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Abstract

The purpose of this paper is twofold. On the one hand, it aims at describing the evolution of Chinese environmental legislation and policy, in particular since the late 1990s. On the other hand, it aims at analysing the parallel development of China's technological abilities and market shares in environmental products.

In China the environmental legislation has progressively offered support for environmental protection in terms of preservation of natural and energy resources, eco-innovation as well as use of renewable energy sources. During the last decade the increasing attention towards environmental issues has been accompanied by a development of Chinese technological skills in the field of environmental protection: Chinese patent applications filed under the Patent Cooperation Treaty (PCT) show an acceleration, in particular in renewable energy technologies, even if they still remain limited in number compared with those of technological leader countries such as US, Japan or Germany.

The evolution of Chinese technological abilities has run parallel to a strong gain in China's market share on international environmental goods market. According to a new database based on UNCTAD trade data (COMTRADE), China during the last decade has rapidly become an exporting leader for these types of goods. These results are partially due to the choice of Western multinationals to locate their production in China in order to benefit from low production costs. However part of the Chinese success in environmental goods is also explained by the increasing skills accumulated over time in this field. These skills, in turn, may have been positively affected by the evolution of environmental legislation and policy in China.

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Introduction

The aim of this paper is to describe the Chinese government environmental policy and the parallel development of a technological and industrial base in the field of environmental goods in China during the past decade.

China's high pace of development lays bare the strong contrast between economic growth, the limited energy resources available, and environmental degradation. The political authorities have long been aware of the problem. China launched its first environmental protection laws in the 1970s, and ever since the 1980s its environmental legislation has consistently evolved, to the point of forming a complex legal system covering not only environmental protection in the widest sense, but also pollution prevention, the protection and conservation of natural resources, the introduction of environmental protection in other sections of the law, and the ratification of the international conventions and treaties on environmental protection.

The first part of this paper analyses the evolution of the environmental legislation and policy in China showing how it has progressively offered support for environmental protection in terms of preservation of natural and energy resources, eco-innovation as well as use of renewable energy sources. Nevertheless, environmental legislation and policy, although abundant, innovative and bold in setting plans and goals, have not always been effective. Despite the measures put in place over the years, China's environmental situation remains in fact very fragile, and poses a major challenge for the country economic development, alongside energy saving. Investments in environmental protection, once adjusted by items not strictly tied to environmental issues (such as gas supply and central heating, improperly classified as Environmental Urban Infrastructure), while on the rise in recent years, remain low as a percentage of GDP, lying between 0.93% and 1.08% in 2008.

In a context of relatively low environmental investment and in the absence of a strongly enforced regulatory framework, China has nevertheless developed specific technological abilities and a leadership in environmental goods in the international market. The second part of this paper describes this evolution using patent counts, derived from OECD database for environmental technology, and environmental goods trade flows, derived by building a new database based on UNCTAD trade data (COMTRADE).

Trade flows of environmental goods are quantified partly using the classification proposed by UNCTAD (used in most of the empirical work on this subject) regarding goods used to provide environmental services, the so called Type A environmental goods (water management, solid urban waste management, etc.). As far as goods that have environmentally preferable characteristics relative to substitutes (i.e., Type B environmental goods), a modified version of the UNCTAD classification has been used in order to define, with the help of industrial and technological experts, an original list of products focusing on energy efficiency technologies[1] and goods for renewable energy. This has allowed us to better match trade flows with available information about patents.

The analysis shows how during the last decade the increasing attention at national and international level towards environmental issues has been accompanied by a development of Chinese technological skills in the field of environmental protection: Chinese patent applications filed under the Patent Cooperation Treaty (PCT) show an acceleration, in particular in renewable

[1] Low-energy-consumption goods in the fields of lighting, household appliances, conditioners, electric motors, etc.

energy technologies, but remain still limited in number compared with those of technological leader countries such as US, Japan or Germany.

The evolution of Chinese technological abilities has run parallel to a strong gain in China's market share on international environmental goods market. China during the last decade has rapidly become an exporting leader for these types of goods. These results are partially due to the choice of Western multinationals to locate their production in China in order to benefit from low production costs. However part of the Chinese success in environmental goods is also explained by the increasing skills accumulated over time in this field. These skills, in turn, may have been positively affected by the evolution of environmental legislation and policy in China.

This evidence seems to confirm that the environmental institutional and regulatory framework may have a positive effect on the development of technological abilities, by enhancing standards and creating potentially interesting markets for innovative environmental products (Johnstone, Hascic, Popp, 2008). Technology advance, in turn, has proved to be a component of international competitiveness, positively related with market share gains on world markets.

China is, already today, a huge source of demand for goods tied to environmental protection and energy saving. Going forward, its impetuous economic growth will imply the need to take on these issues with greater determination. While Chinese current investments in environmental protection are in line with those undertaken in the mid-1990s by previously centrally planned economies such as Eastern European states, China's very high economic growth rates would require them to be significantly increased. On the energy front, these investments add themselves to those in renewable energy sources, which in addition to contributing to the diversification of sources also have positive effects in the reduction of greenhouse gases, as well as of other gas pollutants. Therefore, China will likely become one of the largest markets for environmental protection and energy saving goods, becoming more and more an "environmental goods haven". While the Chinese manufacturing base seems ready to grasp this opportunity, its technological skills, though progressively advancing, are still lagging behind US, Japan and Germany. Therefore China will need further investments in order to better follow scientific and technical progress in this field.

1. Environmental protection policies in China

The Chinese economy has been growing at a fast pace over the past twenty years, generating an unprecedented increase in demand for commodities, especially energy, with significant consequences in terms of energy security, geopolitical tensions, energy industry investment requirement, and, last but not least, environmental sustainability. Environmental sustainability has been put to the severe test by excessive air pollution, extreme ecosystem degradation, and global environmental effects such as climate change, that could jeopardize the continuance of economic growth.

This has been quite clear to Chinese lawmakers who in recent years have placed increasing emphasis on environmental protection and energy saving policies. The aim of the first part of this paper is to give an overview of the evolution of China environmental legislation and policies since the '80s showing how they have progressively offered support for environmental protection in terms of preservation of natural and energy resources, eco-innovation, energy efficiency as well as of renewable energy sources development.

1.1 Evolution of the institutional framework

Although the first pieces of environmental legislation in China were issued in the 1950s and 1960s[2], protection of the environment became an important part of Chinese National Policy only in the wake of China's participation in the United Nations Conference on Human Environment (UNCHE), held in Stockholm in 1972. The following year, the Chinese government called the first National Conference on Environmental Protection, which laid out the first guidelines on the topic, and in 1974 it established a dedicated environmental protection group within the State Council, the Environmental Protection Leading Group (EPLG), charged with the coordination of environmental protection at the national level, albeit with no administrative authority (Sincule and Ortolano, 1995).

Environmental protection was given formal recognition in the Constitution of the People's Republic of China already in the 1978 version, and in a more detailed manner in the 1982 version[3], with Article 9: *"...The State must ensure the rational use of natural resources and protect rare animals and plants. Appropriation or damaging of natural resources by any organization or individual by whatever means is prohibited."* and Article 26: *"The State protects and improves the living environment and the ecological environment, and prevents and controls pollution and other public hazards. The State organizes and encourages afforestation and the protection of forests[4]"*, which laid the foundations for all subsequent environmental legislation. In 1974 the Environmental protection Office was established within the State Council, with no authority and with planning duties under the supervision of the EPLG. It was only after 1978, however, with the reform process initiated by Deng Xiaoping, that environmental protection took on increasing importance. In 1978 the National Science and Technology Development Plan (1978-85) was launched, and the sectors it touched on included natural resources and environmental protection. In 1979 the Standing Committee of the National People's Congress

[2] Some regulations governing mineral resource and workplace safety, which included water pollution prevention and waste management measures. Beyer (2006).

[3] The current version of the Constitution was adopted on 4 December 1982, with some amendments being introduced in 1988, 1993, 1999, and 2004.

[4] Source: http://english.people.com.cn/constitution/constitution.html.

(NPC) passed the Environmental protection Law[5], which laid out the guiding principles to which all subsequent legislation would refer.

During the 1980s, the administrative bodies charged with environmental protection were progressively established and built up. In 1982 the State Council abolished the EPLG and incorporated the Environmental Protection Office into the Ministry of Construction and Environmental Protection. During the second National Conference on Environmental Protection held in 1983, the protection of the environment was declared as a "fundamental state policy" by the vice-premier Li-Peng[6]. In 1984 the State Council's Environmental Protection Commission (EPC) was established, charged with coordinating the different Ministries, and the former Environmental Protection Office was strengthened and renamed National Environmental Protection Bureau, under the authority of the Ministry of Construction and of the EPC. In 1988 the Bureau was made independent form the Ministry of Construction and transformed into the National Environmental Protection Agency (NEPA), with the status of Vice Ministry reporting to the State Council. In 1998 the government dissolved the Environmental Protection Commission and transformed NEPA into the State Environmental Protection Agency (SEPA), awarding it ministerial status, but with no voting rights (Ma and Ortolano, 2000; World Bank, 2007b).

In March 2008, the Chinese government confirmed its political will to promote greater commitment to environmental protection by elevating SEPA to super ministry[7], creating the Ministry of Environmental Protection (MEP), and awarding it full ministerial status with voting rights at the State Council. The MEP is responsible for the implementation of environmental protection plans, the formulation of draft laws and environmental protection regulations, as well as environmental standards. Its duties include the coordination, supervision and guidance of environmental protection at the national level. Two separate Ministries also have environmental functions: the Ministry of Land and Resources, and the Ministry of Water Resources). The Ministry of Environmental protection is supported by another important agency for the analysis and planning of environmental economic policies, the Department of Resource Conservation and Environmental Protection of the National Development Reform Commission (NDRC). The National Coordination Committee on Climate Change was established in 2003, followed in 2008 by the NDRC's Department of Climate Change.

The MEP's transformation into a super ministry was particularly important, as unlike SEPA, the Ministry of Environmental Protection now ranks at the highest levels of Chinese government, and therefore has greater power and authority, including that of directly influencing the decisions of the State Council. Furthermore, given its status as a Ministry with voting rights, any changes affecting it may no longer be introduced simply by the State Council, but must be approved, on the Prime Minister's proposal, by the National People's Congress or by its Commissions (Qiu and Li, 2009). This should guarantee the MEP greater institutional stability in the future, extending its capacity to implement environmental protection policies.

The reform, while important and commendable from the point of view of the strengthening the MEP's authority within government, has left a number of unresolved issues in terms of conflicts

[5] Initially passed for experimental implementation in 1979, it was subsequently replaced by the definitive version in 1989.

[6] The main reasons for this elevation in status was that pollution prevention and the ecosystem were considered necessary for agricultural and economic development and that pollution accidents were increasing at that time (Sincule and Ortolano, 1995).

[7] In March 2008 the NPC proceeded to reorganise and integrate several ministries, creating five super ministries: Industry and Information, Human Resources and Social Security, Housing and Construction, Communications and Transportation, Environmental Protection.

of interest and of overlapping competencies across environmental protection agencies, and in terms of institutional structure instability of the agencies themselves. All these issues appear tied to both the ambiguous vertical and horizontal allocation of authority, and to the lack of operative legislation. A brief discussion of these issues follows below.

The agencies responsible for environmental protection at the local level, from provinces to municipalities, or counties and cities, are the Environmental Protection Bureaus (EPBs). Their responsibilities range from monitoring and reporting infractions, to mediating environmental disputes. EPBs have the same authority on environmental issues at all levels within their jurisdiction. This means that every environmental issues is simultaneously subject to the jurisdiction of the city, municipal, provincial and, ultimately, the national EPB, i.e. the MEP, which creates problems in terms of overlapping competencies and even conflicts of interest between jurisdictions. Also, they depend on the MEP for operational issues, but are administratively and financially dependent on local administrations, which appropriate financing, make budget decisions, appoint positions, and hire staff[8]. However, local administrations have always focused on economic growth as their main priority, based on which local administrators have hitherto always been appraised by central government, often to the detriment of environmental protection.

This clash between the targets of the EPBs at different levels, and especially between local administrations and EBPs, combined with the latter's lack of financial and administrative independence, has significantly compromised the work of EPBs, and is considered as one of the main causes of the ineffectiveness of environmental protection in China. What's more, the duties and responsibilities of local administrations, or the direct responsibility of single officials, have never been accurately defined. Nor does the law prescribe precise sanctions or clarify who has the right/duty of inflicting them on government agencies that fail to guarantee respect of environmental standards.

The ambiguous horizontal allocation of responsibility, on the other hand, leads to problems in terms of the overlapping of competencies between departments of different ministries, which range from environmental planning to defining environmental standards, and on to monitoring[9]. The problems generated by such overlaps are further exacerbated by the lack of a sector administrative organic law[10] providing a detailed definition of structures, institutional responsibilities, authority and organisational procedures, including those governing the establishment, change and abolishment of government bodies. In practice, all these aspects are defined by internal regulations or documents, easily modified at every change of top staff and leadership, thus resulting in institutional instability and in the lack of authority of the bodies themselves[11].

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[8] SEPA had been given the authority to appoint the heads of provincial EPBs to strengthen operative dependence on the national authority, but this did little to improve the effectiveness of their actions (ADB, 2007).

[9] For instance, the MEP has competence for environmental standards, while the State Council, through the General Administration of Quality Supervision, Inspection and Quarantine, lays out the quality and safety standards for consumer goods. The vehicle emissions standards laid out by the two agencies are different (Qui and Li, 2009).

[10] There are two general administrative organic laws: the Organic Law of the State Council, and the Organic Law of the Local People's Congresses and Local People's Governments, which, however, do not govern the issues being discussed (see Qiu and Li, 2009).

[11] Regional environmental supervision centres were established by SEPA in 2006, by means of a proposal document, as an internal political act of the agency, which, however did not have the legal authority to

1.2 Evolution of the regulatory framework

The Environmental Protection Law (1979)[12] is a framework law that covers a wide range of environmental issues, from pollution control to the protection of wildlife, and lays out the general principles of environmental protection, establishing an environmental management system that encompasses monitoring, responsibility, application of the law and sanctions for its breaches, which have become sources for subsequent legislation.

The first specific environmental protection laws date back to the early 1980s, and include for instance the Marine Environment Protection Law (1982), the Law on Water Pollution Prevention (1984), and the Air Pollution Prevention and Control Law (1987). In 1986 the Administrative Regulations on Environmental Protection were introduced, to govern construction projects in the wake of the main principles laid out in the Environmental Protection Law. In 2003, with the aim of unifying these regulations and extending their scope, the Environmental Impact Assessment (EIA) Law was passed. It imposed environmental impact assessment on projects for new constructions and plants, or the extension of existing projects, to be submitted to the competent authorities as an integral part of any construction project.

In the course of the 1990s, China consistently strengthened its body of environmental legislation, amending a number of existing laws[13] and promulgating new ones[14], in the attempt to bring them closer to the principles of sustainable growth introduced at the Rio Conference of 1992 (see next section). Ever since the 1980s, therefore, environmental law has consistently evolved, to the point of forming a complex legal system covering not only environmental protection in the widest sense, but also pollution prevention, the protection and conservation of natural resources, the introduction of environmental protection in other sections of the law, and the ratification of the international conventions and treaties on environmental protection. Starting in the 1980s, China has signed over 20 multilateral conventions on environmental protection, with their protocols, the most important of which starting in the 1990s, such as the Rio Conference on Biodiversity (1992) or the Kyoto Protocol (1997)[15], and takes part in many bilateral environmental cooperation programmes[16].

However, despite its ongoing and positive evolution, Chinese environmental law is still inadequate when compared to the country's level of environmental degradation, and still scarcely applied. According to critics, environmental law, not unlike other branches of Chinese law, is often expressed in a vague language, with which actions are typically encouraged but rarely required, and even where concrete duties are stated, these are often not accompanied by specific goals and the procedures required to achieve them (Beyer, 2006): in many cases,

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create them. Therefore, the centres have no authority, which must be conferred to them on each occasion by SEPA, now MEP, for specific ends (see Qiu and Li, 2009).

[12] See footnote 4.

[13] Marine Environmental Protection Law, promulgated in 1982, was amended in 1999, and the Law on Water Pollution Prevention, promulgated in 1984, was amended in 1996. The Air Pollution Prevention and Control Law, promulgated in 1987, was amended in 1995 and in 2000. See Wang (2007) and OECD (2007).

[14] Solid Waste Prevention and Control Law (1995), Noise Pollution Prevention and Control Law (1996), Clean Production Promotion Law (1998). See Wang (2007) and OECD (2007).

[15] Among others, the Vienna Convention on nuclear security (1994), the Rotterdam Convention on pesticides and hazardous chemicals (1998), the Montreal protocol on bio-security (2000), the Stockholm Convention on persistent organic pollutants (2001). For an exhaustive list of the global and regional international accords, see OECD 2007.

[16] Among others, the Sino-Italian Cooperation Program for Environmental Protection, signed in 2000, the EU–China Partnership on Climate Change, signed in 2005, and the US-China Ten Year Energy and Environment Cooperation Framework, signed in 2008.

enactment regulations are either missing or published with great delay. Also, there is no adequate compensation system for those who have incurred damages, while sanctions for those who cause damage are inefficient[17], and some environmental infractions punished only with administrative sanctions unaccompanied by penal sanctions (Wang C., 2007). Chinese environmental legislation, therefore, offers few incentives towards the respect of environmental standards, which in many cases are also still distant from international standards.

1.3 Evolution of environmental economic policy

The evolution of environmental law has gone hand in hand with an environmental policy that, since the early 1990s, has increasingly supported, at least in its intentions, environmental protection and the conservation of natural resources and energy resources. Strong impulse towards the adoption of a "green strategy" came from China's participation in the Rio Conference of 1992, and from the subsequent subscription to the Rio Declaration, calling for a sustainable economic growth agenda to be drafted for the 21st Century, the so-called Agenda 21, i.e. a plan of action undertaken by each state to achieve economic and social development objectives taking into account the protection of natural and environmental resources[18].

China finalised its Agenda 21 in March 1994, and gradually integrated its objectives in the its national environmental policy, as part of its National Medium and Long Term Plans, and specific sub-plans, as well as its Five-Year National Economic and Social Development Plans starting with the 9th Five-Year Plan (1995-99). In the meantime, China also drew up sector Agenda 21s and their action plans, selecting provinces and municipalities whose growth plans were to be integrated with the Agenda 21 objectives.

Some environmental protection and natural and energy resources conservation objectives, as well as appropriations for investments in environmental protection, have been laid out both in general Five-Year Plans, and in specific environmental protection sub-plans since the 1980s. However, they were subordinated to the priority target of achieving relatively fast economic growth. For the first time in the 11th Five-Year Plan (2006-10), these objectives appeared to be part of a targeted economic growth which, in addition to being fast, should also be sustainable. Unlike the 10th Five-Year Plan, the overall objective of which was "relatively rapid development", the 11th Five-Year Plan aimed to achieve "steady and relatively rapid development", with greater emphasis on long-term sustainable growth. Even more important, the Plan stresses the difference between economic growth and sustainable development, highlighting how over the previous years fast-paced economic growth had been accompanied first of all by environmental degradation and an increase in social inequality. The Plan underlines the principle of "scientific development" in achieving the aim of building a "harmonious socialist society", thus shifting emphasis from mere economic growth to economic growth capable of taking into account the wellbeing of underprivileged people and regions, as well as environmental protection. These principles and aims are going to be even more dominant in the 12th Five-Year Plan as it can be inferred from recent anticipations.

1.3.1 Objectives of the 11th National Environmental Protection Plan

The 11th Five-Year Plan sets objectives both in terms of economic growth and of the structure of the economy, but also objectives pertaining to the quality of life and of public services, as well as

[17] For an analysis of the treatment of environmental damages in the Law on Tort Liabilities, passed at the end of 2009 and in force since 1st July 2010, see: You M. and Huang K., "Annual Review of Chinese Environmental Law: 2009", Environmental Law Institute.

[18] See: Agenda 21 - White Paper on China's Population, Environment and Development in the 21st Century, http://www.acca21.org.cn/ca21pa.html.

the reduction of energy-intensity and the abatement of the main pollutants. The latter are specified in greater detail in the 11th Five-Year Plan for Environmental protection, and in the Medium and Long Term Energy Conservation Plan up to 2020.

IN addition to the specific objectives, the 11th Environmental Protection Plan also contains important guidelines and declarations of intent regarding environmental economic policy, triggered by the acknowledgement that environmental degradation in China is serious, and that the majority of the objectives laid out in the 10th Environmental Protection Plan had not been achieved. The Plan provides for a further increase in appropriations addressed to investments in environmental protection, almost doubled compared to the 10th Five-Year Plan. The Plan acknowledges that environmental protection is critical in achieving modern sustainable growth, and that environmental management is a key instrument in the structural adjustment of the economy. Environmental protection must integrate with economic growth and advance in step with it. The concept of pollution prevention becomes more important than the "end-of-pipe" approach, and fundamental concepts are pursuit of the "Three Rs" (Reduce, Reuse, Recycle) and the accountability of those who cause environmental damages. The Plan also states that environmental protection objectives should be pursued not only using administrative instruments, but also legislative, economic and technical instruments.

Table 1.1 – Main targets of the 11th Five-Year National Economic and Social Development Plan and Environmental Protection Plan

	Variable	Unit measure	2005	2010	Annual Growth Rate or period change	Type of Target
Economic Growth	GDP	trillion yuan	18.2	26.1	7.5%	Expected
	Per capita GDP	yuan	13985	19270	6.6%	Expected
Economic Structure	Ratio of Added Value of Service Industry	%	40.3	43.3	3	Expected
	Employment Ratio of Service Industry	%	31.3	35.3	4	Expected
	Ratio of Expenditure on R&D to GDP	%	1.3	2	0.7	Expected
	Urbanisation rate	%	43	47	4	Expected
Population, Resources and Environmental Protection	Total population	10,000 people	130756	136000	< 8.0%	Obligatory
	Reduction of energy consumption per unit of GDP	%			20	Obligatory
	Reduction of Water consumption per Unit Industrial Added Value	%			30	Obligatory
	Efficient Utilization Coefficient of Agriculture Irrigation Water		0.45	0.5	0.05	Expected
	Comprehensive Utilization Rate of Indutrial Solid Wastes	%	55.8	60	4.2	Expected
	Total Cultivated Land	100 milion ha.	1.22	1.2	-0.3%	Obligatory
	Reduction of total Majour Pollutants Emission Volume	%			10	Obligatory
	Sulphure Dioxide (SO_2)	million tons	25.494	22.944	10%	Obligatory
	Chemical Oxygen Demand (COD)	million tons	14.142	12.728	10%	Obligatory
	Forest Coverage	%	18.2	20	1.8	Obligatory
	Water sections under national monitoring program failing to meet Grade V National Surface Water Quality Standard	%	26.10	>22	-4.1%	Obligatory
	Water sections (of 7 big waters of China) under national monitoring program meeting Grade III National Surface Water Quality Standard	%	41.00	>43	2.0%	Obligatory
	Key cities in which urban air quality is superior to Grade II National Air Quality Standard fore more than 292 days a year	%	69.40	75	5.6%	Obligatory
Public Services and Life Quality	Average Schooling Attainment	years	8.5	9	0.5	Expected
	Population Covered by Basic Pension in Urban Areas	million people	174	223	5.10%	Obligatory
	Coverage of the New Rural Cooperative Healthcare System	%	23.5	> 80	> 56.5	Obligatory
	Newly Increased Urban Employment in Five Years	10,000 people			4500	Expected
	Rural Labour Force Transferred in Five Years	10,000 people			4500	Expected
	Registered Urban Unemployment Rate	%	4.2	5		Expected
	Per Capita Disposable Income of Urban Households	yuan	10493	13390	5%	Expected
	Per Capita Net Income of Rural Households	yuan	3255	4150	5%	Expected

Source: 11th Five-Year National Economic and Social Development Plan and 11th Five-Year National Plan for Environmental Protection

The main objectives laid out in the 11th Plan for Environmental Protection are:

1. Reduction of COD (Chemical Oxygen Demand, main water pollution indicator), improvement of water quality by speeding up the construction of urban sewage and industrial waste water treatment facilities, and containment of the expansion of polluting industries such as chemicals, paper-making, printing & dyeing. Strengthening of the monitoring and prevention of pollution from persistent organic pollutants (POPs), especially in drinking water sources.
2. Reduction of sulphur dioxide (SO_2) and prevention of air pollution in the major cities, through the construction of desulphurisation facilities in the main thermal power plants. Control and monitoring of particulates, of nitrogen oxides (NOx), and POPs in the main urban and industrial areas. Monitoring and reduction of greenhouse gas emissions through increased energy efficiency, energy saving, and energy from renewable sources.
3. Control of soil pollution and promotion of the recycling and reuse of solid waste, both urban and industrial, disposal of medical waste. The target for the reuse of industrial solid waste is set at 60% by 2010.
4. Protection of the ecosystem and improvement of eco safety.
5. Protection of the environment in rural areas and development of organic agriculture, and eco-compatible cities in rural areas.
6. Strengthening of protection of the marine environmental and prevention of environmental degradation in costal area.
7. Supervision and management of nuclear safety.
8. Enhancement of capacity building in the field of environmental management, in terms of monitoring and assessment, and raising law enforcement supervision.

