PC, EC, and SC for three different scenarios:

2005, 2020, 2030. We recall that CASES uses the assumption that CCS technology will not be dispatched until 2010.

The cost estimates produced by CASES can be used to carry out a cost benefit analysis of CCT as follows: let SC_t^B be the social cost of a benchmark technology. Then we can define the benefit of technology i over the benchmark as:

$$B_t^{i,B} = SC_t^B - SC_t^i$$

Then it follows that when $B_t^{i,B} < 0$ technology i implies a lower social cost than the benchmark, and hence is to be preferred. Vice versa, when $B_t^{i,B} > 0$, the i-th technology does not have benefits over the benchmark.

To illustrate the methodology just presented we now focus on technologies that allow for CCS. We recall that these technologies are assumed to be available from 2010 onwards, thus we restrict our attention to the 2020 and 2030 scenarios. In each case we also report the difference in social cost between the technology with CCS and without CCS.

Table 7.3 reports the external cost (EC), the private cost (PC) and the social cost (SC=EC+PC) for different technologies for 2020 and 2030.As we can see from the table in both periods, all coal electricity generation technologies with CCS have a lower social cost than that of their equivalents without CCS. The same does not hold, however, for natural gas technologies.

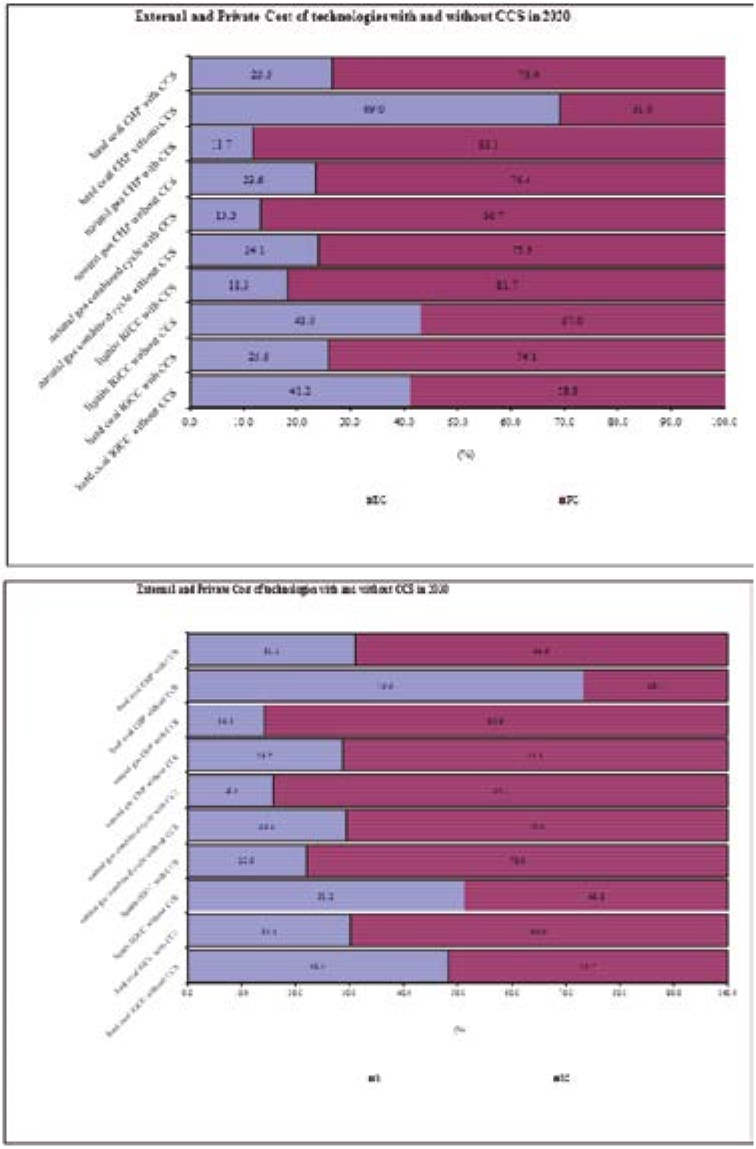
As for the sources of these benefits, we can see from Figure 7.1 that in all cases technologies with CCS have higher private costs than the alternative without CCS; moreover, we can notice that these costs are predicted to decline in the 2030 scenario. Similarly, CCS technologies always display a lower external cost than non-CCS technologies.

Table 7.3
Cost-benefit analysis of CCS technologies

								T
				2020				2030
***i*-th technology**	EC_t^i	PC_t^i	SC_t^i	$B_t^{i,B}$	EC_t^i	PC_t^i	SC_t^i	$B_t^{i,B}$
Hard coal IGCC without CCS	*2.48*	*3.54*	*6.03*	*0.36*	*3.27*	*3.50*	*6.77*	*0.82*
Hard coal IGCC with CCS	*1.47*	*4.20*	*5.66*		*1.79*	*4.16*	*5.95*	
Lignite IGCC without CCS	*2.13*	*2.83*	*4.96*	*0.81*	*2.91*	*2.77*	*5.68*	*1.40*
Lignite IGCC								
with CCS	*0.76*	*3.39*	*4.15*		*0.94*	*3.34*	*4.28*	
Natural gas combined cycle without CCS	*1.45*	*4.58*	*6.04*	*-0.86*	*1.90*	*4.54*	*6.43*	*-0.59*
Natural gas combined cycle with CCS	*0.92*	*5.98*	*6.90*		*1.12*	*5.91*	*7.03*	
Natural gas CHP with extraction condensing turbine without CCS	*1.35*	*4.37*	*5.72*	*-1.50*	*1.77*	*4.40*	*6.17*	*-1.20*
Natural gas CHP with extraction condensing turbine with CCS	*0.85*	*6.37*	*7.22*		*1.04*	*6.32*	*7.36*	
Hard coal CHP with extraction condensing turbine without CCS	*2.98*	*1.34*	*4.31*	*0.05*	*3.82*	*1.39*	*5.21*	*0.73*
Hard coal CHP with extraction condensing turbine with CCS	*1.13*	*3.12*	*4.26*		*1.40*	*3.09*	*4.48*	

Notes: $B_t^{i,B}$ measures the benefit of the technologies with CCS over technologies without CCS. All data are expressed in Euro per kWh. The following shorthand notation is used IGCC = Integrated Gasification Combined Cycle, CCS =CO_2 capture, CHP = Combined Heat and Power.

Figure 7.1
External and private costs of technologies with and without CCS (years 2020 and 2030)



Notes: private and external costs are expressed as percentages of the social costs.

UPDATES

U1. In 2008 wind power installed capacity was 12.2 GW (EIA, n.d. f).

APPENDIX C

China's Environmental Policies - Experts' Evaluation

Table C.1
Experts' evaluation of environmental policies

Panel 1 Environmental Policy-Circular Economy

Benefits	High Benefits	Low Benefits	Costs	High Costs	Low Costs
Improving efficiency of resource utilization	*6*	*0*	*Increasing investment in technology*	*5*	*1*
Reducing pollution emissions	*6*	*0*	*Increasing investment in equipment*	*3*	*3*
Increasing output and product varieties	*3*	*3*	*Increasing dependence between the upstream and downstream industries*	*5*	*1*
Decreasing variable costs of unit products	*3*	*3*			
Total Scores	*54*	*6*		*39*	*5*
Policy Benefits	*60*		*Policy Costs*	*44*	
Conversion Factor	*83.33*			*81.48*	

Table C.1
(continued)

Panel 2 Environmental Policy- Environment Evaluation Policy

Benefits	High Benefits	Low Benefits	Costs	High Costs	Low Costs
Increased awareness of environmental protection	*5*	*1*	*Increased project construction costs*	*5*	*1*
Increased environmental protection efforts	*3*	*3*	*Increased government expenditure*	*0*	*6*
Improved scientificity of project planning and construction	*3*	*3*			
Total Scores	*33*	*7*		*15*	*7*
Policy Benefits	*40*		***Policy Costs***	*22*	
Conversion Factor	*74.07*			*61.11*	

Panel 3 Environmental Policy-Power Rate Protection of Clean Energy Generating Industry

Benefits	High Benefits	Low Benefits	Costs	High Costs	Low Costs
Reducing environmental pollution	*4*	*2*	*Climbing energy supply cost*	*1*	*5*
Improving application of clean energy	*6*	*0*	*Increasing government subsidies*	*2*	*4*
Increasing profit of clean energy suppliers	*4*	*2*	*Impact on revenue of traditional energy industries*	*1*	*5*
			Certain negative impact on the environment	*1*	*5*
Total Scores	*42*	*4*		*15*	*19*
Policy Benefits	*46*		***Policy Costs***	*34*	
Conversion Factor	*85.19*			*47.22*	

Table C.1
(continued)

Panel 4 Environmental Policy-Commercial Fuel Cleaning					
Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Increased use of commercial clean fuel	*5*	*1*	*Increased household energy cost*	*3*	*3*
Reduced coal use	*4*	*2*	*Increased government subsidies*	*0*	*6*
Reduced pollution emissions	*6*	*0*	*Structural unemployment*	*2*	*4*
Improved quality of life	*4*	*2*			
Total Scores	*57*	*5*		*15*	*13*
Policy Benefits	*62*		***Policy Costs***	*28*	
Conversion Factor	*86.11*			*51.85*	

Panel 5 Environmental Policy-Combined Heat and Power Generation					
Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Improved energy utilization efficiency	*6*	*0*	*Eliminating sunk cost of small boilers*	*3*	*3*
Reduced pollution emissions	*5*	*1*	*Increasing investment in heating network*	*4*	*2*
Improved heating quality	*2*	*4*			
Improved production safety	*2*	*4*			
Total Scores	*45*	*9*		*21*	*5*
Policy Benefits	*54*		***Policy Costs***	*26*	
Conversion Factor	*75.00*			*72.22*	

Table C.1
(continued)

Panel 6 Environmental Policy-Coal Cleaning Technology					
Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Reduced transport cost	*3*	*3*	*Increased production cost*	*5*	*1*
Improved coal utilization efficiency	*5*	*1*	*Increased water resource consumption*	*4*	*2*
Reduced pollution emissions	*5*	*1*	*Increased cost of pollution treatment*	*2*	*4*
Total Scores	*39*	*5*		*33*	*7*
Policy Benefits	*44*		***Policy Costs***	*40*	
Conversion Factor	*81.48*			*74.07*	

Panel 7 Environmental Policy-Clean Coal-burning Power Generation					
Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Reduced sulphur dioxide emissions	*6*	*0*	*Increased production cost*	*5*	*1*
Reduced smoke emissions	*5*	*1*	*Increased costs of pollution treatment*	*3*	*3*
			Increased electricity costs	*2*	*4*
Total Scores	*33*	*1*		*30*	*8*
Policy Benefits	*34*		***Policy Costs***	*38*	
Conversion Factor	*94.44*			*70.37*	

Table C.1
(continued)

Panel 8 Environmental Policy-Shut down Small Coal Mines

Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Protecting the environment	5	1	*Declined production*	5	1
Improving production safety of coal mines	4	2	*Reduced employment*	3	3
Reducing resource waste	5	1	*Increased transport cost*	1	5
			Losses of small coal miners	3	3
Total Scores	*42*	*4*		*36*	*12*
Policy Benefits	*46*		***Policy Costs***	*48*	
Conversion Factor	*85.19*			*66.67*	

Panel 9 Environmental Policy-Coal Compensation Fund

Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Restoration and improvement of ecological environment	6	0	*Increased government expenditure*	3	3
Increasing available land	5	1			
Improving safety of buildings	4	2			
Total Scores	*45*	*3*		*9*	*3*
Policy Benefits	*48*		***Policy Costs***	*12*	
Conversion Factor	*88.89*			*66.67*	

Table C.1
(continued)

Panel 10 Environmental Policy-Policy of Treatment of Coal Mine Subsidence Area

Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Benefiting coal mining areas to treat environment	*4*	*2*	*Increasing costs of mining enterprises*	*1*	*5*
Increasing government revenue	*2*	*4*	*Increasing costs of coal utilization*	*1*	*5*
Total Scores	*18*	*6*		*6*	*10*
Policy Benefits	*24*		***Policy Costs***	*16*	
Conversion Factor	*66.67*			*44.44*	

Panel 11 Environmental Policy-Environmental Education

Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Improving environmental protection awareness	*5*	*1*	*Government subsidies expenditure*	*1*	*5*
Improving social pressure on violation of Environmental Protection Law	*3*	*3*			
Total Scores	*24*	*4*		*3*	*5*
Policy Benefits	*28*		***Policy Costs***	*8*	
Conversion Factor	*77.78*			*44.44*	

Notes: see Table A.1.

China's Major Environmental Policies in 1978-2007

Table C.2 China's Major Environmental Policies in 1978-2007

Year	Policy Name	Policy Objective	Main Content	Brief Evaluation
1978	*Constitution of the People's Republic of China*	-	*The country protects the environment and its natural resource, prevents and controls pollution and other public hazards.*	*Formulated provisions on environmental issues in the form of fundamental laws.*
1979	*Environmental Protection Law*	*To protect the environment*	*Nailing down basic guidelines, missions and policies in terms of Chinese environmental protection in the form of laws.*	*Marked the beginning of law governance for Chinese environmental management; positively promoted environmental protection, environmental legislation and jurisdiction*
Year	**Policy Name**	**Policy Objective**	**Main Content**	**Brief Evaluation**
1982	*Interim Measures of Imposition of Pollution Discharge Fee*	*To promote enterprises and institutions to save and comprehensively use resources, treat pollution and improve environment*	-	*Environmental protection with economic means*
1983	*Standard Management Measures of Environmental Protection of the People's Republic of China and Management Provisions on Prevention of vessel-induced Pollution of the People's Republic of China*	*To protect human health and social material wealth, maintain ecological balance, and safeguard quality of atmosphere, water and soil*	*Environmental protection standards include environmental quality standards, pollutant discharge standards, basic environmental standards and environmental protection method standards*	*Protecting environment by formulating standards for pollution source and monitoring method, etc.*

Table C.2
(continued)

1984	Law of the People's Republic of China on the Prevention and Control of Water Pollution (Trial)	To protect water resource environment	Water environment pollution has become a major work content of the government	Reflecting China's recognition of water pollution
1985	Implementation Measures of Environmental Protection Evaluation System of Industrial Enterprises (Trial)	To strengthen planning and management of environmental protection of industrial enterprises, use resource and energy reasonably, and reduce pollutant discharge	Tense energy supply in China	Striving to integrate economic benefit, social benefit and environmental benefit
1988	Water Law of the People's Republic of China and Interim Measures on Compensatory Use of the Special Fund for Source-Pollution Control	To prevent and control pollution	-	
Year	**Policy Name**	**Policy Objective**	**Main Content**	**Brief Evaluation**
1989	Rules for Implementation of the Law of the People's Republic of China on the Prevention and Control of Water Pollution	Operational "Energy Conservation & Emission Reduction" policy	Issue pollutant discharge permit	
1990	Regulations of the People's Republic of China on the Prevention of Pollution Damage to the Marine Environment by Land-sourced Pollutants and Decision of the State Council on Further Reinforcing Environmental Protection Efforts	To reinforce the supervision and management of land-sourced pollutants, prevent and control pollution damage to the marine environment by land-sourced pollutants	-	Prevention and control of environmental pollution and ecological damage have become urgent tasks.

