

Review of Low Carbon Development in China: 2010 Report

Executive Summary

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Executive Summary

In 2006, China began its 11th Five-Year Plan with the explicit goal of reducing the energy intensity of the Chinese economy by 20%. The goal was set, in part, to address the disturbing reversal in 2002-2005 of the long-term decline in energy intensity, but it also addressed other trends, which increased the energy efficiency imperative: the acceleration of GDP growth and the accompanying expansion of energy-intensive heavy industry; rapidly increasing energy and commodity prices; rapid expansion of the coal industry, leading to infrastructure strains; and China's emergence as the world's largest greenhouse gas emitter.

Chapter 22 of the 11th FYP set the following strategies to meet the 20% energy intensity reduction goal:

“The government shall strengthen policies that induce energy conservation and energy efficiency increase. Energy conservation can be achieved through structural changes (optimizing industrial structure and reducing the share of energy-intensive industries), technology improvement (developing and disseminating energy conservation technologies) and better management practices (institutional development and more effective regulation of energy production, transmission and consumption). Industries with priority for energy conservation are iron and steel, non-ferrous metal, coal, electricity, chemistry, building material and other energy-intensive industries. The implementation of vehicle fuel economy policies shall be enhanced and the inefficient old vehicles shall be phased out. Standards for alternative liquid fuels shall be developed to support the alternative fuel industry. The production and consumption of highly energy efficient products shall be encouraged.”

Under these extraordinary circumstances and with this target in mind, China initiated a series of policies aimed at reducing the energy intensity of the Chinese economy. As China begins the 12th Five-Year Plan with all of these trends still in play, it is an opportune time to examine the results of the 11th FYP to understand

1. How China performed against its energy intensity targets and how the results break down by sector;
2. What measures and policies China undertook in order to meet these targets;
3. How well these policies performed and why some policies worked better than others; and
4. What lessons could be learned from China's experience and where more investigation into policy effectiveness is warranted.

This study explores these questions, first reviewing China's performance against targets and then describing key policies and institutions that were designed and implemented to achieve the targets. While further work is required on the direct and quantitative connection between policies and their performance, we can offer some initial insights and questions to consider as China works to meet future goals in the 12th FYP and through 2020.

This study finds that, based on data from the National Development and Reform Commission and from our field survey of local governments and enterprises, energy intensity reduction is in line with the 20% targets. Without closer study of policies and other factors affecting energy intensity, we do not yet attribute all reduction in energy intensity directly to policies, though we do observe a significant level of regulatory and policy activity in support of targets and surmise that at least some of these policies have had an impact on energy intensity. We also make some early observations about the impact and cost of policies as well as remaining opportunities for the plant closure policy, which may have implications for meeting goals set out in the 12th Year Plan:

- **Impact of policies:** Through 2009, China was on track to meet its energy intensity targets. These targets called for a reversal of the trend of increasing energy intensity experienced between 2002 and 2005. China's carbon emissions intensity fell largely as a result of reduced energy intensity, demonstrating the important role of energy efficiency in the transition to a low-carbon economy. With additional carbon-specific policies, China could expect carbon intensity to fall faster than energy intensity in the future.
- **Cost of policies:** Many of the policies implemented to meet the 11th FYP target are top-down administrative measures. These required significant financial and human resources and may not be the most cost-effective way to achieve future targets.
- **Remaining opportunities:** Much of the low-hanging fruit for reducing energy intensity, such as replacing old power plants with new, more energy-efficient plants, has already been picked. Further reductions in energy intensity during the 12th FYP period could impose higher costs on the economy.

Moving forward, key opportunities for China remain in continuing to shift power generation to renewable sources and in reducing the carbon intensity of high energy consuming industries. Doing so in a more cost-effective way may require the development of policy mechanisms that have to date been less used in China, such as effective market systems, regional and local initiatives for low-carbon growth, and implementing macroeconomic measures for further sector rebalancing.

China's performance against its energy intensity targets

Data for the entire 11th Five-Year Plan is not yet available; however, according to the data released in July, 2010 by the National Development and Reform Commission, by the end of 2009 the energy intensity of China had decreased by 15.6% compared to 2005, achieving 78% of the 20% target through the first four years of the plan. On a year-to-year basis, the reduction was 2.74% in 2006, 5.04% in 2007, 5.2% in 2008 and 3.61% in 2009. By 2008 the energy intensity had dropped to the 2002 level. In short, the rapidly increasing energy intensity that was evident during the last few years of the 10th Five-Year Plan period has been curbed.

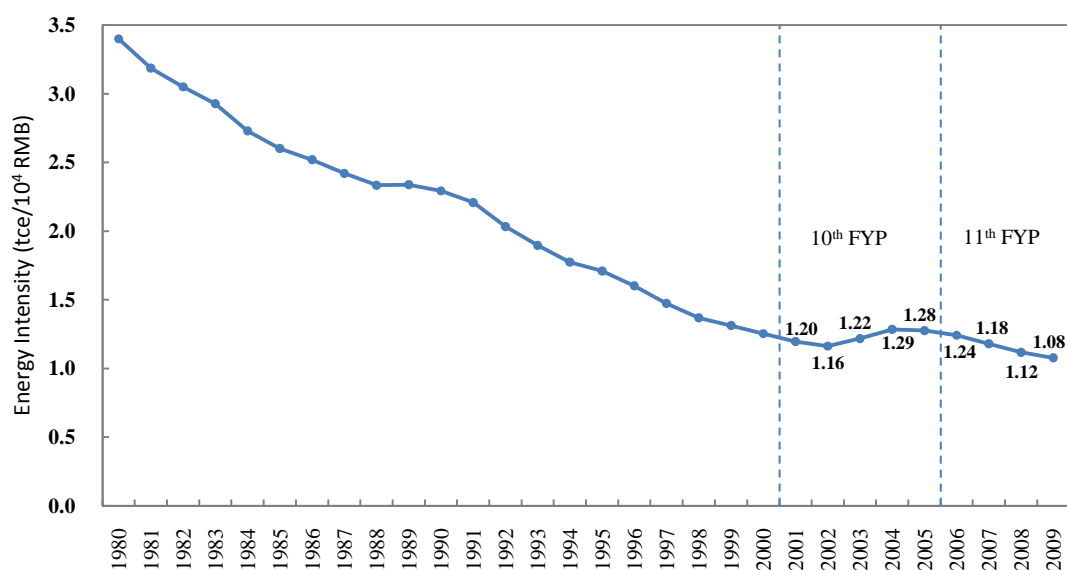


Figure 1. China's Energy Intensity (1980-2009)

During the 11th FYP period, China's drive to lower energy intensity affected most sectors of the economy, including the power, industry, building, transport, and agriculture and forestry sectors. Of these, the power, industry, and buildings sectors are the most important from an energy consumption, GHG emission, and potential carbon savings standpoint, though agriculture and forestry is also important from a GHG emissions perspective.

For many of the sectors, the energy intensity reduction story is similar, with higher than expected growth providing both challenges and opportunities.

In the **Power sector**, electricity production grew 39% between 2005 and 2008, driven by economic growth and industrialization. This growth was partly offset by a 5% improvement in the average efficiency of China's coal fired generation capacity and by improvements in the transmission system. The growth in Chinese electricity demand has also helped to improve generation efficiency, as the share of larger and more efficient capacity increased from 47% in 2005 to 69% in 2009. Additionally, China closed a large number of older, smaller, less efficient plants; by 2009, China had already surpassed its Five-Year Plan target of 50GW of plant closures. New low carbon generation also added to the effect of higher thermal plant efficiency; by 2009 China had added 90GW of additional hydro power, almost 25GW of wind, and 2GW of nuclear. From a CO₂ perspective, the carbon intensity of electricity production decreased about 6.5% between 2005 and 2008.

In the **Industrial sector**, three factors stand out as drivers of energy intensity: the structure of Chinese industry, the movement toward higher value added products, and improvements in the efficiency of production itself. The structure of Chinese industry continued to evolve under the 11th Five-Year Plan, with heavy industry continuing to grow as under 10th FYP, but at a slower rate relative to other sectors, resulting in the share of energy-intensive industries decreasing in later years of the 11th Five-Year Plan. As part of this shift, a move towards higher value added products helped improve energy intensity. Through 2008, energy consumption by the industrial sector per unit value added had decreased by 13.3% and carbon intensity by 14.8%. Lastly,

many of the large industries improved efficiencies significantly, with energy per ton of production falling from 2005-2009 by close to 5% in the steel industry, 17% in the cement industry, and almost 35% in copper smelting. This improvement was driven by process and technology improvement as well as the construction of new facilities and the closure of older, less efficient ones. The decrease in CO₂ intensity was largely in line with the improvement in energy intensity.

The Building sector accounted for over 18% of China's energy use by 2008 and was growing rapidly, with energy use increasing by 28% from 2005. Construction of new buildings was a major driver of this increase, although energy intensity—that is energy use per square meter—contributed equally, increasing by 16% between 2005 and 2008. Both new construction and the increasing energy intensity of the building stock can be attributed to China's rapid urbanization and rising standard of living. Energy intensity and carbon intensity, as measured by CO₂ per square meter, continued to lag significantly behind the world average, so increasing standards of living, including greater appliance usage and space conditioning, further explain increasing energy and carbon intensity. This trend towards higher energy intensity in the building sector began in 2003, though some slowing of this increasing trend was noted in 2008. One particular area of focus for efficiency has been district heating in Northern China where energy consumed per square meter has continued its notable decline.

Energy consumption in **the Transport sector** grew 25% between 2005 and 2008, with two notable trends. First, the proportion of more energy intensive transport modes such as road and air transport rose. Second, the efficiency of most modes of transport, as measured by energy per tonne-kilometer of freight, was either stable or improved slightly.

The Agriculture and Forestry sectors are relatively small consumers of energy, but their impact on CO₂ emissions is significant. Agriculture is the only sector in which direct energy-related emissions declined during the 11th FYP period. While non-CO₂ greenhouse gas emissions were stable, CO₂ emissions embedded in fertilizer production grew, leading to a small net increase in overall agriculture-related greenhouse gas emissions. China's forestry development, especially the large scale of afforestation measures, contributed significantly to the building of carbon sinks, adding 420MtCO₂ per year on average to the current stock, an amount nearly four times the CO₂ emission from direct fossil fuel combustion in agriculture and forestry.

Measures and Policies Undertaken by China

Policies

During the 11th FYP period, China developed many laws, regulations, norms, and policies, which constitute a legal and policy framework for its low carbon development. Key policies in the power sector include the "Renewable Energy Law" that came into effect in 2006 and the "Energy Conservation Law" of 2007. The "Renewable Energy Law" was designed to encourage the development of wind and PV generation. In December 2009, the standing committee of the National People's Commission revised the "Renewable Energy Law" to increase national

support for grid connection for wind and PV plants. The revised “Energy Conservation Law” identified energy conservation as the country’s “fundamental state policy” for the first time in China’s history.

The “Renewable Energy Law” and “Energy Conservation Law” are central government-driven policies that mandate the phase out of backward technologies and capacity and their replacement with more energy-efficient ones, regulate market access for enterprises in energy-intensive industries, and provide incentives such as tax breaks, financial support, and economic instruments, such as tiered pricing for electricity. The central government also endeavored to develop local government capacity and to support the growth of the energy efficiency market by providing incentives and assistance for energy service companies.

These policies have two prominent characteristics. First, central government power was fully deployed: it engaged in permitting control as well as the performance evaluation of regional and local government and state-controlled enterprises. Second, the government made significant investments through financial transfers and subsidies, incentives, interest discounts, and favorable loans. The central government motivated local government and state-owned enterprises to expand their inputs, improve their management practices, optimize their structures, and innovate their policies, while the economic incentives enabled enterprises to better implement the energy conservation policies. These two policy instruments consumed high levels of both funding and administrative resources.

Several other policies stand out, including the Medium and Long-Term Plan for Energy Conservation, the Ten Key Energy Conservation Projects, and a series of fiscal and sectoral policies. The Ten Key Energy Conservation Projects policy focused on ten specific technologies for implementation, such as combined heat and power, efficient lighting, motor systems, and oil conservation; several of the ten projects also included other technological improvement and innovation elements. The sectoral policies included standards for buildings and appliances, intensive enterprise energy audits, energy improvement programmes covering the 1000 largest energy consuming enterprises (the Top 1000 Energy-Consuming Enterprises Program), and limits and taxes on inefficient vehicles. Again, these policies were primarily central government-driven or fiscal policies that required significant administrative and financial resources.