1.3.2 Cleaner production and circular economy

The 11th Environmental Protection Plan reasserts the key importance of developing a Circular Economy, or Recycling Economy, and of Clean Production to achieve the country's sustainable growth objectives.

The general concept guiding the adoption of technologies which reduce pollution and increase efficiency in the use of resources was already embraced by several environmental protection laws, ranging from the 1998 Energy Conservation Law[19] to the Environmental Protection Law[20] (1989), as well as by the Guidelines for Clean Production issued by NDRC in 1999. It was then systematically enacted and strengthened with the Cleaner Production Promotion Law, issued in 2002 and in effect from January 2003. The law encourages the adoption of production and management processes, technologies and materials, which reduce pollution generation and discharge both at the source and at the end of the production processes, as well as during the use of the end products, while at the same time increasing efficiency in the utilisation of resources.

[19] The Law provides for the gradual elimination of technologies and products which require excessive energy consumption (art. 7, art.16 et al).

[20] New or existing enterprises intending to renovate their technological setup should adopt technologies and production processes conducive to increasing efficiency in the use of resources, and which produce less waste (art. 25).

According to the Law all enterprises should monitor resource consumption and waste generation during the course of production and provision of services and conduct environmental audits according to need. Periodical environmental audit is required for enterprises that exceed the national or local discharging standards or volume control targets for pollutants and for all those that use toxic and hazardous materials in their production process or discharge toxic and hazardous substances. New construction, renovation or expansion projects shall undergo environmental impact assessments to analyse and assess the use of raw materials, resource consumption, comprehensive utilisation of resources, as well as generation of pollutants and their treatment. Enterprises shall give priority to adopting cleaner production technologies, processes and equipment, which maximise the resource utilisation rate and generate the fewest pollutants in implementing new projects. All enterprises should also adopt toxin-free, non-hazardous raw materials to replace toxic and hazardous raw materials; provide for the comprehensive use or recycling of materials such as waste products, waste water and heat generated from production procedures; and reduce excess packaging. The Law calls for the implementation of a time-limited system for the elimination of obsolete production technologies, processes, equipment and products gravely hazardous for the environment. The relevant department for economics and trade under the State Council are therefore required to issue a directory of production technologies, processes, equipment and products to be eliminated[21] within a time limit.

The concept of circular economy refers to an economic growth model that maximises efficiency in the use of raw materials through their ***reduction, reuse** and **recycling*** (known as the three 'Rs') in production processes and in the consumption of goods, thus reducing the quantities of natural resources used and the emission of pollutants per unit produced. This concept began to take hold in China in the 1990s, inspired by the German law on waste recycling (1996, Product Recycling and Waste Management Act - *Kreislaufwirtschaftsgesetz*), and subsequently by the Japanese laws on recycling (in particular the Basic Law for Establishing a Recycling-Based Society, 2001), as well as by the principles of industrial ecology[22].

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[21] The Ministry of Commerce (MOFCOM) and the General Administration of Trade have jointly issued lists of products for which processing trade is prohibited or restricted since 2004. The lists of "prohibited" products include products banned under international treaties and high energy-consuming and polluting products and are periodically revised. For last revision see Announcement n. 63/2003 of MOFCOM, partially available in English at: http://www.hktdc.com/info/mi/a/ebt/en/1X078RED/1/Economic---Business-Trends/China-adds-more-products-into-catalogue-of-commodities-prohibited-for-processing-trade.htm.
The lists of "restricted" products include products for which an import licence is required. These products are usually imported raw materials for which there is a large price gap (hard to monitor by the tax authorities) between the overseas markets and China, and some high energy consuming and high polluting products. Products can be prohibited for import, export or both. The MOFCOM and the Ministry of Science and Technology also issue and update Catalogues of Technologies prohibited or restricted from export or import as well as Catalogues of Technologies under Encouragement for import or export. Examples of technologies that are not importable include technologies related to non-ferrous metal processing, chemical engineering or petrochemical production while examples of technologies that are not exportable include technologies related to the manufacture of traditional Chinese medicine, land surveying or breeding of livestock.

[22] Industrial ecology theorises the reorganisation of productive activities based on the ecosystem model, so that the waste of one sector provides production input for another sector, with all sectors striving to produce products with the highest possible rate of reuse and/or recycling, minimising waste and offering longer-lasting products, alongside customer care services. The consumption model is also different, no longer oriented to the disposable product philosophy, but to saving materials and reusing objects. See Frosch, Robert A. and Nicholas AND. Gallopoulos. 1989. Strategies for Manufacturing. Scientific American 1989, 261(3):144-152. D. W. Pearce and R. K. Turner 1990, Economics of natural resources and the environment, Harvester Wheatsheaf, London.

To promote circular economy and clean production, since 2005 China has launched pilot projects in the main industrial sectors, and in some rural and urban areas, and as at 2007, 24 Eco-Industrial Parks, industrial areas organised in accordance with the principles of industrial ecology[23] were still being implemented (World Bank, 2009). The same principles also provide the foundations for the development of similarly organised Eco-Provinces and Eco-Cities.

In August 2008, the State Council approved specific legislation on circular economy (the Circular Economy Law), which came into force on 1st January 2009. The law reaffirms the "three R" approach, i.e. *reduction*, *reuse* and *recycling* in production processes as well as in the end consumption of goods. The law imposes that industrial policies, at both the national and local levels, must be based on the principles of circular economy. The same applies to economic and development plans, as well as to the specific environmental protection, and technological and scientific development plans. Through its competent departments, the State undertakes to draw up an updated list of technologies, equipment, materials, and end products, that are incompatible with circular economy, and therefore must be eliminated and cannot be imported. The law also provides for fiscal incentives to be made available by the State to industrial activities promoting development of circular economy, and to encourage the importation of "green" technologies and more efficient technologies, which allow the saving of energy, water, soil and materials, while limiting exports of polluting or high-energy-consumption products. At the same time, sanctions are defined for the use or production of "eliminated"[24] goods or technologies.

The Law charges the Department for the Development of Circular Economy, reporting to the State Council, with the development of a set of indicators in collaboration with the Statistics Office and the MEP, or other competent offices, to assess the state and progress of "circularity" in the economy, and to make their findings public at regular intervals. A system of trial indicators has already been in place since 2007 (trial Circular Economy Evaluation Indicators System), which includes indicators at the industrial park level and at the macro level (World Bank, 2009), in effect already adopted to assess environmental performance in the framework of the Five-Year Plans[25]. Other indicators should be added to these, pertaining to Green Accounting[26] and to Material Flow Accounting (MFA), on which front China has made significant progress over the past decade[27].

One of the instruments leveraged to implement circular economy and cleaner production, explicitly mentioned by the Law on Cleaner Production, is the environmental certification of both production processes and products. The former corresponds to ISO14000[28] environmental certification, and the latter to Ecolabel certification, already adopted in Europe and in other industrialised countries, and established in China ever since 1993. The agency charged with the development and concession of environmental certifications for products and processes is the

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[23] For further details, see: http://www.eoearth.org/article/Eco-industrial_parks_in_China.

[24] See note 21.

[25] For each level, there are four types of indicators: a) GDP volume produced per unit or resources consumed, b) resource consumption per unit output of products or GDP, c) resource use index, d) waste or pollutant emission index. (World Bank, 2009).

[26] See paragraph 1.6.

[27] "International Experience in Establishing Indicators for the Circular Economy and Considerations For China", László Pinter, World Bank 2006.

[28] In 1997, the State Bureau of Technical and Quality Supervision adapted the ISO 14000 series into equivalent national standards. A national approval scheme for ISO 14001 certification was introduced along with a system of examination of certification entities by a national accreditation body and national registration of auditors. By 2004, the number of certified companies in China reached over 8 000, the second highest number in the world (after Japan). (OECD, 2007, pag. 213).

China Environmental United Certification Centre (CEC), aided by the China Committee for Environmental Labelling (CCEL)[29].

1.3.3 Growth of the environmental protection industry

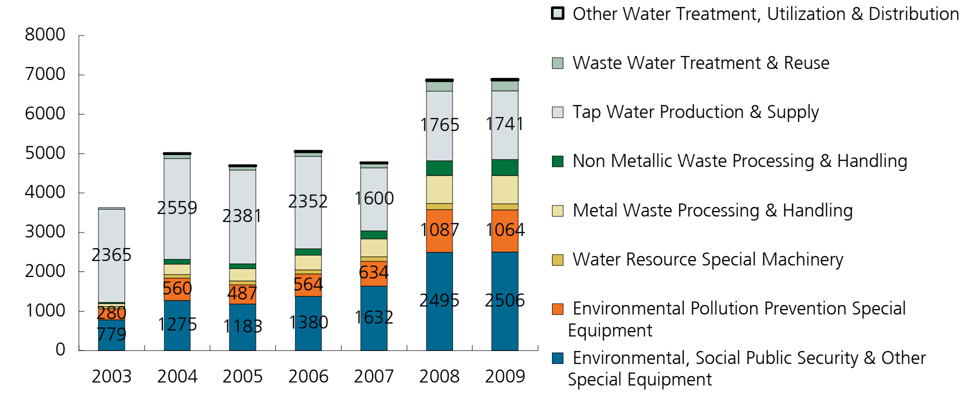
The 11th Plan for Environmental Protection is also geared to actively promoting the development of the environmental protection industry, through key projects as already laid out in the 10th Five-Year Plan for Environmental protection (SETC 2004), and along the guidelines of the National Medium and Long Term Plan for Science and Technology. The Plan aims to support growth of the manufacturing industry of environmental protection equipment, and of the environmental services industry, both with the acquisition of foreign technology and through innovation.

The priority areas for the environmental protection industry highlighted by the Plan are:

1. Water pollution prevention and control technologies and equipment: in particular prevention and control of eutrophication, reuse of waste water, water purification, removal of sulphates and nitrates from industrial waste water.
2. Air pollution prevention and control technologies and equipment, with focus on the desulphurisation of power plants with capacity of over 300 MW, fume denitrification, emission control of coal-fuelled power stations and vehicle engines.
3. Technologies and equipment for the treatment and disposal of solid waste: development of large incineration plants with a capacity of over 600 t/d, control of incineration emissions, landfill biogas recycling, treatment of hazardous waste.
4. Remedy technologies for polluted sites, and mine wasteland in particular.
5. Environmental monitoring technologies and equipment: automatic monitoring systems, instruments for the identification of hazardous waste, instruments for the monitoring of particulates and organic pollutants, dioxin analytical instruments, and remote pollution measurement systems.
6. Physical pollution control: control of noise pollution in heavy urban traffic areas, control of electromagnetic pollution.
7. Special reagents and materials: development of membrane materials for the filtering of dusts, also at high temperatures, and to avoid seepage in landfills.
8. Comprehensive utilisation of resources: recycling and reuse of waste, utilisation of neutralised water, reuse of vehicle and household appliance components.
9. Construction, operation and consultation services for pollution treatment facilities: commercialisation of services and operation of urban sewage treatment plants, waste disposal, industrial effluents, and desulphurisation plants.
10. Environmental service trade: implementation of a system of environmental service standards based on international best practice, participation in international projects, support of the export of environmental products and services.

[29] For further details on Ecolabel standards in China, see: http://www.sepacec.com/cecen/labelling/. On the other hand, safety and quality standards, including energy efficiency standards, are certified by the General Administration of Quality Supervision, Inspection and Quarantine, through the Certification Accreditation Administration of China.

Figure 1.1 – Evolution of the number of selected environmental protection related industries



Source: CEIC

An estimated 35,000 companies were active in the environmental protection industry in 2006, generating revenues of USD 75Bn (around CNY 598Bn - UK Trade and Investment, 2008). According to the recent statements[30] made by Wang Yuquig, Director of the Chinese Society for Environmental Sciences (CSES), the environmental protection industry's revenues grew from CNY 45Bn in 1997 to CNY 790Bn in 2008, achieving an annual growth rate of over 15%. Wang estimates that revenues could exceed CNY 1 trillion, or 3% of GDP, in 2010, and increase to over CNY 2 trillion in 2015. The CSES estimates investments in advanced environmental protection technologies in the 11th Five-Year Plan period to have added up to CNY 4.5Bn. Available financial data on environmental protection related industries, including environmental protection services, often lack continuity both in time and in the classification and aggregation of industries by sector. It is therefore very difficult to give an assessment of the industry and find a perfect match with the above quoted statements, not to mention to make a sound international comparison. We will be able to give a better assessment of the state of the Chinese environmental protection industry, excluding services, using data on environmental goods trade flows and patents in the second part of this work.

1.3.4 The outline of the 12th Five-Year Plan

In mid-October, the plenum of the Communist Party Central Committee approved the draft outline of the 12th Five-Year National Economic Plan. The formal plan will be drawn up on the basis of this draft and be submitted for final approval at next year's National People's Congress in March 2011.

According to recent comments by vice premier Li Kequiang, the Plan aims at "the transformation of China's economic growth pattern, achieving *sound and fast* development of the country's central and western regions" and building a "moderately prosperous society". The Communiqué[31] of the Fifth Plenum of the 17th Communist Party Central Committee, held in October 2010, stress that "the building of a resource-saving and environment-friendly society should be accelerated, and the ecological conservation culture should be promoted" since they are focal points in the transformation China growth pattern. The Plan policies and targets are hence likely to focus, much more than the 11th Plan did, on rebalancing growth and attaining sustainable development through narrowing of the rural/urban and inter-regional income gap, which has widened steadily in recent years despite brilliant macroeconomic growth.

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30 See *Bloomberg news*, 26 March 2010.

31 Available at: http://news.xinhuanet.com/english2010/china/2010-10/18/c_13563388.htm

According to recent news, the plan aims at further development of seven strategic industries, namely new-generation information technology, energy saving and environmental protection, new energy, biology, high-end equipment manufacturing, new materials and new-energy cars through fiscal, tax and financial policies to support major government-level science and technology projects. China in these past years has used policies defined as "protectionist" by its competitors, like its "indigenous innovation" policy, to promote home-grown clean technology companies. These policies set tax incentives, subsidies and local content requirements for some technologies (as the 70% content on wind turbines, which has been dropped in 2010). Moreover the Government Procurement Law (in force from January 2003) has always supported domestic purchases of goods and services though not precisely defining what was considered as "domestic", which is the aim of the controversial new implementation measures, drafted and made public for comments[32] in January 2010.

China's last Five-Year Plan vowed to cut energy intensity by a fifth over five years. That target has proven difficult and efforts to reach the goal by the end of 2010 have resulted in recent steel mill closures, electricity cuts to small businesses, and the dimming of traffic lights. Environmental protection and low-carbon development are still expected to play an important role in restructuring the economy in the coming years and one of the most significant aspects of the 12th Five-Year Plan will probably be new targets for energy efficiency and carbon emission reduction and a proposed anti pollution tax. The plan will probably strengthen the domestic indigenous innovation policies despite recent tensions with major industrialized trading partners on green technology, in particular in the energy efficiency and renewable energy goods sector[33].

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[32] For a draft of the proposed measures, see:
http://www.uschina.org/public/documents/2010/05/uscbc_gp_law_translation.pdf

[33] The US and EU have recently brought forth accusations of unfair treatment of foreign enterprises, especially in new technologies. In the United States, the United Steel Workers Union claims that Chinese policies to stimulate and protect its domestic producers of green technologies are illegal and in direct violation of WTO obligations. In October, the Union announced that it is therefore planning to file a petition under Section 301 of U.S. trade law: http://assets.usw.org/releases/misc/section-301.pdf. On the US position see the testimony of US treasury Secretary T. Geithner on China's Currency Policies and the U.S.-China Economic Relationship: http://www.treasury.gov/press/releases/tg858.htm.To have an overview of EU critique and suggestions on Chinese innovation policies by sectors, see European Chamber of Commerce, European Business in China: Position Paper 2010/2011.

1.4 Investments in environmental protection

The 11th Plan for Environmental Protection laid out key projects in the areas of intervention identified (see Section 1.3), planning investments accounting for 1.35% of cumulated GDP in the period, i.e. CNY 1.5 trillion (USD 225Bn) to achieve the objectives identified. Actual investments were close to the target already in the 2006-09 period, adding up to CNY 1.49 trillion, or 1.32% of cumulated GDP in the period.

Table 1.2 – Investments in environmental protection

	(CNY mln)	in % of period GDP	in % of period fixed asset investments
6th Five-Year Plan 1981-85	17.000	0,52	
7th Five-Year Plan 1986-90	47.642	0,65	2,41
8th Five-Year Plan 1991-95	130.657	0,68	2,05
9th Five-Year Plan 1996-00	347.060	0,82	2,50
10th Five-Year Plan 2001-05	839.930	1,18	2,84
11th Five-Year Plan 2006-10*	1,496,890	1.32	2.32

* Cumulative data from 2006 to 2009
Source: CEIC, CAEP and Intesa Sanpaolo elaborations

Based on the classification of the Statistics Office of the Ministry of Environmental Protection (MEP), investments in environmental protection are fixed asset investments of three types:

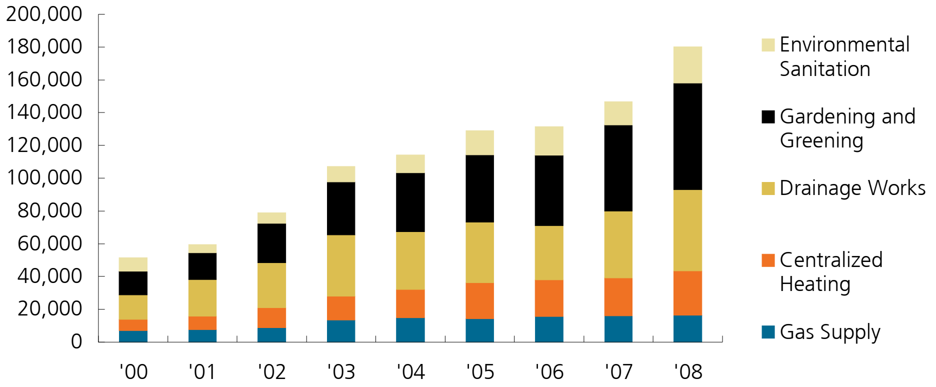
1. Investments in the treatment and reduction of industrial pollution: i.e. pollution caused by industrial waste water, gas emissions, industrial solid waste, noise pollution, and all other forms of pollution produced by the industrial sector. These investments may be strictly considered as Pollution Abatement and Control (PAC) investments, in line with the OECD-Eurostat classification.

2. Investments in urban environmental infrastructure: these include investments in drainage works, environmental sanitation, Gardening, Greening & Landscape, but also Gas Supply and Centralized Heating.

3. Investments in the Three Synchronizations (or Three Simultaneities): investments in installations for pollution prevention and control based on the "three synchronizations system", i.e. designed, built, and made operational simultaneously with the industrial plant they serve, and not subsequently[34].

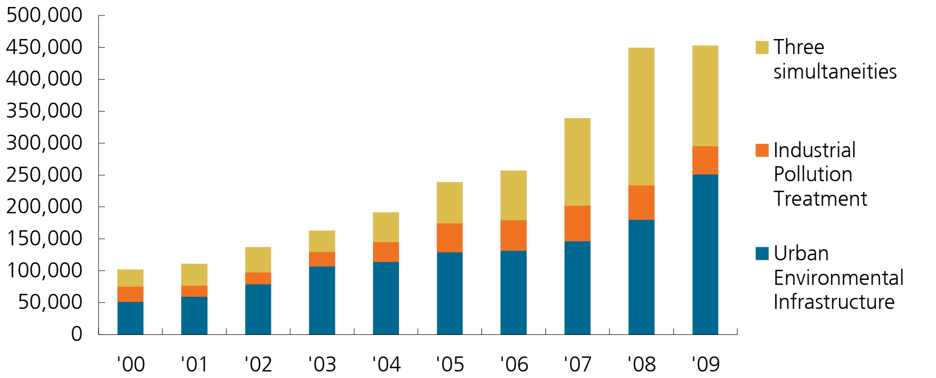
[34] The system provided for by art. 26 of the Environmental Protection Law was extended in art. 16 and following of the Regulations on Environmental Management of Construction Project (1998).

Figure 1.2 – Investments in urban environmental infrastructures (mln CNY)



Source: CEIC, National Bureau of Statistics of China (NBS)

Figure 1.3 – Investments in environmental protection (mln CNY)



Source: CEIC, NBS

Investments in urban environmental infrastructure are not all strictly classifiable as investments in environmental protection. Although the main aim of investments in sewage systems, sludge disposal facilities, and in public hygiene and waste management is to safeguard public health, they overlap with environmental protection, as these infrastructures have a considerable positive fallout on the environment. This is especially true for investments in sewage sludge and in the treatment of waste water and urban waste, the only categories that may be strictly considered as investments in environmental protection based on the OECD-Eurostat classification[35]. Investments in drainage systems for flood control are in actual fact investments in Environmental Management[36]. In investments in Gas Supply and Centralised heating, on the other hand are effectively investments in urban infrastructure, and should not be considered as investments in environmental protection; indeed, they are not considered as such in the OECD-Eurostat classification, and their separation is also suggested by the Chinese Academy for Environmental Planning (CAEP - 2007). Investments in Gardening, Greening & Landscape are controversial.

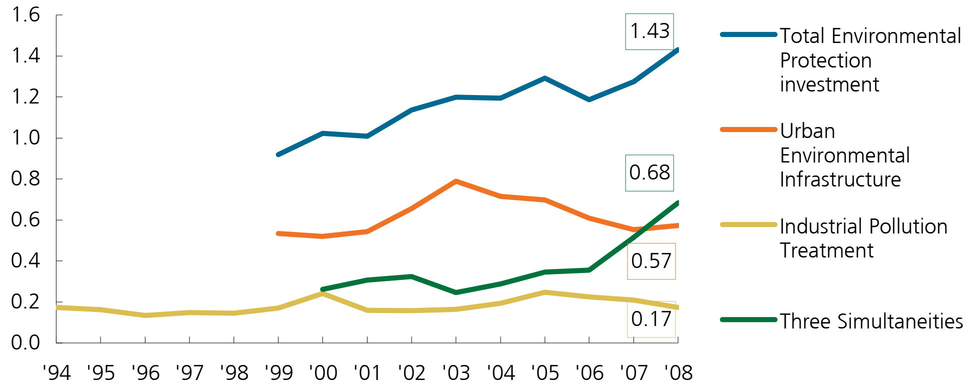
[35] See EC 2007, Eurostat Methodologies and Working Papers, Environmental expenditure statistics 2007 edition, General Government and Specialised Producers data collection handbook, European Commission 2007.

[36] Investment for the prevention of natural hazards (landslides, floods) and investment in the management of natural resources (water supply) are considered as Investment in Environmental Management.

They are considered as investments in environmental protection by OECD-Eurostat[37], together with those addressed to the protection of biodiversity, while the CAEP suggests they should also be separated.

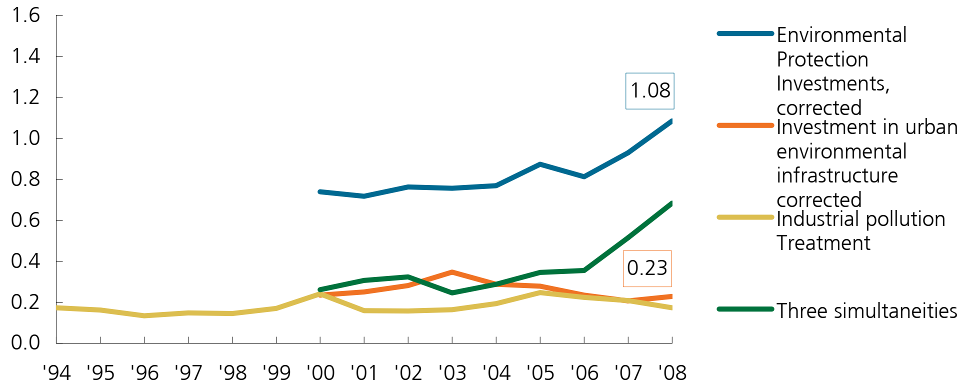
While investments in urban environmental infrastructure undoubtedly reap positive effects on the environment, they are also tied to the urbanisation process, and therefore guided by investments in real estate development, of which they accounted for 5% in 2008.

Figure 1.4 – Investments in environmental protection (% of GDP)



Source: CEIC, NBS, Intesa Sanpaolo elaborations. Note: 2008 values in squares.

Figure 1.5 – Investments in environmental protection corrected (% of GDP)



Source: CEIC, NBS, Intesa Sanpaolo elaborations. Note: 2008 values in squares.