Table C.2
(continued)

1991	*Rules for Implementation of the Law of the People's Republic of China on the Prevention and Control of Atmosphere Pollution*	*Environmental protection has become an important mission for China to carry on sustainable development*	*Local governments at various levels should be responsible for the quality of atmospheric environment within their governance regions, and adopt measures to prevent and control atmospheric pollution, prevent and improve atmospheric environment*	*Worsening industrial pollution and other public hazards, and increasingly severe environmental deterioration*
1992	*Several Opinions Addressing Problems of Domestic Trash in Chinese Cities*	*To strengthen municipal trash management, carry out comprehensive recycling of domestic trash, and improve recycling rate*	-	*By 2000, comprehensive recycling of domestic trash in large- and middle-sized Chinese cities should have exceeded 40%*
Year	**Policy Name**	**Policy Objective**	**Main Content**	**Brief Evaluation**
1993	*Notice on Carrying forward Law Enforcement Inspection for Environmental Protection and Severely Punishing Illegal Activities*	*Governments at all levels should include legal system construction of environmental protection on the important agenda of government work*		
1996	*Decision of the State Council on Several Issues Concerning Environmental Protection and Law of the People's Republic of China on Prevention and Control of Pollution From Environmental Noise*	-	*Implementing total volume control of pollutant emission, establishing national quota system and regular publication system of total volume of major pollutant emission*	
1998	*Regulations on the Administration of Construction Project Environmental Protection*	*Pollution issues during development and construction of real estate*	-	

Table C.1
(continued)

2000	*Rules for Implementation of the Law of the People's Republic of China on the Prevention and Control of Water Pollution*	-	*Volume control system of major pollutant discharge*
	Law of the People's Republic of China on the Prevention and Control of Atmospheric Pollution	-	-
2002	*Management Ordinances for Enforcement and Use of Pollution Discharge Fee*	-	-

NOTES

1 Energy Edge Ltd (2007)
2 The description of the following technologies and all the figures quoted above are available on-line at: World Coal Association (n.d.)

8. Universal Access to Energy

CHINA

8.1. Evaluation of Universal Energy Service Policies

Background

Universal energy service means universality of energy consumption. Considering the dimensions of time and space, universal energy service is the sustainability of consumption, security and reliability of energy supply, and extensiveness of consumption. From an economic perspective, universal energy service is the optimization of resource allocation, that is, how much should be consumed when available resources are limited, who may consume more and who should consume less? The standard of judgement should be largest social benefit, specifically speaking, the largest total added-value produced with existing resources.

Most countries believe that the universality of energy consumption means government serving basic energy demands of all citizens, that is to say, every citizen, no matter in urban or rural areas, economically developed areas or poverty-stricken backward areas, has the right to enjoy basic energy supply required in daily life; and phenomena of unreasonable resource allocation should be reduced.

The main contents of China's universal energy service policy are as follows. First, rural energy services. China's energy supply policy follows the guiding ideology of giving priority to energy supply of industrial production and urban demands. As a result, electricity is insufficient in rural areas. Second, energy consumption of low-income groups and special industries. In order to tackle the problems of energy consumption of low-income groups and special industries, China has been implementing a policy of low-tax, low-price refined oil, and a policy of low electricity price. Third, uneven distribution of energy resources in China. Natural gas and other clean energy sources are mainly located in the western regions. In order to solve the energy consumption problem in the eastern regions, the country implemented the "West-East Natural Gas Transmission Project" and "West-East Electricity Transmission Project".

Rural Energy

The central government has determined that "rural electrification is the basis of modernization in rural areas", China must "unswervingly carry forward the cause of rural electrification, thereby promoting agricultural production, rural economic prosperity and a relatively comfortable life for farmers...", "list rural water and electricity as a small and medium-sized important infrastructure covering all families and promoting an increase of farmers' income." Especially, in order to arrive at a definitive solution to the important problems curbing the development of rural electrification, in 1998 the State Council launched a comprehensive reform of the rural electricity system for the purpose of constructing and transforming rural power grids and achieving the objective of an identical price for electricity in both urban and rural areas. As a result, China's rural electrification has made a substantial leap, helping poverty-stricken areas to become prosperous.

Some policies concerning rural energy aim at encouraging and supporting the construction of small hydropower stations. China's hydropower resources are limited and far flung. It is appropriate for rural areas and remote mountainous areas to develop and utilize small hydropower resources according to local conditions, capable not only of meeting local electricity demands, but also of developing the local economy. Like many developing countries, in order to offer more preference to small private hydropower enterprises and promote the development of small hydropower stations, China has formulated a series of policies to encourage private enterprises to invest in small hydropower stations and ensure power supply for rural areas. More than 30 technical regulations and specifications about the development of small hydropower stations; economic policy (among which various forms of government subsidies, tax breaks, power price concessions, low-interest or soft loans, etc.), and instructive administrative policies (among which power grid, electricity purchase guarantee, quota, etc.) were issued. In 1983, the country brought forward campaign "actively develop small hydropower stations, and construct Chinese-style rural electrification pilot counties." In the new century, the central government attaches great importance to rural electrification, puts forward the campaign "list rural water and electricity as small and medium-sized infrastructure promoting significant income increase for farmers", initiated the campaign "small hydropower stations replacing fuel", an ecological protection project.

China is one of the many countries with the best development of rural small hydropower stations. The rural electrification level of many countries in the Asia-Pacific regions exceeds 70-90% or even higher, however, rural power is mostly supplied by State grids, and the role of small hydropower stations is minimal. The only exception is China, whose rapid development of small hydropower stations is closely related to policy incentives. So far, among over 2,400 counties of China, 1,576 counties have established small hydropower stations, 780 of which supply most of the power demanded locally. In the past 20 years, China has witnessed 653 rural electrification counties with main power supply from small hydropower stations, accounting for 1/3 of all the counties in China. Small hydropower stations have become the most important power source in rural electrification nationwide, second to the State grid.

China has built more than 40,000 small hydropower stations, covering 31 provinces, cities and autonomous regions, over 1,600 counties, and 653 rural electrification counties whose main power supply comes from small hydropower stations[U1]. Small hydropower industry keeps growing, and now has total assets of more than RMB150 billion, and more than 70 local small hydropower companies, which have played an important role in alleviating rural poverty and improving socio-economic conditions.

However, some problems emerged during the development of the small hydropower stations has been disorderly, triggering a number of ecological problems. In recent years, various regions have built small hydropower stations, one after another, without any overall planning, causing many environmental and social problems. For example, on both banks of the 34,000m long river channel of the Xiaoshui River in Shimian County, Sichuan Province, there are 17 hydropower stations that have been built or are under construction, with an average of one at every 2,000m, channeling away a large amount of water, and causing most of the riverbed to dry up.

Another issue of rural energy policies is the development and utilization of methane. China enjoys the largest promotion and application scale of biomass pool in the world. Compared with developed countries, China's project for the anaerobic digestion package technology of methane has become increasingly perfected, and is leading the international level in some aspects; the technology, design and construction of methane projects can be conducted according to the characteristics of different materials; in addition, the investment is relatively small, with low operating costs. By the end of 2004, there were 15.41 million household biomass pools throughout the country, with 6.657 billion cubic meters of methane development and utilization volume, which is equivalent to 5.23 million tons of standard coal or 7.32 million tons of raw coal, calculated according to calorific value equivalent. The country planned to build 26 million biomass pools by 2010. Thus, the number of biomass pools would account for 20% of those agricultural households that are appropriate for developing methane[U2]. The country planned to construct 4,100 agricultural waste methane projects by 2015, forming an annual methane capacity of 450 million cubic meters, equivalent to 580,000 tons of standard coal; and an annual excrement treatment capacity of 123 million tons, so as to solve the pollution problem by means of national intensive aquatic plants, and make a rational use of excrement.

However, the cost of dynamic power generation (the discount rate of 8%) of most methane projects is about 0.5RMB/kwh, much higher than that of coal-burning electricity. A methane project requires large investments, high costs and a low internal rate of returns, and soa methane project in itself cannot compete with conventional energy resources such as gas and electricity, and requires a great deal of long-term State support.

Renovation of rural power grids. From 1998 to 2000, the largest rural power grid construction and renovation project since 1949, was carried out with a total investment of more than RMB100 billion to meet rural power demands by constructing and renovating the rural power grid. After three years, the price of rural electricity decreased dramatically; the rural power grid structure was strengthened; some power substations realized duplicate supplies and two-circuit power supplies. The renovation has enabled Chinese farmers to lead a relatively comfortable life. More than 50%of the counties throughout the country have implemented the same price for county residents; some provinces (autonomous regions and cities), such as Jiangsu and Shanghai, have realized the same price for province-wide residents (autonomous regions and cities). By the end of 2002, the second group of rural power grid renovation projects had been completed; the renovation scale of national rural low-voltage power grids had reached an average of more than 90%; and the objective of setting the same price for both urban and rural areas had been fulfilled. However, the renovation of rural power grids in some areas is at a standstill, and the rural electricity price is more than 1RMB/kwh.

Low-cost and Low-tax Refined Oil Policy

First of all we shall focus on the stable market price of refined oil. In August 2007, the National Development and Reform Commission issued a notice to maintain a stable price for refined oil. Since the price increase of refined oil, would put great pressure on the taxi sector, the country adopted a low-cost, low-tax refined oil policy, because if the price increases significantly, the taxi sector will surely be stricken, and taxi drivers will earn less or even lose their jobs. Since agriculture, tractors, harvesters, and irrigation and drainage equipment all need oil, if the oil price rises, the cost of farming cost will also inevitably increase.

The second crucial point is the postponement of the imposition of a fuel duty. In 1994, the authorities proposed imposing a fuel tax, and in 1997 the National People's Congress passed the Highway Law of the People's Republic of China, which first proposed to substitute a "fuel surcharge" for the highway maintenance fee. The proposal was supposed to be implemented as of January 1, 1998, and the specific measures would be decided by the State Council. However, as of 2008 the fuel tax still had not been imposed by 2008[U3]. The imposition of a fuel duty would involve petrol, diesel and gas in place of the highway maintenance fee, the highway passenger transport associate charge, the highway transport management fee and other relevant charges, cancelling various illegal and unreasonable charges involving transport and vehicles, and retaining a small amount of necessary fees to conduct standardized management. Its significance lies in two factors: first, it is beneficial to promote social equity, fully reflecting the principle of "more duties for more highway use, fewer duties for less highway use"; second, it is beneficial to promote R&D of energy-saving technologies, conserve resources and reduce environmental pollution. For example, the low oil tax policy of the United States has led to excessively large, heavy, high fuel-consuming vehicles. On the contrary, Europe's high oil tax policy has promoted the development of oil conservation technology and the widespread use of small cars. It is obvious that a policy for a fuel duty imposition will bring benefits.

The main reasons behind China's postponement of the introduction of a fuel duty are as follows. First, China's petrol and diesel prices have not connected with international oil prices. If fuel a duty were imposed, oil prices would certainly rise, something the public would not easily accept. Second, the government has to consider the impact a fuel duty would have on agriculture, fishery and other vulnerable industries. Valid approaches have not been found yet to protect these industries. Third, once a fuel duty was put into effect, many toll road fees would be cancelled. The transportation department is worried that 300,000 workers at toll stations would be unemployed. Facing the choice between universal service and energy conservation, Chinese policy prefers universal service.

Main Problems

First of all, a policy system of incentives is not sound. With the current technology, new and renewable energy products cannot compete with conventional ones because of high costs. To this end, it is necessary to establish and improve an incentive policy system in terms of investment, taxation, credit loans, price and management.

Secondly, the management system has some issues. New and renewable energy products belong to different industries, according to their categories. For historical reasons, these products have not formed a unified centralized industry. In addition, leadership and management of new and renewable energy sectors belong to various ministries and commissions, making such a management mechanism incapable of meeting the needs of a market economy and introducing unified policies and measures.

From the above policy analysis and evaluation, it is not difficult to come to the following conclusions: China's energy policy focuses on the sectors that a market mechanism cannot bring into play while according with strategic demands of national economic development and benefitting people's standard of living, such as renewable energy technologies, rural energy services, etc. China's energy policy has switched from focusing on supply to focusing on utilization efficiency and energy conservation; from focusing on economic development and construction to focusing on environmental protection; from energy management relying on monopoly to market regulation; from emphasizing self-sufficiency of energy supply to "going out" into the world.

The implementation effect of China's energy policy is significant. In particular, a "small hydropower station policy" for implementing a universal energy service has made small hydropower stations the most important power supply source, second only to the state grid in Chinese rural electrification; and the effect on industrial energy conservation has been significant.

Cost-Benefit Evaluation of Universal Energy Service Policies

Policy Selection. Universal energy service policies mainly include the "West-East Natural Gas Transmission Project" and the "West-East Electricity Transmission Project," which address the uneven energy distribution in the Eastern and Western Regions of China, the "Limit Commercial Electricity Price" and the "Postpone Imposition of Fuel Duty" policies guaranteeing energy consumption of low-income groups and special industries, the "Same Quality and Same Price of Electricity for Rural and Urban Areas" policy, which is concerned with the rural energy supply, the Infrastructure Construction of Rural Power Grid, Promotion and Application of Rural Methane Technology policy, and the policy of Developing Small Hydropower Stations.

Cost-Benefit Analysis. Experts have scored and calculated the benefits, costs and a benefit-cost ratio of these various policies, the results of which are shown in Table 8.1. Generally speaking, except for "low-price and low-tax petrol policy", the benefit-cost ratio of universal energy service policies is above 1. This indicates that the benefits of implementing these Environmental Policies outweigh the costs. Among these policies, the "Same Quality and Same Price of Electricity for Rural and Urban Areas" policy has the highest benefit-cost ratio: 2.25; followed by "Developing Small Hydropower Stations", with a benefit-cost ratio of 1.85. This shows that the benefit of policies related to rural energy supply is relatively higher than that of other universal energy service policies.

Table 8.1
Cost-benefit analysis of universal energy service policies

Universal Energy Service Policies	Specific Policies	Benefit	Cost	β=Benefit/ Cost	Evaluation
Even Energy Distribution	*West-East Natural Gas Transmission Project & West-East Electricity Transmission Project*	*86.11*	*72.22*	*1.19*	*High Benefit*
Low-price and Low-tax Petrol Policy	*Postpone Imposition of Fuel Duty*	*48.15*	*61.11*	*0.79*	*Costs Higher than Benefits*
Stabilize Energy Prices	*Limit Commercial Electricity Price*	*88.89*	*59.26*	*1.50*	*High Benefit*

Table 8.1
(continued)

Universal Energy Service Policies	Specific Policies	Benefit	Cost	β=Benefit/ Cost	Evaluation
Rural Energy Supply	*Same Quality and Price as Electricity for Rural and Urban Areas*	*100.00*	*44.44*	*2.25*	*Significant Benefit*
	Infrastructure Construction of Rural Power Grid	*100.00*	*77.78*	*1.29*	*High Benefit*
	Promotion and Application of Rural Methane Technology	*80.56*	*55.56*	*1.45*	*High Benefit*
	Developing Small Hydropower Stations	*88.89*	*48.15*	*1.85*	*Significant Benefit*
Comprehensive Evaluation on Environmental Policies		*84.66*	*59.79*	*1.42*	*High Benefit*

8.2. Case-Study: Cost-Benefit Analysis of Heating With Natural Gas in Beijing

Introduction

Boilers burning coal have gradually been replaced by boilers burning natural gas for heating in many Chinese cities since the 1990s. There are two major reasons: (1) heating by burning coal gravely pollutes the environment, and (2) heating by burning natural gas is highly efficient.