Institutions

During the 11th FYP period, China established the Energy Conservation Leading Committee, the Climate Change Leading Committee, the National Energy Commission, and the National Climate Change Expert Pool. Local government also established similar organizations.

The central government also developed a system of targets and accountabilities to assess the energy conservation performance of the local governments and major enterprises and to hold the major leaders of the local government accountable for implementing energy conservation policies and achieving the targets. Three schemes for data collection, supervision, and evaluation were developed to support such a system.

There was initial development in the energy conservation market with the support of the

government's legal and policy framework, which covered full-purchase of renewable energy generation by law and an electricity wholesale rate-making process. Enterprises were encouraged to participate in CDM projects, invest in renewable energy projects, and implement energy efficiency upgrading projects via public tendering.

Analysis

There are three crucial questions regarding the 11th Five-Year Plan that could provide lessons for developing and improving policies under the 12th Five-Year Plan and subsequent plans:

1. How much impact did the various policies under the 11th FYP have on energy use and carbon emissions?
2. How much did these policies cost and what resources – material, administrative and financial - did they use?
3. How much opportunity is left for these policies?

Impact. The Chinese government and others have estimated the impact of each of the key programs associated with energy conservation and energy intensity improvement under the 11th FYP.

These estimates are calculated against a baseline, where efficiency or energy intensity is held constant from the beginning of the period. For guiding policy, this analysis is a useful start, but it falls short of what is ultimately needed in a number of ways.

First, the baseline comparison against constant efficiency is somewhat arbitrary. Some programs will be implemented in an environment where the existing inefficiency makes a natural improvement inevitable, while other programs might be approaching areas of the economy that are already relatively efficient. Thus, it is difficult to separate out the “savings” that result from policy versus those that result from the benchmark or pre-existing conditions.

A second issue is that these categories reflect multi-policy programs rather than single policies. The Top-1000 Enterprises Program, for example, includes policies around energy audits, reporting requirements, standards, investments, and incentives. While it may be possible, baseline issues aside, to evaluate the effectiveness of the program as a whole, the overall program package may allow enormously effective, low-cost policy options to mask costly, ineffective ones. To improve policy, the analysis needs to identify which specific policy components, or sets of related policies, were effective.

Where specific policies are directed at specific technologies, we can better analyze impact. For example, with the early closure of inefficient coal plants and their replacement with newer, more efficient coal plants, we can analyze the impact of the policy versus the case where the plants had been left to operate through their normal life. Our initial analysis of carbon and energy savings in this case is consistent with the savings calculated by the Chinese government.

Overall, we find that while energy intensity is indeed in line with targets, carbon intensity is not falling significantly faster than energy intensity, indicating that despite investment in renewable and other low carbon generation sources, China has large potential for progress on greenhouse gas specific actions and policies.

Cost. The cost of these policies – an important element in understanding their performance — also remains to be assessed. The cost of implementing a policy includes the incremental investment cost (over what would have otherwise been invested) and the incremental operating/fuel costs or savings, weighed against the carbon or energy saved. In aggregate, many of these policies may effectively be free or create economic value. For example, our initial analysis suggests that in many cases replacing a very old, inefficient coal plant with an efficient new one would save enough energy costs to pay for itself in a few years. Thus, complete evaluation of policy performance will require verified estimates of savings against specific investment and operating costs of the policy change. Furthermore, many of these policies and the investments made may produce savings lasting many years, all of which must be accounted for in the policy evaluation.

At this point, only investment figures for the aggregate of the 11th FYP are available. Estimates vary, but the NDRC has estimated that as much as 2-3 trillion RMB were invested during the 11th FYP for energy conservation and environmental protection, while McKinsey estimates that at least \$200 billion, or 1.3 trillion RMB at current exchange rates, was invested for energy efficiency and low carbon development. Tying this spending to specific policies and incorporating the overall economic cost remain issues for ongoing analysis.

Aside from such analysis, we observe that many of the instruments implemented in the 11th Year Plan are top-down regulatory measures that require significant administrative and financial resources, which may not be the most cost-effective way to achieve future targets.

Remaining Opportunities. While a policy may have been effective and relatively inexpensive, the remaining question for policy makers is whether the opportunities for the policy have been exhausted. In some cases, the answer may be somewhat straightforward. For example, how many inefficient plants remain open? In other cases it may be much more complex. Was the plant really being used? Are there other reasons the lighting cannot be replaced? Does replacing a boiler require a complete (and expensive) system overhaul?¹

In our initial analysis, we observe that much of the low-hanging fruit for reducing energy intensity has already been picked, for example, replacing old plants with more energy efficient plants. This means that further reduction in energy intensity could mean a higher cost to the economy.

¹ To some extent, this evaluation is beyond the scope of CPI work. However, the evaluation of both the impact and the cost gives insight into this issue of remaining opportunity with a particular policy. The impact evaluation does so if it measures how much of the available savings the policy achieved, the cost because it addresses the fact that costs tend to increase for any policy as the easy opportunities are addressed first.

Further Areas of Study

To arrive at conclusions that can help China improve policy in the 12th FYP and subsequent plans and perhaps help other nations that are implementing or considering policies similar to China's, requires an in-depth look at policy effectiveness. This challenge involves tying specific policies to specific savings, evaluating costs, assessing how much potential remains, and then extracting lessons learned.

CPI's approach is to focus on select policies to isolate some of these effects and learn lessons that can then be spread more broadly. In the near term, CPI will focus on three elements of the Chinese drive towards lower energy intensity:

1. The cost-effectiveness and energy savings from plant closures inside and outside the power sector;
2. The efficacy of China's focus on the top 1000 enterprises under the 11th Five-Year Plan; and
3. The cost effectiveness of China's focus on specific technologies, particularly as embodied in the 10 Key Projects policy.

1. The cost effectiveness and energy savings from plant closures

Given the important role that plant closures played in the 11th Five-Year Plan, further study on the cost of this instrument, as well as of the carbon savings derived from it, will be valuable.

Estimating the impact of early plant closures on costs and carbon savings has two components: 1) an estimate of what would have been the output and cost from the closed plant, and 2) similar estimates for the replacement plant (including capital cost estimations). Estimations should account for the life of the plant.

CPI plans to collect data on the efficiency and usage patterns of the older Chinese coal fired power plants as well as cost and operating information on the potential replacement plant. Once we have this data, we can assess whether this instrument has been cost-effective and how much further savings are available from this instrument.

2. The efficacy of China's focus on the Top-1000 enterprises

The Top 1000 Energy-Consuming Enterprises Program, which targets the largest industrial energy consumers in China, includes a series of measures including energy audits, mandatory goal setting and reporting requirements, training, incentives, and investment mandates. A closer study of this program will help to determine which components should be continued, which should be strengthened, which could be rolled out to the next set of enterprises, and how much a similar set of policies might contribute to China's future efficiency plans.

CPI plans to disaggregate the Top-1000 program into a set of specific policies, activities, and initiatives in order to answer the following questions:

- Which elements of the Top-1000 program have been most successful?

- Which elements cost the most?
- How much of the effect of this policy will be sustainable over the longer term, both with and without additional policy support?
- How much more opportunity might be available from a continuation of this program?
- How much opportunity would be available in extending it to the next 9000 enterprises? Is that practical from a resources perspective?
- Which elements would it make sense to extend given the cost/benefit?

3. The cost effectiveness of China's focus on specific technologies

Another approach to evaluating policy effectiveness is to use technologies rather than policies as the starting point for the analysis. Beyond plant closures, a range of technologies were targets for Chinese energy and carbon efficiency, including coal-fired industrial boilers, district co-generation, motors, lighting, appliances, cement kilns, and no-till farming. CPI will assess the impact of policies for a subset of technologies and specific projects and will use this analysis to draw lessons on policy impact. In particular, the evaluation will look at three issues:

- **Technology lifecycle cost and energy/carbon savings** – Like the plant closure analysis, the cost is a net lifetime cost, which must include capital costs offset by energy and other savings (where applicable). Obviously, for any given technology the costs will vary depending on the application, whether the installation is new or a replacement, and if a replacement, how much life the old unit had remaining.
- **Policy impact** – When a technology is mandated, the policy impact is clear. However, in other cases, the role of the policy may be less straightforward. For example, an energy audit might provide information about lighting options. The objective will be to identify which policy components might have influenced the technology decision and assess the impact of the policy on that decision.
- **Policy cost** - Some policies can, themselves, consume significant planning or management resources. For example, audits will require inspectors as well as resources from the enterprise undergoing the audit. Evaluating these resource requirements as applied to a specific technology decision adds the final piece to the technology review.

The individual evaluations can then be aggregated to provide feedback on policy costs and effectiveness, as well as furthering our understanding of the costs involved in advancing energy efficiency opportunities.

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1. INTRODUCTION

In 2005, China entered into its 11th Five-Year Plan (FYP) with explicit goals for reducing the energy intensity of the Chinese economy by 20% by 2010. This plan was developed and implemented within the context of a rapidly developing and evolving China, in which energy had become one of the most important challenges facing the country and several unusual economic and energy industry trends complicated the picture. The trends under which the 11th Five-Year Plan was developed included:

- **Prolonged, rapid growth in GDP**

From 1978 to 2000, China achieved its strategic goal of quadrupling its GDP. Entering the new century, GDP growth, which had been slowing in the 1990's in part due to the Asian crisis, once again began to accelerate while the share of energy-intensive heavy industry expanded.

- **A reversal in 2003-2005 of the long term trend of declining energy intensity**

Chinese energy intensity (as measured by energy consumption per unit GDP) has historically been higher than most of the developed countries. For 23 consecutive years up to 2003, this gap narrowed as energy intensity declined, but from 2003-2005 energy intensity rebounded, rising by 4.8% in 2003 and by 5.5% in 2004. In 2005 it increased further to the 1999 level.

The reasons for the sudden reversal of this trend are uncertain, but possible explanations include increased exports following China's entry into the World Trade Organization (WTO), accelerated urbanization, and a decreased emphasis on energy efficiency in the 10th Five-Year Plan.

- **Rapidly increasing energy and commodity prices**

Energy and commodity prices began a long upward trend during the 10th Five-Year Plan, and as a large importer of crude oil and industrial commodities, China felt the impact. The price of Brent crude oil, for instance, rose by close to 150% between 2000 and 2005 and rose by an additional 60% under the 11th Five-Year Plan, with much higher peaks and increased volatility. All of this increased the energy efficiency imperative.

- **Rapid expansion of the Chinese coal industry, leading to strains on infrastructure**

Chinese coal production grew steadily under both the 10th and 11th Five-Year Plans, providing the backbone of China's industrial growth. However, the growth in production was not enough to prevent China from becoming a significant importer of coal rather than continuing as a major coal exporter. At the same time, the rapid growth in demand strained Chinese rail infrastructure, requiring major investment and emergency measures to maintain supplies.

- **China's emergence as one of the largest drivers of global energy prices**

The growth of China's economy under the 10th FYP, which continued under the 11th, meant that China became a major force affecting global commodity prices. Increased Chinese demand for crude oil constituted a significant portion of oil demand growth, and China's internal rail constraints were at one time a major factor behind the rise in global seaborne coal prices.

- **China's became the world's largest emitter of greenhouse gases**

At the beginning of the 11th Five-Year Plan, China was not expected to pass the United States to become the world's largest emitter of greenhouse gases during this FYP period. Chinese GDP and energy consumption growth, however, led China to pass the US in 2010.

While many of these trends played out faster than expected under the 11th Five-Year Plan (FYP), all of them were clear and well established when the plan was being developed. These trends led China to set an explicit goal of curbing the increasing trend of energy intensity and reducing it by 20%. Chapter 22 of the 11th FYP thus set the following goals:

“The government shall strengthen policies that induce energy conservation and energy efficiency increase. Energy conservation can be achieved through structural changes (optimizing industrial structure and reducing the share of energy-intensive industries), technology improvement (developing and disseminating energy conservation technologies) and better management practices (institutional development and more effective regulation of energy production, transmission and consumption). Industries with priority for energy conservation are iron and steel, non-ferrous metal, coal, electricity, chemistry, building material and other energy-intensive industries. The implementation of vehicle fuel economy policies shall be enhanced and the inefficient old vehicles shall be phased out. Standards for alternative liquid fuels shall be developed to support the alternative fuel industry. The production and consumption of highly energy efficient products shall be encouraged.”