The share of investments in Gardening, Greening & Landscape, on total investments in urban environmental infrastructure, grew from 27.8% in 2000 to 36.1% in 2008, and continue to represent the most important single item, followed by investments in drainage systems and sewage systems, with a share of 27.5% in 2008, down from a peak of 37.7% in 2001. The share of investments in Gas Supply and Centralised Heating grew from 26.9% in 2000 to a high of 28.8% in 2006, subsequently dropping to 24.1% in 2008, with investments in Gas Supply decreasing, as opposed to higher investments in Centralized Heating.

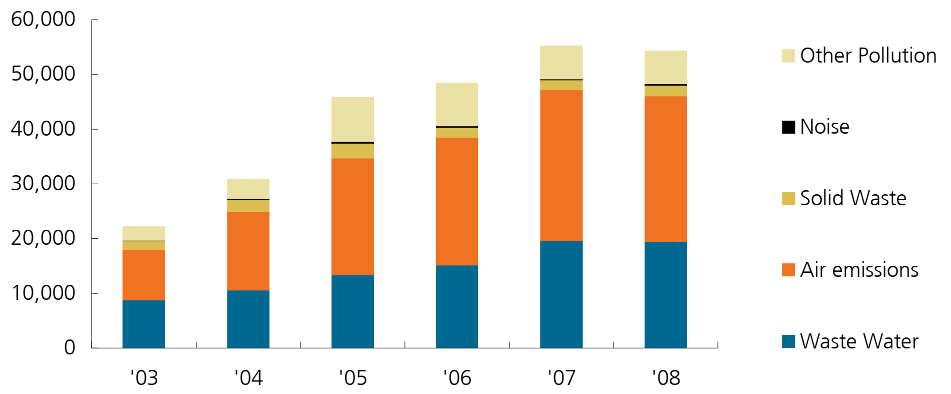
[37] Cf.: OECD 2007 "Pollution Abatement and Control Expenditure in OECD Countries", EPEC/ENV/SE(2007)1.

Embracing in part[38] the CAEP's suggestion (2007), the separation from investments in urban environmental infrastructure of investments in Gardening, Greening & Landscape, investments in Gas Supply, and in Centralised Heating, implies a sharp decline in those classifiable as environmental protection investments, which thus adjusted dropped from 1.18 of GDP in the 10th Plan for Environmental Protection (the only for which data are available), to 0.78% of GDP in the 2001-05 period. Annual data showed a similar trend: in 2008, the most recent year for which detailed data on investments in urban environmental infrastructure are available, total investments in environmental protection amounted to 1.08% of GDP, exceeding the threshold of 1.0% of GDP for the first time, on the rise from 0.93% in 2007, yet less than the 1.43% percentage obtained when leaving data unadjusted, and accounting for 2.0% of total fixed investments (vs. 2.6% unadjusted).

The investments that may strictly be considered as pertaining to environmental protection, are those in the treatment of industrial pollution (that is PAC investments), and in the Three Synchronizations System.

Investments in treatment of industrial pollution are principally addressed to the treatment of waste water and gas emissions to the atmosphere, which combined accounted for 84.8% of investments in the treatment of industrial pollution in 2008, from a low of 75.7% in 2005. The share of investments in the treatment of waste water declined over the years from a peak of 62.5% in 1997 to a low of 35.9% in 2008, in step with the increase of investments in the treatment of gas emissions, the share of which grew over the same time period from 24.7% to 49.0%.

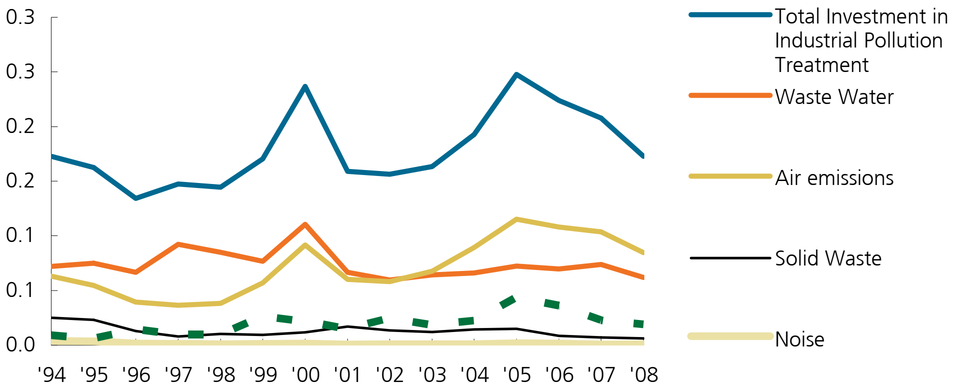
Figure 1.6 – Investments in Industrial Pollution Treatment (mln CNY)



Source: CEIC

[38] We have not separated drainage systems for flood control from the "Sewage and drainage systems", nor activities other than waste management from the "Environmental Sanitation" item, as suggested by CAEP 2007, due to a lack of data continuity. Based on this separation, i.e. considering only investments in the treatment of waste water and urban waste as investments in urban environmental infrastructure, total investments in environmental protection in 2005 are almost halved, from 238 billion yuan to 134 billion, i.e. from 1.29% of GDP to 0.73%.

Figure 1.7 – Investments in Industrial Pollution Treatment (in % of GDP)

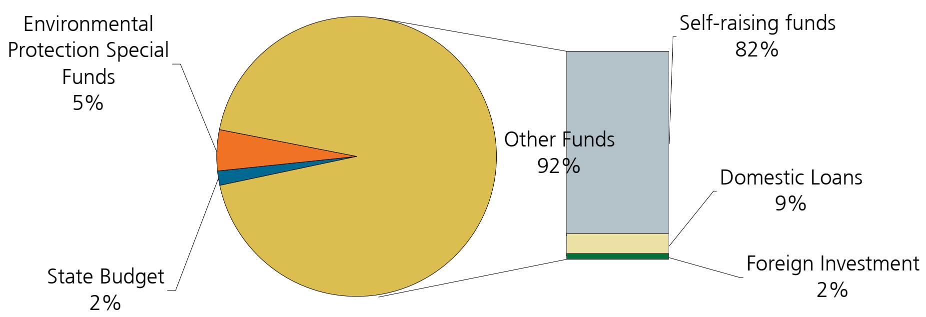


Source: CEIC and Intesa Sanpaolo elaborations

Investments in the treatment of industrial pollution added up to 0.17% of GDP in 2008, in line with the previous years ever since the 1990s, with the exception of 2000 and 2005, when they amounted to 0.24% and 0.25% of GDP respectively. These peaks coincide with the last year of the respective Five-Year Plans (9^{th} and 10^{th}), and may depend on the delay with which actual investments were made compared to the estimates laid out in the Plans, which among other things declared pollution reduction targets to be "compulsory". For instance, investment spending provided for by the 10^{th} Five-Year Plan to achieve the pollution targets identified amounted to CNY 136Bn, but over the 2001-04 period, i.e. with only one year to go to the end of the Plan, actual investments had only added up to CNY 89.29Bn, well short of the planned amount.

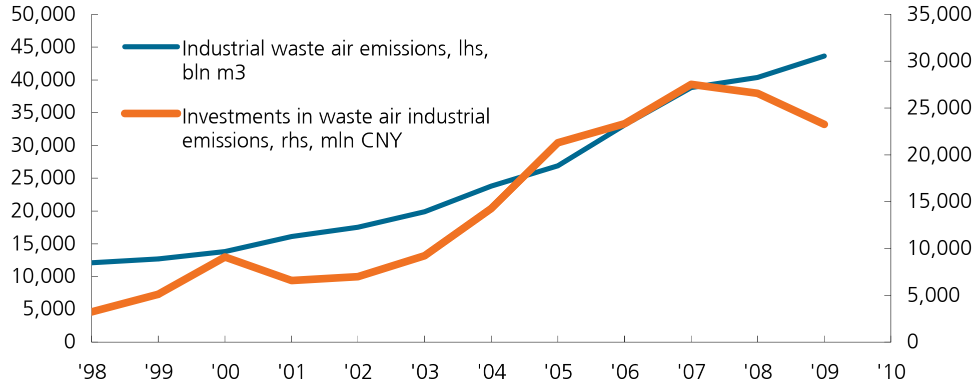
According to preliminary data, total investment in environmental protection declined from 1.43% of GDP in 2008 to 1.33% in 2009. Investment in industrial pollution treatment declined to 0.13% of GDP (the lowest share in the decade) together with three simultaneities investments, while investments in urban environmental infrastructure raised to 0.74% of GDP versus 0.57% in 2008.

Figure 1.8 – Investments in Industrial Pollution Treatment: funding sources (2005)



Source: CEIC

Figure 1.9 – Investments in waste air industrial emissions



Source: CEIC

Most investments in the treatment of industrial pollution are financed by enterprises, with own funds and/or collected independently, and only a minimal portion are financed by government funds or by foreign direct investments, which in 2005 covered only 2% of the amounts addressed by industry to these ends. The new guidelines for foreign investments approved by the State Council[39] in April this year support environmental protection, as they encourage investments in the "green" sectors of the economy, imposing restrictions on investments in projects which imply high pollution levels and high energy consumption.

Investments in the treatment of industrial pollution decreased from 0.5% of total fixed investments in 2005 to 0.3% in 2008, as opposed to a rising share of investments addressed to the Three Synchronizations System, from 0.7% to 1.2% of total fixed investments in the same time period. The latter grew at fast rates especially as of 2004, in excess of 50% in 2007 and 2008, year in which investments in the treatment of industrial pollution actually declined (-1.8%). The Three Synchronizations System was introduced already in 1979, with the first Environmental protection Law, with the main aim of reducing water and air pollution. Indeed, investments in environmental protection falling under the Three Synchronizations System are mostly addressed (56.5% in 2005) to the treatment of this kind of pollution. In theory, the System involves all companies which produce pollutants, although in practice initial enforcement was limited. The number of projects abiding by the System has increased significantly in recent years, probably in step with the process of restructuring the most polluting and inefficient heavy industry facilities, which led to the shutdown of many old factories and their replacement with new plants[40] in line with the System's requirements. This is compatible in part with the slowdown of investments in the treatment of industrial pollution, mostly tied to heavy industry. Indeed, according to the Medium and Long Term Energy Conservation Plan, in 2002, coal combustion alone, the country's main energy source, was responsible for 70-80% of total particulate and SO_2 emissions.

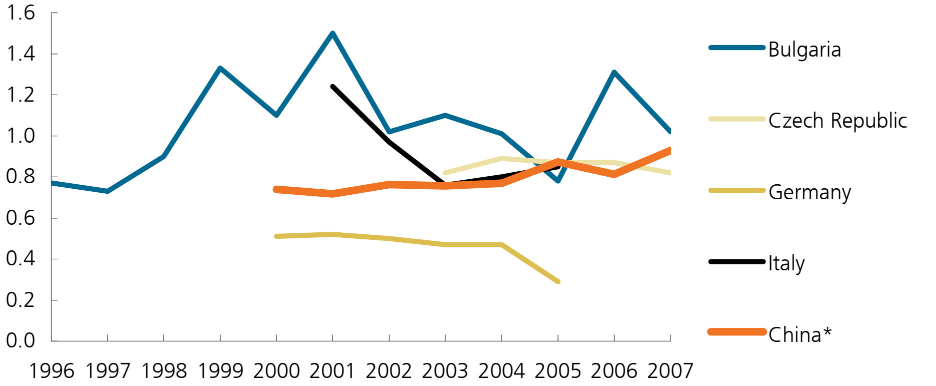
Investments in environmental protection are fixed investments made by all kinds of enterprises, form all state-owned enterprises to private ones. In relation to GDP, they strike as being hefty when compared to the leading industrialised countries, which nonetheless have a very high initial stock, as a result of investments made over previous years. The ratio does not differ greatly

[39] "Several Opinions of the State Council on Further Doing a Good Job in the Utilization of Foreign Investment" April 6 2010 and subsequent joint notices by the Minister of Commerce, SAFE and State Administration of Taxation.

[40] See paragraph 1.5.2.

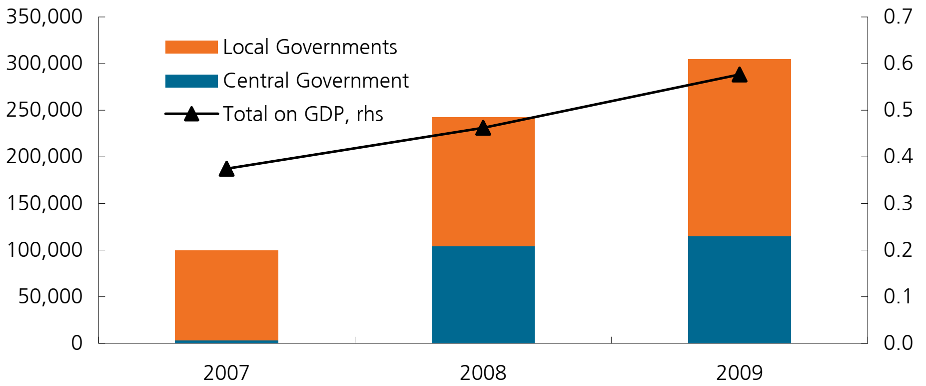
from those of some Eastern European states at the end of the 1990s, and specifically states with an industrial economic structure and a level of development similar to China's. In addition to investments made by enterprises, the government also spends on environmental protection, primarily through local government: spending on this front has increased in the past years raising from 2.0% of total government spending in 2007 to 2.5% in 2009. However, as these figures are also affected by the same classification issues as fixed investments in environmental protection, the percentage weight of spending in environmental protection in strict terms may actually be lower.

Figure 1.10 – Investments in environmental protection (in % of GDP)



Source: Eurostat, CEIC and Intesa Sanpaolo elaborations *Estimate: Urban environmental infrastructure excluding gas supply, central heating and gardening and greening.

Figure 1.11 – Government expenditure in environmental protection (mln CNY and %)



Source: CEIC and Intesa Sanpaolo elaborations

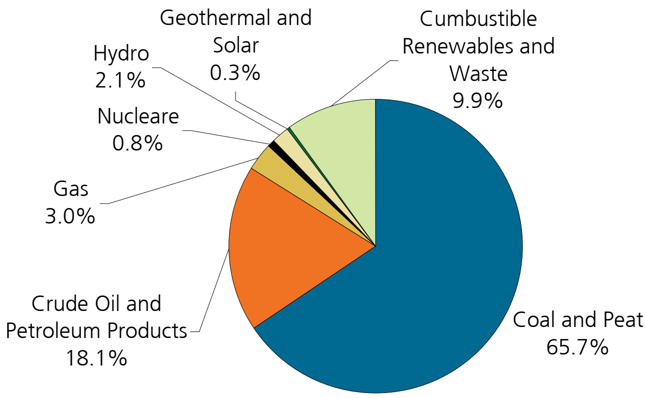
1.5 Environment and Energy Conservation

Expressed during the Communist Party's 16th National Congress in November 2002, the government's main objective is to quadruple GDP from its 2000 level by 2020, hence increasing the population's wealth to the point of making China a middle-income country. To achieve this objective, China must shift growth from high commodity and capital intensive manufacturing to high labour-intensive service industries, and from investment to consumption. Such a shift in the country's economic and industrial structure should slow the increase in China's energy and natural resources requirement. However, population growth, together with an acceleration in urbanisation and industrialisation, will in their own right generate significant demand for energy and commodities, and the development of heavy industry and transport will in any case continue to be the engine of economic growth.

China's energy consumption has increased exponentially since 2000, doubling from 2000 to 2007. The World Energy Outlook 2009 (WEO) forecasts that global energy demand will increase 1.5% per year to 2030, from 12,000 Mtep in 2007 to 16,800 Mtep in 2030.China and India will account for more than 53% of this increase, as well as most of the increase in CO2 emissions. China will satisfy its primary energy demand mainly through the use of coal. According to the IEA (International Energy Agency) China surpassed the US in energy consumption in 2009, and shortly after 2025 China will surpass the US as the biggest importer of oil and gas (WEO 2009).

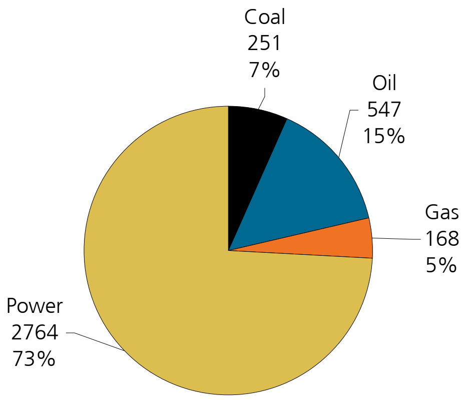
At the same time, China will be experiencing an increase in per capita income and rapid urbanisation: each year in the past three years China has added 2 billion cubic metres of new housing stock. This has led to a steady increase in demand for household appliances and so household energy consumption. Energy consumption per capita by households and businesses will increase by almost 40% by 2030 (WEO 2008). In its baseline scenario for China, WEO 2007 estimated that between 2007 and 2030 the country will have to invest USD 3.7Tn in energy infrastructure, an average of around USD 150Bn per year, most of which in electricity generation, transmission, and distribution. In the alternative scenario, the investment requirement to satisfy energy demand was 10% less, i.e. if China adopted economic policies aimed at reducing green-house gases and energy conservation, and so the development of renewable sources.

Figure 1.12 – China: primary energy sources in % of total



Source: IEA, China Energy Balance 2008

Figure 1.13 – Cumulative investment in energy-supply infrastructure 2006-2030 (USD bln and in % of total)



Source: WEO 2007, Base Scenario

1.5.1 Institutional Framework

Despite the growing importance of energy issues on China's domestic and foreign policy agendas, since the 1950s authority over China's energy sector at the national level has been fragmented among many government agencies, the most important of which is NDRC; and within the NDRC, responsibility for energy has been similarly scattered among multiple departments. Periodic restructuring of China's energy bureaucracy has been much more complicated than was the case for Environmental Protection and produced a series of agencies that often in the past lacked the authority, autonomy, and tools to effectively govern the energy sector.

A National Energy Commission, with planning and supervisory tasks, was established in 1980 by the Fifth National People's Congress Standing Committee but was abolished less than two years later. In 1988 the Ministry of Energy was established through the merger of four related ministries: Coal Industry, Hydroelectricity, Oil Industry and Nuclear Industry. Five years later, in 1993, the Ministry was abolished in another round of the State Council restructuring and a Ministry of Power Industry was established instead, the Ministry of Coal and Industry and the Ministry of Electricity Industry were re-established and from 1993 on, the State Planning Commission (SPC, established in 1952, currently the State Development Planning Commission, SDPC), and the State Economic and Trade Commission (SETC, established in 1993) coordinated policies across energy sub-sectors (Zhao, 2001) together with the Ministry of Science and Technology (MOST).

In March 2003, the State Economic Trade Commission was abolished and the majority of its functions transferred to the National Development and Reform Commission (NDRC). In the same year, recognizing the need for a stronger governing structure, China began consolidating the government's energy-related duties with the establishment of the Energy Bureau under the NDRC. When widespread energy shortages hit China in the following years, in 2005 China's leadership created the National Energy Leading Group (NELG, composed of vice ministers and ministers) and State Energy Office (SEO, which was intended to serve as a sort of secretariat to the Leading Group) to implement a nationwide energy strategy. However, neither of these organisations developed into truly functional policy-making bodies, and both struggled to coordinate the rival interests of other ministries and major state-owned energy companies which often had a higher administrative rank (Zhang and Lee, 2008). State-owned energy companies often took advantage of the paralysis that permeated the national-level energy bureaucracy and were the ones that actually shaped the development of China's energy sector (Downs, E.S. 2008).

In March 2008, in another round of institutional restructuring, the NPC approved two additions to China's energy bureaucracy – the State Energy Commission (SEC) and the National Energy Administration (NEA).

NEA, a vice ministerial body, replaced the NDRC's Energy Bureau and absorbed other energy offices from NDRC. NEA has a broad mandate, which includes managing the country's energy industries, drafting energy plans and policies, negotiating with international energy agencies, and approving foreign energy investments.

The SEC, a high-level discussion and coordination body, replacing the National Energy Leading Group, was actually redefined in January 2010 as the National Energy Commission (NEC). The NEC can be compared to a cabinet within the cabinet (Bo, 2010) since it is chaired by the Premier and formed by a number of leaders from relevant ministries and commissions as well as by military members. It is responsible for energy development strategy planning, energy security, domestic exploration coordination and international cooperation. NEA should carry out the daily specific work of the NEC and function as its operating branch.

The recent changes to China's energy policy-making apparatus are the latest in a series of institutional reforms aimed at improving energy governance that still leave unclear the distribution of power (the NEC does not seem to be totally independent from the NDRC, which, for instance, maintains energy pricing power through different departments) among these newly created agencies, potentially jeopardizing the effectiveness of their work. Moreover, China has been discussing a comprehensive Energy Law since early 2006[41]. The law should settle the principles that sector laws should follow, introducing a regulatory framework governing all energy development, exploitation and management within China, in addition to supply security and the role of foreign investors (WEO, 2007). Passage of the law, which is expected by early next year, might involve some other restructuring of powers and responsibilities of government agencies involved in energy issues.

1.5.2 Energy Conservation

China will be facing an increasingly sharp contrast between limited energy resources and the quest for growth, and especially between growth and environmental degradation. To avoid reaching a crisis point, in late 2004 the NDRC drafted a **Medium and Long-Term Energy Conservation Plan** that, after analysing the country's energy situation, basically sets energy conservation and efficiency targets, as well as the development of energy sources according to the 11th Five-Year Plan to 2010, also laying down long-term guidelines to 2020.

According to the medium and long-term plan, energy intensity as measured by GDP[42] must come down from 2.68 tec in 2002 to 2.25 tec in 2010 and then decrease steadily to 1.54 tec in 2020, in accordance with the 20% reduction target from 2006 to 2010 contained in the 11th Five-Year Plan. The Plan emphasises the need to shift China's economic structure: at 43% in 2009, the weight of the service sector is too low compared to industrialized countries (76% in the United States in the same year) and heavy industry accounts for the bulk of all industry,

[41] For a detailed discussion of the draft see: DLA Piper, "China's Proposed Energy Law Would Create Comprehensive Energy, Regulatory Scheme", February 2009 Newsletter:
http://www.dlapiper.com/files/Publication/591eec2e-807a-4546-80f3-a9ad0e7eb717/Presentation/PublicationAttachment/37f57d7a-74f9-4fba-8ea3-ab083a7fb9dc/%201634616_1_HKGROUPS(China_s%20Proposed%20Energy%20Law%20Would%20Create%20Comprehensive%20Ene.PDF

[42] Energy intensity is expressed per CNY 10,000 of GDP at constant 1990 prices.

featuring companies that are too small and poorly integrated. The Plan also emphasises the need to improve energy and environmental management and to upgrade technology, together with energy statistics measurement systems. In addition to these general guidelines, the Plan requires both major industrial plant and equipment, as well as household appliances and car engines, to achieve 1990 international standards by 2010.

Table 1.3 – Energy consumption index per unit of major products and targets to 2020

	Unit measure	2000	2005	2010	2020
Electricity generation (coal combustion, gross)	gce/kWh	392	377	360	320
Raw steel (total)*	kgce/t	906	760	730	700
Raw steel (comparable)*	kgce/t	784	700	685	640
Average of 10 types of nonferrous metals	tce/t	4.809	4.665	4.595	4.45
Aluminium	tce/t	9.923	9.595	9.471	9.22
Copper	tce/t	4.707	4.388	4.256	4
Oil refining	kgoe/t.factor	14	13	12	10
Ethylene	kgoe/t	848	700	650	600
Synthetic ammonia, large plants	kgce/t	1372	1210	1140	1000
Caustic soda	kgce/t	1553	1503	1400	1300
Cement	kgce/t	181	159	148	129
Plate glass	kgce/weighting box	30	26	24	20
Architectural ceramics (tiles)	kgce/m2	10.04	9.90	9.20	7.20
Railway transportation	tce/million t-km	10.41	9.65	9.40	9.00

Source: WEO 2007 and NDRC 2004, China Medium and Long Term Energy Conservation Plan 2020
*Comparable: adjusted for differences between product structures of different plants; Total: not adjusted.

In the Plan the Chinese government projects a 2,800 Mtep[43] increase in energy demand by 2020 if the scenario does not change. But this demand could be lower, 2,100 Mtep, if the energy conservation and efficiency targets in the Plan are achieved, also allowing for a reduction in the biggest polluters, especially sulphur dioxide (SO2). In any case, the Plan projects demand much lower than the IEA does in its baseline scenario for the same horizon (3,282 Mtep to 2020, WEO 2008).