Environmental pollution in China is mainly generated by burning coal. The air quality of its urban centers displays typical features of smoke pollution: 90% of the SO_2 in the atmosphere comes from coal combustion. In the cold seasons coal consumption increases and the concentration of SO_2 in the atmosphere dramatically rises to 3.5 times that of the warm seasons (30-40μg/m 3 in the non-heating seasons). About 2/3 of the total suspended particles come from soot. The experiences of many of the world's big cities indicate that the fundamental way of alleviating air pollution is to change the fuel structure. Heating with natural gas has a significant effect on improving air quality. Emissions from burning coal, oil and natural gas are given in the table below.

Table 8.2
Emissions of burning coal, oil and natural gas (kg/t of oil equivalent)

Emissions	Burning 1 Ton Oil	Burning Coal (1 ton oil equivalence)	Burning Natural Gas (1 ton oil equivalence)
CO_2	*3100*	*4800*	*2300*
SO_2	*20 (with 8% un-removed)*	*6 (1%sulphur in coal, of which 80% is removed)*	*0*
No_2	*6 (commercial use)*	*11 (commercial use)*	*4 (commercial use)*
CO	*6.30*	*4.52*	*0.53*
Un-burned hydrocarbon	*0.5*	*0.3*	*0.045*
ash	*0*	*220*	*0*
Fly ash	*0*	*1.4*	*0*

Source: Li Xianrui, Liu Xiao (2002). Current Situation and Outlook of Heating with Natural Gas. Beijing Energy Conservation (2000, 2).

It can be seen in Table 8.2 that burning natural gas emits no SO_2 while reducing NO_2 by 45% and CO_2 by 52%,when compared to burning coal; and it reduces NO_2 by 63% and CO_2 by 26% when compared to burning oil. According to the cost-benefit analysis approach adopted internationally, namely, the lowest cost approach for reducing the concentration of air pollution or total emissions to the index level, heating with natural gas is an optimal alternative solution.

The thermal efficiency of boilers fueled with natural gas is rather high, generally above 85%, while the average thermal efficiency of medium to large coal fueled boilers is about 75%.The thermal efficiency of power plants is 33% or so, their heating efficiency is about 83.7%, and their total energy conversion efficiency is hence about 38%. Therefore, more and more Chinese cities have been encouraging natural gas heating systems since 1990s.

In the process of adjusting the urban energy structure, natural gas has become an important type of energy (see Table 8.3). The heating area reached 518.15 million m^2 in Beijing in the 2006-2007 heating season. The area served by the urban heat network was 107.57 million m^2, accounting for 20.8% of the total heating area; the area heated by coal-fueled boilers was 193.62 million m^2, accounting for 37.4% of the total; and the area heated by natural gas fueled boilers (among which wall-hung boilers) was 203.23 m^2, accounting for 39.2% of the total.

Table 8.3
Areas of heat supplied with different ways in Beijing (years 2006 and 2007)

Heating Ways	Urban Heat Network	Coal Fueled Boilers	Natural Gas Fueled Boilers (among which Wall-hung Boilers)	Oil Fueled Boilers	Other	Total
Heating Area (10,000m²)	*10757*	*19362*	*20323*	*841*	*533*	*51815*
Area Percentage	*20.8%*	*37.4%*	*39.2%*	*1.6%*	*1.0%*	*100%*

Source: Beijing Municipal Administration Commission, Mid-phase Assessment Report on the 11th Five-Year Plan for Heating Development in Beijing

Generally speaking, there are three ways of heating with natural gas boilers: single home heating with home-heating natural gas boilers, heating with scattered natural gas boilers, and heating with regionally centralized natural gas boilers. Water is normally used for heating pipes.

Single home heating with natural gas boilers includes heating rooms and water for washing and drinking. Such boilers are highly efficient, heat-conserving, multi-functional devices. A sample survey shows that the gas consumption index of single home heating in Beijing is 7-8m^3/m^2.

Heating with scattered natural gas boilers includes module heating and distributed central heating. Module heating comprises a single unit in a building or one building that uses a natural gas boiler to supply heat (also called unit heating with natural gas boilers). Distributed central heating means multiple adjacent buildings with the same function using a natural gas boiler to supply heat, and a single heat network to directly supply heat. A sample survey shows that the gas consumption index of heating with scattered natural gas boilers in Beijing is 9-12m^3/m^2.

Heating with regionally centralized natural gas boilers means that buildings in one or more communities use a natural gas boiler to supply heat by means of two heat networks – a heat exchange terminal and a large external heat network. The heating area can reach millions of square meters. The smoke is emitted into the air. The gas consumption index of heating with regionally centralized natural gas boilers in Beijing is 10-14m^3/m^2.

Cost Analysis

The costs of heating with natural gas include the investment and maintenance costs for services provided for heating with natural gas. In addition, since heating services in China are not completely marketized – a controlled heating price is lower than its actual cost–government subsidies to enterprises and residents are incorporated into the cost in a broad sense (social cost).

The following analyses of the investment and operation costs of the three natural gas heating approaches were made by investigating actual data on heating with natural gas boilers in Beijing. The floor area of each heated household is assumed to be 100m^2(Tian, Guo and Di, n.d.).

Investment Costs. The table below lists the results of the investment cost analysis.

Table 8.4
Investment costs for heating with natural gas

Items	Household Boilers	Scattered Boilers	Regionally Centralized Boilers
Area (m^2)	*100/household*	*100*	*100*
Boiler Rooms	-	*1000-2000*	*1000-1500*
Boilers	*3500-6500*	*1500-2000*	*1000-1500*
Devices	-	*1000-1500*	*500-1000*
External Networks	-	*1000-1500*	*1500-2500*
Total	*3500-6500*	*4500-7000*	*4000-6500*
Average	*5000*	*5750*	*5250*
Average Cost in Each Heating Season (120 days)	*500*	*512.5*	*425*

Notes: Costs are measured in Yuan. Life of boilers, boiler rooms and devices are assumed to be equal to 10 years, while the life of networks is assumed to be equal to 20 years.

Operation Costs. The thermal value of natural gas is estimated as 8500Kcal/m^3 in this analysis (Tian, Guo and Di, n.d.). Table 8.5 lists the results of the operation cost analysis.

Table 8.5
Analysis of annual operation costs of the three ways of heating with natural gas

Items	Household Boilers	Scattered Boilers	Regionally Centralized Boilers
Natural Gas Fees	*CNY1,368/760m³*	*CNY1,638/90m³*	*CNY1,980/1100m³*
Electricity Consumption	*CNY78.3/150*	*1000-2000*	*1000-1500*
degree	*CNY104.4/200*	*1500-2000*	*1000-1500*
degree	*CNY156.6/300*	*1000-1500*	*500-1000*
degree	-	*1000-1500*	*1500-2500*
Water Consumption	*CNY32/10m3*	*CNY192/ 60m³*	*CNY256/80m³*
Salt Fees	-	*CNY3.4/10kg*	*CNY5.1/15kg*
Maintenance Fees	*CNY150*	*CNY100*	*CNY150*
Labor Cost	-	*CNY200*	*CNY130*
Total	*CNY1,628.3*	*CNY2,133.4*	*CNY2,397.7*

Notes: excluding depreciation, profits and tax revenue.

Government Subsidies to Heating Companies. The heating system is not completely marketized in China, and so heating prices are lower than heating costs. Generally, government fiscal subsidies are provided to heating enterprises to enable them to operate. We have no way of obtaining specific data on the fiscal subsidies provided to the heating enterprises in Beijing, but we can estimate them based on relevant available data.

According to the estimates in Table 8.4 and Table 8.5, the depreciation and operation costs of heating 100m^2 with scattered boilers and regionally centralized boilers is CNY2,645.9 and CNY2,822.7, respectively. At the current price of natural gas heating in Beijing of CNY30/m^3, the income obtained through heating 100m^2 is CNY3,000, if we take into account reasonable profits of heating companies and our computation errors. Governmental subsidies to heating enterprises are mainly provided to those burning coal. In fact, heating subsidies were provided for the first time in Beijing in 2003 when the coal price rose sharply.

Subsidies are given to households adopting single home heating with natural gas household boilers, pursuant to Interim Measures on Providing Subsidies to the Residents Using Single Home Heating with Clean Energy in Beijing. The subsidy standard is CNY15/m^2.

Analysis of Total Annual (Heating Season) Cost of Heating with Natural Gas. The total area heated by a natural gas boiler (among which wall-hung boilers) was

203.323 million m^2 in the heating season of the year 2006-2007 in Beijing. Regionally centralized heating is the dominant mode, but domestic wall-hung boilers are making rapid headway. Suppose the ratio of single home heating with household natural gas boilers to multi-home heating with scattered natural gas boilers to multi-building heating with regionally centralized natural gas boilers is 15:10:75, then the corresponding heating area of these three approaches is 30.48 million m^2, 20.32 million m^2 and 152.43 million m^2, respectively. Hence, the costs of these three heating ways can be calculated as:

i) Annual heating cost of household boilers = (100m^2 investment depreciation + 100m^2 maintenance cost + 100 m^2 subsidies) × heating area. That is:

$$(500+1628.3+1500) \times 3048 \times 104m^2$$
$$= 110591 \times 104CNY$$

ii) Annual heating cost of scattered boilers = (100m^2 investment depreciation + 100m^2 maintenance cost + 100 m^2 subsidies) × heating area. That is:

$$(512.5+2133.4) \times 2032 \times 104m^2$$
$$=53765 \times 104CNY$$

iii) Annual heating cost of regionally centralized boilers = (100m^2 investment depreciation + 100m^2 maintenance cost + 100 m^2 subsidies) × heating area. That is:

$$(425+2397.7) \times 15243 \times 104m^2$$
$$= 430264 \times 104CNY$$

iv) Total annual cost of heating with natural gas is computed as:

$$11059+5376+43026=594620 \times 104CNY$$

Then, the total annual cost of heating with natural gas in Beijing is 594620×104CNY, namely, CNY594.62 billion.

Benefit Analysis

The primary motive for heating with natural gas is that it has high thermal efficiency and generates much lower environmental pollution than coal. Therefore, the benefit of developing natural gas heating on a large scale is mainly saving coal. The environmental benefit is thus achieved.

Reducing Coal Consumption. The total heating area of houses with coal boilers was 193.62 million m^2 in the 2006-2007 heating season in Beijing, coal consumption for heating was 4.7 million tons, and coal consumption for heating per square meter was 0.0243 ton. Therefore, to supply heat to 203.23 million m^2, 4.93 million tons of coal were consumed. In other words, natural gas boilers with a higher thermal efficiency than coal boilers saved 500,000 tons of coal.

Environmental Benefits. The purpose of using natural gas heating is to solve the environmental pollution matter of coal heating. Emissions from the combustion of natural gas only include NOX, SO_2, smoke, CO and CO_2. No coal ash, coal cinders and pollutants are generated in coal transport. In Beijing's 2006-2007 heating season, natural gas replaced 4.93 million tons of coal, equivalent to 2.42 million tons of standard oil . According to the data on pollutants emitted by burning natural gas given in Table 8.1, it can be calculated that heating with natural gas reduced CO_2 emissions by 6.05 million tons, SO_2 emissions by 14,520 tons, NOX emissions by 26,620 tons, CO emissions by 10,900 tons and ash emissions by 532,400 tons.

THE EUROPEAN UNION

8.3. Case-Study: Energy Poverty in Europe

Background

Residential access to commercial energy represents a crucial need, insofar as it is associated with health. Cooking, refrigeration and heating, for example, are relevant aspects for ensuring a healthy life, and their provision is guaranteed by a continuous access to energy sources. Moreover, given that poor people are more likely to lack energy resources, universal energy access helps to alleviate poverty in developing countries.

Despite its importance, universal access in its narrow sense is not an issue in Europe, as access to energy is virtually universal. Therefore, in Europe emphasis has switched to the concepts of affordable energy and consequently to concerns about efficient use of energy and secure supply. Unstable, rising fuel prices, as countries have moved to a market-based system, are responsible for serious problems of affordability, which are more relevant for poor people. For this reason, the concept of fuel poverty has been introduced. This term refers to a situation in which households cannot afford to keep their living quarters adequately heated at a reasonable price, and in which families who need to spend more than 10% of their resources on fuel are generally referred to as "fuel poor". The main cause of fuel poverty can be found in the interaction between low incomes and poor energy efficiency in dwellings. In particular, the incidence of fuel-poor households increases in houses with inadequate insulation, lacking draft-free windows or characterised by leaky roofs. It becomes clear why the notion of affordability is not simply related to the short-run payment of energy but also to the long-run investment in infrastructure, which ensures an efficient use of the energy.

European Situation of Dwelling Type

The link between fuel poverty, ill health and housing conditions has received a great deal of attention, with housing conditions as a main cause for the other two. For example, Ireland and the UK display the highest rates of seasonal mortality in northern Europe, and such high rates have been associated with inadequately protected, thermally inefficient housing stocks. Housing standards in terms of energy efficiency are subject to great variation across the countries in Europe, as indicated by the information available in the European Community Household Panel-ECHP (Table 8.6). Southern Europe displays the worst conditions in terms of poor housing conditions and consequently in terms of fuel poverty. For example, in Greece and Portugal 16 and 19% of households, respectively, live in houses with leaky roofs. In Spain 11% are affected by the same problem, whereas the percentage drops to 3% in Finland. The consequences of leaky roofs are not only related to insufficient insulation, but also to damp and mould spores that spread inside dwelling's walls and are dangerous for human health.

The provision of hot water is considered an essential household feature. Nevertheless in Europe there are still some families, though few, without access to it. These are nearly 5% in Germany, 4% in Belgium and Ireland. Among European countries with warm climates, Greece and Portugal exhibit the lowest rate, with respectively 70% and 20% of families lacking this amenity.

Table 8.6
Households with housing problems (mean percent, years 1994-1997)

	Leaky roofs	No hot running water	Damp	Rot
Germany	*4.3*	*4.6*	*7.9*	*5.3*
Denmark	*3.9*	*0.8*	*6.2*	*5.6*
Netherlands	*4.4*	*0.5*	*10.8*	*9.7*
Belgium	*5.7*	*3.6*	*14.4*	*9.1*
Luxembourg	*5.0*	*3.1*	*7.5*	*4.8*
France	*5.3*	*2.0*	*16.3*	*10.4*
UK	*3.8*	*0.2*	*13*	*12.7*
Ireland	*4.1*	*4.0*	*9.6*	*7.3*
Italy	*6.3*	*2.8*	*5.4*	*6.2*
Greece	*16.4*	*70.2*	*18.8*	*9.3*
Spain	*11.4*	*3.5*	*21.5*	*7.6*
Portugal	*18.7*	*22.6*	*33.4*	*25.2*
Austria	*3.6*	*2.4*	*8.8*	*4.6*
Finland	*2.9*	*1.8*	*3.8*	*2.6*

Source: European Community Household Panel, 1994-97.