For the first time, the 11th FYP defined the targets as “mandatory targets” and “guiding targets.” While guiding targets were largely considered as a prediction or goal, all government departments and local government bodies were required to meet mandatory targets with maximum effort and full allocation of resources. The 20% energy intensity reduction target was established as a mandatory target and implemented with the full force of national government support.

Under these extraordinary circumstances and with these targets in mind, China initiated a series of policies aimed at reducing the energy intensity of the Chinese economy. As China begins the 12th Five-Year Plan with all of these trends still in play, it is an opportune time to examine the results of the 11th FYP to understand

1. How China performed against its energy intensity targets and how the results break down by sector;
2. What measures and policies China undertook in order to meet these targets;
3. The evidence available on how well these policies performed; and

4. What lessons could be learned from China's experience and where more investigation into policy effectiveness is warranted.

For those outside China, examination of the effectiveness of China's energy and climate policies is interesting not just because China has become the largest and one of the fastest-growing emitters of greenhouse gasses, but also because of the speed and intensity with which related policies have been enacted. Lessons from the Chinese experience may provide valuable insight not just for China's future targets but for other nations implementing or considering similar policies.

The rest of this paper addresses performance in each sector (power, industry, buildings, transport, and agriculture and forestry), the policies implemented to meet targets in each sector, and initial analysis.

2. THE POWER SECTOR

2.1 Performance

In the Power sector, electricity production grew 39% between 2005 and 2008, driven by economic growth and industrialization. This growth was partly offset by a 5% improvement in the average efficiency of China's coal fired generation capacity and by improvements in the transmission system. The growth in Chinese electricity demand also helped improve generation efficiency, as the share of larger and more efficient capacity increased from 47% in 2005 to 69% in 2009. At the same time, China closed a large number of older, smaller, less efficient plants. By 2009, China had already surpassed its FYP target of 50GW of plant closures. In addition, China added low-carbon generation; by 2009 China had added 90GW of additional hydro power, almost 25GW of wind, and 2GW of nuclear. From a CO₂ perspective, the carbon intensity of electricity production decreased 6.5% between 2005 and 2008, as new low-carbon generation added to the effect of higher thermal plant efficiency.

2.1.1 Carbon emission intensity

China's power industry is a major energy consumer and carbon emitter, and thus a crucial target for emissions reduction and efficiency efforts. Coal is China's primary fuel for thermal power generation – indeed, electricity generated by coal combustion made up 95.2% of the total thermal power generation in 2009, while electricity generated by oil and natural gas accounted for only 0.6% and 0.2% respectively. Power sector energy consumption was 928.3 million tons coal equivalent (Mtce) in 2008, accounting for 32% of total energy consumption in China. Power sector CO₂ emission was 2.5 GtCO₂ in 2008, or roughly 40% of energy-related CO₂ emissions.

Absolute energy consumption in the power sector increased 29% from 2005 to 2008. The efficiency of power generation and transmission improved significantly, however, and CO₂

emissions intensity also fell over that period, establishing a trend towards low-carbon development in the power sector. Coal consumption per kWh supplied in the power sector fell 7%, from 370gce/kWh in 2005 to 345gce/kWh in 2008. As a result of efficiency improvements in thermal power generation, the CO₂ emissions intensity of the power industry also fell: CO₂ emissions intensity of thermal power generation decreased 5.1%, from 935.8gCO₂/kWh in 2005 to 887.8gCO₂/kWh in 2008.

2.1.2 The modernization of thermal conventional power

China made significant gains in thermal power generation efficiency during the 11th FYP period. Shutting down small, low-efficiency generators and replacing them with large, high-efficiency facilities produced most of the gains. Small thermal power plants totaling 26.17GW of generation capacity were shut down in 2009 alone; between 2006 and 2009, 60.06GW of backwards generation capacity was closed, allowing China to reach its 2010 target of shutting down 50GW of inefficient generation capacity more than a year early. The number of large-scale generation facilities increased over the same period -- units larger than 600MW accounted for only 13% of thermal power generation in 2005, but by 2009 such facilities made up 34% of China's thermal power generation. The proportion of generation units smaller than 300MW fell from 53% to less than 31% of China's thermal power generation. The average capacity per thermal power unit was 103.1MW in 2009, up from 60.9MW in 2005. Units larger than 300MW now make up the majority of China's thermal power generation capacity, rising from 47% in 2005 to 69% in 2009 (Figure 2-1).

China is also operating 21 ultra-supercritical generation facilities (million kilowatt units) with an additional 24 units under construction. Globally, China leads in terms of the number of ultra-supercritical units both in operation and under construction.

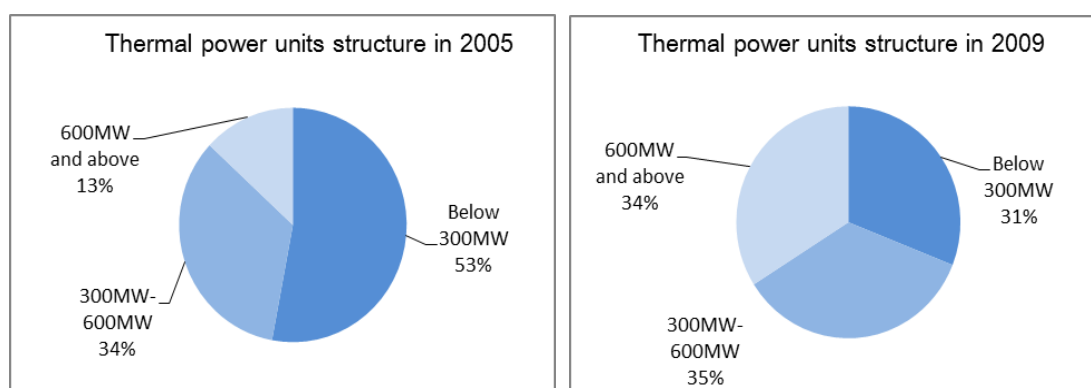


Figure 2-1 Thermal power units structure in 2005 and 2009

(Data source: Xu Huaqing, 2007; State electricity regulatory commission, 2010.)

2.1.3 Renewables and nuclear power

China's nuclear and renewable energy industry has developed rapidly since the adoption of the Renewable Energy Law in 2006, increasingly diversifying the power supply structure. New

installed capacity of hydropower, wind, and other renewable sources was 37GW in 2009, 46.3% of the world market. China's cumulative capacity of nuclear, renewable, and hydropower reached 226GW in 2009. Among all sources of non-fossil energy, China's hydropower generation experienced the largest absolute growth, bringing on an average of 20GW of new generation capacity annually and increasing 2.6 times faster than under China's 10th Five-Year Plan period (2001-2005). In 2010, China's total installed hydropower capacity reached 200GW. Wind power growth has proceeded fastest, with an annual growth rate of 130% from 2006 to 2009. Total installed capacity of wind power reached 25.8GW in 2009, one third of the world total. It should be noted that China's total wind power capacity was only 8GW in 2004, or around 2% of the world total in that year. Nuclear power generation will continue to expand over the next decade – as of late 2009, China had 12 nuclear power generators in operation for an installed capacity of over 10GW, and 22 additional nuclear power plants, 40% of the global total, are under construction.

Power generated from nuclear, hydro, and other renewable sources accounted for 19.2% of China's total power generation in 2008. Electricity generated by hydro, wind, and nuclear power increased from 451.4TWh in 2005 to 666.7TWh in 2008, a nearly 50% increase. By comparison, power generated from fossil fuel sources grew only 36.3% in the same period. Wind power's share of China's generation mix is still small but is expanding rapidly – from .05% in 2005 to .75% in 2009.

Coupled with gains from non-fossil sources, improved efficiency in thermal power generation played a key role in China's power sector's low-carbon development. The CO₂ emissions intensity of China's power sector fell 6.5% between 2005 and 2008, from 766.8gCO₂/kWh in 2005 to 716.6gCO₂/kWh (Table 1-1) in 2008.

Table 1-1 Summary of carbon development of power industry from 2005 to 2008

	2005	2006	2007	2008
Power industry total capacity (GW)	517	621	713	791
Thermal power capacity (GW)	391	484	554	601
Hydro power capacity (GW)	117	129	145	172
Wind power capacity (GW)	1.1	1.9	4.0	8.9
Nuclear power capacity (GW)	6.9	6.9	8.9	9.1
Power industry total generation (TWh)	2500	2866	3282	3467
Thermal power generation (TWh)	2047	2370	2723	2790
Hydro power generation (TWh)	397	436	485	585
Wind power generation (TWh)	1	3	6	13
Nuclear power generation (TWh)	53	55	62	68
Thermal power industry energy consumption (Mtce)	720	830	935	928

Power industry CO ₂ emission ¹ (GtCO ₂)	2	2.2	2.5	2.5
Thermal power industry energy intensity ² (gce/kWh)	352	350	344	333
Power industry CO ₂ emission intensity ³ (gCO ₂ /kWh)	766.8	772.4	760.3	716.6
Thermal power industry carbon emission intensity ⁴ (gCO ₂ /kWh)	935.8	933.2	914.7	887.8
Thermal power industry CO ₂ reduction ⁵ (MtCO ₂)	0	6.4	57.4	133.9
Thermal power industry energy saving ⁶ (Mtce)	0	3.6	22.1	52.7

Data source: China electricity council, 2010. China energy statistical yearbook 2009.

Note: ¹ Thermal power industry CO₂ emission = \sum each kind of energy consumption for thermal power \times respective conversion coefficient

² Thermal power industry energy intensity = Thermal power industry energy consumption / Thermal power generation

³ Power industry CO₂ emission intensity = Thermal power CO₂ emission / Power industry total generation

⁴ Thermal power industry carbon emission intensity = Thermal power carbon emission / Thermal power generation

⁵ Assumed 2005 as the base year, Thermal power industry CO₂ reduction in 2008 = Thermal power generation in 2008 \times (Thermal power industry CO₂ emission intensity in 2005 – thermal power industry CO₂ emission intensity in 2008)

⁶ Assumed 2005 as the base year, Thermal power industry energy saving in 2008 = Thermal power generation in 2008 \times (Thermal power industry energy intensity in 2005 - Thermal power industry energy intensity in 2008)

2.2 Policies in the Energy Sector

The 11th FYP guidelines stated that energy savings should be achieved using three approaches: replacement of old plants with newer, larger, more efficient plants; technology; and management.

The Chinese government has promulgated a series of policies encouraging the development of renewable energy power and nuclear power as well as the closure of small thermal power units with high energy consumption and high pollution levels. These policies include the formulation of laws and regulations, financial subsidies, preferential taxes, price subsidies for renewable energy power, price penalties for small thermal power units, implementing and improving standards, as well as other means (Figure 2-2).

China has sought to support the development of wind and other renewable resources through a number of mechanisms, such as

- the renewable energy law and a series of specialized policies to create good a policy and institutional environment;
- feed-in-tariffs to reduce the risks of wind power development and to make it more competitive with traditional power generation;
- assigning mandatory renewable power market share for large thermal power enterprises;

- reducing the administrative approval procedures required for wind power projects.

Local governments have also accelerated the development of wind power, and the falling production costs and incentives in other countries have made wind power more economically viable.

In terms of technology, the Chinese government has actively encouraged research and deployment of low-carbon energy technology. The government has formulated the *Chinese Energy-Saving Technology Policy Outline (Amendment)*, *Development of Major Technical Equipment and Special Plan for Major Industrial Technology Development in the 'Eleventh Five-Year Planning'*, *Medium and Long Term Special Plan of Energy Saving*, *National 'Eleventh Five-Year Plan' Outline*, and *China's National Climate Change Program*. Other important plans also include supports to various types of low-carbon energy technologies.