Table 1.4 – Selected Energy Efficiency Indicators of Major Energy Consuming Equipment and targets to 2010

	Unit measure	2000	2010
Coal-fired industrial Boilers (under operation)	Efficiency %	65	70-80
Small and medium power generation units (design)	Efficiency %	87	90-92
Wind Turbines (design)	Efficiency %	70-80	80-85
Pumps (design)	Efficiency %	75-80	83-87
Air compressors (design)	Efficiency %	75	80-84
Room air conditioners	Energy Efficiency Ratio, EER	2.4	3.2-4
Refrigerators	Energy Efficiency Index, EEI	80	62-50
Household gas cook stoves	Thermal efficiency %	55	60-65
Household gas water heaters	Thermal efficiency %	80	90-95
Average automobile fuel consumption	Liter/100km	9.5	8.2-6.7

Source: WEO 2007 e NDRC 2004, China Medium and Long Term Energy Conservation Plan 2020

The Plan looks not only at energy efficiency in the final use of products, but also energy efficiency in energy production and transformation processes and calls for key projects by industry. The Plan sets the outline of 10 Key Projects, then incorporated in the 11th Five-Year Plan, of which the four most significant are: the renovation of coal-fired industrial boilers; district-level combined heat and power projects; oil conservation and substitution; and energy efficiency and conservation in buildings. The Plan calls for the adoption of new and more energy

[43] Converted into Mtep by an estimate in the China Medium and Long Term Energy Conservation Plan (2006-2010) which calls for a 4,000 Mtec increase by 2020 with the scenario unchanged and a 3,000 Mtec increase if the set targets are achieved.

efficient technologies and guidelines for development for each type of heavy industry, transport industry, construction, and household appliance. For example, it calls for coal to be mainly used for electricity generation in big combustion plants that must be equipped with desulphurisation systems[44]. Power companies equipped with these systems enjoy a favourable rate of RMB 0.0015 per kWh above those not so equipped (OECD 2009a).

The strategy of closing small thermal power plants is considered very important in the national energy saving and pollution reduction effort to meet the national target of 20 percent reduction in energy intensity by 2010. This strategy has been formalized in a program which operates in parallel with plans to build larger, more efficient plants, and which is officially called "The Program of Large Substituting for Small" (LSS program). In order to promote the robust development of China's power industry, NDRC has required the closure of small-scale thermal power units with high energy consumption and poor pollution control, and delegated this task to provincial governments and the power and grid companies[45]. Total installed capacity needed to be decommissioned was set to be 50 GW during the 11th Five-Year Plan Period (2006-2010). By the end of 2008 China had closed small plants with a total installed capacity of 34.21 GW (Zhang, 2010). Complementary to the LSS program is the Energy Conservation Scheduling Program (ECS Program or Energy Conservation Power Generation Dispatch Program) aiming at weeding out the remaining inefficient generating capacity that survived the LSS program. The program, approved in 2008, intends to create a market mechanism by substituting the current even load power generation scheduling rule on the grids with an energy efficiency based rule favouring lower carbon energy.

Another important program is the Top 1000 Energy-Consuming Enterprises Program, setting specific targets for the 1,000 companies with the highest energy intensity belonging to nine key industries[46] that in 2004 had consumed 33% of the total energy generated in the country and 47% of the energy consumed by the entire industrial sector (Price, Wang, and Yun, 2008).The target was to conserve a total of 100 million tec from 2006 to 2010. Conservation in 2006-2007 alone was 58.17 million tec (Zhang, 2010), well on pace to achieve the program target.

China passed its first Energy Conservation Law in 1997. It revised and expanded it in light of the medium-term plan targets in 2008. In its 1997 version the law mostly addressed the industrial sector, but in its 2008 version it expanded to include construction, transport, trade, government agencies, and households. The law establishes that energy conservation policy is among the country's fundamental policies, supporting and encouraging energy conservation technology research and development. As in the laws on the Promotion of Cleaner Production and on Circular Economy, the law reiterates the prohibition on high energy consumption products, technologies and production techniques, and that products must have energy efficiency certification through a labelling system[47]. Particularly important is the application of an energy

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[44] From 2006 new coal-fired plants must be equipped with a flue gas desulphurisation facility and plants built after 1997 must have begun to be retrofitted with such a facility by 2010. (Zhang, 2010).

[45] The program sets specific characteristics for units facing closure, which are anyway all units below 50MW. For a detailed description of the program and of the Energy Conservation Scheduling Program see Tian (2008).

[46] Iron and steel, oil and petrochemicals, chemicals, electricity generation, non-ferrous metals, coal mining, construction materials, textiles, and pulp and paper.

[47] Energy efficiency standards and energy efficiency labelling system are important measures aimed at enhancing the energy efficiency of electric appliances. China formulated its first set of energy efficiency standards back in the 1980s. The energy efficiency labelling system was established in 2004 with the aim to provide energy efficiency information to consumers. There are currently two kinds of labels regarding energy consumption: the Energy Conservation Certification and the China Energy Label. The Energy Conservation

efficiency measurement system for investment projects, including buildings, that must satisfy minimum standards to receive approval. The law also prohibits the construction of new coal and fuel-oil fired power stations that do not comply with the energy efficiency provisions[48]. The law requires government agencies to set annual energy conservation targets, implement plans to achieve them and report energy consumption in the previous year to departments set up by the State Council at both the local and national levels. Government agency purchases must favour low energy-consumption products. The law also calls for incentives and tax breaks to stimulate the production and use of low-energy consumption technologies and products, also encouraging financial companies to issue favourable terms loans. The government supports the development of energy conservation service companies in the areas of consulting, design, energy efficiency evaluation, monitoring, auditing, and certification[49]. Unlike other similar laws, such as the Cleaner Production Promotion Law and the Circular Economy Law, the Energy Conservation Law calls for detailed penalties for infractions, comprising as many as 18 articles.

In September 2006, the State Council issued a specific directive to reiterate the need to pursue the energy conservation targets[50]. Moreover, in 2007, the NDRC published a Comprehensive Action Plan for Energy Saving and Emission Reduction designed to ensure maximum participation at all levels of government, another expression of the government's deep commitment to energy conservation. In 2007, the Chinese government set aside CNY 23.5Bn for energy conservation and in 2009 CNY 41.8Bn for lowering emissions.

Energy efficiency and green building

China introduced its first energy efficiency standards for buildings in the 1980s, but according to IEA estimates compliance is spotty, ranging from 8% in the southern regions to 60% in the northern regions (WEO 2007). To improve energy efficiency, in 2006 the Ministry of Housing Urban-Rural Development (MOHURD) set tighter energy standards, applied initially only to the Beijing and Shanghai areas and in the metropolitan city of Tianjin, with the target of reducing by two-thirds energy consumption by buildings (OECD 2008). These standards are slated for national application in 2010. In its 11th Five-Year Development Plan, the Chinese government set a target of reducing energy consumption by buildings by 89.5 TWh by 2010, of which 57 TWh should come from newly constructed buildings (equivalent to cutting energy consumption by 50% compared to 1980) and 30 TWh from the upgrading of existing buildings. Energy conservation in new buildings is set at 65% in 2020.

Average per capita residential space was 26m^2 in 2005, and MOHURD's target is to increase it to 35m^2 in urban areas and 40m^2 in rural areas. In addition, the Ministry forecasts that by 2020 the urban population will increase by 180 million and that in the next 20 years China will need to construct 13 billion m^3 of housing stock, equivalent to the current amount in the EU-15. Coal is still the most used fuel for heating buildings and it will probably remain so for some time to come since it is in greater supply and cheaper than other sources. Right now energy

Certification is awarded to equipment that meets specific energy efficiency standards or technological criteria, but the label contains no specific info on the product energy efficiency that are contained instead in the China Energy Label, which is mandatory. (WRI, 2009).

[48] Art. 33.

[49] These companies are the so-called Energy Service Companies (ESCO) that began to develop in 1998 through the First Energy Conservation Project with the help of the World Bank, the European Commission and the Global Environmental Fund, and later through the Second Energy Conservation Project (2003). These companies are compensated with a percentage of the cost saving that their customers have by buying their services (World Bank, 2010).

[50] Decision of the State Council on Strengthening Energy Conservation, 19 September 2006.

consumption to heat buildings is estimated to be 50% higher than in industrialised countries with a similar climate. Buildings have a useful life that lasts decades, if not centuries, so the decisions made on buildings constructed today will determine energy and water efficiency and emissions for years to come. Hence appropriate incentives and building codes have very high potential for reducing the sector's environmental impact.

In August 2008, the State Council issued two codes, one on energy efficiency in private housing construction and one on energy efficiency in public building construction[51]. These codes lay down green building standards ("Three Star") that provide guidelines for building design and construction, as well as use of specific materials for water and energy consumption efficiency. In addition to these mandatory standards, there are voluntary certifications, such as "Green Building Design Label" and "Green Building Label", issued by the "Office of Green Building Labelling System" set up by MOHURD[52]. From 2010 to 2012, the Ministry will invest CNY 900Bn (USD 132Bn) in housing construction. In addition, according to China Real Estate Chamber of Commerce estimates, the private and government sectors will invest another CNY 2.7Tn (USD 397Bn) in housing and commercial construction[53].

1.5.3 Renewable Energy

Zhang (2010) estimates that China invested USD 12Bn (around CNY 96Bn) in renewable energies in 2007, compared to USD 14Bn invested by Germany in the same year. In 2008, China announced USD 15Bn in investment (around CNY 105Bn) for the following year (REN21, 2009). China and Germany were the investment leaders in 2009, each spending roughly USD 25–30Bn on new renewables capacity, including small hydro (REN21, 2010). The United States was third, with more than USD 15Bn in investment. Italy and Spain followed with roughly USD 4–5Bn each. Wind power received more than 60 percent of utility scale renewables investment in 2009 (excluding small projects), mostly attributable to rapid expansion in China (REN21, 2010). China added 37 GW of renewable power capacity, more than any other country in the world, to reach 226 GW of total renewables capacity. Globally, nearly 80 GW of renewable capacity was added, including 31 GW of hydro and 48 GW of non-hydro capacity.

To encourage renewable energy development, in 2006 China passed a Renewable Energy Law[54], later amended in late 2009. It is basically a framework law that lays down several general guidelines on the development of renewable energies, followed by a series of implementing regulations on targets, prices and technical standards issued by the Council of State and the competent departments. The 2006 law is based on the principle of compulsory grid connections for companies that generate electricity from renewable sources and compulsory purchase by public utility companies of electricity generated by renewable sources. According to the law, public utility companies must purchase all electricity generated by renewable energy producers and they must provide grid-connection services (including constructing grid connections) and related technical support to renewable energy power companies[55]. The Price Administration Department of the State Council was supposed to set the price of energy from renewable sources. An auction procedure was to be used to set prices, such as for a license assignment, only in the case of several applications for authorisation for a single project. Part of the related

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[51] Council of State Decree nos. 530 and 531, August 2008. People's Republic of China Council of State Decree nos. 530 and 531, August 2008.
[52] For in-depth information, see: Cao, Shujuan, "China: Green Building Opportunity" United States of America, Department of Commerce, US Commercial Service, October 2009.
[53] IBID.
[54] Passed on 28 February 2005, in effect as of 1 January 2006, later amended and passed on 26 December 2009 and in effect as of 1 April 2010.
[55] RELaw Assist Issues Paper, Renewable Energy Law in China, June 2007.

electricity grid construction and hook-up cost must be included in the cost of electricity, and the differential between the price of energy from a renewable source and the price of energy from conventional sources must be partially added to the final retail price in accordance with measurements prescribed later.

The **Renewable Energy Law** as amended in late 2009 and the new version came into effect in April 2010. The new version is designed to make operational what had been prescribed in the previous version, i.e. mandatory hook-up to the electricity grid and mandatory electricity purchase by public utility companies, introducing a system based on specific purchase targets to be set later based on Energy Department and NDRC Finance Department guidelines. In fact, despite the very sharp increase in installed capacity, very few plants are connected to the grid. For example, it is estimated that only as much as one-third of the 20GW of wind-powered installed capacity is hooked up to the grid. The amended law provides for the creation of a government managed fund funded by the premium added to retail electricity prices paid by consumers that was partly envisaged in the old version with the aim to support research.

According to some analysts and news[56], the real innovation of the new version is the doubling of penalties compared to the previous version of the law for failure by electricity generation and public utility companies to comply[57], and the introduction of new incentives. The law also requires companies to expand grids that transmit electricity generated by renewable sources from the north-western regions, richer in wind and solar energy, to the eastern coastal regions, where most of industry is concentrated, and it emphasises the importance of smart grids for the development of renewable sources.

The development of renewable energy sources has been much helped also by the implementation of **Clean Development Mechanism** (CDM)[58] projects. China has made many steps forwards in terms of building capacity with the help of international donors agencies during the 10th Five-Year Plan Period. The number of CDM Projects has steadily increased since 2005, thanks to pilot projects and clear regulations and procedures (Zhang, 2010; World Bank, 2007b). According to the NDRC Climate Change Department database[59], as of October 2010 China approved 2731 CDM projects, 88.4% of which in the area of renewable energy (70.5%) and energy efficiency (17.9%). As of 1 November 2010 China total CDM projects (registered and waiting for registration or at validation stage) accounted for 40.2% of the world's total CDM projects.

In 2007, the NDRC launched the **Medium and Long-Term Development Plan for Renewable Energy.** The Plan assumes that the development of renewable energies is fundamental for both

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[56] See: http://news.xinhuanet.com/english/2009-12/26/content_12706612.htm.

[57] A power grid enterprise failing to purchase the entire quantity of power generated by a renewable energy company can be fined not more that the amount of the economic losses suffered by the renewable energy power generating company (see art. 29, 2006 version). According to many scholars such penalties have been rarely if ever enforced.

[58] The Clean Development Mechanism (CDM) is one of the three flexible mechanisms established under the Kyoto Protocol (1997). The CDM allows developed countries listed in Annex 1 of the United Nations Framework Convention on Climate Change (UNFCCC) to invest in greenhouse gas (GHG) emission reduction projects in non-Annex 1 developing countries and to claim the resulting Certified Emission Reductions (CERs) to assist them in compliance with their binding GHG emission reduction commitments under the Protocol. More details on CDM mechanism in China can be found in: "Clean Development Mechanism in China, Taking a Proactive and Sustainable Approach", World Bank, September 2004.

[59] http://cdm.ccchina.gov.cn/english/ .

energy saving and sustainable economic development, and it provides installed capacity growth targets for individual renewable sources. It considers biomass a major priority because it dovetails with the dual objective of promoting access to electricity in rural areas and developing a "recyclable" economy, by contributing to the treatment and re-use of organic waste. According to the Plan, the share of primary energy consumption from renewable sources will increase from 8.9% in 2008 to 10% in 2010 and to 15% in 2020[60] (Zhang, 2010), and China will develop its own innovative capability in the development of renewable energy technologies through support of investment in research and development. The Plan objective is for the manufacturing sector to develop its own technologies in this area by 2020, protected by intellectual property rights.

Table 1.5 – Medium and Long-Term Renewable Energy installed capacity targets

	Unit measure	2010	2020
Hydropower	GW	190	300
Biomass	GW	5.5	30
of which:			
from agricultural and forestry wastes and energy crops plantations	GW	4	24
from large-scale biogas projects on livestock farms and biogas projects utilizing industrial organic effluent	GW	1	3
form municipal solid waste	GW	0.5	3
with consumption of			
Pellets	mln tons	1	50
Biogas	bln m^3	19	44
Bio-ethanol from non-food-grain feedstock	mln tons	2	10
Biodiesel	mln tons	0.2	2
Wind			
Total installed grid-connected wind capacity	GW	5	30
Solar	GW	0.3	1.8
of which:			
in rural remote areas	GW	0.15	0.3
in developed large and mid size cities	GW	0.05	1
Large-scale, grid-connected solar PV power stations	GW	0.02	0.2
Solar thermal power stations	GW	0.05	0.2

Source: NDRC (2007), Medium and Long-Term Development Plan for Renewable Energy

A new Renewable Energy Development Plan is expected to contain other details on the development of renewable resources, especially solar energy, in terms of planned investment, incentives packages, and guidelines. The Plan was supposed to have been made public in early 2010, but it has been delayed until the fall. According to some analysts, this delay is in part due to developments in solar panel prices[61], down a sharp 40% in 2009, making any subsidies useless. But according to other analysts, the delay in publishing the Plan is more due to its integration with the 12th Five-Year Plan objectives.

At the time of writing it is still unclear to us whether this plan is a new Medium and Long-Term Renewable Energy Plan, prepared by the Chinese Academy of Engineering with goals up to

[60] The percentages cited in the Plan are actually on non-fossil fuel and consistent with Statistics Department data which does not include biomass and solar energy counts, but does include as renewable, or better, as "non-fossil fuels", nuclear, water, geothermal and wind. This explains the difference with IEA statistics which reflect a different count, as well as a different conversion ratio for hydro-electric energy, making international comparisons difficult. See also the notes in the NBS statistical bulletin, "Energy" section, and WEO 2007, page 264.

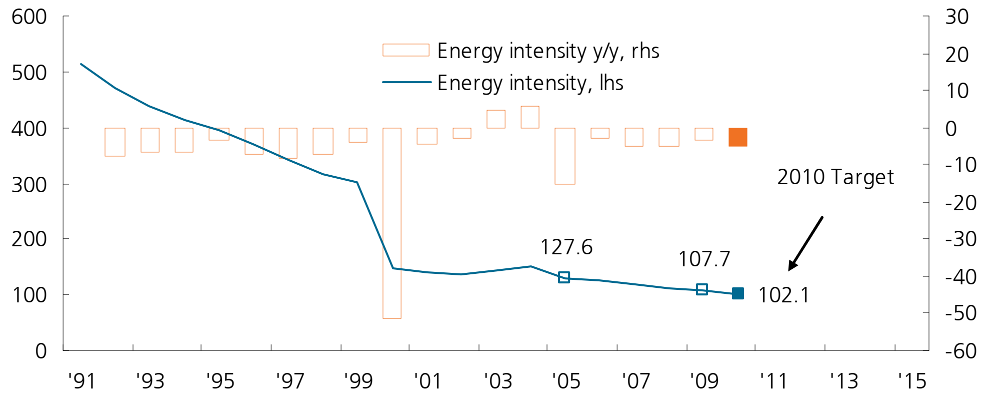
[61] World Business Council for Sustainable Development, "China to delay energy stimulus plan", 15 April 2010: http://wbcsd.org/pluginds/DocSerach/details.asp?type=DocDet&ObjectId=MzgyNzY.

2030[62], whether it refers to a new Energy Development Plan drafted by the National Energy Administration (NEA) with medium-term objectives and investment targets for all kinds of new energy sources (including nuclear) up to 2020[63], or whether it is a five-year sub-plan of the 12th Five-Year National Economic Plan (2011-2015) and will be disclosed after approval of the national plan.

1.6 Plans Objectives and Current Environmental Situation: still a lot to do

Sulphur dioxide (SO_2), the major cause of acid rain, and chemical oxygen demand (COD), the main indicator of water pollution, peaked in 2006. But a program to restructure the most polluting industries put them on a downward path and, at least for sulphur dioxide and COD, consistent with achieving the 2010 target. These two items were among the major objectives in the 11th Environmental Protection Plan.

Figure 1.14 – Energy consumption per unit of GDP (TCE/RMB mln, constant prices 2005)



Source: CEIC, NBS, Intesa Sanpaolo

According to Statistics Office data, energy intensity, calculated at constant 2005 prices, declined by 15.6% from 2005 to 2009. To achieve the target of a 20% decrease from 2005 to 2010, it must decline 5.2% in 2010. According to the most recent data, energy intensity increased by 0.9% in the first half of 2010 versus the same period of 2009, so it will be difficult to reach the 2010 target, although getting close to it is anyway appreciable. Despite the positive trend of recent years, China's energy intensity is still high compared to countries of early industrialisation and there is much room for further decrease going forward. China's energy use per unit of GDP in 2009 was around 3.6 times as large as in the US and 7.3 times as high as in Japan if GDP is measured at market exchange rates. If GDP is measured at PPP, China's energy intensity in 2009 was around 1.5 times as high as the US level[64].

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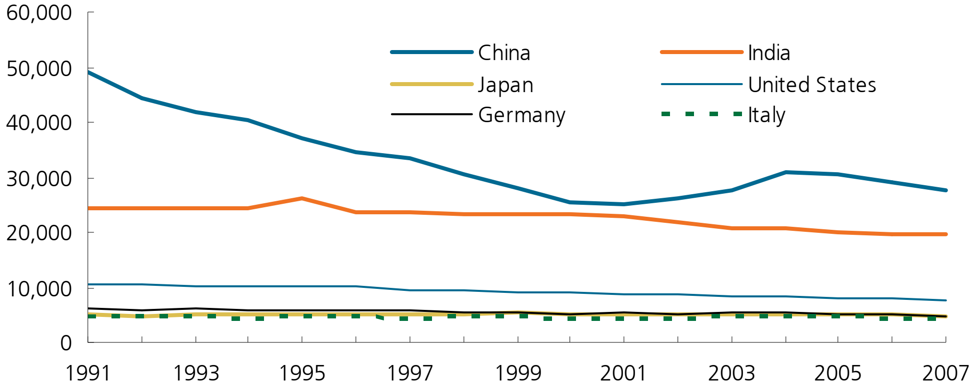
[62] CNTV English, 21.06.2010: http://english.cntv.cn/program/bizasia/20100621/102015.shtml.

[63] Xinhuanet 28.07.2010: "5 trillion yuan investment plan to spur energy development": http://news.xinhuanet.com/english2010/china/2010-07/28/c_13418682.htm ;
English People's Daily, 22.07.2010: "China develops 5-trillion-yuan alternative energy plan" http://english.peopledaily.com.cn/90001/90778/90862/7076933.html.

[64] World Bank, China Quarterly Update, November 2010.

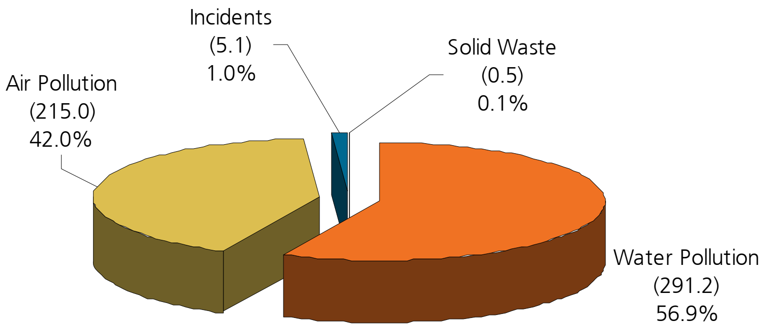
Figure 1.15 – China energy intensities versus other selected countries (Btu/GDP in 2005 USD, market prices)



Source: US Energy Information Administration

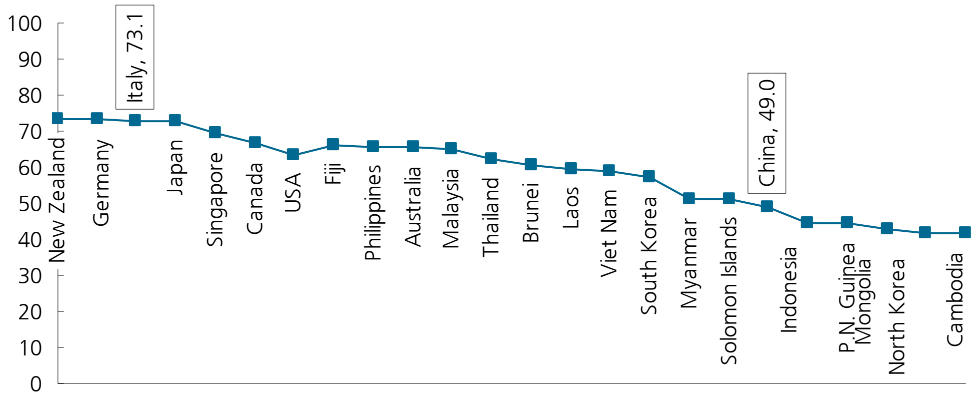
Other ambitious objectives include air quality in cities, water quality, water use efficiency in industry and agriculture, the expansion of forests, and an increase in re-use of industrial solid waste. Despite progress made in recent years to achieve these objectives, both Chinese authorities and international organisations agree that China's environmental situation is serious and social costs are high.