Poorly energy-efficient dwellings are also characterised by damp, which is likely to occur in continuously unheated or insufficiently heated homes, and for this reason they are associated with fuel poverty. Families in southern European countries are more likely to be affected by damp, since 19% of households in Greece, 21% in Spain and 33%in Portugal display damp patches.

Table 8.7
Energy efficiency measures (percent, year 1996)

	Cavity wall insulation	Double glazing	Floor insulation	Roof Insulation
Germany	*24*	*88*	*15*	*42*
Denmark	*65*	*91*	*63*	*76*
Netherlands	*47*	*78*	*27*	*53*
Belgium	*42*	*62*	*12*	*43*
France	*68*	*52*	*24*	*71*
UK	*25*	*61*	*4*	*90*
Ireland	*42*	*33*	*22*	*72*
Greece	*12*	*8*	*6*	*16*
Portugal	—	*3*	—	—
Austria	*26*	*53*	*11*	*37*
Finland	*100*	*100*	*100*	*100*
Sweden	*100*	*100*	*100*	*100*
Norway	*85*	*98*	*88*	*77*
Mean	*49*	*61*	*37*	*63*

Source: European Community Household Panel, 1996.

In the UK 13% of families face damp in their houses, 14% in Belgium and 16% in France. Finally, rotted windows are present in 25% of Portuguese dwellings, 10 % of French dwellings and 12% of British dwellings.

ECHP also gathers information on energy-efficiency levels. As indicated in Table 8.7, energy efficient measures are poorly adopted in Southern Europe, as they do not represent a priority in the building regulations of these countries. Ireland performs more poorly than its Northern counterparts, in particular in terms of penetration of double-glazed dwellings. Germany and the UK rank poorly regarding wall insulation, since only 24% and 25% of dwellings are equipped with this feature. The UK moreover displays very low levels of floor insulation, with a penetration of only 4%. These results have important policy implications, since energy inefficiency can make home heating very expensive for low income countries. Families that cannot afford to heat their homes adequately live in a state of fuel poverty.

Case-Study: Cost-Benefit Analysis of Energy Efficiency Measures in Ireland

Research to date suggests that an effective way to reduce fuel poverty is through allocation of resources to energy efficiency programmes. It should be noted that behavioural changes have a role in improving the thermal/energy efficiency in houses, but investment in capital stock remains the key strategy. Different studies have been conducted to assess whether the implementation of energy-conservation measures in the domestic sector can, through a cost-benefit analysis, be considered socially efficient. However, most studies evaluate the advantage of such measures only in terms of energy savings, and normally omit considerations related to improvements in health and comfort, which are an important aspect of such programmes. An exception is a paper by Clinch and Healy (2001), which makes a comprehensive evaluation of a wide range of costs and benefits of energy-efficiency programmes. The case study provides an ex-ante evaluation of retrofitting 1.2 million dwellings in Ireland over a 10-year period, with various energy-efficiency technologies and heating upgrades. In particular, the following energy-efficiency measures are considered:

- Fitting of lagging jackets
- Roof insulation and roof insulation upgrade
- Draught-stripping
- Civility-wall insulation
- Central heating
- Heating control upgrades
- Low-emissivity double-glazing

Both material and labour costs associated with these measures are accounted for. Moreover, the combination of two contrasting factors, namely improvements in competitiveness and efficiency on the one hand, and capacity constraints in the economy on the other, would determine different scenarios in the time trend of prices, depending on which factor dominates. For these reason, high, medium and low cost scenarios are considered.

In the medium cost scenario, the total cost of the energy-efficiency programme would amount to € 1601 million, which corresponds to € 207 million per year undiscounted (Table 8.8). In the high-cost scenario, which assumes a tightening in the labour market, the cost might increase by € 90 million. On the contrary, an increase in competitiveness may result in a € 192 million fall in costs, under the low-cost scenario. The costs considered can be decomposed into € 881 million for material costs, which account for 55% of total, and € 720 million, which account for the remaining 45% of the total cost of the programme.

Table 8.8
Total costs of the domestic energy efficiency programme (million Euros)

Discount rate (percent)	Low-cost scenario	Medium-cost scenario	High-cost scenario
0	*1817*	*2065*	*2180*
3	*1554*	*1766*	*1865*
5	*1409*	*1601*	*1691*
8	*1227*	*1395*	*1473*
10	*1126*	*1279*	*1351*

As mentioned above, the analysis here considers the benefits related to both the energy/emission savings and the comfort/health effects. It should be noted that this objective introduces some difficulties since there is a trade-off between the two forces. In fact, improvements in energy efficiency contribute to lower spending only if the families maintain the original level of comfort. However, reduced heating bills may induce a rise in temperature in the house, offsetting the beneficial effects of efficiency in the bill. The model here assumes the existence of a comfortable mean internal temperature, set at approximately 17.7 degrees centigrade. As this mean temperature is approached, all efficiency improvements will produce energy/emission savings.

To compute the value of energy savings, three scenarios again are accounted for, depending on the trend in fuel price. The development of more energy efficient machinery and technology, together with improved availability of non-fossil fuel and deregulation of the energy sector may result in fuel price reduction. On the contrary, rapid growth which may increase the demand for energy, carbon taxes, market power in oil production and fuel scarcity are all possible causes of inflationary pressures. Table 8.9 reports the monetary benefits associated with energy savings in three different scenarios.

Table 8.9
Energy savings from the domestic energy efficiency programme (million Euros)

Discount rate (percent)	Static energy price	1% energy price inflation	1% energy price deflation
0	*6520.92*	*7713.00*	*5328.84*
3	*3774.47*	*4405.14*	*3143.81*
5	*2711.68*	*3136.99*	*2286.35*
8	*1730.20*	*1976.36*	*1484.02*
10	*1319.35*	*1495.19*	*1143.51*

There are additional benefits addressed in this study that are worth mentioning. On the one hand, a monetary evaluation of reduced morbidity from efficiency improvements is computed (see Table 8.10). This evaluation considers the excess winter inpatient cost for respiratory disease, which is attributed to poor thermal housing standards. The benefits related to the forgone disease amount to € 58 million at a 5% discount rate.

Table 8.10
Morbidity benefits of the domestic energy efficiency programme (million Euros)

Discount rate (percent)	Morbidity benefits
0	*110*
3	*75*
5	*58*
8	*42*
10	*34*

On the other, the study evaluates the benefits related to comfort (see Table 8.11). As mentioned before, it is assumed that the initial benefits of the energy efficiency programme concern an increase in comfort, since a minimum temperature is not reached. The monetary quantification of such comfort amounts to € 461 million, discounted at 5%.

Table 8.11
Comfort benefits of the domestic energy efficiency programme (million Euros)

Discount rate (percent)	Comfort benefits
0	*728*
3	*549*
5	*461*
8	*361*
10	*309*

In this analysis, the benefits of energy efficiency-programmes always outweigh the costs. Overall, at a 5% discount rate, the benefits amount to € 3656 million, while the costs amount to € 1601 million.

Case-Study: The Costs of Tackling Fuel Poverty in England

A different approach to analyzing fuel poverty, in an evaluation conducted for England by the Fuel Poverty Advisory Group (2003), regards the amount of resources required by vulnerable households to free themselves of fuel poverty. The approach first identifies the number of people who require basic measures to escape from poverty, and then quantifies the costs of such measures. Table 8.12provides average estimates of the total costs of tackling fuel poverty in England by aggregating vulnerable households in three possible situations. The first group are households with an existing gas connection; the second are families without an existing gas connection, but for which a connection is feasible. The third group are households with no connection and for which connection would not be feasible.

Table 8.12
Measures needed in vulnerable fuel poverty households (pound sterlings, year 2003)

	Estimated number of households	Total cost
Gas central heating-existing gas connection	*270,000*	*£ 550 million*
Gas central heating-new connection required	*60,000 to 90,000*	*£ 170 to £ 270 million*
Boiler replacement	*320,000*	*£ 260 million*
Solid wall insulation	*130,000*	*£ 330 to £ 510 million*
Oil fired central heating	*90,000*	*£ 220 to £ 300 million*
High rise flat- communal heating	*4,000*	*£ 50 million*
High rise flat- electric storage heaters	*4,000*	*£ 8 million*
Cavity insulation	*630,000*	*£ 190 million*
Loft insulation	*1,160,000*	*£ 232 million*
Draft proofing	*850,000*	*£ 85 million*

Source: Fuel Poverty Advisory Group

The problem of fuel poverty is addressed not only through private investments, but also by means of government policies. Social welfare subsidies are one of the most significant public measures taken to combat fuel poverty. The UK Government provides Winter Fuel Payments for persons aged 60 or over to help meet winter fuel bills. It should be noted that the eligibility criteria do not take into account the heating requirements or the energy efficiency of the dwelling. For this reason this scheme, while not directly addressing fuel poverty, provides a generic aid to low income families. In 2005/06 expenditures for winter payments reached around £ 2 billion (€ 2.35 billion), while in 1999/00 the amount was £ 759 million (€ 892 million). Such a large increase resulted from the extension of payments to all households containing members aged 60 or over. Moreover, the entitled payment rose from £ 100 to £ 200 (from € 118 to € 236) and an extra £ 100 were assigned to families with members aged 80 or over. In 2005/06 8.5 million families received such benefits. A second type of Government assistance are grants for providing energy efficiency, insulation and heating measures for vulnerable households by, for example extending them to the gas network. This is an important way to tackle fuel poverty, since 32% of fuel-poor families are without gas, compared to13% overall in England. Moreover, 14% of those without gas in England are fuel poor, while about 4.5% of those with gas are poor. The Warm Front Scheme[U4], designed to improve the energy conditions of dwellings, is another measure the Government has taken in its commitment to combat fuel poverty. During an 8-year period, from 2000 to 2007, over 1.4 million households received assistance under the Scheme, whose total funding amounted to £ 800 million (€ 941 million). Similar measures have been adopted in Ireland, where the Department of Social and Family Affairs (DSFA) pays supplementary welfare payments to poor families unable to meet their heating needs. Among these payments is the Fuel Allowance, paid weekly from October to April. In total, 274,000 families received this allowance in 2001. The weekly amount paid was € 6.35, which increased in January 2002[U5]. to € 9.00.The total expenditure for fuel allowance amounted to € 61.3 million in 2001 and € 85.6 million in 2002.

Another allowance which better targets fuel poverty is free electricity and gas. The Free Electricity Allowance guarantees free electricity of up to 1500 units annually. The Free Natural Gas Allowance is an alternative to Free Electricity, which can also be granted to families not connected to the natural gas supply, by means of free bottled gas refill.

Table 8.13
Total expenditure for fuel poverty allowances
(million Euros, Ireland, year 2001)

	Number of recipients	Expenditure
Free Electricity Allowance	*264,407*	*51.8*
Free Natural Gas Allowance	*18,600*	*2.5*
Free Bottled Gas Refill Allowance	*442*	*0.1*

In Ireland, the Government offers Special Housing Aid for the Elderly which provides funding for private housing residents in poor conditions. Additional funding has been provided under the scheme to facilitate the installation of central heating, whose2001 expenditure amounted to €11 million.

A critical issue in evaluating the effectiveness of social programmes is related to targeting. A well-targeted program is one that limits the number of individuals who do not receive the scheme despite being eligible for it, and that reaches a large proportion of the target group. An interesting study conducted for England evaluated the cost-effectiveness of the New Home Energy Efficiency Scheme (HEES)[U6], which provides grants for better insulation and new heating systems (Sefton, 2002). The British government allocated over £ 600 million (€ 706 million) to HEES between 2000 and 2004.

Given that the effectiveness of a scheme depends on its ability to reach those families that need social help the most, the study compares the impact of the HEES scheme as designed, and the impact of alternative ways of targeting the scheme. Two packages are evaluated under the scheme:

- basic insulation package (roof insulation, cavity wall insulation, cylinder/ tank insulation
- insulation package plus standard central heating system

The alternative ways of targeting the schemes are:

- Optimal HEES: Grants are allocated so as to maximise the overall impact on fuel poverty. This implies that only fuel-poor families receive the grant and that the allocation responds to the best cost-effective improvements
- Realistic HEES: This allocation tries to get as close as possible to an optimal allocation, while taking into consideration various administrative constraints.

The result of the analysis is the following. Since the fuel poverty gap is estimated at £ 574 million (€ 675 million), the scheme is able to reduce the gap by £ 25 million (€ 29 million), which represents 4%. The reason for such limited effectiveness is related to the high proportion of resources that are inefficiently allocated, and to the great proportion of families that do not benefit from the scheme, despite being in fuel poverty. 78% of the households receiving grants are not fuel poor, while 82% of the fuel poor families do not qualify for it (Table 8.14).

Table 8.14
Households qualifying for HEES

	Not fuel poor	Fuel poor	Total
Not eligible for HEES	*11,970 (88%)*	*1700 (12%) (82%)*	*13,660 (100%)*
Eligible for HEES	*1350 (78%)*	*390 (22%) (18%)*	*1730 (100%)*
Total		*2080 (100%)*	*15400*

Under an optimal HEES, there is no leakage of resources among the non-fuel recipients, and within the fuel poor categories the most cost effective improvement is targeted. The estimated reduction in fuel poverty under the optimal allocation is £ 188 million (€ 222 million), which is a third of the poverty gap. This implies that there is much room for improving the targeting of the scheme. The limitation of this type of targeting is that it is unfeasible. In fact, to get such results detailed information on families and their homes is required, but is currently unavailable to the administration. For this reason, a more realistic targeting is simulated with the effect of reducing the fuel poverty gap by £ 55 million (€ 65 million), which is still higher than the result of the scheme implemented.

UPDATES

U1. Small hydropower is an abundant resource in China, widely distributed in more than 1,700 counties in over 30 provinces, regions and municipalities – principally in the Western regions and mainly among remote mountainous areas, minority groups' territories and revolutionary sites. Featuring vast areas, sparse populations and decentralized energy demand, these regions can neither be served by the state grid nor are appropriate for long distance power-supply to the grid. Because of the development of small hydropower, more than 300 million people in one third of all the counties, and covering half of all the territories in China, have access to electric power. (UNIDO & ICSHP, 2013).

In 2012 there were 45,799 hydropower stations in rural areas (China's Statistical Yearbook, 2013).

U2. Figures from the Ministry of Agriculture show that biogas users in China had reached 41.68 million households by the end of 2011, among which 39.96 million households with domestic biogas digesters. Biogas households accounted for 23% of all households in rural China, or about one third of the rural households suitable for biogas installation. With the financial support of the government, 24,000 small biogas plants and 3690 medium and large biogas plants had been installed, supplying biogas to 1.7 million households. The government aims to have 50 million biogas user households in rural China by 2015, or around half of all rural households suitable for biogas installation. (Zuzhang, 2013).

U3. The Chinese government launched a fuel tax and reform of the domestic product pricing mechanism in 2009. In November 2011 China also installed an ad valorem resource tax of 5% on all oil and gas production (EIA, 2015).