Management measures include policies such as power generation rights trading, energy-saving power generation dispatching, and demand-side management. The trading volumes of electricity rights totaled about 145 billion kWh in 2009, saving about 12.5 Mtce and reducing over 0.3 million tonnes of sulfur dioxide emissions. Energy-saving power generation dispatching pilot programs have been carried out in Guizhou, Henan, Guangdong, Sichuan, and Jiangsu province. Government data indicates that the pilot programs in these provinces cumulatively saved 4.14 Mtce in 2009 and reduced 90,100 tonnes of sulfur dioxide emission. Grid utilities have made progress in demand-side management systems that incorporate dynamic management of load and promote preferential pricing, resulting in peak shifting and ensuring power supply reliability.

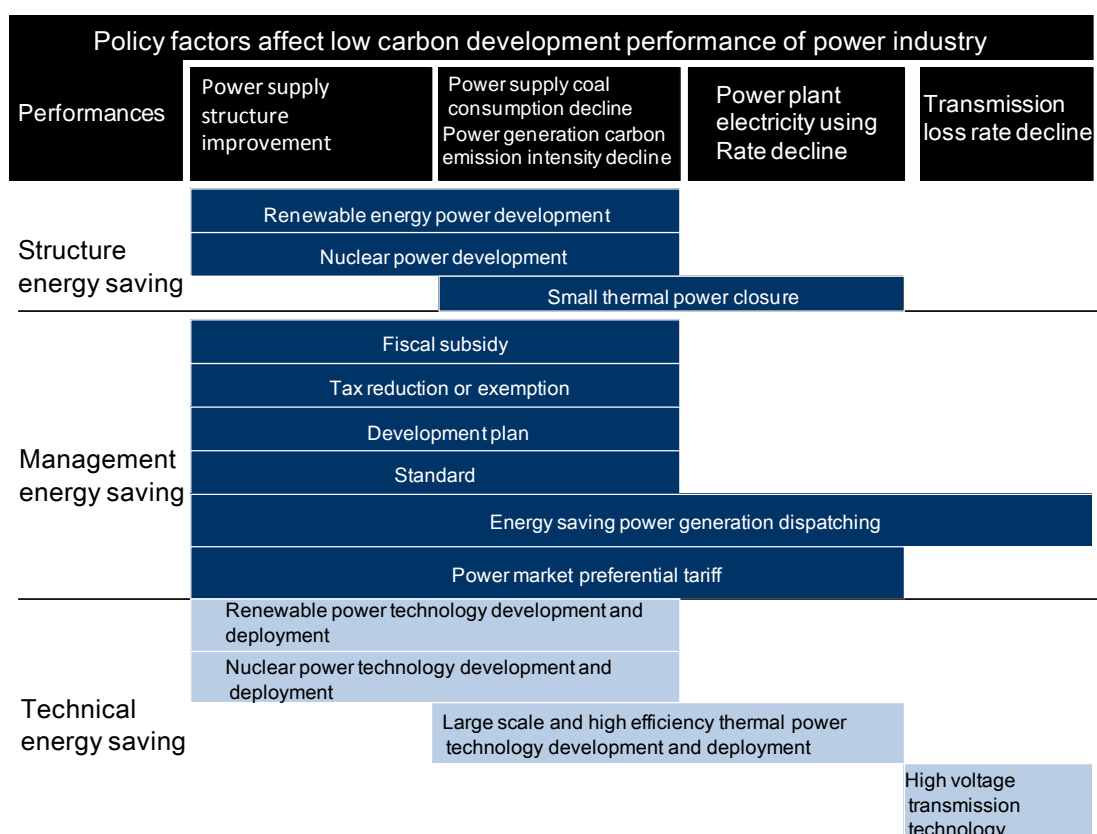


Figure 2-2 Policies affecting low carbon development of the power industry

3. THE MANUFACTURING INDUSTRY SECTOR

3.1 Performance

For the **manufacturing industrial sector**, three factors stand out as drivers of energy intensity: the structure of Chinese industry, its move to higher value added products, and improvements in the efficiency of production itself. During the 11th FYP, the structure of Chinese industry continued to evolve. As under the 10th FYP, heavy industry continued to grow, but it began slowing down relative to other sectors, with the share of energy-intensive industries decreasing in later years of the 11th Five-Year Plan. As part of this shift, a move towards higher value added products helped improve energy intensity. Through 2008, energy consumption by the industrial sector per unit industrial value added had decreased by 13.3%. Lastly, many of the large industries improved efficiencies significantly, with energy per ton of product falling from 2005-2008 by close to 5% in the steel, 17% in the cement, and by almost 35% in copper smelting. This improvement was driven by process and technology improvements as well as the construction of new facilities and closure of older, less efficient ones. The 14.8% decrease in CO₂ intensity was largely in line with the improvement in energy intensity.

We observe, however, that many of the instruments used in the industry sector are top-down

regulatory measures requiring significant administrative resources, which may not be the most cost-effective way to achieve future targets.

3.1.1 Energy Savings and CO₂ Emissions Reductions

China's manufacturing sector is the largest energy consumer of any sector of the economy – indeed, two thirds of China's total use is attributed to the manufacturing industry. Those industries identified as the most energy-intensive, including iron and steel, building materials, chemical and petrochemicals, non-ferrous metals, textiles, and the pulp and paper industries, together account for 70% of China's industrial sector energy use and are the foci of this report.

Two indices are useful for assessing energy conservation efforts in the manufacturing industry: energy use per unit of industrial value added (IVA) and energy use per unit product. In terms of IVA, energy use per value (in Chinese RMB terms) declined 13.3% between 2005 and 2008, with a 4.6% average annual reduction. In absolute terms, energy use per IVA fell from 21 tce per hundred thousand RMB to 18.2 tce per hundred thousand RMB during the period 2005 to 2008 (Figure 3-1(a)). By comparison, China experienced a 4% average annual reduction in energy use per unit GDP during the same period – illustrating that energy intensity of IVA fell quite markedly. Further, industry sector carbon emissions fell from 53.4 t-CO₂ per hundred thousand RMB to 45.5 t-CO₂ per hundred thousand RMB during the period of 2005 to 2008; CO₂ emission per unit of IVA declined 14.8%, with a 5.4% average annual reduction (Figure 3-1(b)).

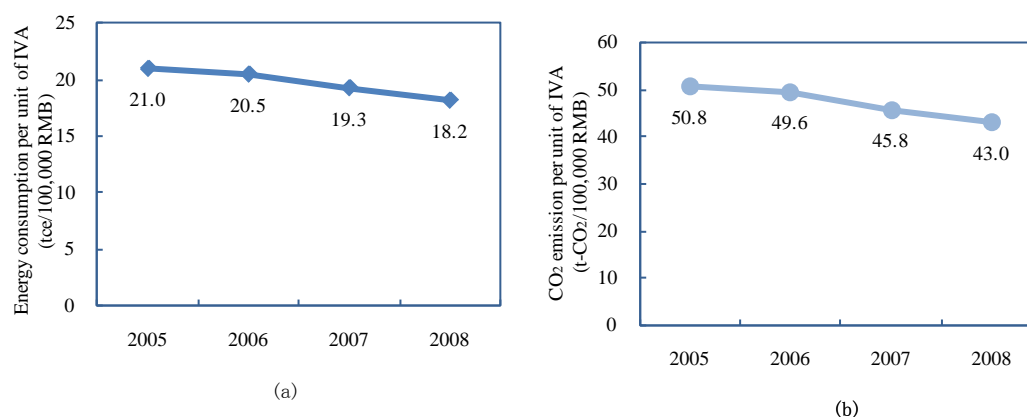


Figure 3-1 Energy consumption and CO₂ emissions of the manufacturing industry sector during the period of 2005 to 2008 (a) energy consumption per unit of IVA; (b) CO₂ emissions per unit of IVA

In order to evaluate 2006-2008 energy performance, a baseline is calculated based on 2005 energy intensity, i.e. what energy consumption would have been in these years if energy use per unit IVA remained constant at 2005 levels. Using this approach, energy savings are equal to the difference between the frozen 2005 energy intensity baseline and actual energy consumption (Figure 3-2).

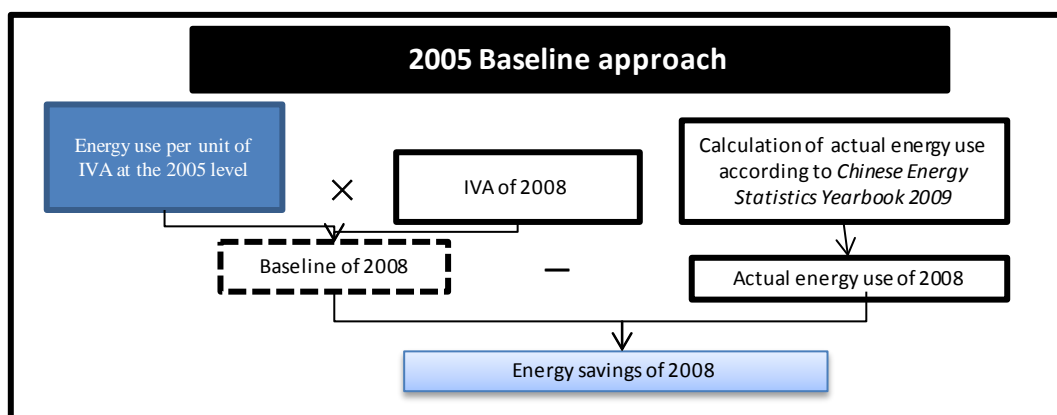


Figure 3-2 Flow chart of the calculation of energy savings

According to the 2005 baseline methodology, the manufacturing industry sector achieved energy savings of 34Mtce, 140Mtce, and 248Mtce in 2006, 2007, and 2008, respectively (Figure 3-3(a)). This resulted in cumulative energy savings of 421Mtce when compared to a continuation of 2005 levels. Based on these calculations the manufacturing industry alone contributed 58.7% of the entire national intensity reduction. Further, the industrial manufacturing sector reduced CO₂ emissions by 80Mt, 398Mt, and 695Mt in 2006, 2007, and 2008, respectively (Figure 3-3(b)), contributing 65.7% of the national CO₂ emission reduction, or a cumulative 1170Mt CO₂ between 2006 and 2008.

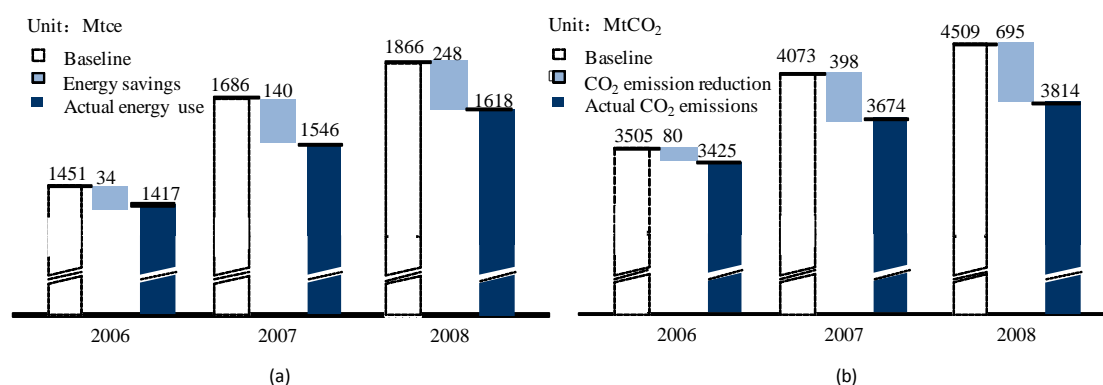


Figure 3-3 Energy savings and CO₂ emission reduction during from 2006 to 2008

A group of 13 highly energy consuming industrial products (crude steel, aluminum ingot, copper, cement, flat glass, oil refining, ethylene, caustic soda, soda ash, synthetic ammonia, calcium carbide, pulp and paper, and fiber) achieved significant efficiency gains (Table 3-1). Our calculation² shows that this group of 13 products alone realized energy savings of

² To evaluate energy savings, a calculation is conducted by multiplying annual production of the 13 products for 2006-2008 by 2005 unit energy consumption for each product to determine what the energy use would have been in these years if energy use per unit product remained static. This value is then subtracted from the actual energy consumption for these products to determine energy savings.