Figure 1.16 – Pollution damage cost in % of total environmental damage costs (CNY bln)



Source: CAEP 2010

Figure 1.17 – Environmental Performance Index: Eastern Asian countries and selected industrial countries (score*)



Source: http://epi.yale.edu/.*the highest the score the best the environmental performance, max 93.5 (Island) min 32.1 (Sierra Leone)

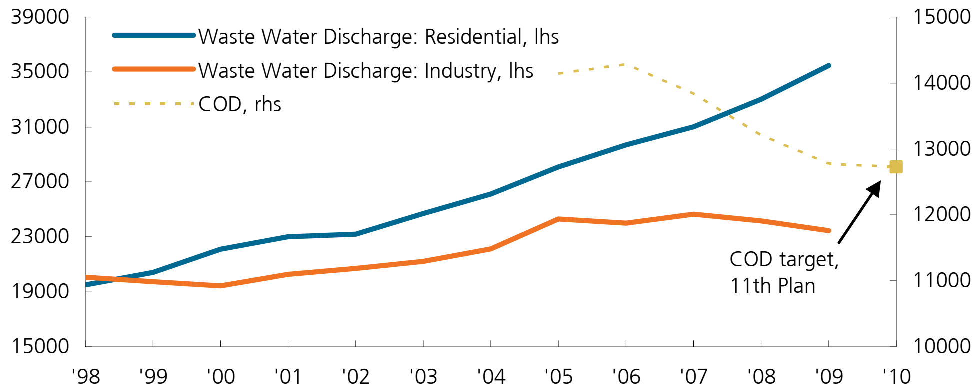
In 2010, China came in 121st out of 163 countries in Environmental Performance Index (EPI) standings compiled by Yale and Columbia Universities[65]. China started a Green National Accounting Research Project (Green GDP Project) in March 2004 with the objective of measuring GDP taking into account the cost of using natural resources and environmental degradation, consistent with the guidelines of the United Nations system for this type of accounting (Integrated Environmental and Economic Accounting, IEEA). The first green accounting GDP report, published in 2006, estimated that in 2004 pollution-related damage amounted to 3.05% of GDP, i.e. CNY 511.8Bn (around USD 61Bn in 2004), mainly caused by water pollution (56.9%) and air pollution (42%). In those regions where the environmental pollution was particularly severe, the environmental damage accounted for as much as 7.6% of the local GDP. Subtracting pollution abatement costs, GDP was 1.8 percentage points lower. Extended research at the provincial level from 2004 to 2007 showed that disparity in terms of economic growth and environmental degradation among the eastern, western, and central regions is increasing (CAEP 2010). In view of these results, industry and many authorities have fiercely resisted continuing with the program[66], though citizens[67] and the Ministry of Environmental Protection have strongly supported it and the Ministry is working to resume it.

[65] The index is based on 25 performance indicators relative to 10 categories of economic policy, ranging from public health to ecosystem health, providing a measurement of how close these countries are to achieving environmental policy targets. See: http://epi.yale.edu/.

[66] See Newsweek 7-14 July 2008: "Where Poor is a Poor Excuse" by Melinda Liu and Jonathan Ansfield, available at: http://www.newsweek.com/id/143693/output.

[67] See: "Most Chinese Support Green GP Calculations", MEP 06.08.2007: http://english.sepa.gov.cn/News_service/media_news/200712/t20071217_114995.htm.

Figure 1.18 – Waste water discharge and COD discharge (mln tons lhs, thousand tons rhs)

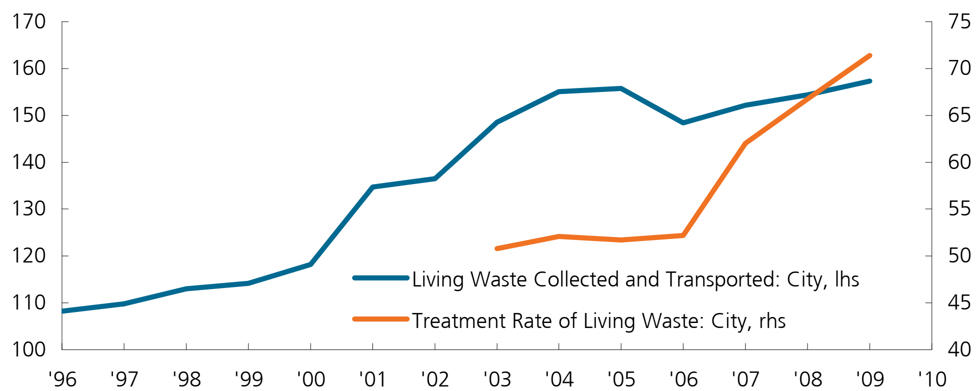


Source: CEIC, NDRC and MEP

According to a recent Responsible Research[68] report, 70% of Chinese rivers and lakes are significantly contaminated and 50% of ground waters are polluted. The Water Pollution Prevention and Control law of 2008 is a big step forward, doubling penalties, and COD dynamic in 2009 is consistent with achieving the 2010 target, however pollution is so high that it will require further effort in the coming years. In recent years, there have been many incidents of drinking water suspensions in cities. It is estimated that the direct economic loss due to the lack of drinking water amounts to USD 35Bn per year (around CNY 293Bn), four times the estimate of damage caused by floods.

The increase in urban population and disposable income will sustain a sharp increase in consumption, especially in emerging countries. So we can expect exponential growth rates in the production of urban solid waste, and managing it is currently an issue even in advanced countries. In addition to urban solid waste, there is also industrial solid waste. In China, the quantity of industrial solid waste doubled from 2000 to 2008, though the country has made noticeable progress in the rate of re-use over the same period of time, up from 45.9% to 64.9%, surpassing the target set in the 11th Five-Year Plan for 2010 (60%).

Figure 1.19 – China urban solid waste (mln tons)



Source: CEIC. Note: As comparison, in 2005 urban solid waste collected were 279 mln tons in Europe and 284 mln tons in NAFTA countries (OECD 2008)

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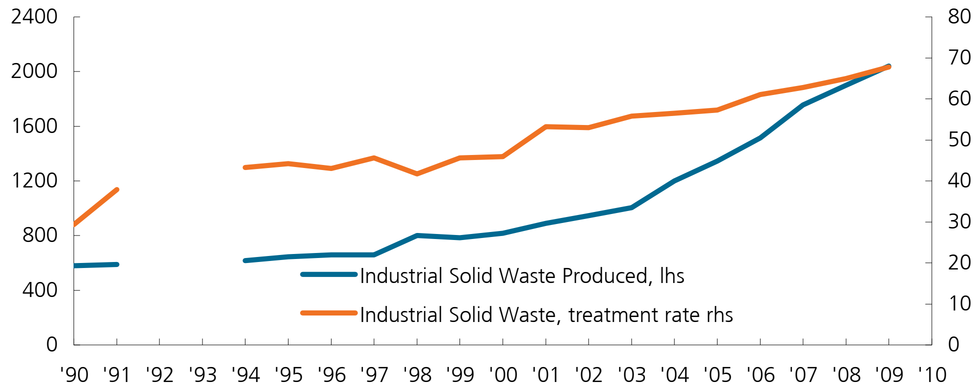
[68] Responsible Research, Water in China, February 2010: http://www.asiawaterproject.org/wp-content/uploads/2009/12/WATER-IN-CHINA-Issues-for-Responsible-Investors-FEB2010.pdf.

Figure 1.20 – Industrial solid waste (mln tons)



Source: CEIC. Note: data for 1992 and 1993 non available

OECD (OECD, 2008) estimates that annual average PM emissions in southern Asia in the Baseline Scenario will increase from 156.4 µg/m^3 to 202.5 µg/m^3, and from 107.3 µg/m^3 to 154.5 µg/m^3 over the same period in Indonesia and the rest of Asia. The forecasted increase for China is not very high (from 91 to 95 µg/m^3) but such is the starting level. The World Health Organisation 2006 recommendation contains three interim decrease targets (70, 50, and 30 µg/m^3 based on already existing levels of pollution) and a final target of 20 µg/m^3 which would allow for a 15% reduction in premature deaths. The European Union imposes a minimum threshold of 50 µg/m^3, while China imposes 100 µg/m^3 in urban areas[69], a Grade II standard.

The rate of premature deaths due to air pollution is set to increase especially in southeast Asia if policies remain unchanged. According to the OECD, in China alone premature deaths caused by excessive PM concentrations are on a path to increase from 266 per million inhabitants in 2000 to 872 per million inhabitants in 2030. According to the World Bank, in 2006 the number of annual premature deaths attributable to sicknesses caused by water pollution in China cost 1.9% of GDP, and attributable to sicknesses caused by air pollution 3.8% of GDP (World Bank 2007a).

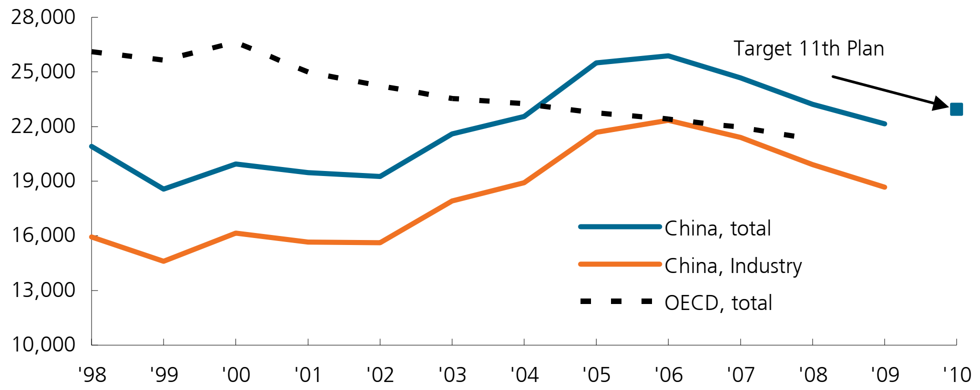
Table 1.6 – Annual mean PM10 concentration and forecasts to 2030 (µg/m^3), baseline scenario

	2000	2030
Australia and New Zealand	19.1	10.9
Russia and Caucasus	28.2	21.1
NAFTA	29.6	19.5
Central and Western Europe and Turkey	32.5	26.4
Eastern Europe and Central Asia	35.2	39.1
Japan and South Korea	40.1	30.6
Brazil	42.8	40.3
Rest of Latin America	52.4	56.2
China and Chinese Territories	91.0	95.8
Indonesia and rest of South Asia	107.3	154.5
Africa	113.9	153.8
South Asia	156.4	202.5

Source: OECD 2008, Regional mean population weighted

[69] See OECD 2007, Environmental Performance Reviews: China. China has three thresholds for air pollution levels, one for natural reserves (Grade I), one for urban areas (Grade II), and one for industrial zones (Grade III). There are also specific indoor air pollution levels.

Figure 1.21 – Sulphur Dioxide Emissions (thousand tons)



Source: CEIC, OCSE* from OECD 2008

Green-house gas emissions are also an increasing concern for Chinese authorities. In 2007 they published a National Program on Climate Change, and in 2008 a White Paper on China's Policies and Actions for Addressing Climate Change, followed by an assessment report in November 2009[70]. In addition, at the Copenhagen Conference last year, China stated that by 2020 it wants to reduce CO_2 emissions as a unit of GDP by 40%-45% below its 2005 level, and in the spring of 2010 it started up a specific climate change cooperation program with the European Union.

The situation is not much different for pollutants other than green-house gasses, such as sulphur dioxide and carbon monoxide, massively produced by the combustion of fossil fuels, especially coal, and they are main causes of acid rain. China is making progress in the reduction of SO_2, (the 2010 target, 22944 thousand tons, has been reached in 2009, 22144 thousand tons) and it is studying a market for emissions quotas similar to the one in the United States[71]. However, around 30% of China is still awash in acid rain. According to the World Bank (World Bank 2007a), acid rain in China causes CNY 30Bn in damage to crops each year, i.e. 1.8% of agricultural production, in addition to CNY 7Bn in material damage.

However, notable synergies can be generated by coordinating climate change policies with environmental protection policies in other fields. For example, implementation of energy policies capable of improving energy security or efficiency is also capable of mitigating other forms of air pollution, and it can also decrease globally the cumulative energy requirement by 11% in 2030, i.e. 2,000 million equivalent tonnes of oil, with around USD 3Tr in saving of cumulative spending on energy infrastructure investment. This is even more significant for China which is starting from high total emissions levels (WEO, 2007).

[70] See State Council: http://english.gov.cn/2008-10/29/content_1134544.htm and NDRC: China's Policies and Actions for Addressing Climate Change -The Progress Report 2009: http://www.ccchina.gov.cn/WebSite/CCChina/UpFile/File571.pdf.

[71] Part of the ten-year energy and environmental cooperation program signed in December 2008 during a Economic and Strategic Dialogue Summit with the United States. See: http://www.treas.gov/press/releases/hp1310.htm

1.7 What To Expect Going Forward

In the absence of bolder corrective measures, China will be facing an increasingly sharp contrast between limited energy resources and the quest for growth, and especially between growth and environmental degradation. This has been quite clear to Chinese lawmakers who in recent years have placed increasing emphasis on environmental protection and energy saving policies but whose actual implementation has often unfortunately fallen well short of targets. Though increasing in recent years, investment in environmental protection, factoring out items not strictly environmental, is still low as a percentage of GDP, 0.93%-1.08% on 2008 GDP. These levels are consistent with those of countries with a similar development experience, such as eastern Europe in the 1990s, but the high rate of economic growth that China has achieved would require a sharp increase. According to some analysts at the China Academy for Environmental Planning, to achieve results in terms of lowering pollution and a noticeable improvement in environmental conditions, investment in environmental protection should increase to around 3% of GDP.

Recent statements by officials at the Ministry of Environmental Protection[72] point in that direction, providing environmental protection investment guidelines in the 12th Five-Year Plan (2011-2015), possibly reaching CNY 3.1Tr (around USD 454Bn), including CNY 1Tn to lower air pollution. Though not factored out for items that are not strictly environmental, this would be double the planned investment in the 11th Five-Year Plan. Given the new guidelines in the 12th Five-Year Plan and developments in legislation and environmental economic policy in recent years, we can expect the green economy to play an increasingly bigger role in China's overall economic policy going forward.

China is in a stage of economic and global trade development in which it can greatly benefit from advanced air treatment and energy saving technologies developed in countries of early industrialisation. At the same time, China has the resources to continue investing in the development of its own innovative technologies and experimental projects in this area, as demonstrated in the 10th Environmental Protection Industry Support Plan and the 11th Environmental Protection Plan. China's commitment to developing a "recyclable" economy would have positive effects on the environment and the quality of life for the average person not only in China, but also throughout the global economy in view of trade links and the competitiveness challenges with countries of early industrialisation. So it would be positive if China can continue to make progress in this area without letting itself be influenced, especially in this downshift in the global economy, by the dominant paradigm that still measures environmental protection as an additional cost, possibly to avoid, and that does not take into account the costs of use and abuse of natural capital and its finiteness when measuring GDP.

[72] People's Daily On Line, 25.11.2009: http://english.people.com.cn/90001/90778/90862/6823402.html.

2. Environmental goods trade and technology in China

The description of the evolution of the environmental legislation and policy in China shows how it has progressively offered support to the environmental protection and the preservation of natural and energy resources, to the eco-innovation as well as to the use of renewable energy sources. Despite the measures put in place over the years, China's environmental situation remains very fragile, and poses a major challenge for the country, alongside energy saving.

In a context of relatively low environmental investment and in the absence of a strongly enforced regulatory framework, China has built a leadership in environmental goods on international market and it is currently developing a specific technological base in these fields. In this second part of the paper we will describes this evolution using a new database based on UNCTAD trade data (COMTRADE) at very high level of detail for environmental goods international trade and patent counts, derived from OECD database for environmental technology.

The description of China growth process both as a supplier of goods and an innovator in environmental field will be complete by a simple exercise, aiming at exploring if Chinese recent development as a world leader in environmental goods trade flows is also due to local suppliers and not only by an internationalisation of production promoted by major industry multinationals.

2.1 Environmental goods: a complex definition

The main problem in assessing the scope and structure of world trade in a perspective of environmental protection is the definition itself of "environmental good", both from a theoretical point of view, and, especially, within the statistical framework in which data on global trade is surveyed.

From a theoretical point of view, extensive literature has been produced over time on the topic of the environment, with particular focus, in recent years, on global warming and carbon dioxide emissions issues. There is widespread agreement on the fact that the definition of an environmental product/service must take into account its impact over its entire lifecycle, ranging from the raw materials chosen, the production processes and the resulting emissions, the shipping and distribution methods (packaging included), to waste management when the lifecycle is exhausted. This analysis, commonly identified with the LCA acronym (Life Cycle Assessment[73]) provides the basis for environmental certification assessments (ISO 14000 and developments, eco-labelling), and holds increasing importance in the Research & Development (R&D) stage and designing of products, as well as in the strategic planning of enterprises.

Despite increasing awareness of environmental issues and the efforts made towards creating databases, LCA is still not so widespread as to cover the entire range of productions, but concentrated on specific products and supply chains, often defined on ad hoc criteria, which prevent them from being used within the context of world trade data analysis.

The classification methods of foreign trade flows, which are periodically reviewed in function of the changes that intervened both on the technological and regulatory fronts, respond mostly to needs tied to calculating customs duty and tariffs.

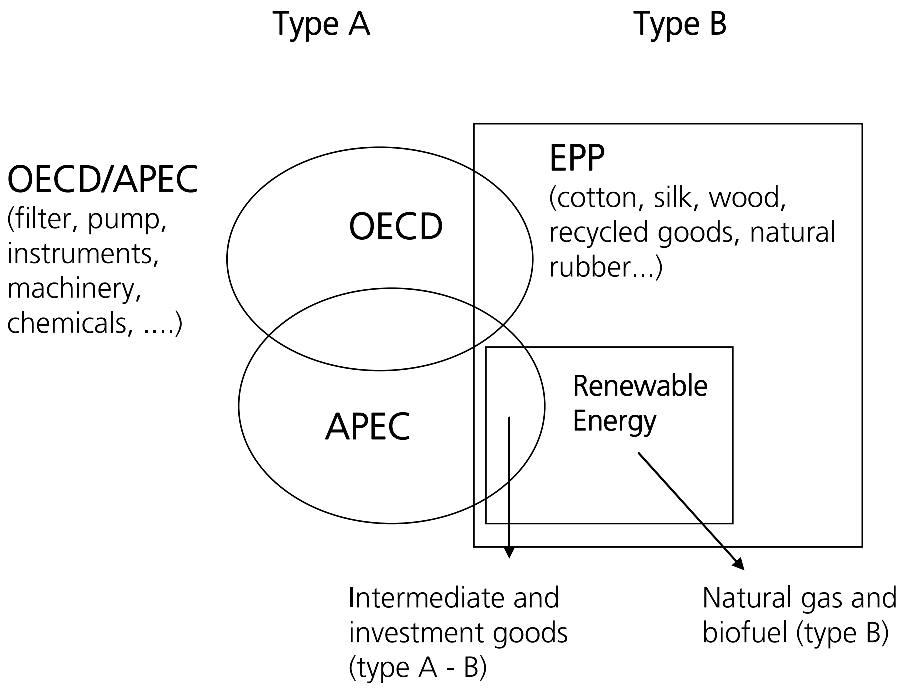
[73] There are several variants of this analysis, depending on the number of life stages considered, for instance cradle-to-grave or cradle-to-gate, i.e. not inclusive of shipping and distribution costs. Other analyses are specifically dedicated to single aspects, most notably energy related.

In the second half of the 1990s, however, the issue of environmental protection became the object of negotiations within international organisations, and a proposal was set forth of defining a list of products on which customs duty should be cut or abolished. The list, initially drafted by the OECD (1996), and refined in collaboration with Eurostat (1999), was subsequently revised, in particular by APEC (2001), as well as by a circle of individual countries, and at first essentially included a number of goods (intermediate, but mostly investment goods) allowing the offer of environmental services: prevention of polluting emissions, reduction of the impact of emissions, control and monitoring. These products may be classified in function of their main destination, e.g. for water management, solid waste management, etc. and are defined as Type A environmental goods.

More recently, many emerging countries have proposed their own lists of products to international organisations such as UNCTAD, mostly including consumer goods and commodities with features that make them preferable, from the point of view of environmental protection, to alternative products. These products, defined as Type B environmental goods, Environmentally Preferable Products (EPP), include for instance natural fibres (wool, cotton, other fibres), rubber, recycled products, wood and wooden products, as well as agricultural products used in the production of bio fuel and natural gas (Figure 2.1).

There is some overlapping between Type A and Type B products, the most prominent of which are products conducive to the production of energy from renewable sources, are included, almost unanimously, in all negotiations on the liberalisation of environmental goods.

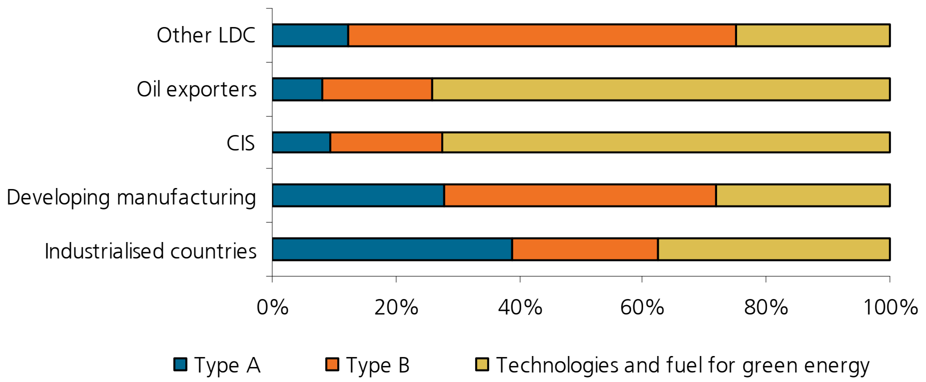
Figure 2.1 – Classification of environmental goods



Source: UNCTAD

The list of environmental goods negotiated, constantly monitored by UNCTAD (2003, 2005) includes around 700 items in the 6-digit Harmonised System classification, and accounted for world trade flows worth just under USD 2,000Bn in 2008, i.e. around 12% of overall world trade. In general terms, Type A goods are produced and exported mostly by industrialised countries[74], while emerging countries are predominantly exporters of Type B goods, therefore with diverging interests in the process of liberalising the environmental goods trade (Figure 2.2).

Figure 2.2 – World exports of environmental goods by type of product and country (2008)



Source: Intesa Sanpaolo on UNCTAD Comtrade

Beyond the negotiations, still under way, and the interests of the various blocks of countries, it is important to underline that these lists in any case pose considerable problems, for the very fact that of being based on the customs nomenclature system.

- The first problem concerns the detailing of classifications. The highest level of disaggregation allowed by international trade statistics (6-digit Harmonised System), used to define the list under negotiation, cannot be sufficient: in some cases, a code may embrace different goods, of which only a few can be considered as environment-friendly.
- A second limitation concerns the double use some products can be put to, in particular Type A products, both for machinery (lasers, items related to generic machinery, taps and valves, etc.), and some products of widespread use, such as gloves, brushes, etc.
- A further limitation is specifically related to the definition adopted for Type B environmental goods, drawn up without a careful analysis of the lifecycle of products, regardless of any considerations on production processes, or more complex considerations on their overall environmental impact (for instance the consequences on ecosystems of deforestation, in the case of the products made of exotic wood included in the list). Furthermore, as the classifications do not specify such data, it is not possible to analyse the environmental features, in terms of reduced CO_2 emissions, or lower energy intensiveness, of some specific products within the consumer goods category. This limitation is especially important, given the economic importance, and the weight on global trade, of product segments such motor vehicles or household appliances, which have determinedly set out along the path of reducing energy consumption and polluting emissions.

This latter limitation appears to be particularly significant. Therefore, our analysis will focus exclusively on Type A goods (hereinafter goods for waste management and pollution control),

[74] The classification adopted is the one laid out in the UNCTAD Handbook of Statistics (2005). The manufacturing emerging countries are: Brazil, China, India, Hong Kong, Taiwan, India, Korea, Malaysia, Mexico, the Philippines, Singapore, Thailand and Turkey. Russia is included among CIS countries, together with Central European and South Eastern European countries (Albania, former Yugoslavia, Croatia, Bulgaria, Romania, Ukraine), and Central Asian countries. The main oil producer include countries of the Arab Gulf, of Africa (Congo, Angola and Nigeria), of the South Mediterranean Rim (Libya, Algeria), Asia (Indonesia, Brunei), and Central and Latin America (Venezuela).

and then take a closer look at some Type B goods supply chains, in which selecting customs codes in greater detail is possible. Specifically, we will concentrate on two supply chains which seem especially promising in terms of higher forecast requirements in the years ahead: that of investment goods for the production of energy from renewable sources, and that of solutions geared to improving energy efficiency.

The analysis, carried out with sector experts, has led to the compilation of a list of codes which take into account, in part, the definition proposed to UNCTAD, but which stands out for the higher selectivity applied to the products considered.

As regards products for the production of energy from renewable sources, we have excluded from the list both overly generic products of which use in this supply chain is residual, and commodities such as silicon for solar panels, and nuclear energy technologies. On the other hand, we have added some products linked with the production of bio-masses, non taken into account by the UNCTAD list.