U4. The Warm Front Scheme ended on January 19, 2013 (UK Government, 2014).

U5. As of December 2014 the weekly amount was 20€ (Citizens Information, 2014).

U6. The Home Energy Efficiency Scheme has now been closed and replaced by the Green Deal, officially launched in 2013 (UK Government, 2015).

APPENDIX D

China's Universal Energy Service Policies - Experts' Evaluation

Table D.1
Experts' evaluation of universal energy service policies

Panel 1 Universal Energy Service Policy- West-East Natural Gas Transmission Project" and "West-East Electricity Transmission Project" policies

Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Expanding natural gas market	*6*	*0*	*Costs of pipeline and network construction*	*5*	*1*
Improving energy supply capacity in the Eastern Regions	*5*	*1*	*Impact on environment along the line*	*2*	*4*
Increasing income of the Western Regions	*4*	*2*			
Increasing supply of cities along the line	*4*	*2*			
Total Scores	*57*	*5*		*21*	*5*
Policy Benefits	*62*		***Policy Costs***	*26*	
Conversion Factor	*86.11*			*72.22*	

Panel 2 Universal Energy service Policy- "Postpone Imposition of Fuel Duty" policy

Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Safeguarding farmers' production oil (diesel)	*1*	*5*	*Encouraging low-efficient oil utilization*	*4*	*2*
Maintaining employment of toll stations	*0*	*6*	*Unfavourable for the promotion of energy-saving equipment*	*1*	*5*
Low petrol costs	*3*	*3*			
Total Scores	*12*	*14*		*15*	*7*
Policy Benefits	*26*		***Policy Costs***	*22*	
Conversion Factor	*48.15*			*61.11*	

Table D.1
(continued)

Panel 3 Universal Energy Service Policy-Limit Commercial Electricity Price

Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Ensuring power supply for low-income groups	*5*	*1*	*Reduced profits of power enterprises*	*1*	*5*
Low commercial electricity prices;	*5*	*1*	*Increased government subsidies*	*3*	*3*
			Unfavorable for power conservation	*3*	*3*
Total Scores	*30*	*2*		*21*	*11*
Policy Benefits	*32*		***Policy Costs***	*32*	
Conversion Factor	*88.89*			*59.26*	

Panel 4 Universal Energy Service Policy-Same Quality and Same Price of Electricity for Rural and Urban Areas

Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Low electricity price for farmers	*6*	*0*	*Reduced profits of power enterprises*	*1*	*5*
			Increased government subsidies	*1*	*5*
Total Scores	*18*	*0*		*6*	*10*
Policy Benefits	*18*		***Policy Costs***	*16*	
Conversion Factor	*100.00*			*44.44*	

Panel 5 Universal Energy Service Policy-Infrastructure Construction of Rural Power Grid

Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Guaranteeing rural power supply	*6*	*0*	*Increased inputs*	*4*	*2*
Total Scores	*18*	*0*		*12*	*2*
Policy Benefits	*18*		***Policy Costs***	*14*	
Conversion Factor	*100.00*			*77.78*	

Table D.1
(continued)

Panel 6 Universal Energy Service Policy-Promotion and Application of Rural Methane Technology					
Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Protecting forest environment	*5*	*1*	*Cost of biogas pool construction*	*2*	*4*
Reducing environmental pollution	*4*	*2*	*Government subsidies*	*2*	*4*
Improving quality of life	*5*	*1*			
Improving utilization of organic fertilizer	*3*	*3*			
Total Scores	*51*	*7*		*12*	*8*
Policy Benefits	*58*		***Policy Costs***	*20*	
Conversion Factor	*80.56*			*55.56*	

Panel 7 Universal Energy Service Policy-Developing Small Hydropower Stations					
Benefits	**High Benefits**	**Low Benefits**	**Costs**	**High Costs**	**Low Costs**
Ensuring power supply of small and medium-sized cities and remote areas	*5*	*1*	*Impact on the environment*	*2*	*4*
Increasing supply of clean energy	*6*	*0*	*Cost of construction*	*1*	*5*
Reducing pollution	*4*	*2*	*Flood prevention in flood season*	*1*	*5*
Total Scores	*45*	*3*		*12*	*14*
Policy Benefits	*48*		***Policy Costs***	*26*	
Conversion Factor	*88.89*			*48.15*	

Notes: see Table A.1.

NOTES

1 According to report of IEA, the definition and standard of rural electrification is "ratio of the population of rural families having access to electricity to the population of the country, is the degree of electrification, regardless of power resource or power consumption."
2 Converted based on the formulas that 1 metric ton raw coal=0.714metric ton standard coal, and 1 metric ton of standard coal =0.687623 metric tons of standard oil
3 The poverty gap captures the amount of resources required to completely eradicate poverty

References

Articles, books and reports

Adelman, M.A. (2002), 'World oil production & prices 1947-2000', The Quarterly Review of Economics and Finance, 42(2), 169-191.

AEN – NEA (2005), 'Projected costs of generating electricity', retrieved from: https://www.iea.org/textbase/nppdf/free/2005/ElecCost.pdf

AEN – NEA (2010), 'Projected costs of generating electricity', retrieved from: https://www.iea.org/publications/freepublications/publication/projected_costs.pdf

Allsopp, C. (2006), 'Why is the macroeconomic impact of oil different this time?', Oxford Energy Forum (August).

Anderson, J.E. (2003), Public Policymaking, Wadsworth, Cengage Learning.

Arnold, S., Behrens, A., Egenhofer, C., Hunt, A., Markandya, A., van der Welle, A., van der Zwaan, B. (2010), 'Electricity supply externalities, energy security' in Bigano A., Markandya, A., Porchia, R. (eds.), The Social Cost of Electricity. Scenarios and Policy Implications, Elgar.

Arnold S., Markandya, A., Hunt, A. (2007), National and EU Level Estimates of Energy Supply Externalities, Fondazione Eni Enrico Mattei, Milan, Deliverable D.5.1 Section 1 of the CASES Project.

Azar, C., Johansson, D., Hedenus, F. (2008), 'Energy security policies in EU-25 - The expected cost of oil supply disruptions', Paper presented at the 16th Annual Conference of the European Association of Environmental and Resource Economists, Gothenburg, Sweden.

Bachmeier, L.J., Griffin, J.M. (2006), 'Testing for market integration: crude oil, coal and natural gas'. The Energy Journal, 27(2), 55-71.

Bahgat, G. (2011), Energy Security: an Interdisciplinary Approach, John Wiley & Sons.

Barell, R., Pomerantz, O. (2004), 'Oil prices and the world economy', NIESR Discussion Paper, N. 242.

Barsky, R.B., Kilian, L. (2004), 'Oil and the macro economy since the 1970s', Journal of Economic Perspectives, 18(4), 115-134.

Beccue, P.C., Huntington, H.G. (2005), 'An assessment of oil market disruption risks', EMF, Final Report, N. SR 8.

Behrens, A., Egenhofer, C. (2008), 'Energy policy for Europe - Identifying the European added-value', Report of a CEPS Task Force, CEPS, Brussels.

Bergerson, J., Lave, L. (2007), 'The long-term life cycle private and external costs of high coal usage in the US', Energy Policy, 35(12), 6225-6234.

Bigano, A., Markandya, A., Porchia, R. (2010) (eds.), The Social Cost of Electricity. Scenarios and Policy Implications, Elgar.

Bohi, D.R., Toman, M.A. (1993), 'Energy security: externalities and policies', Energy Policy, 21(11),1093-1109.

Bohi, D.R., Toman, M.A. (1996), The Economics of Energy Security, Kluwer, Boston.

Bohm, M.C., Herzog, H.J., Parsons, J.E., Sekar, R.C. (2008), 'Capture-ready coal plants - options, technologies and economics', International Journal of Greenhouse Gas Control, 1(1), 113-120.

Böhringer, C., Hoffmann, T., Vögele, S. (2000), 'The cost of phasing out nuclear power: a quantitative assessment of alternative scenarios for Germany', ZEW Discussion Report, N. 00-23, retrieved from ftp://ftp.zew.de/pub/zew-docs/dp/dp0023.pdf

BP (2005), BP Statistical Review of World Energy, BP, London.

BP (2006), 'Quantifying energy', in BP Statistical Review of World Energy, retrieved from http://www.rrojasdatabank.info/bpstats2006.pdf.

BP (2007), BP Statistical Review of World Energy, BP, London.

Broadman, H.G., Hogan, W.W. (1988), 'Is an oil tariff justified? An American debate: II the numbers say yes', The Energy Journal, 9(3), 7-29.

Brown, P.A., Yücel, M.K. (2002), 'Energy prices and aggregate economic activity: an interpretative survey', The Quarterly Review of Economics and Finance, 42(2), 193-208.

Burtraw, D., Palmer, K., Bharvirkar, R., Paul, A. (2001), 'Cost-effective reduction of NOX emissions from electricity generation', Journal of the Air & Waste Management Association, 51(10), 1476-1489.

CAAC – CLEAN AIR ALLIANCE OF CHINA (2013), 'Twelfth Five-Year Plan on air pollution prevention and control in key regions', retrieved from http://www.epa.gov/ogc/china/air%20pollution.pdf.

Canadian Energy Research Institute (2004), 'Levelised unit electricity cost comparison of alternate technologies for baseload generation in Ontario', Report prepared for the Canadian Nuclear Association.

CCCHINA - CHINA CLIMATE CHANGE INFO-NET (2011), 'China's policies and actions for addressing climate change', retrieved from http://www.ccchina.gov.cn/WebSite/CCChina/UpFile/File1148.pdf.

CCCHINA - CHINA CLIMATE CHANGE INFO-NET (2012), 'China's policies and actions for addressing climate change', retrieved from http://www.ccchina.gov.cn/website/ccchina/upfile/File1324.pdf.

CCCHINA - CHINA CLIMATE CHANGE INFO-NET (2013), 'China's policies and actions for addressing climate change', retrieved from http://www.ccchina.gov.cn/archiver/ccchinacn/UpFile/Files/Default/20131108091218654702.pdf.

CCCHINA - CHINA CLIMATE CHANGE INFO-NET (2014), 'China's policies and actions for addressing climate change', retrieved from http://en.ccchina.gov.cn/archiver/ccchinaen/UpFile/Files/Default/20141126133727751798.pdf.

Chengzhang, Z. (2004), 'China's electricity system reform for 50 years', China Reform (April).

China Electricity Council (2007), 'Report on development of China's Electrical Power industry'.

China Electricity Newspaper (2008), 'History of power demand management in China', January 22, 2008.

NBS, (1992 – 2014), 'China's Statistical Yearbook'.

Chinese Academy of Social Sciences (2006), 'Key conditions for setting national energy policy'. Institute of Quantitative & Technical Economics, Review of Economic Research, 36.

Christou, C., Hadjipaschalis, I., Poullikkas, A. (2007), 'Parametric cost-benefit analysis of integrated gasification combined cycle technology', Paper presented at the Third International Conference on Clean Coal Technologies for Our Future, Sardinia, Italy, 15-17 May.

Clinch, J. P., Healy, J. D. (2001), 'Cost-benefit analysis of domestic energy efficiency', Energy Policy, 29(2), 113-124.

Clinch, J. P., Healy, J. D. (2003), 'Valuing improvements in comfort from domestic energy-efficiency retrofits using a trade-off simulation model', Energy Economics, 25(5), 565-583.

CNREC – CHINA NATIONAL RENEWABLE ENERGY CENTRE (2012), 'Renewable energy in China 2010', retrieved from http://en.cnrec.info/publications/.

CNREC – CHINA NATIONAL RENEWABLE ENERGY CENTRE (2014), 'China renewable energy outline 2012', retrieved from http://www.cnrec.org.cn/english/publication/2014-01-20-408.html.

Coal Information Research Institute (2007), 'China coal industry yearbook'.

Coltrain, D., Dean, E., Barton, D. (2004), 'Risk factors in ethanol production', Department of Agricultural Economics, Kansas State University.

Confindustria (2008), 'Efficienza energetica in Italia. Tendenze e prospettive', Rome.

Constantini, V., Gracceva, F., Markandya, A., Vicini, G. (2007), 'Security of energy supply: comparing scenarios from a European perspective', Energy Policy, 35(1), 210- 226.

Costas, C., Hadjipaschalis, I., Poullikkas, A. (2008), 'Assessment of integrated gasification combined cycle technology competitiveness', Renewable and Sustainable Energy Reviews, 12(9), 2459-2471.

CPB (2003), 'Energy policies and risks on energy markets, a cost-benefit analysis'. CPB Bijzondere Publicatie 51, The Hague, retrieved from http://www.cpb.nl/nl/pub/cpbreeksen/bijzonder/51/bijz51.pdf

CPG - CENTRAL PEOPLE'S GOVERNMENT OF THE PEOPLE'S REPUBLIC OF CHINA (2012), 'Full text: China's energy policy 2012', retrieved from http://www.gov.cn/english/official/2012-10/24/content_2250497.htm.

Daalsgard, T., André C., Richardson, P. (2001), 'Standard shocks in the OECD interlink model', OECD Economics Department. Working Paper Series, N. 306.

Dasgupta, P.S., Heal, G.M. (1979), Economic Theory and Exhaustible Resources, Cambridge University Press.

Davison, J. (2007), 'Performance and costs of power plants with capture and storage of CO_2', Energy, 32(7), 1163-1176.

de Joode, J., Kingma, J., Lijesen, M., Mulder, M., Shestalova, V. (2004), 'Energy policies and risks on energy markets: a cost-benefit analysis', Netherlands Bureau for Economic Policy Analysis. Special Publication, N. 51.

DG CLIMA (2013), 'The EU Emissions Trading System (EU ETS)', retrieved from http://ec.europa.eu/clima/publications/docs/factsheet_ets_en.pdf.

Dieppe, A., Henry, J. (2004), 'The Euro area viewed as a single economy: how does it respond to shocks?', Economic Modelling, 21(5), 833–875.

DOE/NETL (2008), 'Reducing CO_2 emissions by improving the efficiency of the existing coal-fired power plant fleet', 2008/1329, July.

Dones, R., Heck, T., Hirschberg, S. (2003), 'Greenhouse gas emissions from energy systems: comparison and overview', PSI Annual Report (2003 Annex IV), Paul Scherrer Institute, Villigen, Switzerland.

DSS Management Consultant Inc. (2005), 'Cost benefit analysis: replacing Ontario's coal-fired electricity generation', Report prepared for the Ontario Ministry of Energy, RWDI Air Inc., April.

Dunn, W. (2002), An Introduction to Public Policy Analysis, China Renmin University Press.

Egenhofer, C., Gialoglou, K., Luciani, G. (2004), 'Market-based options for security of energy supply - Summary and conclusions', INDES Working Paper, N.1, CEPS, Brussels.

Elobeid, A., Tokgoz, S. (2006), 'Removal of U.S. ethanol domestic and trade distortions: impact on U.S. and Brazilian ethanol markets', Working Paper Series (N. 06-WP 427), Center for Agricultural and Rural Development, Iowa State University.

Energy Charter Secretariat (2013), 'Status of ratification of the Energy Charter Treaty', retrieved from http://www.encharter.org/fileadmin/user_upload/document/ECT_ratification_status.pdf.