138Mtce and CO₂ emissions reductions of 340Mt between 2006 and 2008. Energy consumed by the group of 13 products accounted for 63.8%, 66.5%, and 64.2% of total energy consumed by the industrial manufacturing sector. When the remaining industrial products not accounted for in the group of 13 products are included, we estimate an aggregate energy savings of 218Mtce and a CO₂ emissions reduction of 523 Mt for all industrial products from 2006 to 2008. Highly energy consuming industrial products increasingly improved energy efficiency in 2009. The group of 13 products achieved energy savings of 110Mtce and CO₂ emissions reductions of 169 Mt in 2009; all industrial products achieved energy savings of 169Mtce and CO₂ emissions reductions of 411Mt in 2009.

Table 3-1 Energy consumption per unit product of highly energy consuming products

	2005	2006	2007	2008	2009	International Advanced Level
Crude Steel						
Output (Mt)	353.2	419.2	489.3	503.1	572.2	
Comprehensive Energy (the whole industry) (kgce/t)	1019	998	976	975	973	
Comprehensive Energy (big enterprises only) (kgce/t)	760	745	733	729	717	
Electricity (kWh/t)	452		433	445	434	
Comparative Energy (big enterprises only) (kgce/t)	732	729	718	709	697	610
Aluminum Ingot						
Output (Mt)	7.79	9.27	12.34	13.17	12.89	
AC electricity (kWh/t)	14680	14671	14488	14323	14171	14100
Copper						
Output (Mt)	2.61	2.92	3.44	3.79	4.14	
Comprehensive Energy (kgce/t)	780	729	610	549	509	500
Electricity (kWh/t)			310	304	309	
Cement						
Output (Mt)	1068.9	1236.8	1361.2	1423.6	1644.0	
Comprehensive Energy (kgce/t)	167	161	158	151	139	118
Electricity (kWh/t)	92		91	91	90	
Flat Glass						
Output (Million Box)	402.1	465.8	497.5	513.3	579	
Comprehensive Energy (kgce/box)	22	19	17	16.6	16.5	15
Electricity (kWh/t)			7.6	7.4	6.9	
Oil Refining						
Output (Mt)	286.2	306.5	326.8	342.0	374.6	
Comprehensive Energy (kgce/t)	114	112	110	108	106	73
Electricity (kWh/t)			60.0	60.3	60.2	
Ethylene						

REVIEW OF LOW CARBON DEVELOPMENT IN CHINA 2010 REPORT

Output (Mt)	7.56	9.41	10.48	9.98	10.73	
Comprehensive Energy (kgce/t)	1073	1013	1026	1010	976	629
Electricity (kWh/t)			124.5	126.4	126.1	
Synthetic ammonia						
Output (Mt)	52.20	55.93	57.87	49.95	51.34	
Comprehensive Energy (kgce/t)	1700	1700	1702	1661	1591	
Electricity (kWh/t)	1280		1202	1184	1172	
Caustic soda						
Output (Mt)	12.4	15.1	17.59	19.26	18.32	
Comprehensive Energy (kgce/t)						
Diaphragm	1448		1272	1351	1293	1250
Ion-exchange Membrane	1067		937	922	916	910
Weighted Average	1297	1248	1146	1137	1087	
Electricity (kWh/t)						
Diaphragm			2364	2340	2309	
Ion-exchange Membrane			2213	2201	2186	
Soda Ash						
Output (Mt)	14.21	16	17.72	18.81	19.38	
Comprehensive Energy (kgce/t)	396	402	398	355	323	310
Calcium Carbide						
Output (Mt)	8.95	11.7	13.63	13.61	15.03	
Electricity (kWh/t)	3450	3666	3465	3440	3395	3000
Paper and Pulp						
Output (Mt)	62.05	68.63	77.92	84.04	89.65	
Comprehensive Energy (the whole industry) (kgce/t)	528	502	476	440	395	
Electricity (the whole industry) (kWh/t)	745		605	578	567	
Comprehensive Energy (Self-made pulp enterprises only) (kgce/t)	1380	1290	1225	1153	1090	610
Fiber						
Output (Mt)	26.65	20.73	24.14	24.15	27.3	
Electricity (kWh/t)	1396	1207	1086	1094	1091	980

3.1.2 Technology Improvement

China realized significant efficiency gains in its industrial sector through improved manufacturing technologies between 2006 and 2008. These improvements mainly took three forms – phasing out outdated production capacity, promoting advanced technologies, and manufacturing highly efficient equipment.

The Chinese government pushed for accelerated closures of small and outdated production capacity in 14 energy intensive industries between 2005 and 2008. The cement industry, for

example, phased out 240Mt of vertical shaft production capacity, and the iron and steel industry phased out 81.7Mt of small blast furnace (300m³ and smaller) production capacity. As of late 2009, reductions in outdated industrial capacity had produced energy savings of 110Mtce.

Advanced technologies were promoted in all manufacturing industries. For example, the iron and steel industry improved its efficiency by encouraging coke dry quenching (CDQ), blast furnace gas dry treatment, and BOF gas dry treatment. Further, the industry introduced water recycling, gas recovery, and slag reuse to realize additional efficiency increases. As a result, comparative energy consumption per ton of steel declined from 723kgce in 2005 to 697kgce in 2008 (big enterprises). Other manufacturing industries also experienced significant efficiency gains as a result of technological improvements.

Additionally, China has considerably improved its capacity for manufacturing highly efficient industrial equipment, enabling rapid scaling-up of technological efficiency improvements. For example, China can now make 160kA (and beyond) preoasters for electrolytic aluminum, large-scale (5,000-10,000t/d) dry process cement production lines, large-scale (900t/d) floating glass production lines, CDQ equipment, and top gas pressure recovery turbines. Overall, efficiency improvements across the manufacturing sector have been achieved through the adoption of cutting-edge technology in enterprises.

3.1.3 Structural Change

China's industrial sector underwent some structural changes between 2006 and 2008, and the dominance of heavy industry declined to some extent. Heavy industry grew rapidly under the 10th FYP, representing 62.9% of IVA in 2001 and 68.6% in 2005. This trend slowed from 2006 to 2008, as heavy industry IVA increased less than 2 percentage points, from 69.5% in 2006 to 71.3% in 2008. At the product level, the manufacture of high value-added products and low energy-consuming products increased. For example, China's production of high value-added steel products (i.e., steel boards, tubes, and strips) was inefficient under the 10th FYP when the imports of steel boards, tubes, and strips represented 80% of China's total steel imports. This situation improved significantly under the 11th FYP, however, as the share of production of boards, tubes, and strips increased from 49.4% in 2006 to 53.2% in 2008, a gain of 3.8 percentage points. In addition, many highly energy consuming enterprises have scaled up in size. For example, the share of steel production from enterprises that have an annual production capacity of 10,000t (and beyond) increased from 31% in 2005 to 43% in 2008; the share of cement production from dry process kilns that have a daily production capacity of 4,000t increased from 15% in 2005 to 30% in 2008. These and other changes reflect that China's manufacturing industry is moving toward a more rational structure of industries, products, and industrial organization.

3.2 Policies in the Manufacturing Industrial Sector

Between 2006 and 2010, a series of policies and programs were put in place in the industrial sector to support China's efforts to reach the 20% energy intensity reduction target. In

particular, the Top-1000 Energy Consuming Enterprises Program, the Ten Key Energy Conservation Projects, and the Small Plant Closure Program were the most critical initiatives.

Launched in 2006 by NDRC in collaboration with a number of other government agencies, the *Implementation Plan of the Top-1000 Energy Consuming Enterprises Program* set energy savings targets for a group of China's 1000 highest energy consuming enterprises across nine industries that each consumed a minimum of 180,000tce in 2004. The goals of the *Top 1000 Program* were to significantly improve energy efficiency within this group of 1,000 enterprises, reduce per unit energy consumption to levels on par with China's highest efficiency producers for all major products, and cut energy use overall by 100Mtce from 2006 to 2010. According to the NDRC, between 2006 and 2009, the *Top 1000 Program* achieved an aggregate energy savings of 132Mtce, already exceeding its targets. The *Top 1000 Program* alone contributed 27% of the savings needed to reach China's national mandatory target of a 20% reduction in energy intensity.

Recommendations for Implementation of the Ten Key Energy Conservation Projects during the Eleventh Five-Year Plan was jointly released in 2006 by NDRC and a group of relevant government agencies. The fundamental target of *Ten Key Projects* was to save 240Mtce during the 11th FYP. The Ten Key Projects included coal-fired industrial boiler (kiln) retrofit projects, district co-generation projects, waste heat and pressure utilization projects, petroleum conservation and substitution projects, motors energy efficiency projects, energy system optimization projects, buildings energy conservation projects, green lighting projects, government agency energy conservation projects, and energy savings monitoring and testing and technology service system building projects. The *Ten Key Projects* program was designed to push enterprises to take the lead in implementing energy efficiency projects while the government guided private sector investments through financial allocations, pricing mechanisms, and tax policies. From 2006 to 2009, government investment in the *Ten Key Projects* was 28.8 billion RMB, and the *Projects* achieved an estimated energy savings of 140Mtce. NDRC data shows that the *Ten Key Projects* contributed 29% of energy savings needed to meet the overall national target of 20% energy intensity reduction.

The *Small Plant Closure Program* was devised as the key initiative for optimizing the structure of China's industrial manufacturing sector during the 11th FYP. The 2005 policy *Interim Provisions on Promoting Industrial Structure* called for careful and technical evaluation of development priorities within the industrial sector and pushed for the optimization and integration of industries. The 2007 set of *Government Financial Incentives for Eliminating Outdated Production Capacity* issued a set of financial incentives to ease social costs associated with the elimination of outdated production capacity. The 2010 circular *Notice on Clarifying Preferential Electricity Rates for Highly Energy Consuming Enterprises* helped push for the closure of small plants through pricing mechanisms. According to the NDRC, from 2006 to 2009, the Small Plant Closure Program achieved energy savings of 110Mtce and made a 22% contribution to the national target of 22% energy intensity reduction.

Table 3-2 is a summary of the effectiveness of key policies.

Table 3-2 A summary of key policies

Policy	Energy savings achieved, 2006-2009	Contribution to the national – 20% energy intensity reduction target
Top-1000 Energy Consuming Enterprises Program	132Mtce (exceeds the target)	27%
Ten Key Energy Conservation Projects	140Mtce (2006-2008)	29%
Small Plant Closure Program	110Mtce	22%

The Chinese government issued two consecutive policies to help support the growing energy efficiency market in 2010: *Recommendations for Accelerating the Implementation of Energy Performance Contracting and Promoting the Development of the Energy Services Industry* and *Financial Incentives for Energy Performance Contracting Projects*. These policies clarify the existing policy environment for energy service companies and provide direct subsidies to these companies according to energy savings achieved. Any industrial project that achieves annual energy savings of at least 500tce is eligible for the subsidy, which is provided from two sources: central government financing of 240 RMB/tce and local government funding of at least 60 RMB/tce. This strong financial incentive complements the administrative measures supporting energy service companies that were already in effect for the first three years of the 11th FYP.

3.3 Institutional Analysis

Under the 11th FYP, China implemented energy intensity reduction policies by disaggregating targets and responsibility to individual provinces and enterprises. The national 20% energy intensity reduction target was disaggregated to the provincial level so that each province was assigned an individual energy conservation target. Province-level officials and bureaucrats were evaluated based on their implementation of the energy conservation target and were not eligible for promotion if their provinces had not met the target. At the local level, provincial targets were further disaggregated to the city, county, and enterprise level. Officials and bureaucrats at various levels were held responsible for their achievement. Such an approach was viable in large part because of China’s unique, top-down administrative system, which grants the national government the authority needed to achieve its targets. However, the government recognizes the need for reform in the economic structure to allow enterprises to increasingly take the lead in implementing energy efficiency projects; we expect that market mechanisms will play an increasing role in China’s energy efficiency policy regime.

4. THE BUILDING SECTOR

In the building sector, increased building stock and increased energy intensity associated with higher standards of living mask policy impact. The building sector was responsible for over 18% of China’s energy use by 2008 and was growing rapidly, with energy use increasing by 28% from 2005. The energy consumption of new buildings was a major driver of this increase, although energy intensity—energy use per square meter—contributed equally, increasing by

16% between 2005 and 2008. Both new buildings and the increasing energy intensity of the building stock can be attributed to rising standards of living (including greater appliance and space conditioning) and China's rapid urbanization. Our analysis indicates that one area that clearly demonstrates policy effectiveness has been district heating in Northern China where energy consumed in heating per square meter has continued its notable decline.