Technological solutions addressed to improving energy efficiency are of essential importance, in terms of containing CO_2, ranking alongside renewable energy sources as a key instrument in achieving the objectives identified in Kyoto and Copenhagen, as well as the European Commission's recent commitments on this front. Unless greater power efficiency is pursued in production processes, power grids, and residential housing, power requirements, based on population growth projections, will rise to the extent of causing not only a further increase in temperature, but also severe tensions on the energy commodity markets. Low-emission automobiles and high-efficiency-class household appliances are also legitimately part of this category, on transition to which some national governments have in fact started offering incentives. However, as underlined above, it is not possible to isolate the most innovative products within world trade flows, which in the case of automobiles and household appliances, also strike as being extremely complex to decode, and are strongly influenced by the high level of internationalisation of the production setups of the large players which operate in these sectors. Products for the restructuring of buildings geared to increasing energy efficiency (so-called "green building") are difficult to isolate in customs codes, and, apart from tiles, account for only a small portion of global trade. Therefore, we have focused on five categories of products (electric motors, UPS[75], condensers, lighting elements, and air conditioning units), which have features that may be considered as almost entirely dedicated to improving energy efficiency.

The lists of customs codes obtained, both for goods addressed to waste management and pollution control, and to the two supply chains of renewable sources and energy efficiency, have the advantage of being more directly comparable with the definitions of the classes of technology used in patent analysis, with the sole exception of insulation systems, embraced by patent analysis, but not in that of the international trade flows of products addressed to improving energy efficiency.

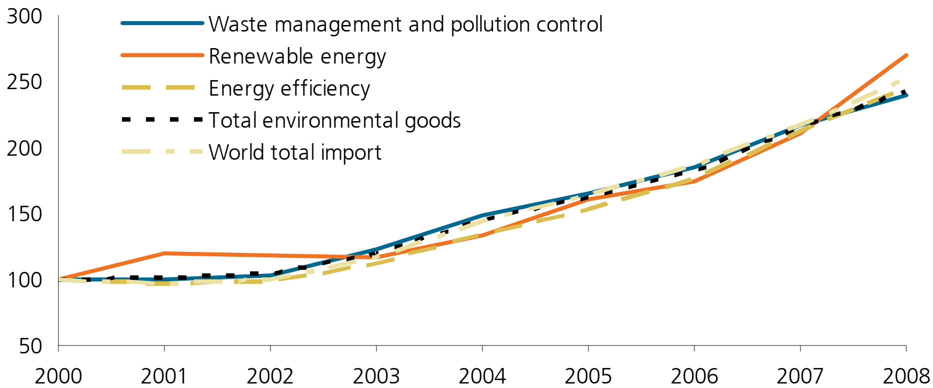
The analysis will be based on UNCTAD's Comtrade database, using the 6-digit Harmonised System classification, in the 1996 version, the one used in reference lists on the definitions of environmental goods. The time period considered is 2000-2008 for the analysis of global trade, the last year for which disaggregated data are available for a sufficient number of countries. Concerning Chinese trade, instead, we will be able to analyses also 2009 data.

[75] Uninterruptable Power Supply units, static power converters and transformers placed between the power source and the powered up device.

2.2 World trade in environmental goods

Environmental goods, as defined in this paper, account for around 4.7% of world trade, worth a total of just under USD 780Bn in 2008, and have experienced a broadly similar trend to that of overall international flows (Figure 2.3). Trade in goods addressed to renewable energy sources was slightly livelier, but accounted in 2008 for only 0.4% of total world trade, i.e. just under USD 70Bn. Trade flows in energy efficiency goods were only slightly stronger (0.6%, or USD 106Bn in 2008), as opposed to the significantly greater weight of environmental services goods, which added up to USD 603Bn in 2008, accounting for around 3.6% of the world total.

Figure 2.3 – Environmental goods imports (2000=100)



Source: Intesa Sanpaolo on UNCTAD Comtrade and IMF

The main importers of environmental goods (Table 2.1) are the industrialised countries, especially for what concerns goods tied to environmental protection services (waste management and pollution control), more developed in these countries.

However, it is interesting to note how, in the period considered, the role of the other countries as importers of environmental goods has significantly increased, with non-manufacturing emerging countries at the fore (CIS, oil producers, other regions). The shares of environmental goods imported by manufacturing emerging countries, with China among them, were broadly stable.

The situation on the front of exports is considerably different: in this case, the success of manufacturing emerging countries is significant, albeit not to the point of overtaking countries with a longer history of industrialisation, which remain by far the leaders in world trade flows, also in the export segment.

On the whole, industrialised countries also account for the largest share of exports in the total international trade flows in environmental goods and services, with emerging countries commanding an increasing share of imports. In the case of environmental goods, however, the emerging economies' role as destination countries is more significant by almost five per cent compared to their share of total world trade.

Table 2.1 – Environmental goods world trade by type and area (million USD and %)

Waste management and pollution control	2000 Import	2008	2000 Export	2008
Industrialised countries	68.9	62.2	82.3	74.1
Developing manufacturing	24.1	25.4	15.0	21.5
CIS	1.4	4.2	0.8	1.7
Oil exporters	2.2	3.1	1.0	1.3
Other developing countries	3.4	5.1	0.9	1.4
World	100	100	100	100
Renewable energy	**2000 Import**	**2008**	**2000 Export**	**2008**
Industrialised countries	59.2	50.9	92.0	81.3
Developing manufacturing	19.2	18.5	6.2	15.5
CIS	2.2	5.3	1.1	1.9
Oil exporters	10.7	13.2	0.3	0.5
Other developing countries	8.7	12.2	0.4	0.7
World	100	100	100	100
Energy efficiency	**2000 Import**	**2008**	**2000 Export**	**2008**
Industrialised countries	63.6	53.2	69.1	61.0
Developing manufacturing	23.0	23.7	29.2	36.5
CIS	1.2	3.9	0.8	1.2
Oil exporters	1.6	4.1	0.5	0.5
Other developing countries	10.7	15.1	0.4	0.8
World	100	100	100	100
Total Environmental goods	**2000 Import**	**2008**	**2000 Export**	**2008**
Industrialised countries	67.7	60.3	81.3	72.9
Developing manufacturing	23.7	24.7	16.2	23.1
CIS	1.5	4.3	0.8	1.7
Oil exporters	3.1	4.5	0.9	1.1
Other developing countries	4.1	6.1	0.8	1.2
World	100	100	100	100
World trade total	**2000 Import**	**2008**	**2000 Export**	**2008**
Industrialised countries	71.4	65.6	67.4	61.8
Developing manufacturing	19.8	22.5	20.5	24.1
CIS	1.6	4.4	2.6	5.3
Oil exporters	2.9	3.1	6.1	4.9
Other developing countries	4.2	4.3	3.3	3.8
World	100	100	100	100

Source: Intesa Sanpaolo on UNCTAD Comtrade

The Revealed Symmetric Comparative Advantage (RSCA) Index (Dalum et al. 1998)[76] shows that countries with a longer history of industrialisation have retained strong specialisation in environmental goods as a whole, mostly thanks to goods for the production of energy from renewable sources (Table 2.2). More recently industrialised countries, however, have

[76] The Revealed Symmetric Comparative Advantage (RSCA) index is a modification, to make it symmetric, of the most widespread revealed comparative advantage index, the Balassa Index, which is the ratio of the market share of specific good i held by country j, and the share held by country j in all categories of goods. Formally:

RSCA= (RCA-1)/(RCA+1) where RCA= (Xij/Xi)(Xj/X)

where i is the good, j the country, and X are exports.

experienced sharp growth in their shares of world exports of these products, particularly in terms of energy efficiency products.

Table 2.2 – Revealed Symmetric Comparative Advantage in environmental goods

Waste management and pollution control	2000	2008
Industrialised countries	0.10	0.09
Developing manufacturing	-0.15	-0.06
CIS	-0.52	-0.51
Oil exporters	-0.73	-0.59
Other developing countries	-0.59	-0.47
Renewable energy	**2000**	**2008**
Industrialised countries	0.15	0.14
Developing manufacturing	-0.53	-0.22
CIS	-0.42	-0.47
Oil exporters	-0.90	-0.81
Other developing countries	-0.79	-0.68
Energy efficiency	**2000**	**2008**
Industrialised countries	0.01	-0.01
Developing manufacturing	0.18	0.20
CIS	-0.54	-0.63
Oil exporters	-0.84	-0.83
Other developing countries	-0.81	-0.65
Total Environmental goods	**2000**	**2008**
Industrialised countries	0.09	0.08
Developing manufacturing	-0.12	-0.02
CIS	-0.52	-0.53
Oil exporters	-0.76	-0.64
Other developing countries	-0.63	-0.51

Source: Intesa Sanpaolo on UNCTAD Comtrade

A more detailed analysis reveals the main actors behind these changes and, specifically, the important role taken on by China with regards to world environmental goods trade flows.

As regards imports, in the past decade a number of markets grew rapidly, to the detriment of the United States, which nonetheless remain the world's largest importer, accounting for 13.7% of all environmental goods imports in 2008.

China's growth was particularly significant, which in 2008 became the world's second-largest importer, with a 7.6% share of world imports. Imports of waste management and pollution control products was particularly impressive: increasing environmental awareness, combined with the high pace of urbanisation surely contributed to this development (see paragraph 1.6). China is the world's second-largest importer also of energy efficiency devices, accounting for a share of just under 9% of the total.

Purchase of goods for the production of electricity from renewable sources were less impressive, placing China in fourth place among the largest importers in 2008 (with a smaller share of total imports than in 2000) preceded as well as by the United States, also by Germany and the United Kingdom.

A significant and stable role is played by Germany, which ranks third or second, depending on the segment, among the main world importers of environmental goods, just behind China.

Table 2.3 – Main world importers of environmental goods (current USD, % share and ranking)

	Waste management and pollution control		Renewable energy		Energy efficiency		Total environmental goods	
% share	2000	2008	2000	2008	2000	2008	2000	2008
USA	17.5	13.8	16.1	13.0	20.7	13.2	17.8	13.7
China	4.2	7.8	4.3	3.8	4.9	8.9	4.3	7.6
Germany	7.3	7.6	7.2	5.5	6.6	7.5	7.2	7.4
France	5.0	4.6	3.7	2.9	4.4	4.1	4.8	4.4
United Kingdom	5.0	3.8	8.1	5.1	5.1	3.4	5.3	3.9
Rep. of Korea	3.6	4.2	1.9	2.2	2.0	2.4	3.2	3.8
Japan	5.0	4.0	4.7	2.1	4.8	3.3	5.0	3.8
Canada	5.1	3.0	4.3	3.6	3.9	2.8	4.9	3.0
Italy	3.4	2.8	2.3	2.7	3.4	3.4	3.3	2.9
Mexico	4.6	2.9	4.5	2.1	3.5	2.5	4.4	2.8
Netherlands	2.4	2.7	1.6	1.4	2.5	2.3	2.3	2.5
Spain	2.2	2.1	1.2	2.3	2.8	2.7	2.2	2.2
Belgium	2.2	2.4	1.2	1.1	1.4	1.6	2.0	2.2
Russian Federation	0.6	2.0	0.7	2.7	0.4	1.9	0.6	2.0
Singapore	2.9	1.9	2.3	2.5	2.7	1.7	2.8	1.9
China, Hong Kong SAR	2.3	1.4	0.6	0.2	6.5	5.6	2.8	1.9
Poland	1.0	1.7	0.7	0.5	0.8	1.4	1.0	1.6
India	0.6	1.6	1.2	1.9	0.3	1.2	0.6	1.6
Australia	1.5	1.6	1.3	1.9	1.2	1.3	1.4	1.6
Austria	1.5	1.6	0.4	0.5	1.2	1.5	1.4	1.5

	Waste management and pollution control		Renewable energy		Energy efficiency		Total environmental goods	
Ranking	2000	2008	2000	2008	2000	2008	2000	2008
USA	1	1	1	1	1	1	1	1
China	8	2	6	4	5	2	8	2
Germany	2	3	3	2	2	3	2	3
France	4	4	8	6	7	5	6	4
United Kingdom	6	7	2	3	4	7	3	5
Rep. of Korea	9	5	13	12	14	12	10	6
Japan	5	6	4	14	6	8	4	7
Canada	3	8	7	5	8	9	5	8
Italy	10	10	11	8	10	6	9	9
Mexico	7	9	5	16	9	11	7	10
Netherlands	12	11	16	24	13	13	13	11
Spain	15	13	19	11	11	10	14	12
Belgium	14	12	20	27	17	16	15	13
Russian Federation	31	14	31	7	37	14	35	14
Singapore	11	15	12	9	12	15	11	15
China, Hong Kong SAR	13	23	38	60	3	4	12	16
Poland	24	16	32	44	24	19	24	17
India	32	18	21	19	42	24	31	18
Australia	18	20	18	18	20	20	17	19
Austria	19	17	43	43	19	17	19	20

Source: Intesa Sanpaolo on UNCTAD Comtrade

Germany's role is even more important when considering the exports of environmental goods: with a total share of almost 16%, and growing fast, German environmental goods topped the world export ranking in 2008. Germany is particularly strong in environmental services goods, a sector in which German products accounted for 16.8% of global exports in 2008, on the rise from 13.1% in 2000.

Germany's leadership takes advantage of the sharp contraction in the role of the United States, now second, which nonetheless continue to lead the ranking in terms of investment goods for the production of power from renewable energy sources, with a still impressive share, albeit on the decline, in 2008 (around 20%). With regards to the other environmental products considered here, the United States' role is being seriously challenged, as well as by Germany's impressive growth, as already mentioned, also by the success of "Made in China" products.

Table 2.4 – Main world exporters of environmental goods (current USD, % share and ranking)

	Waste management and pollution control		Renewable energy		Energy efficiency		Total environmental goods	
%	2000	2008	2000	2008	2000	2008	2000	2008
Germany	13.1	16.8	11.1	11.2	11.6	13.8	12.8	15.9
USA	20.0	11.7	23.8	20.1	13.0	7.3	19.4	11.8
China	3.5	9.4	0.8	7.1	7.5	19.8	3.8	10.7
Japan	14.5	9.7	11.1	7.0	8.5	5.8	13.5	8.9
Italy	5.2	5.1	8.0	7.4	5.0	5.0	5.3	5.3
France	4.2	4.0	6.3	5.6	5.7	4.9	4.5	4.3
United Kingdom	5.5	3.8	10.4	5.9	5.2	3.8	5.8	4.0
Netherlands	2.7	3.4	1.6	1.7	2.5	2.0	2.6	3.0
Mexico	2.9	2.2	1.8	1.9	5.1	1.9	3.1	2.2
Switzerland	2.3	2.1	4.7	4.1	1.1	1.2	2.3	2.1
China, Hong Kong SAR	2.4	1.5	0.4	0.2	8.6	6.3	3.0	2.0
Belgium	2.2	2.3	1.3	0.9	1.4	1.0	2.0	2.0
Canada	3.0	2.2	3.4	1.7	2.3	1.4	3.0	2.0
Rep. of Korea	1.5	2.1	1.7	1.4	1.8	1.7	1.6	2.0
Singapore	1.7	1.6	0.6	1.9	2.1	2.0	1.6	1.7
Austria	1.2	1.5	1.1	1.7	1.4	2.3	1.2	1.7
Denmark	1.1	1.2	2.4	3.8	1.4	1.1	1.2	1.4
Sweden	1.4	1.3	1.5	1.8	1.4	1.3	1.4	1.3
Spain	1.3	1.3	1.0	1.7	1.2	1.2	1.2	1.3
Czech Rep.	0.5	1.1	0.9	1.4	0.9	1.7	0.5	1.2

	Waste management and pollution control		Renewable energy		Energy efficiency		Total environmental goods	
Ranking	2000	2008	2000	2008	2000	2008	2000	2008
Germany	3	1	2	2	2	2	3	1
USA	1	2	1	1	1	3	1	2
China	7	4	19	4	5	1	7	3
Japan	2	3	3	5	4	5	2	4
Italy	5	5	5	3	9	6	5	5
France	6	6	6	7	6	7	6	6
United Kingdom	4	7	4	6	7	8	4	7
Netherlands	10	8	12	14	11	11	11	8
Mexico	9	10	10	10	8	13	8	9
Switzerland	12	13	7	8	23	20	12	10
China, Hong Kong SAR	11	16	25	40	3	4	9	11
Belgium	13	9	14	21	18	23	13	12
Canada	8	11	8	15	12	16	10	13
Rep. of Korea	15	12	11	19	14	14	15	14
Singapore	14	14	22	11	13	12	14	15
Austria	18	15	15	13	19	10	19	16
Denmark	19	20	9	9	16	21	18	17
Sweden	16	18	13	12	17	18	16	18
Spain	17	19	17	16	21	19	17	19
Czech Rep.	26	23	18	18	24	15	26	20

Source: Intesa Sanpaolo on UNCTAD Comtrade

China's share of global exports of waste management and pollution control products increased from 3.5% in 2000 to 9.4% in 2008 (from seventh to fourth place). The country's growth was also very strong as an exporter in the renewable energy sources chain, in which China was virtually absent at the beginning of the last decade, and in 2008 ranked fourth among world exporters, with a 7.1% share of global exports. However, the segment in which China's growth was most impressive was that of products addressed to improving energy efficiency: the country's share increased from 7.5% in 2000 to 19.8% in 2008, clinching leadership for China in the segment.

Japan's decline was noteworthy (from second to fourth place overall), as was the United Kingdom's, while Italy and France proved resilient. The ranking of the top 20 world exporters of environmental goods confirms the dominance of countries with a longer history of industrialisation: in addition to China (and Hong Kong), only Mexico, South Korea, and the Czech Republic appear in this ranking, what's more with small and contracting shares.

The normalised trade balance[77] draws a comprehensive picture of import and export flows, highlighting, in addition to their specialisation, also the performances achieved over time by the various countries (Iapadre, 2001). Table 2.5 shows the normalised trade balances for the different categories of environmental goods of the 20 most important players in the global trade of these products, ordered by the overall sum of exports and imports in 2008.

Table 2.5 – Normalised trade balance in environmental goods

	Waste management and pollution control		Renewable energy		Energy efficiency		Total environmental goods	
	2000	2008	2000	2008	2000	2008	2000	2008
USA	0.08	-0.08	0.16	0.21	-0.26	-0.27	0.05	-0.07
Germany	0.30	0.38	0.18	0.33	0.24	0.31	0.28	0.37
China	-0.08	0.09	-0.70	0.30	0.18	0.39	-0.06	0.17
Japan	0.49	0.41	0.37	0.53	0.25	0.29	0.46	0.41
France	-0.08	-0.07	0.23	0.32	0.09	0.10	-0.03	-0.02
Italy	0.21	0.29	0.52	0.46	0.14	0.21	0.23	0.30
United Kingdom	0.06	0.01	0.09	0.06	-0.03	0.07	0.06	0.02
Rep. of Korea	-0.40	-0.32	-0.09	-0.24	-0.08	-0.16	-0.34	-0.30
Netherlands	0.08	0.12	-0.04	0.12	-0.05	-0.06	0.05	0.10
Canada	-0.24	-0.15	-0.15	-0.36	-0.29	-0.32	-0.24	-0.19
Mexico	-0.22	-0.14	-0.44	-0.06	0.16	-0.10	-0.17	-0.13
Belgium	0.00	-0.01	-0.01	-0.10	-0.05	-0.22	0.00	-0.03
China, Hong Kong SAR	0.03	0.03	-0.24	-0.14	0.10	0.07	0.05	0.05
Singapore	-0.25	-0.09	-0.60	-0.15	-0.15	0.11	-0.25	-0.06
Spain	-0.26	-0.26	-0.14	-0.16	-0.41	-0.36	-0.28	-0.26
Switzerland	0.33	0.26	0.41	0.43	-0.16	-0.10	0.29	0.24
Austria	-0.10	-0.02	0.41	0.53	0.03	0.23	-0.06	0.06
Russian Federation	-0.03	-0.45	0.03	-0.65	-0.05	-0.68	-0.03	-0.50
Poland	-0.40	-0.20	-0.04	0.40	-0.36	-0.20	-0.37	-0.17
Sweden	-0.03	-0.03	0.30	0.27	0.11	0.04	0.01	0.01
Thailand	-0.33	-0.18	-0.85	-0.71	0.38	0.20	-0.24	-0.18

Source: Intesa Sanpaolo on UNCTAD Comtrade

The first aspect which emerges from an analysis of normalised trade balances is how the diminishing role played by the United States both as a purchaser and seller of environmental goods, has created, over time, an unbalanced situation, with the normalised trade balance turning from positive to negative in the course of the 2000s for environmental goods as a whole. Goods for the production of electricity from renewable energy sources are the exception, where the US's leadership is firm, and has in fact increased, as shown by the improvement in the normalised trade balance. Germany confirms its status as one of the best performers in the period considered, in terms of international trade flows, with a strengthening of its normalised trade balance in all supply chains, together with China, which starting from an unbalanced situation, has managed to strengthen its normalised balance in all productions. Unlike the US, Japan, while on the retreat, has succeeded in retaining a positive and very strong normalised balance, above Germany's. Italy's performance has also been good and is improving.

[77] The normalised trade balance is the ratio of the trade balance (exports minus imports) and total trade flows (exports plus imports). Its range is normalised between -1 and 1.

2.3. Chinese trade in environmental goods

China, as described in the previous section, has taken on a leading position in the field of environmental goods in the course of this decade 2000, becoming one of the largest exporters of this category of products in the world, more than offsetting, thanks to its performance, a significant rise in imports, principally of waste management and pollution control products.

This section will analyse in greater detail China's foreign trade flows in these categories of products, indicating the main countries in which Chinese imports originate, and the main destination markets for "Made in China" products.

Over the past decade, China has strengthen its production base in many environmental friendly products. All the main MNE (multinational enterprises) operating in these sectors hold at least a production site in China, activating both imports and exports, with a role that is albeit very difficult to assess on a quantitative base. It is worth to note, that the increasing need of environmental products in China has also contributed to further strengthen this production base to serve the internal market[78]. Many MNE are currently enhancing also their R&D facilities based in China[79], as a mean to fulfill Chinese government requirement about technological content (see also paragraph 1.5). In the past decade, here considered, also local operators have strongly developed productions and R&D facilities. In the field of renewable energy, for example, three Chinese firms producing wind turbines are currently among the top ten world players and China is now the largest world manufacturer of solar photovoltaic (PV), supplying almost 40% of all solar PV worldwide in 2009[80].

2.3.1 Chinese imports of environmental goods

Overall imports of environmental goods (Table 2.6) clearly highlight the importance of trade relations between China and Japan: while to decreasing degrees in the period considered, Japan remains by far the main supplier of environmental goods to China. Germany follows, having achieved consistent growth and overtaken in 2008 the United States, whose share of Chinese imports has declined since the beginning of the decade.

In step with the weakening of Japan and USA, the share of imports from the Chinese special zones has consistently increased, to around 7%. China-to-China imports may signal the existence of investments in the special zones by foreign multinationals, in the production of environmental goods.

A breakdown of the various type of environmental goods shows that the importance of China-to-China flows is mostly tied to the energy efficiency segment (Table 2.9), in which this category of imports has surged to over a 20% share in a matter of years, overtaking Japan, Germany, and the United States.

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[78] It is worth to note that for some strategic products, such as wind turbines, there was a "domestic contents" requirement of at least 70%. This requirement was dropped in 2010 as no longer necessary, as virtually all turbine installations were Chinese-produced products-

[79] In the past few weeks, General Electric and Vestas decided to create or strengthen their Chinese R&D centre, only to cite the more recent announcements.

[80] Martinot and Jungfeng (July 2010)

Table 2.6 – Chinese imports in environmental goods (% share, current USD)										
Partner	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Japan	26.0	23.2	24.0	25.3	26.1	25.2	26.2	23.4	22.5	20.3
Germany	10.3	11.4	13.2	14.9	14.6	14.3	14.0	14.2	16.2	17.7
USA	17.7	18.1	16.5	15.4	14.9	14.4	14.6	15.3	15.4	14.1
China (FTZ and special areas)	1.5	1.8	2.6	3.0	3.9	5.0	6.2	7.7	6.9	7.3
Rep. of Korea	6.1	6.7	6.2	7.4	8.1	8.1	7.5	7.4	6.6	6.8
Italy	2.5	3.0	2.8	2.6	2.5	2.4	3.1	2.8	2.6	3.8
Other Asia, nes*	9.4	8.6	9.0	7.2	6.3	6.1	5.5	5.3	4.5	3.2
France	3.2	2.8	2.8	2.9	3.2	3.3	2.6	2.9	2.6	2.6
Switzerland	1.7	1.6	1.5	1.5	1.6	1.5	1.5	1.9	2.3	2.5
United Kingdom	4.2	3.8	2.8	2.4	2.5	2.5	2.3	2.2	2.2	2.0
Singapore	2.5	2.2	2.5	2.4	2.6	2.8	2.5	1.9	1.9	1.8
Netherlands	0.9	1.1	1.1	0.9	0.8	0.8	0.8	1.8	1.8	1.5
Canada	0.7	1.3	1.0	0.8	0.9	0.8	0.7	0.7	0.8	1.4
Sweden	1.2	1.4	1.0	1.2	1.0	0.9	0.8	0.8	1.1	1.2
Finland	1.0	1.4	0.9	0.9	0.9	0.8	0.8	0.9	1.1	1.2
Malaysia	0.8	0.8	0.9	1.1	0.9	1.2	1.3	1.1	1.0	1.0
Denmark	0.9	1.0	1.1	1.1	0.9	0.7	0.8	0.9	1.1	1.0
Austria	0.5	0.7	0.7	0.6	0.8	0.9	0.8	0.8	0.8	1.0
Thailand	0.9	0.7	0.6	0.7	0.7	0.8	0.7	0.7	0.8	0.8
India	0.1	0.1	0.3	0.2	0.2	0.4	0.5	0.6	0.3	0.7

Source: Intesa Sanpaolo on UNCTAD Comtrade *not elsewhere specified

However, the share controlled by Chinese special zones in the environmental services goods segment (Table 2.7) is also increasing, although it remains limited, and does not pose a threat to the position of the main suppliers (Japan, Germany and the United States). In this category of products, an important role is also played by Korea and by flows from other Asian countries.