Energy Edge Ltd. (2007), 'Coal of the future', retrieved from http://www.energy-edge.net/EUR%2022644%20EN%20Coal%20of%20the%20Future.pdf

Environmental Law & Policy Center (2001), 'Repowering the Midwest: the clean energy development plan for the Heartland'.

Espirito Santo, D.B. (2006), 'Comparing two engines of 425 kwe with the same cogeneration configuration through a computational simulation methodology', International Journal of Thermodynamics, 9(4), 147-159.

Eurostat (2007), 'Energy: long-term indicators'.

Fengqi, Z., Qingyi, W. (2002), China Energy 50 Years, China Electrical Power Publishing House.

Fuel Poverty Advisory Group (2003), 'Estimating the costs of tackling fuel poverty in England', Department of Trade and Industry, UK.

Geller, H., Harrington , P., Rosenfeld, A.H., Tanishima, S., Unander, F. (2006), 'Policies for increasing energy efficiency: thirty years of experience in OECD countries', Energy Policy, 34(5), 556-573.

Gielen, D., Podkanski, J., (2005), 'The future role of CO_2 capture in the electricity sector', in Rubin E.S., Keith D.W., Gilboy C.F., Wilson M., Morris T., Gale J., Thambimuthu K. (eds.), Greenhouse Gas Control Technologies 7, Elsevier, pp. 873-880.

Global Energy Net (2006), 'List of countries for CO_2 emission in the world in 2006'.

Goldemberg, J., Coelho, S.T., Natari, P.M., Lucon, O. (2004), 'Ethanol learning curve - The Brazilian experience', Biomass and Bioenergy, 26(3), 301-304.

Greene, D.L. (1991), 'A note on OPEC market power and oil prices', Energy Economics, 13(2), 123-129.

Greene, D.L., Leiby,P.N. (2006), The Oil Security Metrics Model, Oak Ridge National Laboratory (ORNL/TM-2006/505).

Growth Analysis (2014), 'China's National Energy Administration – A short overview', retrieved from http://www.tillvaxtanalys.se/download/18.65ca4b24146d72da1d67d1f6/1404302537634/direct_response_2014_11_China%E2%80%99s+National+Energy+Administration.pdf.

Gullì, F. (2006), 'Small distributed generation versus centralised supply: a social cost-benefit analysis in the residential and service sectors', Energy Policy, 34(7), 804-832.

Hammerlink, C.N. (2004), 'Outlook for advanced biofuels', Utrecht University.

Hoftyzer, J., Millner, E.L., Harks, E. (2003), 'Security of oil supply, oil crisis mitigation stocks', Presentation at the INDES Workshop on Insuring Against Disruptions of Energy Supply, 6-7 May.

Hogwood, B. (2004), Analysis of Policies of the Real World, China Renmin University Press.

Hoogwijk, M., Faaij, A., Erickhout, B., de Vries, B., Turkenburg, W. (2005), 'Potential biomass energy out to 2100 for four IPCC SRES land-use scenarios', Biomass and Bioenergy, 29(4), 225-257.

Hunt, A.S.P., Markandya, A. (2004), 'Final Report on Work Package 3: The externalities of energy insecurity', ExternE-Pol Research Project for European Commission, retrieved from http://www.externe.info/externe_2006/expolwp3.pdf.

Hunt, B., Isard, P., Laxton, D. (2001), 'The macroeconomic effects of higher oil prices', IMF Working Paper series (N. WP/01/14).

Huntington, H.G. (1998), 'Crude oil prices and US economic performance: where does the asymmetry reside', The Energy Journal, 19(4), 107-131.

Huntington, H.G. (2003), 'Energy disruptions, interfirm price effect and the aggregate economy', Energy Economics, 25(2), 119-136.

Huntington, H.G. (2004), 'Shares, gaps and the economy's response to oil disruptions', Energy Economics, 26(3), 415-424.

International Energy Agency (2001), 'Energy price volatility: trends and consequences', IEA Paper.

International Energy Agency (2004), 'Analysis of the impact of high oil prices on the global economy', IEA Paper.

International Energy Agency (2006), 'World Energy Outlook 2006'.

International Energy Agency (2007a), 'Data services'.

International Energy Agency (2007b), 'Energy security and climate policy assessing interaction'.

International Energy Agency (2007c), 'IEA response system for oil supply emergencies'.

International Energy Agency (2008), 'Oil markets and emergency preparedness'.

International Energy Agency (2014), 'Energy supply security. Emergency response of IEA countries 2014', retrieved from https://www.iea.org/publications/freepublications/publication/ENERGYSUPPLYSECURITY2014.pdf.

International Monetary Fund (2000), 'The impact of higher oil prices on the global economy', IMF Research Department, December.

International Monetary Fund (2007), 'World Economic Outlook database'.

Jansen, J.C., van Arkel, W.G., Boots, M.G. (2004), 'Designing indicators of long-term energy supply security'. Working Paper Series (N. ECN-C-04-007), Energy Research Centre of the Netherlands.

Johansson, D.J.A., Azar, C., Lindgren, K., Persson, T.A. (2009), 'OPEC's strategies and oil rent in a climate conscious world', The Energy Journal, 30(3), 23-50.

Johnson, T.L., Keith, D.W. (2004), 'Fossil electricity and CO_2 sequestration: how natural gas prices, initial conditions and retrofits determine the cost of controlling CO_2 emissions', Energy Policy, 32(3), 367-382.

Jones, C. (2004), An Introduction to Public Policy Research, China Renmin University Press.

Jones, D. W, Leiby, P.N., Paik, I.K. (2004), 'Oil shocks and the macro economy: what has been learnt since 1996?', The Energy Journal, 25(2), 1-32.

Kaufman, R.K., Dees, S., Karadeloglou, P., Sanchez, M. (2004), 'Does OPEC matter? An econometric analysis of oil prices', The Energy Journal, 25(4), 67-90.

Klare, M.T. (2004), Blood and Oil: The Dangers and Consequences of America's Growing Dependency on Imported Petroleum, Henry Holt, New York.

KPMG, China (2011a), 'China's 12th Five-Year Plan: overview', retrieved from http://www.kpmg.com/CN/en/IssuesAndInsights/ArticlesPublications/Publicationseries/5-years-plan/Documents/China-12th-Five-Year-Plan-Overview-201104.pdf.

KPMG China (2011b), 'China's 12th Five-Year Plan: energy', retrieved from https://www.kpmg.com/CN/en/IssuesAndInsights/ArticlesPublications/Documents/China-12th-Five-Year-Plan-Energy-201104.pdf.

KPMG China (2011c), 'China's 12th Five-Year Plan: iron and steel', retrieved from http://www.kpmg.com/CN/en/IssuesAndInsights/ArticlesPublications/Documents/China-12th-Five-Year-Plan-Iron-Steel-201105-2.pdf.

Lam, P.L. (2004), 'Efficiency and productivity of China's thermal power generation', Review of Industrial Organization, 24(1), 73-93.

Lardic, S., Mignon V. (2006), 'The impact of oil prices on GDP in European countries: an empirical investigation based on asymmetric cointegration', Energy Policy, 34(18), 3910-3915.

Larsson, R. (2007), 'Tackling dependency: the EU and its energy security challenges', Swedish Defence Agency, Stockholm.

Leiby, P.N. (2007), 'Estimating the energy security benefit of reduced US oil imports', Working Paper (October), Oak Ridge National Laboratory.

Leiby, P.N., Jones, D.W., Curlee, T.R., Lee, R. (1997), 'Oil imports: an assessment of benefits and costs', Working Paper (November), Oak Ridge National Laboratory.

Lifeng, Z., Xiao, Y., Gallagher, K.S., Wang, B., Xu X. (2008), 'Technical, environmental, and economic assessment of deploying advanced coal power technologies in the Chinese context', Energy Policy , 36(7), 2709-2718.

Lundqvist, R.G. (1993), 'The IGCC demonstration plant at Varnamo', Bioresource Technology , 46(1), 49-53.

Mahlia, M.I., Said, M.F.M, Masjuki, H.H., Tamjis, M.R. (2005), 'Cost-benefit analysis and emission reduction of lighting retrofits in residential sector', Energy and Buildings, 37(6), 573-578.

Maisonnier, G. (2006), 'The ties between natural gas and oil prices', IAEE Newsletter (15, 26-29).

ManagEnergy (2014), 'Directory of energy agencies', retrieved from http://www.managenergy.net/lib/documents/1145/original_Directory_ME_complet_2014_BR.pdf.

McFarland, J.R., Herzog, H.J., Reilly, J. (2003), 'Economic modeling of the global adoption of carbon capture and sequestration technologies', in Gale J., Kaya Y. (eds.) Greenhouse Gas Control Technologies - 6th International Conference, Pergamon, pp. 1083-1088.

MEP (2005), 'Bulletin for China's environment statistics'.

MEP (2006), 'Bulletin for China's environment statistics'.

Mi, J. (2007a), 'Summary of current energy and power saving policies in China's electric sector'. Electric Devices, July 2007, 4 -6.

Mi, J. (2007b), 'Energy-saving dispatch: it is the key how to solve the problems?', Management of Chinese Electrical Power Enterprises, 3.

Mitchell, J. V. (2007), 'Analysing energy insecurity', Oil, Gas & Energy Law Journal, 5(4).

Mixon, J.W. (1989), 'On the comparative statics of the dominant-firm model', Review of Industrial Organization, 4(1), 119-130.

Mueller, F. (2007), 'Energy security - Demands imposed on German and European foreign policy by a changed configuration in the world energy market', SWP Research Paper, N. 2, German Institute for International and Security Affairs.

MVV Consulting (2006), 'Implementation of TEN-E projects (2004-2006), Evaluation and analysis', Final Report.

Naughten, B. (2003), 'Economic assessment of combined cycle gas turbines in Australia. Some effects of microeconomic reform and technological change', Energy Policy, 31(3), 225–245.

Neff, T.L. (1997), 'Improving energy security in Pacific Asia: diversification and risk reduction for fossil and nuclear fuels', Pacific Asia Regional Energy Security Project.

Nesbitt, D.M., Choi, T.Y. (1988), 'Is an oil tariff justified? An American debate: III the numbers say no', The Energy Journal, 9(3), 31-59.

Nowicki, P., van Meijl, H., Knierim, A., Banse, M., Helming, J., Margraf, O., Matzdorf, B., Mnatsakanian, R., Reutter, M., Terluin, I., Overmars, K., Verhoog, D., Weeger, C., Westhoek, H. (2007), 'Scenario 2020 - Scenario study on agriculture and the rural world', European Commission, Directorate-General of Agriculture and Rural Development (Contract No. 30 - CE - 0040087/00-08).

Odeh, N.A., Cockerill, T.T. (2008), 'Life cycle GHG assessment of fossil fuel power plants with carbon capture and storage', Energy Policy, 36(1), 367-380.

OECD (2006), 'Agricultural market impact of future growth in the production of biofuels'.

OECD/International Energy Agency (2006), 'Energy technology perspectives: scenarios and strategies to 2050'.

Ordorica-Garcia, G., Douglas, P., Croiset, E., Zheng, L. (2006), 'Technoeconomic evaluation of IGCC power plants for CO_2 avoidance', Energy Conversion and Management, 47(15), 2250-2259.

Ordorica-Garcia, G., Douglas, P., Croiset, E., Zheng, L. (2007), 'Techno-economic Evaluation of IGCC Power Plants With CO_2 Capture', in Rubin, E.S., Keith, D.W., Gilboy, C.F., Wilson, M., Morris, T., Gale, J., Thambimuthu, K. (eds.), Greenhouse Gas Control Technologies 7, Elsevier, pp. 1193-1198.

Parry, I.W.H., Damstadter J. (2003), 'The costs of US oil dependency', Resources for the Future, N. 03-59).

Poullikkas, A. (2005), 'Technical, economic and environmental analysis of future sustainable gas turbine technologies', IEEE Lecture, December.

Poullikkas, A. (2006), 'Implementation of MAST gas turbine technologies for large scale power generation', Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 28(15), 1433-1446.

Poullikkas, A. (2009), 'A decouple optimization method for power technology selection in competitive markets', Energy Sources, Part B: Economics, Planning, and Policy, 4(2), 199-211.

Pruschek, P., Oeljeklaus, G., Haupt, G., Zimmermann, G., Jansen, D., Ribberink, J.S. (1997), 'The role of IGCC in CO_2 abatement', Energy Conversion and Management. 38(Supplement), S153-S158.

Ram, C. S., Parsons, J.E., Herzog, H.J., Jacoby, H.D. (2007), 'Future carbon regulations and current investments in alternative coal-fired power plant technologies', Energy Policy, 35(2), 1064-1074.

RFA – RENEWABLE FUELS ASSOCIATION (2015), 'Going global', 2015 ethanol industry outlook, retrieved from http://ethanolrfa.3cdn.net/

c5088b8e8e6b427bb3_cwm626ws2.pdf.

Roeger, W. (2005), 'International oil price changes: impact of oil prices on growth and inflation in the EU/OECD', International Economics and Economic Policy, 2(1),15-32.

Röller, L., Delgado, J., Friederiszick, H. (2007), Energy: Choices for Europe, Bruegel Blueprint Series, Brussels.

Rubin, E.S., Chen, C., Rao, A.B. (2007), 'Cost and performance of fossil fuel power plants with CO_2 capture and storage', Energy Policy, 35(9), 4444-4454.

Rungsuriyawiboon, S. (2004), 'An analysis of cost structures in the electricity generation industry', Working Paper Series, No. 05/2004, Centre for Efficiency and Productivity Analysis, University of Queensland.

Sanyong, G. (2006), 'Recommendations for Government countermeasures to regulate the oil industry under the new landscape', Industry Observation, 21.

Sauter, R., Awerbuch S. (2003), 'Oil price volatility and economic activity: a survey and literature review', IEA Research Paper (August).

Sefton, T. (2002), 'Targeting fuel poverty in England: is the Government getting warm?', Fiscal Studies, 23(3), 369-399.

Shui, B. and Li, J. (2012), 'Building energy efficiency policies in China', GBPN and ACEEE Technical Report, retrieved from http://www.gbpn.org/sites/default/files/08.%20China%20Report_0.pdf.

Slaski, A. (2008), 'The economic and environmental effects of eliminating the U.S. tariff on ethanol', Related Publication, N. 08-05, REG-Markets Center, AEI Center for Regulatory and Market Studies, USA.

Smeets, E., Faaij, A., Lewandowski, I., Turkenburg, W. (2006), 'A bottom-up assessment and review of global bio-energy potentials to 2050', Progress in Energy and Combustion Science, 33(1), 56-106.

Spalding-Fecher, R. (2005), 'Health benefits of electrification in developing countries: a quantitative assessment in South Africa', Energy for Sustainable Development, 9(1), 53-62.

Starr, F., Tzimas, E., Peteves, S. (2007), 'Critical factors in the design, operation and economics of coal gasification plants: the case of the flexible co-production of hydrogen and electricity', International Journal of Hydrogen Energy, 32(10), 1477-1485).

State Council Information Office (2007), 'China's energy conditions and policies', White Paper, retrieved from http://www.china.org.cn/english/environment/236955.htm.