For the purpose of our analysis, energy use and CO₂ emissions in the building sector refer to the energy use and CO₂ emissions from daily activities in civil buildings; energy use from industrial plants and the construction of new buildings are not included. Taking into account divergent urban-rural economic gaps and regional climate differences, China's building energy use is divided into four categories: 1) district heating energy use in north urban China, 2) energy use in urban residential buildings (excluding district heating energy use), 3) energy use in urban commercial buildings (excluding district heating energy use), and 4) energy use in rural residential buildings.

Energy use and corresponding CO₂ emission has been calculated for the period from 1996 to 2008. Specifically, electricity use has been converted into tons of standard coal equivalent according to annual national average thermal power generation coal consumption.

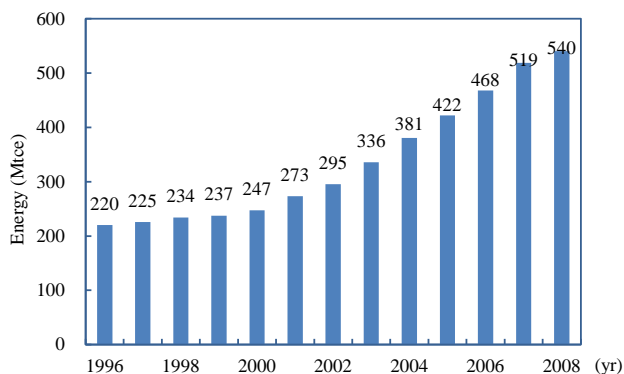
4.1 Performance

4.1.1 The growth of CO₂ emissions in the building sector is slowing down

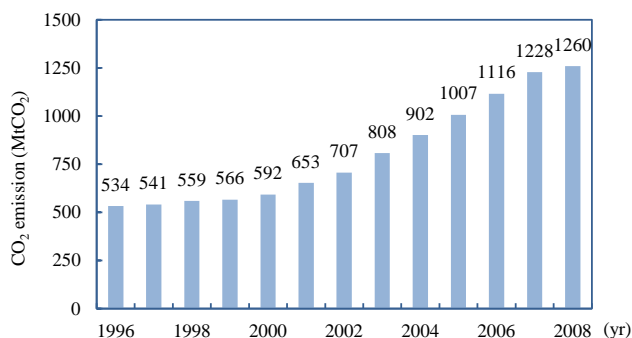
Commodity energy use³ in China's building sector was 540 Mtce in 2008, accounting for 18.4% of China's total energy use. CO₂ emissions in the building sector reached 1260MtCO₂ in 2008, accounting for 19.8% of China's total.⁴ Building energy use and related CO₂ emissions climbed steadily over the last decade, increasing by 28% between 2005 and 2008 to reach 540Mtce (growing an average of 8.6% per year). Corresponding CO₂ emissions increased 253MtCO₂ (25%), growing an average of 7.8% per year. However, the rate of CO₂ emission growth has slowed. As shown in Figure 4-1, compared with the 10th FYP, a slower growth rate was observed during the period of 2006 to 2008.

³ Commodity energy refers to all energy resource markets. Primary biomass, such as firewood and straw is excluded.

⁴ It should be noted that a considerable amount of coal consumption in rural areas is not included in the national statistic system, as use of coal from small coal mines in rural areas is usually out of reach for statistic counting. According to a survey carried out by Tsinghua University from 2006 to 2007, coal consumption from those small mines in rural areas would amount to 100Mtce. Taking this number into account, commodity energy use in China's building sector in 2008 would be 640Mtce, accounting for more than 22.2% of China's total energy use, and the corresponding CO₂ emission would be 1530MtCO₂.



(a)



(b)

Figure 4-1 Energy use and CO₂ emissions in China's building sector, 1996-2008

(a) Energy consumption; (b) CO₂ emissions

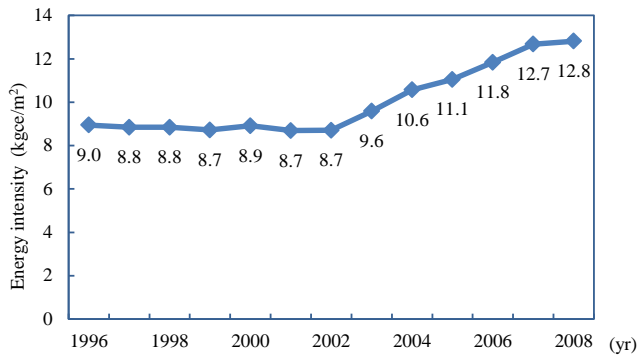
4.1.2 China's energy and CO₂ intensity is still significantly lower than developed

countries

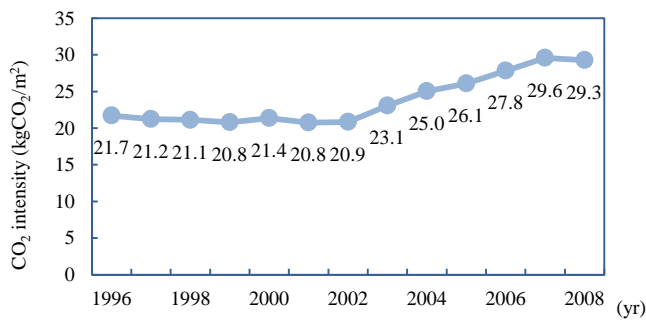
Figure 4-2 illustrates the energy intensity and corresponding CO₂ emission intensity in China's building sector from 1996 to 2008. The energy intensity hit a record high of 12.8kgce/m² in 2008, and the CO₂ emission intensity reached 29.3kgCO₂/m².

The energy intensity of the buildings sector increased 16.0% between 2005 and 2008, an average increase of 5.1% per year; CO₂ emissions increased by 12.2%, or 3.9% per year. A significant decrease in CO₂ emissions intensity was observed in 2008 relative to 2007, and their respective intensities grew much more slowly than total energy use and CO₂ emissions in buildings.

CO₂ emissions per square meter in the building sector grew slightly more slowly from 2006 to 2008 than during the 10th FYP (growing at an annual rate of 4.06%).



(a)

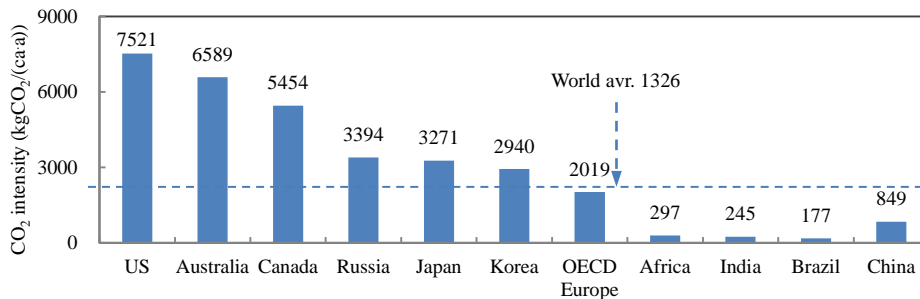


(b)

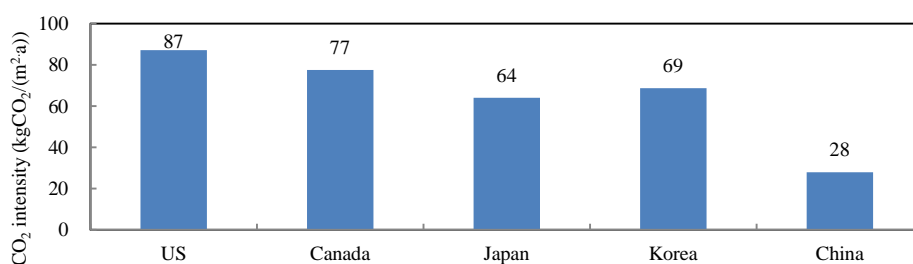
Figure 4-2 Energy intensity and CO₂ emission intensity in the building sector, 1996~2008

(a) Energy intensity; (b) CO₂ emission intensity

Figure 4-3 shows per-capita and per unit-area CO₂ emission intensities from around the world. In 2006, CO₂ emission per capita in China were around 849 kgCO₂/(ca·a), which was lower than the world average and only 1/3, 1/4, and 1/9 of per capita emissions levels in OECD Europe, Japan, and the USA, respectively. The unit area CO₂ emissions (emissions per square meter) in China was 27.9kgCO₂/(m²·a), which was less than 1/3 of that in the USA and lower than the average level in developed countries.



(a)



(b)

Figure 4-3 International comparison in CO₂ emission intensity in the building sector, 2006

(b) Per capita CO₂ emission intensity; (b) Unit area CO₂ emission intensity

4.1.3 Performance of the four energy categories in the building sector

Among the four energy categories in China's building sector, as shown in Figure 4-4:

- (a) The CO₂ emission intensity of district heating energy use in north urban China has decreased in recent years. The CO₂ emission per square meter fell 5.1% between 2005 and 2008 to reach 45.7kgCO₂/(m².a) (27% lower than 1996 levels). Though the floor area utilizing district heating systems (DHS) increased 42.5% over the same timeframe, from 5.4 billion m² in 2005 to 7.7 billion m² in 2008, total energy use and CO₂ emission growth slowed due to the decrease of unit area CO₂ emission. Considering that the energy use for district heating in north urban China accounted for 25% of total energy use in China's building sector, the enhanced efficiency of district heating contributed significantly to lowering total building energy use below what it might otherwise have been.
- (b) In urban residential buildings, the unit area CO₂ emission displays an inconsistent pattern: a marked decrease of over 50% was observed during the period 1996~2002, possibly due to the rapid expansion of district heating systems and the resulting decrease of household coal-fueled heating. However, CO₂ emission per unit-area rose steadily from 2002 to 2007, only to fall slightly in 2008.
- (c) In urban commercial buildings, a similar pattern is observed: From 1996 to 2002, the unit area CO₂ emission decreased nearly 40%, then climbed steadily from 2002 to 2007, followed by a small decrease in 2008.
- (d) Among the four building categories defined here, rural residential buildings had the lowest CO₂ emissions per square meter, measuring only 1/3 and 1/4 of those in urban residential and commercial buildings in 2008, respectively. With China's government prioritizing further improvements to living standards and access to energy in rural areas, the unit area CO₂ emissions displayed a continuous increase from 1996 to 2008, rising more than 50% over that period. However, recent increases in the use of solar energy and biogas (methane) in rural areas have to some extent slowed their growing demand for commodity energy.

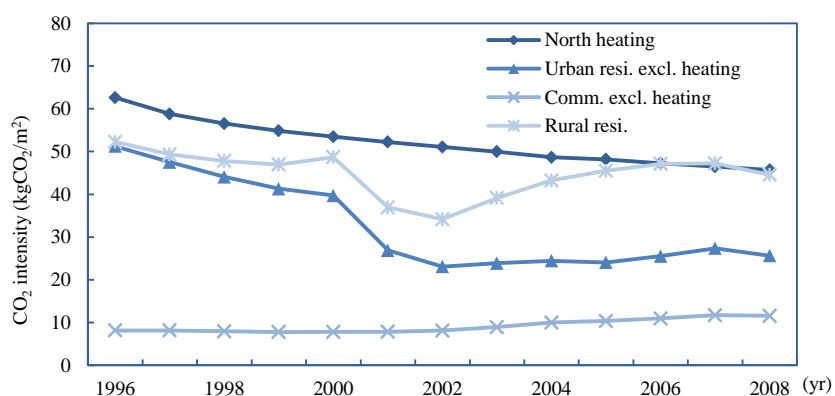


Figure 4-4 Carbon intensity of the four categories in the building sector, 1996-2008

4.1.4 75% of the energy saving targets outlined in the 11th FYP were met between 2006~2008

The amount of energy savings⁵ in the buildings sector (compared to business as usual projections) increased annually from 2006 to 2008. Energy savings in 2006, 2007, and 2008 were 11.7Mtce, 25.3Mtce, and 40.1Mtce, respectively, for a cumulative energy savings of 77.2Mtce. These savings are equivalent to 75% of the overall savings target specified in the 11th FYP, as shown in Figure 4-5.