Table 2.7 – Chinese imports in waste management and pollution control goods (% share, current USD)										
Partner	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Japan	29.0	25.9	26.3	27.5	28.3	26.9	28.0	25.2	24.2	21.8
Germany	10.2	11.5	13.7	15.5	15.7	15.0	14.4	14.4	16.4	17.4
USA	18.1	18.2	16.8	16.0	15.7	15.2	15.7	17.1	16.3	15.2
Rep. of Korea	5.8	6.6	6.2	7.6	8.6	8.8	8.1	7.8	7.1	7.0
China (FTZ and special areas)	0.8	0.8	1.0	1.3	1.6	2.3	3.2	4.2	4.1	4.1
Italy	2.6	2.9	2.9	2.5	2.5	2.4	2.9	2.2	2.5	4.0
Other Asia, nes	9.9	9.2	9.6	7.4	6.6	6.8	6.2	5.9	4.8	3.5
Switzerland	1.7	1.7	1.5	1.6	1.9	1.8	1.7	2.2	2.6	2.8
France	2.5	2.2	2.6	2.5	2.2	2.6	2.6	2.7	2.6	2.4
United Kingdom	3.2	3.3	2.7	2.3	2.3	2.4	2.5	2.2	2.2	2.0
Singapore	1.9	1.6	1.8	1.8	1.6	1.9	1.7	1.7	1.8	2.0
Canada	0.7	1.5	1.0	0.9	0.9	0.9	0.8	0.8	0.9	1.7
Netherlands	0.9	1.2	1.1	1.0	0.8	0.8	0.9	2.0	1.9	1.7
Sweden	1.1	1.0	0.9	1.2	1.0	0.9	0.9	0.9	1.1	1.1
Denmark	0.7	0.7	0.8	0.8	0.6	0.7	0.8	0.7	0.9	1.0
Malaysia	0.8	0.9	0.9	1.2	1.0	1.3	1.3	1.1	1.0	0.9
Austria	0.5	0.7	0.8	0.7	0.9	0.7	0.7	0.7	0.8	0.9
Saudi Arabia	0.6	0.6	0.7	0.5	0.2	0.2	0.2	0.2	0.3	0.9
China, Hong Kong SAR	2.4	2.0	1.9	1.5	1.2	1.5	1.2	1.2	1.1	0.8
Finland	0.9	1.3	0.8	0.5	0.7	0.4	0.4	0.6	0.7	0.7

Source: Intesa Sanpaolo on UNCTAD Comtrade

Imports of products for the production of electricity from renewable energy sources (Table 2.8) are more volatile, due to the high unit value of some goods, and the limited size of flows. Germany and Japan battle for leadership in the supply of these technologies to China, followed by the United States. Important growth on this front has been achieved in recent years by Spain, mostly in the solar power supply chain. While taking into account the very high volatility of flows, France and Italy post a good performance, albeit with unmatched past peaks. An interesting aspect is Denmark's increasingly prominent role, on the back of its specialisation in wind power technologies, and the weaker presence, compared to the other supply chains considered here, of import flows from other Asian countries, with the exception of Japan.

Table 2.8 – Chinese imports in renewable energy goods (% share, current USD)

Partner	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Japan	17.5	9.7	13.5	13.7	16.5	22.2	28.2	23.4	18.0	21.5
Germany	18.1	16.8	18.5	22.1	16.0	17.6	16.4	15.0	18.8	17.7
USA	10.7	18.3	9.3	11.3	12.8	17.2	15.5	10.1	11.1	17.2
France	10.7	10.9	6.1	10.5	20.3	12.2	5.1	4.5	7.7	9.1
Italy	2.2	4.4	2.6	3.9	4.4	3.5	7.3	10.5	6.1	4.2
Rep. of Korea	3.5	3.9	2.7	3.6	5.0	5.0	4.8	4.4	3.5	3.7
Finland	0.5	1.4	0.5	2.5	1.3	0.7	1.4	2.0	2.9	3.4
Austria	0.2	0.2	1.0	0.6	1.2	2.9	2.2	2.0	2.4	2.5
Denmark	3.0	2.5	2.4	2.7	3.2	1.1	0.9	3.4	5.1	2.4
United Kingdom	13.8	7.6	3.1	2.7	1.9	1.6	0.9	1.8	2.5	2.1
Switzerland	4.2	2.5	4.0	3.0	0.6	0.3	1.2	1.4	0.9	2.1
Netherlands	1.1	0.8	1.6	1.1	1.9	1.2	1.2	1.2	3.3	1.9
India	0.0	0.1	0.1	0.1	0.3	0.9	2.9	4.1	0.3	1.9
Belgium	2.1	0.8	0.2	0.8	0.5	1.6	0.2	2.1	1.2	1.4
Other Asia, nes	3.7	4.4	5.1	5.2	4.2	2.1	1.7	1.6	3.2	1.3
Spain	2.5	0.3	4.9	2.7	2.3	5.6	4.2	5.4	5.5	0.9
Russian Federation	2.3	8.7	11.2	6.2	0.2	0.2	0.4	0.3	0.7	0.8
Brazil	0.4	3.5	3.8	1.4	0.4	0.8	1.2	1.2	1.2	0.7
Romania	0.1	0.1	0.5	0.1	0.2	0.6	0.6	1.2	0.7	0.7
Sweden	0.5	0.5	0.5	0.5	0.6	0.2	0.2	0.3	1.0	0.6

Source: Intesa Sanpaolo on UNCTAD Comtrade

Table 2.9 – Chinese imports in energy efficiency goods (% share, current USD)

Partner	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
China (FTZ and special areas)	5.6	7.1	11.1	12.9	17.9	21.3	23.2	27.2	23.1	24.4
Germany	6.5	8.5	8.7	9.5	8.1	8.8	11.3	12.9	14.6	19.1
Japan	15.3	13.9	15.7	17.2	17.6	18.0	16.8	14.3	14.9	12.8
USA	19.6	17.4	17.0	13.6	11.8	8.6	9.0	8.2	12.3	8.5
Rep. of Korea	9.0	7.9	7.6	7.7	6.3	6.5	6.1	6.1	5.4	6.9
Finland	1.9	1.7	1.3	2.6	1.8	2.4	2.5	2.1	2.7	2.9
Italy	2.2	3.0	2.5	2.6	2.3	1.9	2.4	3.4	2.1	2.7
Other Asia, nes	9.8	7.5	7.4	7.0	5.9	4.7	3.8	3.6	2.9	2.4
France	2.9	2.8	2.5	2.7	2.6	2.4	1.5	3.2	1.3	2.1
United Kingdom	4.6	5.1	3.4	2.8	4.1	3.4	2.1	2.1	2.4	2.0
Sweden	2.5	3.7	1.8	1.5	1.1	1.1	0.9	0.8	1.2	1.9
Malaysia	1.1	1.0	0.7	0.9	1.0	1.2	1.9	1.9	1.5	1.7
Thailand	0.7	1.1	1.7	2.2	1.7	2.5	2.3	2.2	2.1	1.7
Singapore	6.3	5.9	6.8	6.2	8.4	8.5	7.6	3.4	3.2	1.5
Switzerland	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.7	1.1	1.4
Denmark	0.9	1.9	1.9	2.2	1.4	0.8	0.9	0.9	1.1	1.0
Austria	0.3	0.4	0.3	0.3	0.3	0.5	0.5	0.6	0.7	0.9
Philippines	0.2	0.4	0.3	0.4	0.3	0.8	1.1	1.0	0.9	0.7
Indonesia	0.3	0.3	0.3	0.3	0.6	0.5	0.6	0.4	0.5	0.6
Hungary	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.5

Source: Intesa Sanpaolo on UNCTAD Comtrade

For what concerns products for the production of electricity from renewable sources, where technologies are not yet standardised and the innovation content is significant, the main supplier countries seem to be those with a longer history of industrialisation, whereas for other categories of products, such as energy efficiency products, an important share of China's imports originate from the Chinese special areas and from other Asian countries.

2.3.2 Chinese exports of environmental goods

A breakdown of Chinese exports by country of destination reveals the dominant position of the United States, which alone accounted for around one-fifth of China's total foreign sales in 2008, a still impressive share despite the downtrend observed since 2001.

Table 2.10 – Chinese export in environmental goods (% share, current USD)

Partner	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
USA	26.1	27.4	27.1	25.6	24.9	24.9	23.6	22.5	20.8	20.5
China. Hong Kong SAR	12.1	11.4	11.9	11.8	11.3	10.5	9.9	10.1	8.9	9.6
Japan	13.8	13.8	13.3	12.8	12.4	11.4	10.5	9.1	8.4	8.1
India	0.4	0.7	0.7	0.6	1.0	1.3	2.0	2.8	3.9	5.3
Germany	5.6	5.0	4.5	5.0	5.1	4.7	4.5	4.5	4.1	3.9
Rep. of Korea	2.3	2.6	2.9	3.1	3.2	3.5	3.9	4.1	3.9	3.5
United Kingdom	4.5	3.9	4.0	3.9	4.0	3.5	3.3	3.2	2.8	2.6
Indonesia	1.2	1.1	1.2	1.3	1.3	1.5	1.4	1.5	2.2	2.2
Netherlands	3.2	2.7	2.4	2.5	2.5	2.2	2.2	2.1	2.3	2.1
Australia	2.0	1.7	1.7	1.8	1.7	1.7	1.7	1.7	1.7	2.0
Italy	2.2	2.0	2.7	2.5	2.4	2.5	2.4	2.4	2.1	1.9
France	2.4	2.1	1.8	1.9	2.0	1.8	1.9	1.8	1.7	1.8
Viet Nam	0.4	0.6	0.7	0.8	0.8	0.9	1.0	1.3	1.5	1.7
Canada	1.3	1.5	1.8	1.8	1.9	1.9	1.9	1.9	1.8	1.6
Other Asia. nes	2.2	2.0	2.1	2.3	2.2	2.1	2.0	2.1	1.9	1.5
Turkey	0.6	0.4	0.5	0.6	0.8	1.0	0.9	1.1	1.2	1.4
Brazil	0.6	1.2	0.4	0.4	0.6	0.7	1.0	1.0	1.4	1.4
Thailand	0.6	0.7	0.8	0.9	1.1	1.2	1.2	1.2	1.3	1.4
Singapore	1.5	1.3	1.2	1.2	1.2	1.3	1.3	1.4	1.3	1.4
Malaysia	0.7	0.7	0.9	1.1	1.1	1.2	1.2	1.3	1.3	1.3
Russian Federation	0.5	0.6	0.7	0.8	1.0	1.1	1.4	1.6	2.3	1.3

Source: Intesa Sanpaolo on UNCTAD Comtrade

Hong Kong ranks second among destination markets, having lost over time its role as a transit country for Chinese goods directed to other markets, followed in third place by Japan, whose role as a target market for Chinese environmental goods exports has weakened.

By contrast, environmental goods export flows have increased, in terms of shares of the total, towards other Asian markets. Particularly strong growth was recorded by Chinese exports to India[81], which in 2009 accounted for 5.3% of the total, although strong increases were also seen in exports to South Korea, Indonesia, Vietnam, and other Asian countries, at least until 2007. Worth to note also the increase in the share of Chinese exports directed to the Russian Federation and Turkey.

In step with the increasing importance of emerging countries, the industrialised countries are losing trade shares: as well as the United States and Japan, the share of environmental goods addressed to Germany, the United Kingdom, the Netherlands, etc. is also declining.

An analysis by sector confirms the strong weight of the United States and Japan in absorbing exports of waste management and pollution control products. Significant exports are also directed to Hong Kong. The diminishing importance of countries with a longer history of industrialisation, and a shift in geographical orientation to the advantage of the Asian countries, is also confirmed.

[81] In its statistics, always included in the UNCTAD database, India does not indicate such significant imports of environmental goods from China, probably included in the "other countries" item.

Table 2.11 – Chinese export in waste management and pollution control goods (% share, current USD)

Partner	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
USA	27.3	29.0	29.1	28.3	27.8	27.5	26.2	25.1	23.4	23.2
Japan	12.0	12.6	12.5	12.1	11.6	11.1	10.6	9.3	9.0	8.8
China, Hong Kong SAR	10.8	9.7	9.5	9.3	8.7	7.8	7.5	8.1	7.5	8.2
Germany	6.6	5.7	5.0	5.5	5.4	4.9	4.3	4.4	4.1	4.1
Rep. of Korea	2.2	2.4	2.8	2.8	2.9	3.0	3.4	3.6	3.7	3.3
United Kingdom	4.9	4.4	4.5	4.5	4.7	4.1	4.0	3.8	3.5	3.3
India	0.5	0.8	0.8	0.6	1.0	1.2	1.5	2.0	2.2	2.9
Netherlands	3.8	3.0	2.6	2.6	2.4	2.3	2.4	2.3	2.5	2.3
Australia	2.1	1.9	2.0	2.1	2.0	2.0	1.9	2.0	2.0	2.2
Italy	2.2	1.9	2.9	2.4	2.3	2.6	2.4	2.4	2.2	2.1
France	2.5	2.1	1.9	2.0	2.0	2.0	1.9	1.8	1.8	2.0
Canada	1.5	1.7	2.1	2.2	2.2	2.3	2.3	2.2	2.1	1.9
Russian Federation	0.7	0.8	0.8	1.0	1.2	1.3	1.6	1.8	2.3	1.5
Indonesia	1.3	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.4	1.4
Thailand	0.7	0.7	0.8	0.9	1.1	1.2	1.3	1.2	1.4	1.4
Brazil	0.7	1.4	0.4	0.5	0.6	0.7	1.1	1.0	1.4	1.4
Other Asia, nes	1.5	1.3	1.4	1.6	1.7	1.8	1.6	1.7	1.7	1.4
Viet Nam	0.4	0.6	0.8	0.9	1.0	1.0	1.0	1.1	1.2	1.4
Malaysia	0.6	0.7	0.9	0.9	1.0	1.1	1.1	1.2	1.3	1.3
Singapore	1.3	1.1	1.0	1.0	1.0	1.0	1.0	1.3	1.2	1.3

Source: Intesa Sanpaolo on UNCTAD Comtrade

This shift becomes more obvious when analysing the exports of investment goods linked with renewable energy sources, characterised (as discussed in the paragraph on imports), by higher volatility. India and Indonesia were the main destination markets for Chinese products in 2009, and together with Vietnam accounted in that same year for around 50% of China's exports of these products.

Table 2.12 – Chinese export in renewable energy goods (% share, current USD)

Partner	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
India	0.2	1.7	0.4	1.5	11.0	9.5	21.9	21.5	29.7	33.0
Indonesia	3.4	3.3	3.8	8.5	10.5	19.3	8.3	7.5	13.8	11.7
Viet Nam	2.5	3.5	2.0	7.1	4.1	4.0	5.6	11.4	8.0	6.6
USA	7.5	16.2	13.4	11.0	7.0	9.1	9.8	12.8	8.2	6.0
Turkey	0.8	0.4	0.0	0.9	5.2	1.3	0.9	2.9	3.0	5.5
Japan	6.5	10.4	9.0	10.3	8.3	8.4	6.4	5.7	4.2	3.1
Azerbaijan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	2.4
Rep. of Korea	3.5	2.7	4.4	6.4	6.0	4.4	2.9	2.2	2.6	2.4
Pakistan	2.2	3.1	1.8	1.3	2.4	3.6	2.6	0.9	2.1	2.3
Thailand	1.6	0.5	0.6	1.4	2.2	2.6	2.3	2.4	1.7	2.2
Belgium	0.3	0.2	0.1	0.4	0.4	0.6	0.5	0.5	0.7	1.5
Saudi Arabia	0.4	0.5	0.5	0.8	0.8	0.3	0.9	1.7	1.3	1.1
Denmark	0.0	0.1	0.0	0.1	0.1	0.0	0.1	0.2	1.0	1.1
Sri Lanka	0.2	0.1	0.3	0.3	0.2	0.1	0.1	0.1	0.1	1.1
Nigeria	2.3	3.4	1.6	2.5	3.4	5.1	12.4	2.2	0.4	1.0
Myanmar	1.7	4.2	13.9	9.7	2.0	1.3	0.5	1.3	0.5	1.0
Malaysia	0.8	1.2	1.8	8.7	2.5	1.2	0.6	2.6	1.0	1.0
Singapore	2.7	2.1	2.2	2.4	2.9	2.8	2.1	1.6	1.2	1.0
Italy	0.8	1.6	2.2	2.2	1.3	1.1	1.1	1.2	0.5	0.9
Brazil	0.3	0.5	0.4	0.2	0.2	1.3	0.4	0.6	1.9	0.8

Source: Intesa Sanpaolo on UNCTAD Comtrade

It should be noted that the list of leading import markets also includes African and Latin American countries, signalling the efforts being made by China to penetrate these markets as well.

As regards energy efficiency products, in addition to the importance of the US, substantial flows are addressed to Hong Kong. This element makes the evolution of flows and shares less transparent and interpretable, as a significant portion of products destined to Hong Kong is probably subsequently redirected to other destinations.

Table 2.13 – Chinese exports in energy efficiency goods (% share, current USD)

Partner	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
USA	23.7	23.8	22.1	18.9	18.3	19.3	18.1	16.6	16.8	16.8
China, Hong Kong SAR	16.4	16.8	19.4	19.1	18.4	18.4	17.0	16.2	14.5	16.2
Japan	19.5	17.5	15.8	14.9	14.9	12.2	10.7	9.0	7.7	7.6
Rep. of Korea	2.8	2.9	3.2	3.8	4.0	4.8	5.6	5.7	4.6	4.3
Germany	2.8	3.3	3.4	3.9	4.7	4.7	5.4	5.1	4.5	4.3
India	0.4	0.3	0.5	0.5	0.7	1.0	1.5	2.6	2.7	4.1
Other Asia, nes	4.4	4.0	4.0	4.0	3.6	2.9	3.1	3.3	2.7	2.3
Netherlands	1.6	1.7	1.7	2.1	2.6	2.0	1.8	1.8	1.9	2.1
Nigeria	0.5	0.8	0.9	1.3	0.9	1.1	0.8	1.2	1.8	1.9
Italy	2.5	2.4	1.9	2.6	2.9	2.4	2.3	2.7	2.2	1.8
Indonesia	0.6	0.7	0.9	1.0	0.9	1.0	1.0	1.2	1.7	1.7
Australia	1.0	0.9	1.0	1.2	1.2	1.1	1.2	1.1	1.2	1.7
Mexico	0.5	1.1	1.5	1.0	0.8	0.8	1.1	1.4	1.7	1.7
France	2.3	2.0	1.7	1.6	1.9	1.6	1.8	1.7	1.5	1.6
Singapore	2.1	1.8	1.8	1.8	1.6	1.9	1.9	1.6	1.7	1.6
United Kingdom	3.6	2.8	2.5	2.3	2.4	1.9	1.7	1.8	1.6	1.5
Hungary	0.1	0.3	0.4	0.4	0.5	0.4	0.8	1.1	1.1	1.5
United Arab Emirates	0.7	0.8	1.2	2.1	2.2	2.7	1.8	1.7	1.9	1.5
Malaysia	0.8	0.8	1.1	1.2	1.3	1.5	1.5	1.4	1.4	1.5
Brazil	0.5	0.5	0.4	0.4	0.4	0.7	0.9	1.2	1.3	1.4

Source: Intesa Sanpaolo on UNCTAD Comtrade

In addition to Hong Kong, also other Asian countries are becoming increasingly important trade partners for China, joined by, as already observed in the trade of goods for the production of energy from renewable sources, some African countries (Nigeria) and Latina America (Mexico, Brazil).

2.3.3 Chinese normalised trade balance in environmental goods

An analysis of the normalised balance of bilateral Chinese trade flows shows that the country's positive performance, already underlined in the comparison with other countries, is mostly built on trade with the United States: purchases of technologies, in the field of renewable sources in particular, are more than balanced by the sale of products, especially in the energy efficiency supply chain.

China's normalised trade balance vs. Japan and Germany, on the other hand, has remained in negative territory, and actually worsened further against Germany, mostly due to flows of products for the control and management of pollutants and for the production of electricity from renewable energy sources.

By contrast, China's performance is much stronger vis-à-vis the emerging countries, where the country has managed to safeguard or step up a substantial positive normalised balance (in some cases of 1, due to the lack of imports).

Table 2.14 – Chinese normalised trade balance in environmental goods by country

	Waste management and pollution control		Renewable energy		Energy efficiency		Total environmental goods	
	2000	2009	2000	2009	2000	2009	2000	2009
World	-0.08	0.08	-0.70	0.38	0.18	0.33	-0.06	0.15
USA	0.13	0.29	-0.78	-0.12	0.27	0.59	0.14	0.33
China, Hong Kong SAR	0.59	0.85	0.54	0.98	0.60	0.98	0.60	0.90
Japan	-0.48	-0.36	-0.88	-0.51	0.30	0.08	-0.35	-0.30
India	0.63	0.68	0.76	0.95	0.65	0.90	0.64	0.83
Germany	-0.29	-0.57	-1.00	-0.82	-0.24	-0.39	-0.35	-0.54
Rep. of Korea	-0.52	-0.28	-0.69	0.17	-0.39	0.11	-0.49	-0.18
United Kingdom	0.14	0.31	-0.99	-0.32	0.06	0.22	-0.02	0.28
Indonesia	0.65	0.66	0.94	1.00	0.52	0.69	0.64	0.78
Netherlands	0.56	0.25	-0.92	-0.51	0.54	0.79	0.52	0.33
Australia	0.51	0.65	0.88	0.70	0.58	0.97	0.54	0.71
Italy	-0.18	-0.23	-0.87	-0.36	0.25	0.13	-0.12	-0.18
France	-0.07	-0.01	-0.99	-0.75	0.06	0.20	-0.19	-0.04
Viet Nam	0.97	0.86	1.00	1.00	0.95	0.79	0.97	0.89
Canada	0.28	0.16	-0.92	0.40	0.52	0.73	0.25	0.23
Other Asia, nes	-0.77	-0.37	-0.97	-0.38	-0.21	0.32	-0.65	-0.22
Turkey	0.98	0.87	1.00	1.00	1.00	0.94	0.99	0.92
Brazil	0.60	0.83	-0.79	0.43	0.95	0.91	0.59	0.83
Thailand	-0.29	0.44	0.52	0.99	0.08	0.06	-0.21	0.40
Singapore	-0.27	-0.11	0.40	0.58	-0.35	0.35	-0.29	0.01
Malaysia	-0.20	0.25	0.79	0.91	0.03	0.26	-0.13	0.28

Source: Intesa Sanpaolo on UNCTAD Comtrade

2.3.4 Trade balance in environmental goods and total Chinese trade

When considered in relation to overall Chinese foreign trade, environmental goods show some peculiarities (Table 2.15). First of all, China's weight, both in terms of imports and exports, emerges as being slightly higher than the total Chinese share of world trade. The largest difference is recorded on the import side, signalling the importance of the purchases of foreign technologies in this category of products.

As regards the distribution of trade flows across countries, the most evident aspect is the predominant weight of the industrialised countries, such as the US, Japan and Germany, on the import side. As regards target markets, on the other hand, China's trade penetration in various segments of environmental goods is much more in line with the overall figure. The geographical diversification process which embraces markets that are alternative to the advanced countries is proceeding along similar lines, with countries such India, Brazil, Russia, or the United Arab Emirates, all stepping up their position between the early 2000s and 2008.

The geographical concentration of exports (as measured by the Herfindhal Index[82]), illustrated in Figure 2.4, shows that the diversification of environmental goods export flows is very similar to that of the total aggregate, and with a comparable trend. The same analysis carried out on imports, on the other side, confirms a much higher concentration of supplier countries in the environmental goods segment, with a weaker impulse towards increasing the diversification of procurement sources.