State Power Regulatory Commission, (2007), 'Annual report on electricity regulation 2007'.

Sterner, T. (2007), 'Fuel taxes: an important instrument for climate policy', Energy Policy, 35(6), 3194-3202.

Stockton, W. (2008), 'Bringing home the benefits of energy efficiency to low-income households', Enterprise Community Partners, Inc.

Tian, G., Guo, F., Di, K. (n.d.), 'Comparison and analysis of different ways of heating with natural gas boilers'.

Tian, J. (2008), 'How the People's Republic of China is pursuing energy efficiency initiatives: a case study', ADB Sustainable Development Working Paper Series, retrieved from http://www.adb.org/sites/default/files/publication/28699/how-prc-pursuing.pdf.

Toman, M.A. (1993), 'The economics of energy security: theory, evidence, policy', in Kneese A.V., Sweeney J.L. (eds.), Handbook of Natural Resource and Energy Economics, Elsevier, pp. 1167-1218.

Turton, H., Barreto, L. (2006), 'Long-term security of energy supply and climate change', Energy Policy, 34(15), 2232-2250.

UNDP (2001), 'Energy subsidy reform and sustainable development: challenges for policy makers', Synthesis Report, UNDP, Geneve.

UNIDO and ICSHP (2013), 'World small hydropower development report 2013', retrieved from http://www.smallhydroworld.org/fileadmin/user_upload/pdf/WSHPDR_2013_Final_Report-updated_version.pdf.

USDA Foreign Agricultural Service (2006), 'GAIN annual report on Japan biofuels', GAIN Report, N. JA6024, retrieved from http://www.fas.usda.gov/gainfiles/200605/146197881.pdf.

USDA Foreign Agricultural Service (2007), 'GAIN annual report on EU-27 biofuels', GAIN Report, N. E47051, retrieved from http://www.fas.usda.gov/gainfiles/200706/146291509.pdf.

USDA Foreign Agricultural Service (2013), 'EU biofuels annual 2013', retrieved from http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_The%20Hague_EU-27_8-13-2013.pdf.

USDA Foreign Agricultural Service (2014), 'EU biofuels annual 2014', retrieved from http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_The%20Hague_EU-28_7-3-2014.pdf.

van Meijl, H., van Rheenen, T., Tabeau, A., Eickhout, B. (2005), 'The impact of different policy environments on land use in Europe', Agriculture, Ecosystems and Environment, 114(1), 21-38.

Vasconcelos, J. (2005), 'Towards the internal energy market: how to bridge a regulatory gap and build a regulatory framework', European Review of Energy Markets, 1(1), 1-17.

Viebahn, P., Nitsch, J., Fischedick, M., Esken, A., Schuwer, D., Supersberger, N., Zuberbuhler, U., Edenhofer, O. (2007), 'Comparison of carbon capture and storage with renewable energy technologies regarding structural, economic, and ecological aspects in Germany', International Journal of Greenhouse Gas Control, 1(1), 121-133.

Villar, J.A., Joutz, F.L. (2006), 'The relationship between crude oil and natural gas prices', Energy Information Administration (October).

Walsh, K.D. (2003), 'Cost-benefit analysis of residential energy-efficiency upgrades in Phoenix, Arizona', Journal of Architectural Engineering, 9(1), 11-17.

Walton, D. (2006), 'Has oil lost the capacity to shock?', University of Warwick Graduates' Association Senior Directors' Forum.

Winkler, H., Spalding-Fecher, R., Tyani, L., Matibe, K. (2002), 'Cost–benefit analysis of energy efficiency in urban low-cost housing', Development Southern Africa, 19(5), 593-614.

World Bank (1998), 'Thermal power: guidelines for new plants', in Pollution Prevention and Abatement Handbook, World Bank, pp. 413-426.

World Bank (2000), 'Fuel for thought - An environmental strategy for the energy sector'.

World Bank (2005), 'Global economic prospects: economic implications of remittances and migration'.

World Bank (2008), 'The welfare impact of rural electrification: a reassessment of the costs and benefits'.

World Energy Council (2008), 'Energy efficiency policies around the world: review and evaluation'. London.

World Energy Council (2013), 'Energy efficiency policies and trends at world level', Report prepared by Enerdata for the World Energy Council under the supervision of the WEC Energy Efficiency Committee coordinated by ADEME, retrieved from http://www.ademe.fr/sites/default/files/assets/documents/89828_rapport-wec-energy-efficiency-policies-trends-world-level.pdf.

Xiangfu, Z. (2003), 'Scientific administration of the Government reform – A theoretical reflection on the evolution of China's coal industry administration system', China Economist, 1, 259-260.

Xinqian, O. (2007), 'Perspectives of the Electrical Power industry in China', International Forum for DSM of China's Electrical Power.

Yijian, Y. (2008), 'An analysis of the Ministry of Energy established and abolished thrice in 59 years since the founding of New China', 21st Century Business Herald, March 12.

Zhang, X. (2008), 'Address of the Vice Director of NDRC, at the national power industrial conference on shutting down small thermal power generation units and setting up large power generation units: sum up experiences, make determined and persistent effort to firmly accomplish the shutdown task in 2008'.

Zhong, X., Mei, G., Gong, T., Bian, Y., Wei, J. (2007), New China Coal Industry, Ocean Press.

Zhiyue, B. (2010), 'China's new National Energy Commission: policy implications', EAI Background Brief No. 504, East Asian Institute, retrieved from http://www.eai.nus.edu.sg/BB504.pdf.

Zuzhang, X. (2013), 'Domestic biogas in a changing China: can biogas still meet the energy needs of China's rural households?', International Institute for Environment and Development, London, retrieved from http://pubs.iied.org/pdfs/16553IIED.pdf.

Other documents

China's State Council (2005), The decision of the State Council on Establishing the National Energy Leading Group (No.14, 13/05/2005).

CMLR - CHINA'S MINISTRY OF LAND AND RESOURCES (2005), Circular on Issues of Regulating Prospecting Licenses and Mining License (N. 200, 30/09/2005).

Commission Delegated Regulation (EU) No 1059/2010 of 28 September 2010 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of household dishwashers. OJ L 317/1. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32010R1059.

Commission Delegated Regulation (EU) No 1060/2010 of 28 September 2010 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of household refrigerating appliances. OJ L 314/17. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32010R1060.

Commission Delegated Regulation (EU) No 1061/2010 of 28 September 2010 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of household washing machines. OJ L 314/47. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32010R1061.

Commission Delegated Regulation (EU) No 626/2011 of 4 May 2011 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of air conditioners. OJ L 178/1. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32011R0626.

Commission Delegated Regulation (EU) No 392/2012 of 1 March 2012 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of household tumble driers. OJ L 123/1. Retrieved from http://eur-lex.europa.eu/legal-content/EN/

TXT/?uri=CELEX:32012R0392.

Commission Delegated Regulation (EU) No 874/2012 of 12 July 2012 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of electrical lamps and luminaires. OJ L 258/1. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012R0874.

Commission Regulation (EC) No 245/2009 of 18 March 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaires able to operate such lamps, and repealing Directive 2000/55/EC of the European Parliament and of the Council. OJ L 76/17. Retrieved from http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:32009R0245.

Commission Regulation (EC) No 643/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for household refrigerating appliances. OJ L 191/53. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009R0643.

Commission Regulation (EU) No 813/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for space heaters and combination heaters. OJ L 239/136. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32013R0813.

Commission Staff Working Document. Directorate-General Energy and Transport. Inventory of Public Aid Granted to Different Energy Sources. Working Document from the Services of the European Commission. [SEC(2002)1275].

Commission Staff Working Document. Annex to [COM(2005)628 final]. Impact Assessment.

Commission Staff Working Document. The Support of Electricity From Renewable Energy Sources. [SEC(2008)57].

Commission Staff Working Document. Accompanying Document to[COM(2011)109 final]. Impact Assessment. Retrieved from http://eur-lex.europa.eu/legalcontent/EN/TXT/PDF/?uri=CELEX:52011SC0277&from=EN.

Communication from the Commission. Energy for the Future: Renewable Sources Of Energy - White Paper for a Community Strategy and Action Plan. [COM(97)599 final].

Communication from the Commission to the European Parliament and European Council. The Internal Market in Energy: Coordinated Measures on the Security of Energy Supply. [COM(2002)0488 final].

Communication from the Commission. The Support of Electricity from Renewable Energy Sources. [COM(2005)627 final].

Communication from the Commission. Biomass Action Plan. [COM(2005)628 final].

Communication from the Commission to the Council and the European Parliament. Nuclear Illustrative Programme, presented under Article 40 of the Euratom Treaty for the opinion of the European Economic and Social Committee Brussels. [COM(2006)844 final].

Communication from the Commission to the Council and the European Parliament. Renewable Energy Road Map. Renewable Energies in the 21st Century: Building a More Sustainable Future. [COM(2006)848 final].

Communication from the Commission to the European Council and the European Parliament. An energy policy for Europe. [COM(2007)1 final].

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. 20 20 by 2020 - Europe's climate change opportunity. [COM(2008)30 final].

Communication from the Commission to the Council and the European Parliament. Report on Progress in Creating the Internal Gas and Electricity Market. [COM(2008)192 final].

Communication from the Commission - Energy efficiency: delivering the 20% target. [COM(2008)772 final]. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52008DC0772.

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Energy Efficiency Plan 2011. [COM(2011)109 final]. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52011DC0109.

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on security of energy supply and international cooperation. "The EU Energy Policy: Engaging with Partners beyond Our Borders". [COM(2011)539 final]. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52011DC0539.

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A policy framework for climate and energy in the period from 2020 to 2030. [COM(2014)015 final]. Retrieved from http://eurlex.europa.eu/legalcontent/EN/TXT/?uri=CELEX:52014DC0015.

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Progress towards completing the Internal Energy Market. [COM(2014)634]. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2014:0634:FIN.

Council Decision 2010/787/EU of 10 December 2010 on State aid to facilitate the closure of uncompetitive coal mines. OJ L 336/24. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1422875250308&uri=CELEX:32010D0787.

Council Directive 98/93/EC of 14 December 1998, amending Directive 68/414/EEC which imposes an obligation on Member States of the EEC to maintain minimum stocks of crude oil and/or petroleum products. Official Journal of the European Communities. OJ L 358/100.

Council Directive 2003/96/EC of 27 October 2003 restructuring the Community framework for the taxation of energy products and electricity. OJ L 283/51.

Council Directive 2009/119/EC of 14 September 2009 imposing an obligation on Member States to maintain minimum stocks of crude oil and/or petroleum products. OJ L 265/9. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32009L0119.

CSPC - China's State Planning Commission. (1998), The Crude Oil and Oil Product Price Reform Scheme (June).

CSPC - China's State Planning Commission. (2001), Circular of the State Planning Commission on the Methods of Improving Oil Price Convergence and Adjusting Oil Product Price (October).

DG COMP. (2006) Report on Energy Sector Inquiry. [SEC(2006)1724].

DG ECFIN (2004), How Vulnerable is the Euro Area Economy to Higher Oil Prices?. Quarterly Report on the Euro Area (3, 15–20).

DG TREN. (2004), Notes for the implementation of the Electricity Directive 2003/54/EC and the Gas Directive 2003/55/EC. The Unbundling Regime.

DG TREN. (2005), EU-25 Energy Fiches (TREN C1).

DG TREN. (2006), Mid Term Evaluation of the Multiannual Programme for Action in the Field of Energy "Intelligent Energy Europe, 2003-2006". Final Report to Directorate-General Energy and Transport (C3005. Ref: 14/03/2006),

DG TREN. (2007), Study on Outputs, Performances and Future Perspectives of SAVE Energy Agencies. Ecuba srl. (Service Contract for EC DG TREN N°.TREN/04/EISave/S07.34282. Presentation for EUSEW, Brussels, 31/01/2007).

DG TREN. (2008), Annex. Results of the Fact-finding Analysis Undertaken in Preparation of the Consultation Document on the Revision of the Emergency Oil Stocks Regime in the EU.

Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market. OJ L 283/33.

Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport. OJ L 123/42.

Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32009L0028.

Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC. OJ L 211/55. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32009L0072.

Directive 2009/73/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC. OJ L 211/94. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32009L0073.

Directive 2010/30/EU of the European Parliament and of the Council of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products. OJ L 153/1. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32010L0030.

Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings. OJ L 153/13. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32010L0031.

Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control), OJ L 334/17. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32010L0075.

Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC. OJ L 315/1. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012L0027.

EAEC Council (1958), Statutes of the Euratom Supply Agency.

European Commission. White Paper “An Energy Policy for the European Union”. [COM(95)682 final].

European Commission. Green Paper “Towards a European Strategy for the Security of Energy Supply”. [COM(2000)769 final].

European Commission. Green Paper “A European Strategy for Sustainable, Competitive and Secure Energy". [COM(2006)105 final].

European Commission. Green Paper on Market-based Instruments for Environment and Related Policy Purposes. [COM(2007)140 final].

European Commission (2008), Consultation Document on the Revision of the Emergency Oil Stocks Regime in the EU "Towards a Modern and Effective System of Oil Stocks in Europe".

European Parliament resolution of 9 June 2011 on the EU-Russia summit. OJ C 380 E/15. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1423146001021&uri=CELEX:52011IP0268.

EWEA (2005), Re-Xpansion, WP 2 Evaluation of renewable support schemes, final report. Retrieved from http://www.ewea.org.

GCR - Global Competition Review (2006a), Getting the Deal Through – Gas Regulation 2006 in 30 Jurisdictions Worldwide.

GCR - Global Competition Review (2006b), Getting the Deal Through – Electricity Regulation 2006 in 30 Jurisdictions Worldwide.

Law on the Prevention and Control of Air Pollution. Adopted at the Fifteenth Meeting of Standing Committee of the Ninth National People's Congress on April 29, 2000; promulgated by the President of the People's Republic of China on the same date, effective as of September l, 2000. Retrieved from http://faolex.fao.org/docs/pdf/chn52652E.pdf.

MOFCOM (2006), Decree No.23, 2006 of the Ministry of Commerce of the People's Republic of China, Promulgating the Measures for Administration of the Market of Processed Oil. Retrieved from http://english.mofcom.gov.cn/aarticle/policyrelease/domesticpolicy/200701/20070104269768.html.

NDRC (2004), Coal Export Quota Administration Measures. The National Development and Reform Commission, China, and China's Ministry of Commerce and the General Administration of Customs (07/01/2004).

NESD (2005), Outline of the Eleventh Five-Year Plan for National Economic and Social Development of the People's Republic of China.

Notice of the National Development and Reform Commission on Strengthening Price Controls on Coal Used for Power Generation. (No.299, 11/30/2011). Retrieved from http://www.lawinfochina.com/display.aspx?id=9090&lib=law&SearchKeyword=coal&SearchCKeyword.

OPTRES (2006), Assessment and Optimisation of Renewable Support Schemes in the European Electricity Market. Interim Report.

Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources [COM(2008)30 final].

REEP (2007), Symposium: The European Union Emissions Trading Scheme. Review of Environmental Economics and Policy (1, 66-133).

Regulation (EC) No 714/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation (EC) No 1228/2003. OJ L 211/15. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32009R0714.