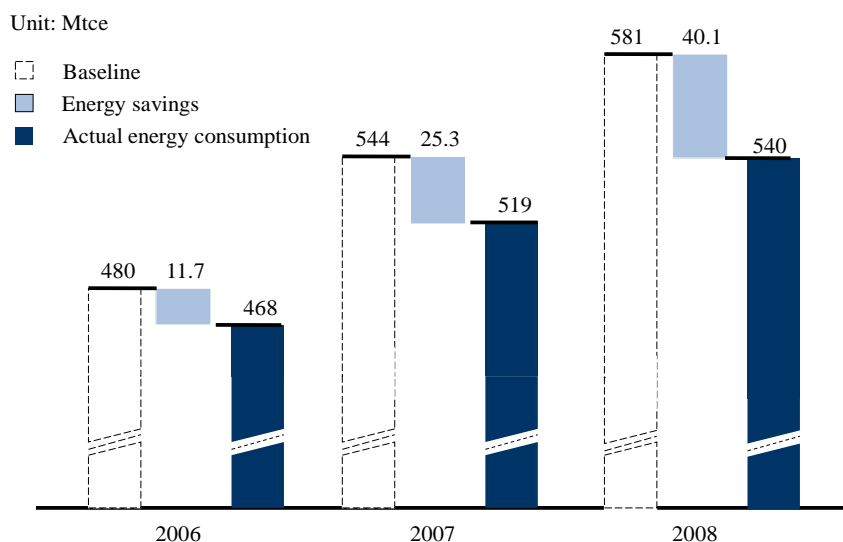


Figure 4-5 Energy savings in the building sector, 2006-2008

⁵ Energy savings for each category are calculated based on estimated baseline energy use minus real energy use. The baseline energy use is calculated based on the energy intensity in 2005 and the average annual rate of energy intensity growth in each category during 10th FYP.

4.2 Policies in the building sector

China's policy environment for development in the buildings sector consists of three levels of structure, as shown in Figure 4-6:

- (a) **Laws and regulations** state in concrete terms the essential requirements for energy conservation in the buildings sector as well as implementation activities that must be carried out by relevant government authorities.
- (b) **National plans**, in accordance with laws and regulations, specify targets for energy conservation in the building sector.
- (c) **Key policy clusters**: based on the levels above, policy clusters consist of a series of policies, usually very specific and related to one sector, industry, or law, that are launched to specify how a target within a national plan shall be fulfilled. It is common for several policies to be developed in order to achieve one target. Therefore, these policies are considered as a group and called a "key policy cluster" in the report.

Classification	Rural	district heating in urban North China	Commercial building	Residential building
National Law	<Energy conservation law>, 2008			
	<Renewable Energy law>,2006			
Regulation		<Civil building energy conservation regulation>, 2008		
			<Public institution energy conservation regulation>, 2008	
National planning	<Energy conservation mid-and-long-term planning>, 2004			
	<Notice on key point of work on energy saving society>, 2005			
		<Outline of the 11 th five year on construction>, 2006		
	<The 11 th five year on energy development>, 2007			
	<Comprehensive work program on energy saving>, 2007			
	<Renewable energy planning>,2007		<Renewable energy planning>,2007	
		Working on energy saving in 2009>,2009		
			<Energy conservation mid-and-long-term planning>, 2009	
Classification	Rural	district heating in urban North China	Commercial building	Residential building
Key policy clusters	New building	New building	New building	New building
	Retrofitting	Retrofitting	Retrofitting	Retrofitting
	Home appliances rural subsidies	EMC	Energy management	Appliances & lighting
	Renewable application	Heat reform	Renewable application	Renewable application
			Appliances	
			EMC	

Figure 4-6 Policy system in the building sector

China's energy policy system in the buildings sector is moving beyond its initial state as a

collection of stopgap measures and is increasingly becoming a systematic framework of related policies. Energy savings for each energy category in China's building sector are estimated as follows:

- (a) District heating energy use in urban North China contributed the most to energy conservation among the four categories. It achieved an energy savings of 37.7Mtce, accounting for roughly half of the total energy savings, as shown in Figure 4-7.
- (b) The building codes policy cluster proved particularly effective in terms of energy efficiency gains, achieving an energy savings of 31.0Mtce, which accounted for 40% of total energy savings in the buildings sector. Heating reform was the second most effective cluster, achieving energy savings of 23.3Mtce, or roughly 30% of energy savings in the building sector, as shown in Figure 4-8.

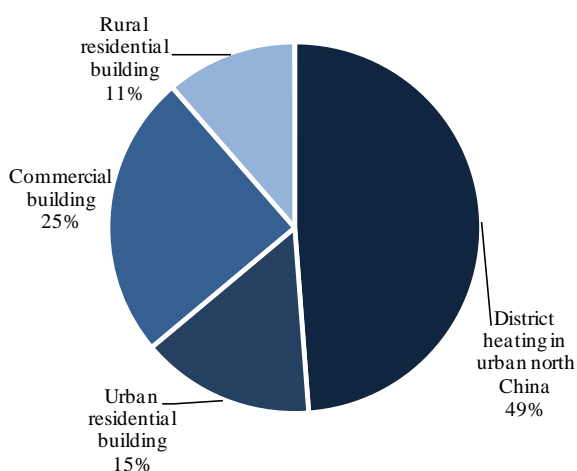


Figure 4-7 The contribution of each energy category to energy savings from 2006 to 2008 in the building sector

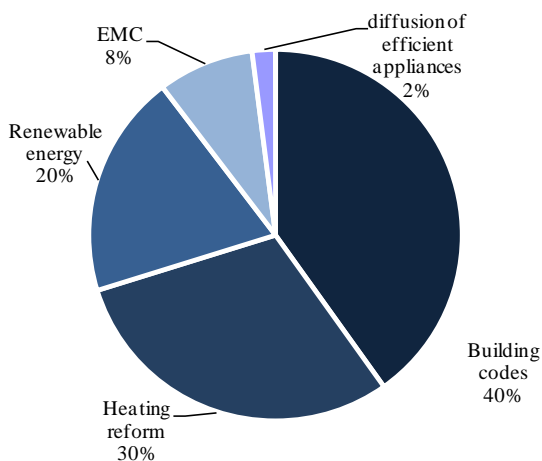


Figure 4-8 The contribution of key policy clusters to energy savings from 2006 to 2008 in the building sector

5. TRANSPORTATION SECTOR

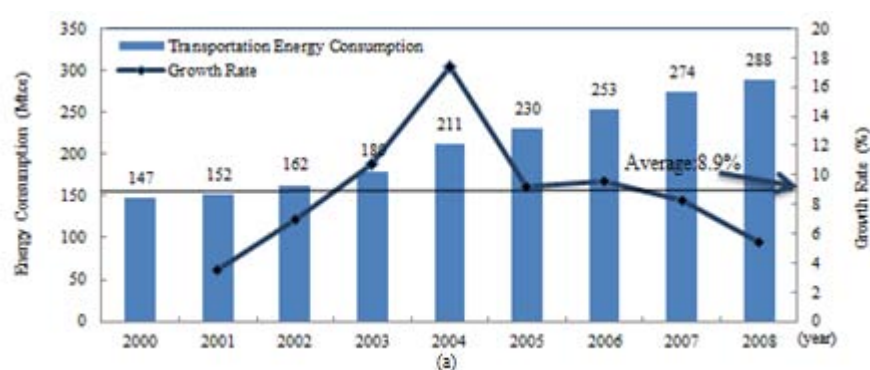
Energy consumption in the transport sector grew 25% between 2005 and 2008. Given the array of different transport modes, a global comparison is difficult, but two trends are notable. First, the proportion of more energy intensive transport modes such as road and air rose. Second, the efficiency of most modes of transport, as measured by energy per tonne-kilometer of freight, was either stable or improved slightly.

5.1 Performance

China's growing demand for passenger and freight transportation and structural shifts towards energy-intensive transportation modes have led to an increase in energy consumption and CO₂ emission in the transportation sector. Transportation sector energy consumption reached 288Mtce in 2008, accounting for 10.4% of total energy consumption and 15.9% of end-use energy consumption. CO₂ emissions from transportation reached 631Mtonne, accounting for 9.9% of China's end-use CO₂ emissions. Compared to the first year of the 11th FYP (2006), China's transportation energy consumption and CO₂ emissions were 14.1% and 13.3% higher in 2008, respectively.

5.1.1 Transportation energy consumption and CO₂ emissions rose as their rates of growth slowed

China's transportation energy consumption and CO₂ emissions increased steadily during the last eight years, but starting in 2004, the growth slowed down. This was particularly apparent at the beginning of the 11th FYP (See Figure 5-1).



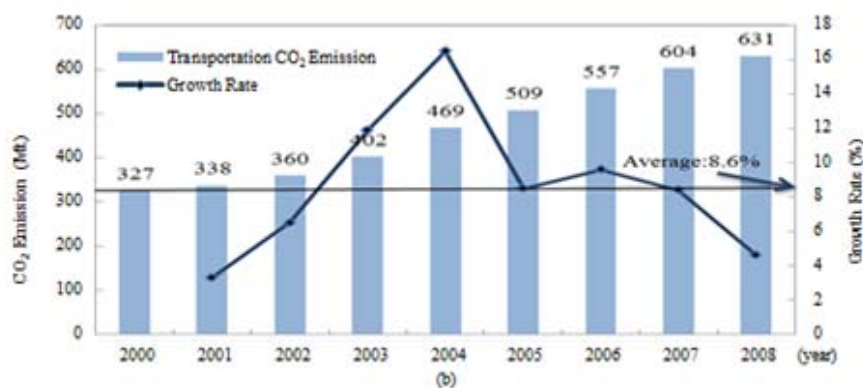


Figure 5-1 Transportation Sector 2000~2008 Total Energy Consumption and CO₂ Emissions: (a) Transportation Total Energy Consumption and Its Growth Rate; (b) Transportation Total CO₂ Emissions and Its Growth Rate

(Sources: China Energy Statistical Yearbook 2009)

5.1.2 Transportation energy intensity⁶ decreased

The average growth rates of transportation energy consumption and CO₂ emissions from 2006 to 2008 were 7.8% and 7.5% respectively, lower than the passenger-kilometers and freight-tonne-kilometers growth rates of 10.0% and 23.9% (private freight vehicles are not included) in the same period. Therefore, China's transportation energy intensity decreased during the 11th FYP. Table 5-1 shows that with the exception of water transport and gasoline freight vehicles, energy intensity for all other transportation modes, such as railway, road transport, and air transport, was lower in 2008 than in 2005.

Table 5-1 Energy Intensity of Different Transportation Modes
(tce/Million-tonne-kilometers)

Transportation Modes	Vehicles	2005	2008
Railway	Electric Power locomotive Engine	1.37	1.36
	Internal-Combustion Engine	3.58	3.63
Road Transport	Gasoline Passenger Vehicle	141.8	140.7*
	Diesel Passenger Vehicle	143.7	138.7*
	Gasoline Freight	85.9	89.2*

⁶ Defined as energy consumption per unit weight-distance Energy Consumption

	Vehicle		
	Diesel Freight Vehicle	78.0	78.0*
Water Transport	Ships	10.0	17.1*
Air Transport	Airplane	488.5	453.7

(Sources: China Transportation Yearbook)

Note : * indicates 2007 data

5.1.3 The proportion of energy-intensive transportation modes rose

As China continues its transition to a developed economy, the use of energy-intensive transportation modes will account for an increasing share of all passenger kilometers traveled. For passenger transport, between 2005 and 2008 the proportion of railway use shrank modestly while road and air transport use rose slightly (see Figure 5-2(a)). Air transport rose from 9.36% of all domestic passenger kilometers traveled in 2005 to 10.19% in 2008, and passenger road transport increased its share of passenger kilometers traveled from 54.61% to 55.16% over the same period. Conversely, passenger rail use fell from 35.63% to 34.39% between 2005 and 2008. For freight transport, railway's share of total million-tonne-kilometers of freight moved decreased from 49.75% to 32.45%, and freight road transport's proportion increased from 20.87% to 42.48% during the period 2005-2008 (see Figure 5-2(b)).