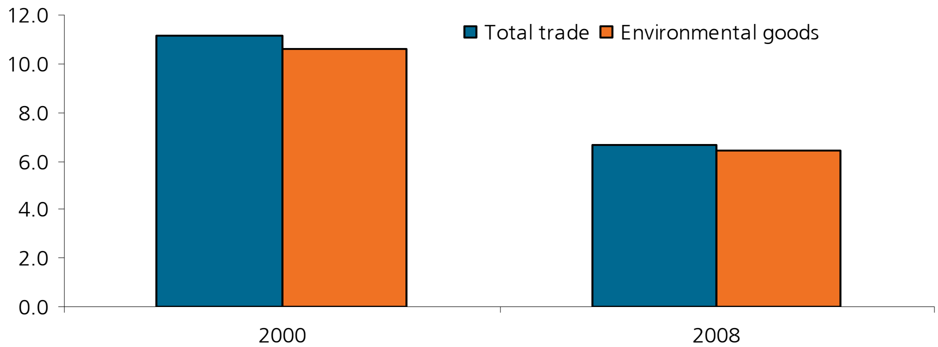
[82] The Herfindhal concentration index is the sum of the squared shares of single countries.

Table 2.15 – Chinese trade: world market share and origin/destination by country (current USD, %)

	Total trade				Environmental goods			
	Export		Import		Export		Import	
	2000	2008	2000	2008	2000	2008	2000	2008
Chinese market share*	6.0	10.3	3.3	6.2	3,8	10,7	4,3	7,6
Chinese trade by country (%)								
USA	20.9	17.7	9.9	7.2	26,1	20,8	17,7	14,1
China, Hong Kong SAR	17.9	13.3	4.2	1.1	12,1	8,9	2,8	0,0
Japan	16.7	8.1	18.4	13.3	13,8	8,4	26,0	20,3
Rep. of Korea	4.5	5.2	10.3	9.9	2,3	3,9	6,1	6,8
Germany	3.7	4.1	4.6	4.9	5,6	4,1	10,3	17,7
Netherlands	2.7	3.2	0.5	0.5	3,2	2,3	0,9	1,5
United Kingdom	2.5	2.5	1.6	0.8	4,5	2,8	4,2	2,0
Russian Federation	0.9	2.3	2.6	2.1	0,5	2,3	0,3	0,0
Singapore	2.3	2.3	2.2	1.8	1,5	1,3	2,5	1,8
India	0.6	2.2	0.6	1.8	0,4	3,9	0,1	0,7
Italy	1.5	1.9	1.4	1.0	2,2	2,1	2,5	3,8
Other Asia, nes	2.0	1.8	11.3	9.1	2,2	1,9	9,4	3,2
United Arab Emirates	0.8	1.7	0.2	0.4	0,8	1,5	0,0	0,0
France	1.5	1.6	1.8	1.4	2,4	1,7	3,2	2,6
Australia	1.4	1.6	2.2	3.3	2,0	1,7	0,5	0,0
Canada	1.3	1.5	1.7	1.1	1,3	1,8	0,7	1,4
Malaysia	1.0	1.5	2.4	2.8	0,7	1,3	0,8	1,0
Spain	0.9	1.5	0.3	0.5	1,3	1,1	0,5	0,0
Brazil	0.5	1.3	0.7	2.6	0,6	1,4	0,1	0,0

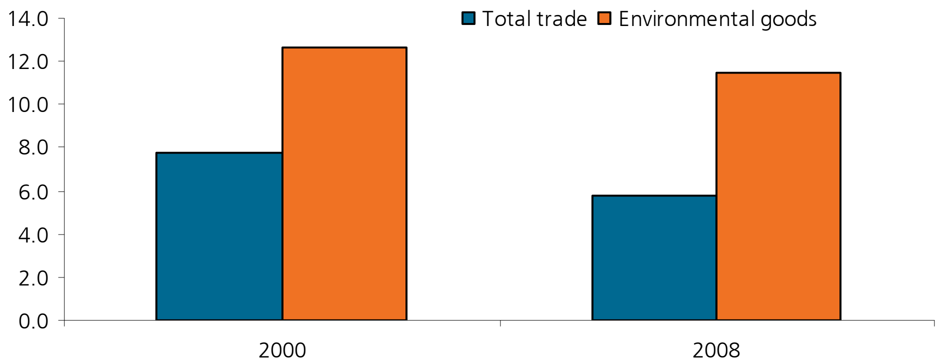
* Total market shares are calculated on IMF DOTS data; total trade distribution by country is calculated on Comtrade data. Countries are ranked according to total trade export in 2008.
Source: Intesa Sanpaolo on UNCTAD Comtrade and IMF

Figure 2.4 – Concentration of Chinese exports (Herfindhal Index)



Source: Intesa Sanpaolo on UNCTAD Comtrade

Figure 2.5 – Concentration of Chinese imports (Herfindhal Index)



Source: Intesa Sanpaolo on UNCTAD Comtrade

2.4 Patents in environment-related technologies

China's increasing role in the international trade of environmental goods is explained by several factors, tied both to production delocalisation strategies pursued by sector multinationals, and to economic policy decisions taken by the Chinese government which, as mentioned, have strongly influenced domestic demand in the country as well as the production setup. The latter, in addition to welcoming foreign players interested in exploiting low production factor costs and the high potential offered by the Chinese economy, has experienced a proliferation of local enterprises, prompted both by incentives and by technological advancements.

A number of issues will be tackled in this section. In addition to outlining China's position in environment-related technologies, the progress made over the past decade will be analysed, with particular focus on how and to what extent China's success on world markets is also explained by increasing technological specialisation, and not only by an internationalisation of production promoted by major industry multinationals.

2.4.1 Definition of environment patents and Database description

In this section China's position in environment-related technologies is measured through patents. Patents are one of the most important innovation indicators to assess the technological competitiveness of innovation systems, as they are a means of protecting inventions and one output of R&D processes (Freeman 1982; OECD, 2009b). Patents provide information on the technological content of the invention and the geographical location of the inventive process (owners and inventors). Moreover, patent data are available at relatively low cost for most countries across the world, often in long time series. Patent indicators have drawbacks as well. Not all inventions are patented. In addition, few patents have high economic value whereas many are never used. Therefore simple counts, which give the same weight to all patents regardless of their value, may be misleading. Not to mention, the different standards across patent offices and over time which affect patent numbers (OECD, 2009b).

All the elaborations presented in this section are based on the technological classifications used by the OECD, as outlined in its "Environmental Policy and Technological Innovation" project. More in detail, by using the approximately 70,000 subdivisions of the International Patent Classification (IPC), the OECD has identified three classes of green patents within its Patent Database:

- renewable energy generation patents, which include wind, solar, geothermal, ocean, hydro, biomass and waste-to-energy power-generation technologies;
- waste management and pollution control patents, i.e. air and water pollution abatement, and solid waste management;
- energy efficiency technologies in buildings and lighting.

Investments in these three types of clean technology may help achieve a wide range of environmental objectives, from controlling air and water pollution to enhancing resource efficiency and substituting fossil fuels with renewable energy sources, which, in turn, would result in reduced atmospheric emissions.

In this paper, data relate to patent applications filed under the Patent Cooperation Treaty (PCT), in the international phase, designating the European Patent Office (EPO). Patent counts are based on the priority date and the inventor's country of residence. The PCT, signed in 1970 and which came into force in 1978, is an international treaty administered by the World Intellectual Property Organization (WIPO), and offers patent applicants a means for obtaining patent protection internationally. The number of PCT contracting states grew from 18 to 142 in 2009.

The PCT provides the possibility to seek patent protection in a high number of countries by filing a single international application with a single patent office, and then entering the national stage in the chosen countries at a later date. Although a significant part of the patent application procedure is undertaken in the international phase, a patent can only be granted by each designated State during the subsequent national phase.

Given the international dimension, the number of PCT applications may be used as a proxy of countries' inventive activities. In fact, since 2004 each application filed through the PCT designates all signatory states (142) of the PCT. Thus, a PCT filing can be seen as a "worldwide patent application" and is less biased than national applications (USPTO, EPO and JPO) where domestic applicants tend to file more patents in their home country (or region) than non-resident applicants. Moreover, the PCT is increasingly used by applicants from all member countries and reflects the technological activities of emerging countries quite well (Brazil, Russia, China, India, etc.; OECD 2009b). Because of this long transition period, meaningful country comparisons are not possible until about 2000.

PCT information has also drawbacks. PCT applications are not patent applications, but options for future applications to patent offices around the world: a fair share of PCT applications never reaches the national/regional phase (OECD, 2005, 2009b).

2.4.2 Ranking of countries in clean technologies

Over the past decade, a sharp increase in the number of patents tied to environment-related technologies has been recorded. Between 1999 and 2007, the number of PCT applications in these technologies increased yearly by 10%, growing faster than overall patents (+7.4%). The highest growth rate was achieved by renewable energy technology (+22.5%) and energy efficiency patents (+12.7%), followed by air pollution control and waste management technologies (+5.7%).

The United States and Japan are the most active countries, accounting for 22.4% and 20.8% shares of all environmental patents (Table 2.16), followed by Germany (13%). These countries boast a strong presence in all three technological areas. The United States hold leadership in both water management and pollution control technologies, and in renewable energy patents, while Japan leads the energy efficiency technology ranking.

The other economies lag behind, with individual shares of less than 5%. Among European countries, Denmark is highly specialised in the development of wind energy technologies, Spain in solar technologies, and the Netherlands in energy efficiency patents. China ranks sixth, with an overall share of 3.4%, not far off the United Kingdom (3.9%) and France (4.3%), and ahead of the Republic of Korea, the Netherlands, and Italy. More in detail, China is heavily involved in renewable energy (with a share of 5%), but it is also active in energy efficiency (3.2%), and waste management and water pollution control (2.8%). China, alongside the Republic of Korea, is without a doubt the leading emerging country in environment-related technologies, outdistancing the Russian Federation, which ranks 19th with a share of close to 1%.

Table 2.16 – Main world countries in environment-related technologies, 2006-'07 (% share)	Waste management and pollution control	Renewable energy	Energy efficiency	Total environmental goods
USA	24.6	22.9	14.4	22.4
Japan	22.0	9.7	32.9	20.8
Germany	12.7	12.1	15.3	13.0
France	5.3	3.5	2.5	4.3
United Kingdom	4.0	4.4	2.7	3.9
China	2.8	5.0	3.2	3.4
Rep. of Korea	3.0	4.3	3.5	3.4
Netherlands	1.6	1.8	10.4	3.2
Italy	2.4	4.2	1.3	2.7
Canada	2.9	2.6	3.6	2.9
Australia	2.7	2.5	1.2	2.4
Denmark	1.0	5.3	1.0	2.1
Spain	1.0	5.5	0.8	2.1
Sweden	1.9	1.5	0.8	1.6
Switzerland	1.3	1.1	1.0	1.2
Austria	0.9	1.0	1.3	1.0
Norway	0.8	1.5	0.3	0.9
Belgium	1.1	0.4	0.7	0.9
Russian Federation	1.0	1.3	0.3	0.9
Israel	0.8	1.6	0.2	0.9

Source: Intesa Sanpaolo on OECD Patent Database

2.4.3 Some preliminary evidence of internationalisation processes in environmental goods

The strong similarity between the definition of the three types of environmental goods used in analysing global trade flows, and the one identified for clean technologies, allows a comparison to be drawn, albeit approximate, between foreign trade market shares and shares of the technology market. This simple exercise makes it possible to assess, albeit in rough terms, the competitive positioning and degree of production internationalisation of the world economies' environmental goods industries.

In economies where technology outweighs trade, production delocalisation and/or externalisation to other economies is very frequent, or production potential is not fully utilized. A specialisation in advanced environment-related productions may also be present. This is the case, for instance, of both the United States and Japan, which especially in the field of waste management control and energy efficiency products, show a wide differential in terms of technological potential (Table 2.17).

By contrast, economies whose trade is greater than their technological weight, are often used as production centres by foreign multinationals (passive internationalisation), or are more specialised in basic environment-related productions. This is the case of China, for instance, which shows a wide differential in terms of global foreign trade shares, with the exception of the renewable energy goods segment. Therefore, it is very likely that an important portion of Chinese industry, specialised in waste management and pollution control goods, and in energy efficiency goods, is activated by foreign multinationals or, alternatively, is positioned on relatively limited technological levels.

Table 2.17 – Difference between environment-related technologies share and trade market share in environment goods: first ten countries in terms of PCT clean patents

	Waste management and pollution control	Renewable energy	Energy efficiency	Total environmental goods
USA	12.9	2.8	7.1	10.6
Japan	12.3	2.7	27.1	11.9
Germany	-4.1	0.9	1.5	-2.9
France	1.3	-2.1	-2.4	0.0
United Kingdom	0.2	-1.5	-1.1	-0.1
China	-6.6	-2.1	-16.6	-7.3
Rep. of Korea	0.9	2.9	1.8	1.4
Netherlands	-1.8	0.1	8.4	0.2
Italy	-2.7	-3.2	-3.7	-2.6
Canada	0.7	0.9	2.2	0.9

Source: Intesa Sanpaolo on OECD Patent Database and UNCTAD Comtrade data

Among the countries which together with China show a differential skewed to the advantage of foreign trade shares, Italy stands, presumably thanks to its ability to make the most of a relatively limited technological potential or, at least to date, to a smaller recourse to production delocalisation and/or externalisation.

2.4.4 Not only delocalisation in China: the increasing role of clean patents

Up to this point, our analysis has mostly highlighted the Chinese economy's great capacity to attract foreign investments in production activities tied to environmental goods. However, China's progressively greater presence on foreign markets cannot be explained solely by the presence of foreign investors. In fact, the local production setup in China has progressively grown, fuelled at least in part by increasing investments aimed at strengthening the country's technology base in environment-related fields. This is confirmed by the trend of China's share of the environment-related technologies market, which between first half of the 2000s (2003-2004) and the second half of the 2000s (2006-2007) expanded significantly (Table 2.18)[83]. China is in fact the economy that has most improved its overall standing in the three types of environmental technologies. Particularly strong progress was made in renewable energy technologies, where China's technology share in few years increased from 2.1% in 2003-2004 to 5% in 2006-2007, with a differential of +2.9%, wider than the values recorded for the Republic of Korea (+2.4%), and Italy (+1.9%) and in line with Spain. Only the USA did better.

China has also made significant progress in the other two segments of environmental technology, where Chinese economy showed the greatest improvement. It experienced a growth of 1.3% in absolute terms in its share in waste management and pollution control patents, and an increase of 1% in energy efficiency control patents.

Once again, the results achieved are remarkable and stronger by far than those observed in other emerging economies. Therefore, in step with the expansion of its production structure, China is clearly strengthening its local technology base, which in perspective may also be functional to upgrading Chinese's specialisation in environmental technologies.

[83] Till the end of 1990s the number of PCT patents may underestimate the real technological potential of some countries, such as Japan, due to the delay by which they began using the PCT procedure. However, since the early 2000s, most countries are well represented, including Japan and Republic of Korea (OECD, 2009). This is why the evolution shown in this paragraph relates to PCT patents applications after 2002.

Table 2.18 – Evolution of environment-related technologies shares between 2003-2004 and 2006-2007 (absolute difference between shares in the two periods)

	Waste management and pollution control	Renewable energy	Energy efficiency	Total environmental goods
USA	-1.3	5.9	-4.1	-0.6
Japan	1.2	-3.2	-8.3	-3.4
Germany	0.6	-5.0	3.0	0.2
France	0.0	0.1	1.1	0.2
United Kingdom	-0.8	-2.0	-0.4	-0.8
China	1.3	2.9	1.0	1.7
Rep. of Korea	-1.1	2.4	-0.9	-0.4
Netherlands	-0.1	-0.2	3.7	0.4
Italy	0.2	1.9	0.5	0.8
Canada	0.3	-0.8	0.9	0.2
Australia	-0.6	-3.0	-0.1	-0.8
Denmark	-0.3	-0.6	0.5	0.3
Spain	0.1	3.1	0.6	1.2
Sweden	-0.5	0.2	0.2	-0.2
Switzerland	0.5	-0.4	0.2	0.3
Austria	0.0	0.0	0.4	0.1
Norway	0.2	-1.0	0.1	0.1
Belgium	0.3	-0.4	0.4	0.2
Russian Federation	0.0	-0.1	-0.1	0.0
Israel	0.1	0.1	0.2	0.2

Source: Intesa Sanpaolo on OECD Patent Database

2.5 Does clean technology base influence trade market share in environmental goods?

The impact of Chinese clean technology base on its trade market share in environmental goods can also be observed through a simple econometric exercise. The following equation has been estimated for a panel data of 38 countries[84] (for each country three observations are considered relating to the three type of environmental goods) and 2 years (2000 and 2008):

$$Trade\,share_{i,2008} - Trade\,share_{i,2000} = \alpha\left(tech\_share_{i,2006/07} - tech\_share_{i,2003/04}\right) + \delta\,labor\,\mathrm{costs}_{i,2000} + \eta_i$$

The exercise has been conducted on the countries for which data on trade (Trade $share_i$) and technology shares (Tech $share_i$)[85, 86] on environment goods and labour costs per hour (USD; labour $costs_i$) are simultaneously available.

In this first difference equation independent variables are not correlated with the error term and the effects of time invariant variables (i.e. labour costs) are assumed not constant. With this specification it is possible to take into consideration countries' specific time-invariant terms

[84] Germany, USA, China, Japan, Italy, France, United Kingdom, Netherlands, Mexico, Switzerland, Hong Kong, Belgium, Rep. of Korea, Singapore, Austria, Denmark, Sweden, Spain, Czech Rep., Malaysia, Poland, Finland, Hungary, Thailand, Brazil, India, Russian Federation, Indonesia, Australia, Romania, Portugal, Slovenia, Philippines, Lithuania, Greece, New Zealand, Egypt, Iceland.

[85] To reduce the great variability of data on patents, technology shares are calculated as average of two years.

[86] In this equation technology shares at time t_{-1} are based on data for 2003/04 (and not for 2000 like data for trade shares) since till early 2000s some countries, such as Japan and Republic of Korea, are not well represented through PCT patents. Nevertheless, this specification should allow to take into consideration the influence of the change in technology base between 2003/04 and 2006/07 on the evolution of trade share between 2000 and 2008.

capturing the effects of "unobservable" characteristics which do not change over time (bureaucracy, corruption, legality,...).

The results of the estimate are shown in Table 2.19. The coefficient of Labour costs in 2000 is significantly negative: the lower the labour cost, the higher the gain in export share. This indirectly may also be a consequence of the processes of delocalization in low cost country by multinationals. At the same time, change in export share is positively influenced by the increase of the clean technology base.

Table 2.19 – Dependent Variable: difference between Trade share in 2008 and Trade share in 2000

	Estimate	t	P
Intercept	0.60	2.15	0.034
Labor $costs_{2000}$	-0.06	-2.85	0.005
Tech. $Share_{2006/07}$ - Tech. $Share_{2003/04}$	0.37	2.94	0.004
R-Square = 0.1485	F = 9.68		
Adj R-Sq = 0.1331	Pr > F = 0.0001		

These results, if read through a Chinese perspective, seem to indicate that the low cost of labour of this economy has played a positive role in explaining the increase of Chinese market share. As a matter of fact, local firms may have had a competitive advantages, not to mention the attractiveness of China as a production base for multinational firms intentioned to realize basic environment-related productions in this economy. At the same time, the impressive improvements of Chinese technology base has also positively affected the increasing presence of Chinese environment goods on international markets.

3. Conclusions

In a context of relatively low environmental investments and in the absence of a strongly enforced, although evolved, regulatory framework, China has developed specific technological abilities and a leadership in environmental goods in the international market. China during the last decade has rapidly become an exporting leader for these types of goods. These results are partially due to the choice of Western multinationals specialised to locate their production in China in order to benefit from low production costs. However part of the Chinese success in environmental goods is also explained by the increasing skills accumulated over time in this field. These skills, in turn, may have been positively affected by the environmental legislation and policy in China.

This evidence seems to confirm that the environmental institutional and regulatory framework may have a positive effect on the development of technological abilities, by enhancing standards and creating potentially interesting markets for innovative environmental products (Johnstone, Hascic, Popp, 2008). Technology advance, in turn, has proved to be a component of international competitiveness, positively related with market share gains on world markets.

China is, already today, a huge source of demand for goods tied to environmental protection and energy saving. Going forward, its impetuous economic growth will imply the need to take on these issues with greater determination. While Chinese current investments in environmental protection are in line with those undertaken in the mid-1990s by previously centrally planned economies such as Eastern European states, China's very high economic growth rates would require them to be significantly increased. On the energy front, these investments add themselves to those in renewable energy sources, which in addition to contributing to the diversification of sources also have positive effects in the reduction of greenhouse gases, as well as of other gas pollutants. Therefore, China will likely become one of the largest markets for environmental protection and energy saving goods, becoming more and more an "environmental goods haven". While the Chinese manufacturing base seems ready to grasp this opportunity, its technological skills, though progressively advancing, are still lagging behind US, Japan and Germany. Therefore China will need further investments in order to better follow scientific and technical progress in this field.

Appendix I

Main energy and energy efficiency related national policies			
Type of Policies	Policies	Date Effective	Responsible agency
Laws and Regulations	Revision of the Energy Conservation Law	Oct. 2007	National People's Congress and NDRC
	Revision of the Renewable Energy Law	Jan. 2010	National People's Congress and NDRC
	Government Procurement Law and proposed new Implementation Measures (Domestic Content Requirement definition)	Jan. 2003 Jan. 2010	NDRC
Comprehensive policies	Medium And Long-Term Plan For Energy Conservation	2005	NDRC
	11th Five-Year Plan	Mar. 2006	NDRC
	The State Council Decision on Strengthening Energy Conservation	Aug. 2006	State Council
	Implementation Measures of 10 Key Projects in 11th FYP	Oct. 2006	NDRC
	Medium And Long-Term Development Plan For Renewable Energy	2007	NDRC
	National Climate Change Program	Jul. 2007	State Council
	Opinions of the State Council on the Utilization of Foreign Investments	Apr. 2010	State Council
Fiscal Policies	Reduced Export Tax Rebates For Many Low-Value-Added But High Energy-Consuming Products	Sep. 2006	NDRC and MOF
	Interim Management Measures for Incentives to Energy Consuming Technology Reforms and Phase out program	2007 Dec. 2010	MOF
	Regulations on Implementation of Corporate Income Law a. Tax Reduction and Exemption for Energy Conservation Projects (such as income tax for wind project reduced from 33% to 15%, 2003) b. Tax Credit for Capital Expenditure on Energy Conservation Equipment (such as VAT reductions from 17% to 8.5% for wind generation equipment, 2001) c. Renewable energy projects exemption from local income tax	Some in force since 2001 then modified or extended Jan. 2008	State Administration of Taxation
Sector Policies			
Industry	Top-1000 Energy-Consuming Enterprise Program	Apr. 2006	NDRC
	Large Substituting for Small Program (for coal-fired plants)	2006	NDRC
	Energy Conservation Power Generation Dispatch Program (or Scheduling Rule Program)	2008	State Council/NDRC
Buildings	National Energy Efficient Design Standard For Public Buildings	2005	MHURD
	Interim administrative method for incentive funds for heating metering and EERERB (Energy efficiency retrofit for existing residential buildings) in China’s northern heating area	2007	MOF
Appliances	Appliance Standards and Labelling	Various years	AQSIQ
	Government Procurement Program: Energy Efficient Products for Government Procurement - Publication of Official Listing	2005 2007	NDRC and MOF
Transportation	Fuel Consumption Limits For Passenger Cars	2004	AQSIQ
	National Phase III Vehicle Emission Standards	Jul. 2007	MEP

Source: Levine, Mark D., Price, L. and Zhou, N. (2010), IEA database and authors

Appendix II

Acronyms	
AQSIQ	General Administration of Quality Supervision, Inspection and Quarantine
EPP	Environmentally Preferable Products
CAEP	Chinese Academy for Environmental Planning
CIS	Commonwealth of Independent States
CSES	Chinese Society for Environmental Sciences
IEA	International Energy Agency
MEP	Ministry of Environmental Protection
LCA	Life Cycle Analysis
MNE	Multinational enterprises
MOHURD	Ministry of Housing Urban-Rural Development
NBS	National Bureau of Statistics
NDRC	National Development and Reform Commission
PCT	Patent Cooperation Treaty
OECD	Organization for Economic Development
RSCA	Revealed Symmetric Comparative Advantage
SETC	State Economic and Trade Commission
UN	United Nations
WEO	World Energy Outlook

Units of measurement			
Units		Definitions	
Btu		British Thermal Unit	
toe		Tons of oil equivalent	
Mtoe		Million toe	
tce		Tons of coal equivalent	
Mtce		Million tce	
gce/kWh		Grams of coal equivalent kilowatt hour	
kWh		Kilowatt/hour	
goe/t		Grams of oil equivalent per tons	
tce/million t-km		tec per million tons kilometer	
GW		Gigawatt	
t/d		Tons per day	
Conversion factors			
1Mtoe=	1,4286 Mtce	39.683.201,650Btu	11.630GWh

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