Regulation (EU) No 994/2010 of the European Parliament and of the Council of 20 October 2010 concerning measures to safeguard security of gas supply and repealing Council Directive 2004/67/EC. OJ L 295/1. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32010R0994.

Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC. OJ L 88/5. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32011R0305.

Regulation (EU) No 347/2013 of the European Parliament and of the Council of 17 April 2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009. OJ L 115/39. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32013R0347.

Regulations on Environmental Management of Construction Project. Promulgated by Decree No. 253 of the State Council on November 29, 1998. Retrieved from http://www.ecolex.org/ecolex/ledge/view/RecordDetails;DIDPFDSIjsessionid=3A734D1296ECFDFD1B65C2C674103409?id=LEX-FAOC052694&index=documents.

Report from the Commission to the European Parliament and the Council. Progress Towards Achieving The Kyoto And EU 2020 Objectives (required under Article 21 of Regulation (EU) No 525/2013 of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC). [COM(2014)689 final]. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1432651761061&uri=CELEX:52014DC0689.

SCIO (2005), White Paper entitled "China's Energy Conditions and Policies", by the State Council Information Office.

SEPA (2006), Communiqué of Emission Limits of Key Pollutants released for 2005 and the first half of 2006 by the Chinese State Environmental Protection Administration, the Chinese National Bureau of Statistics and the Chinese National Development and Reform Commission.

Electronic documents and websites

ÄFAB. (n.d.), www.afabinfo.com.

AgManager.info. (n.d.), www.agmanager.info.

BASE (n.d.), http://www.energy-base.org/.

BP (n.d.), www.bp.com.

CARMA (n.d.), Geographic Regions, retrieved from http://carma.org/dig/.

China Water Risk (n.d.), Water policy, China's 12th Five-Year Plan, retrieved from http://chinawaterrisk.org/regulations/water-policy/.

Citizens Information (2014) Fuel allowance, retrieved from http://www.citizensinformation.ie/en/social_welfare/social_welfare_payments/extra_social_welfare_benefits/fuel_allowance.html.

EC (n.d. a), Climate Action, retrieved from http://ec.europa.eu/environment/climat/emission.htm.

EC (n.d. b), Climate Action, Allowances and caps, retrieved from http://ec.europa.eu/clima/policies/ets/cap/index_en.htm.

EC (n.d. c), Climate Action, The EU Emissions Trading System (EU ETS), retrieved from http://ec.europa.eu/clima/policies/ets/index_en.htm.

EC (n.d. d), Research and Innovation, Research and innovation funding 2014-2020, retrieved from http://ec.europa.eu/research/fp7/index_en.cfm.

EC (2013a), Energy, Progress reports, retrieved from http://ec.europa.eu/energy/en/topics/renewable-energy/progress-reports.

EC (2013b), Energy, EU oil stocks, retrieved from http://ec.europa.eu/energy/en/topics/imports-and-secure-supplies/eu-oil-stocks.

EC (2014), Energy, Single market progress report, retrieved from http://ec.europa.eu/energy/en/topics/markets-and-consumers/single-market-progress-report.

EIA (2015), China analysis, Overview, retrieved from http://www.eia.gov/beta/international/analysis.cfm?iso=CHN.

EIA (n.d. a), International energy statistics, retrieved from http://www.eia.gov/cfapps/ipdbproject/iedindex3cfm?tid=2&pid=27&aid=12&cid=CG1,&syid=2004&eyid=2013&unit=BKWH.

EIA (n.d. b), International energy statistics, retrieved from http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=44&pid=44&aid=2&cid=CH,US,&syid=2008&eyid=2012&unit=QBTU.

EIA (n.d. c), International energy statistics, retrieved from http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=44&pid=44&aid=1&cid=CH,US,&syid=2005&eyid=2012&unit=QBTU.

EIA (n.d. d), International energy statistics, retrieved from http://www.eia.gov/ cfapps/ipdbproject/iedindex3.cfm?tid=2&pid=2&aid=7&cid=CH,&syid=1995&eyid=2012&unit=MK.

EIA (n.d. e), International energy statistics, retrieved from http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=2&pid=38&aid=7&cid=CH,&syid=1995&eyid=2012&unit=MK

EIA (n.d. f), International energy statistics, retrieved from http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=2&pid=37&aid=7&cid=CH,&syid=2005&eyid=2012&unit=MK.

EIA (n.d. g), International energy statistics, retrieved from http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=2&pid=36&aid=7&cid=CH,&syid=2005&eyid=2012&unit=MK.

EIA (n.d. h), International energy statistics, retrieved from http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=92&pid=46&aid=2&cid=CH,IN,JA,US,&syid=2005&eyid=2011&unit=BTUPUSDM.

EIA (n.d. i), International energy statistics, retrieved from http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=79&pid=80&aid=1&cid=CG1,&syid=2006&eyid=2012&unit=TBPD.

EIA (n.d. j), Annual energy review, retrieved from http://www.eia.doe.gov/aer/txt/ptb0810.html.

ELPC (n.d.), www.repoweringthemidwest.org.

ENTSOE (n.d.), European Transmission System Operators (ETSO), Retrieved from https://www.entsoe.eu/news-events/former-associations/etso/Pages/default.aspx.

EU (n.d.), Treaty establishing the European Atomic Energy Community (Euratom), Retrieved from http://europa.eu/legislation_summaries/institutional_affairs/treaties/treaties_euratom_en.htm.

EUR-Lex (n.d.), Security of energy supply in the EU and international cooperation, retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1423148256459&uri=URISERV:en0032.

Euractiv (2007), EU renewable energy policy, retrieved from http://www.euractiv.com/en/energy/eu-renewable-energy-policy/article-117536.

European Pellet Centre (n.d.), Pellet Price Index, retrieved from www.pelletcentre.info/CMS/site.asp?p=955.

Eurostat (n.d.), http://ec.europa.eu/eurostat.

Eurostat (2014a), Renewable energy in the EU28. Share of renewables in energy consumption up to 14% in 2012, retrieved from http://ec.europa.eu/eurostat/documents/2995521/5181358/8-10032014-AP-EN.PDF/91350d4a-4b57-4833-b9f0-32cfe0a6d360?version=1.0.

Eurostat (2014b), Natural gas consumption statistics, retrieved from http://ec.europa.eu/eurostat/statistics-explained/index.php/Natural_gas_consumption_statistics.

Eurostat (2015a), Combined heat and power generation, retrieved from http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tsdcc350&plugin=1.

Eurostat (2015b), Electricity generated from renewable sources, retrieved from http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tsdcc330&plugin=1.

IEA (n.d. a), retrieved from http://www.iea.org/.

IEA (n.d. b), Data service, retrieved from www.wds.iea.org/.

IEA (n.d. c), Member countries, retrieved from http://www.iea.org/countries/membercountries/.

IEA (2014), Net imports. Closing oil stock levels in days of net imports, retrieved from http://www.iea.org/netimports/?y=2014&m=11.

IEA (n.d. d), People's Republic of China: electricity and heat for 2012, retrieved from http://www.iea.org/statistics/statisticssearch/report/?country=CHINA&product=electricityandheat&year=2012.

IEA (n.d. e), People's Republic of China: indicators for 2012, retrieved from http://www.iea.org/statistics/statisticssearch/report/?country=CHINA&product=indicators&year=2012.

IEA (n.d. f), People's Republic of China: oil for 2012, retrieved from http://www.iea.org/statistics/statisticssearch/report/?country=CHINA&product=oil&year=2012.

Managenergy (n.d. a), Energy agencies, retrieved from http://www.managenergy.net/energy_agencies.

Managenergy (n.d. b), Map, retrieved from http://www.managenergy.net/map.html.

Managenergy (n.d. c), SAVE agencies, retrieved from http://www.managenergy.net/indices/I30.htm.

MEP (n.d.), SOE, retrieved from http://english.mep.gov.cn/standards_reports/soe/.

MEP (2013a), SOE 2010, Atmospheric environment, retrieved from http://english.mep.gov.cn/standards_reports/soe/soe2010/201307/t20130711_255311.htm.

MEP (2013b), SOE 2011, Reduction of total discharge of major pollutants, retrieved from http://english.mep.gov.cn/standards_reports/soe/soe2010/201307/t20130711_255311.htm.

MEP (2014), SOE 2013, Reduction of total discharge of major pollutants, retrieved from http://www.mep.gov.cn/zhxx/hjyw/201406/

W020140605385940287254.pdf.

MOA (2013), 2012 policy measures to support increase in grain output and farmers' income (Part II), retrieved from http://english.agri.gov.cn/governmentaffairs/pi/201304/t20130422_19485.htm.

MOFCOM (2104), Phase I of China's national oil reserve project put into use, retrieved from http://english.mofcom.gov.cn/article/newsrelease/significantnews/201412/20141200819674.shtml.

NBS (2010), Communiqué on energy consumption per GDP unit and other indicators in the first half of 2010, retrieved from http://www.stats.gov.cn/tjsj/tjgb/qttjgb/qgqttjgb/201008/t20100803_30645.html.

NBS (n.d.), National data, retrieved from http://data.stats.gov.cn/english/easyquery.htm?cn=C01.

NDRC (n.d.), Retrieved from http://en.ndrc.gov.cn/

Propellets (n.d.), www.propellets.at/cms/cms.php?pageName=27.

Reuters (2009), Factbox – China's strategic oil reserve plan, retrieved from http://in.reuters.com/article/2009/12/30/idINIndia-45061520091230?rpc=401&feedType=RSS&feedName=businessNews&rpc=401.

Reuters (2014), Update 1 – China makes first announcement on strategic oil reserves, retrieved from http://www.reuters.com/article/2014/11/20/china-oil-reserves-idUSL3N0TA1QE20141120.

UK Government (2014), Warm Front Scheme, retrieved from https://www.gov.uk/warm-front-scheme.

UK Government (2015), Green Deal: energy saving for your home, retrieved from https://www.gov.uk/green-deal-energy-saving-measures/overview.

World Bank (n.d.), Population, total, retrieved from http://data.worldbank.org/indicator/SP.POP.TOTL?order=wbapi_data_value_2006+wbapi_data_value&sort=desc&page=1.

World Coal Association (n.d.), http://www.worldcoal.org.

Zhang, X., Lin, H. (2011), Remarkable achievements in rural biogas development, retrieved from http://english.agri.gov.cn/news/201301/t20130115_8822.htm

Volumes Published by Fondazione Eni Enrico Mattei in the FEEM Press Series

The Global Revolution of Unconventional Oil: New Markets, New Governances, New Policies, by John M. Deutch, Milan, FEEM Press, Economy and Society Series, 1/2014

Islamism and Modernity: an Unconventional Perspective, by Tarek Heggy, Milan, FEEM Press, Economy and Society Series, 2/2014

The Ukraine Debacle, by Anatol Lieven, Milan, FEEM Press, Economy and Society Series, 3/2014

Growth Inequality and Poverty Reduction in Africa, by Francisco H. G. Ferreira, Milan, FEEM Press, Economy and Society Series, 1/2015

Coalitions and Networks, by Carlo Carraro (ed.), Milan, FEEM Press, Climate Change and Sustainable Development Series, 2/2015

Insights from China: Leadership, Policies, New World Order, by Jean Christophe Iseux von Pfetten, Milan, FEEM Press, Economy and Society Series, 3/2015

Un patto globale per lo sviluppo sostenibile. Processi e attori nell'Agenda 2030, by Ilaria Lenzi, Ilaria Pais, Andrea Zucca, Milan, FEEM Press, Social Innovation and Sustainability Series, 4/2015

Water and Development, by Michel Camdessus and Giulio Sapelli, Milan, FEEM Press, Economy and Society Series, 5/2015

Arctic Amplification, Climate Change, Global Warming. New Challenges from the Top of the World, by Peter Wadhams, Milan, FEEM Press, Climate Change and Sustainable Development Series, 6/2015

Los Otros Welfare. Esperienze storiche e proposte di sicurezza sociale nel Messico contemporaneo (secoli XIX e XX), by Veronica Ronch (ed.), Milan, FEEM Press, Economy and Society Series, 1/2016

Greening the World Trade Organization, by Raymond Saner, Milan, FEEM Press, Climate Change and Sustainable Development Series, 2/2016

Turkey's Regional Gas Hub Ambitions: a Critical Assessment, by Simone Tagliapietra, Milan, FEEM Press, Energy Scenarios and Policy Series, 3/2016

The Evolving Geopolitics of North Africa and its Impact on Energy Markets, by Sara Brzuszkiewicz, Milan, FEEM Press, Energy Scenarios and Policy Series, 4/2016

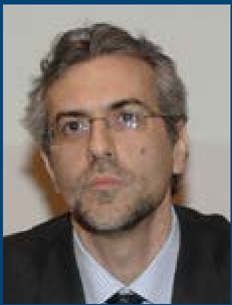
L'evoluzione dello scenario geopolitico nordafricano e il suo impatto sui mercati dell'energia di Sara Brzuszkiewicz, Milano, FEEM Press, Collana Energy Scenarios and Policy, 5/2016

Bruegel-FEEM Euro-Mediterranean Energy Talks, by Domenico Favoino and Simone Tagliapietra, Milan, FEEM Press, Energy Scenarios and Policy Series, 6/2016

Il turismo nei Parchi. L'analisi del potenziale competitivo delle aree protette: il caso Basilicata, di L. Chiarullo, D. Colangelo, M. De Filippo, Milano, FEEM Press, Collana Progetti Territorio per lo sviluppo sostenibile, 7/2016

Energy Governance, Institutions and Policies in China and the EU. A comparative Assessment, by Matteo Manera (ed.), Milan, FEEM Press, Energy Scenarios and Policy Series, 1/2017

In the fall of 2007 the Institute of Industrial Economics of the Chinese Academy for Social Sciences (CASS) and the Italian Ministry for the Environment, Land and Sea (IMELS) have agreed to develop a joint project on China's energy management policies and measures and their international comparison.
Both CASS and IMELS decided to entrust a group of experts at the Fondazione Eni Enrico Mattei (FEEM) to investigate the current status of the EU energy system, while a team of researchers from CASS would have focused on China's energy governance, institutions and policies.
This monograph includes a careful selection of the work carried out by the FEEM and CASS research teams, both individually and as a result of the repeated interactions during the whole project lifetime.
The book is organized in two intertwined parts. The first part surveys the main energy institutions and policies in China and the EU. The second part discusses the assessment of energy policies and illustrates, for both China and the EU, several specific policies on energy security, energy conservation, environment and energy access.
Postgraduate students, researchers, and practitioners with a solid background in energy and environmental economics are the target audience for this book.



Matteo Manera is Professor of Econometrics at the University of Milan-Bicocca and visiting scholar at the Fondazione Eni Enrico Mattei (FEEM). He is Coordinator of the PhD programme in Economics DEFAP-Bicocca, and of the postgraduate course on Energy and Environmental Econometrics organized by the Italian Society of Econometrics in collaboration with the University of Palermo. He was the Coordinator of the research programme "International Energy Markets" at FEEM.
Professor Manera has published several papers on the price dynamics of international markets for oil and gas, the impact of financial speculation on the energy futures markets, the empirical assessment of the Environmental Kuznets hypothesis, the presence of asymmetries in the oil-fuel price relationship, the effects of oil shocks on international stock markets.