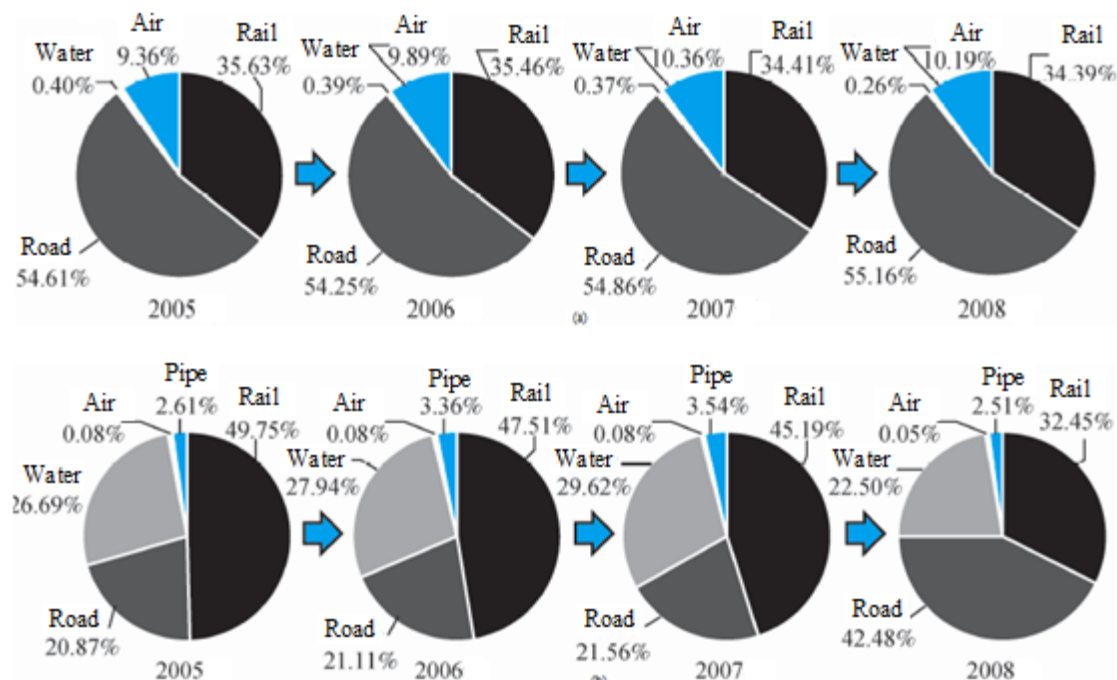


Figure 5-2 2005~2008 Passenger and Freight Transportation Modes Change

(a) Passenger Transportation Modes Passenger-kilometers Share Change

(b) Freight Transportation Modes Million-tonne-kilometers Share Change

(Sources: China Transportation Yearbook)

The shift towards relatively more energy-intensive transportation modes reflects China’s rapid economic transformation and poses a challenge for the country’s lower- carbon transport development goals.

5.2 Policies in the transport sector

Energy consumption and CO₂ emissions in the transportation sector are directly affected by factors commonly summarized as “ASIF”: A-transportation *activities*; S-transportation *structure*; I-*intensity* of energy use; and F-*fuel* structure. China’s major energy conservation and carbon emissions reduction policies in the transportation sector focused heavily on optimizing structure and decreasing energy intensity under the 11th FYP.

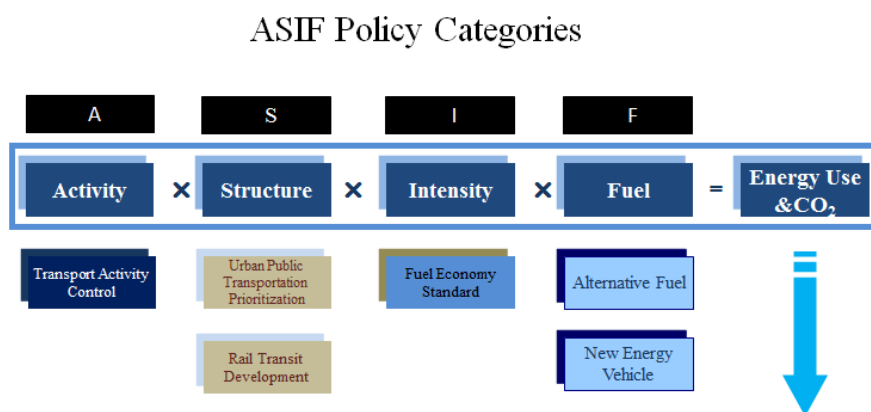


Figure 5-3 ASIF Policy Categories

5.2.1 Fuel Economy Standards

China has promulgated fuel economy standards and related policies for light passenger vehicles, light commercial vehicles, operating coaches and freight vehicles, mopeds, motorcycles, three-wheeled vehicles, and low-speed goods vehicles – including both new vehicles and those under production.

Regulation of vehicle fuel economy has evolved greatly in terms of the standards, measures, targets, and test methods applied within and across countries. Figure 5-4 compares the relative stringency and implementation schedules of passenger vehicle fuel economy standards in different regions. It shows that although China is one of the newest countries to regulate vehicle fuel economy, its passenger vehicle fuel economy standard is already more stringent than that of the U.S., Canada, and Australia, though it lags behind Japan and the European Union.

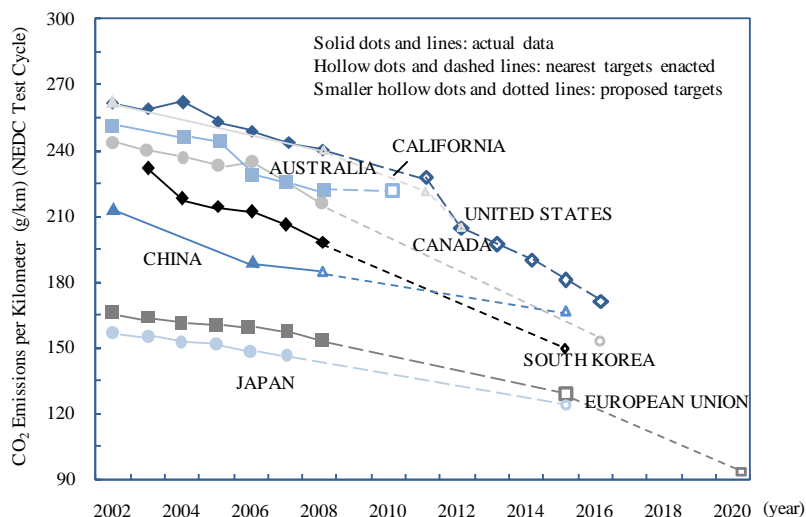


Figure 5-4 Passenger Vehicle Fuel Economy Stringency Comparison

(Sources: ICCT, 2010)

Limits on Fuel Consumption for Passenger Cars are among the most direct and effective fuel conservation policies. The first phase of this single standard, issued in 2004, has already driven down fuel consumption per 100 kilometers by 3.02%, from 9.11L in 2002 to 8.06L in 2006. Fuel economy has continued to improve, reaching an average of 7.79L/100km in 2008 under the second phase of the standard.

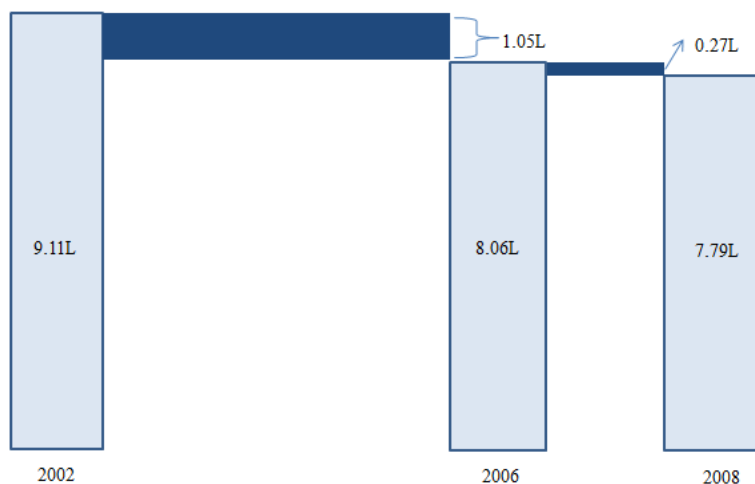


Figure 5-5 Change in China's Fuel Consumption Per 100km.

(Sources: National Development and Reform Commission, Innovation Center of Energy and Transportation 2009 Report)

If average vehicle fuel economy for light passenger vehicles in 2005 is used to calculate BAU CO₂ emission in 2006, 2007, and 2008, improvements to vehicle fuel economy over the first three years of the 11th FYP have saved 2710 thousand tons of CO₂ emissions.

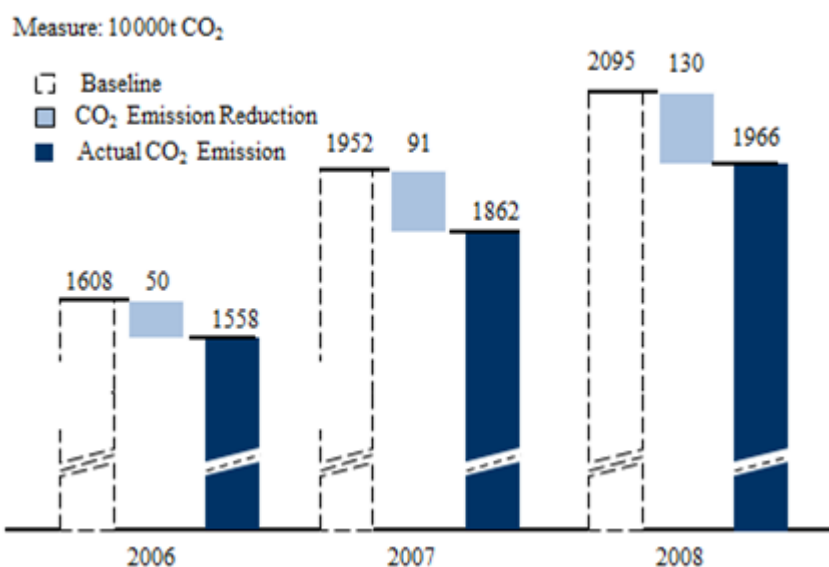


Figure 5-6 Light Passenger Vehicle CO₂ Reduction during the “11th Five-Year Plan”

(Sources: China Association of Automobile Manufacturers, ICCT, NDRC)

5.2.2 Public Transportation Prioritization

The Chinese government has introduced policies prioritizing the development of public transportation as a strategic low-carbon development mechanism. China has promulgated three major related policies since 2004: No.38 Document-*Recommendation on Prioritizing Urban Public Transit*; No. 46 Document-*State Council’s Reissue of Ministry of Construction’s Recommendation on Prioritizing Urban Public Transit*; and No. 288 Document-*Recommendation on Prioritizing Urban Public Transit Economic Policies*. Figure 5-7 compares the timing of the three policies against increases of passenger transport volume on public transportation modes.

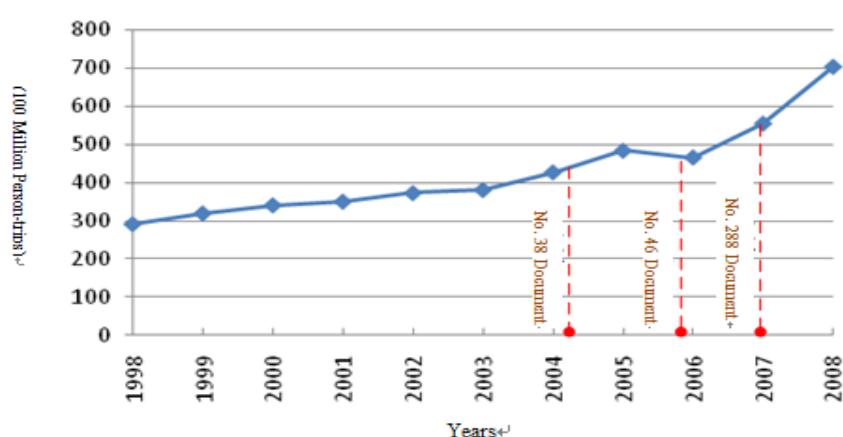


Figure 5-7 Public Transportation Passenger Volume Change

Public transportation prioritization policies helped to maintain and even consolidate public transportation’s primary role despite significant growth in China’s private car market, and thus helped conserve energy and reduce carbon emissions. Table 5-2 shows that compared to

private cars, public transportation can achieve a wide range of CO₂ emissions reduction impacts, which range from 23 million to 240 million tons CO₂ under different scenarios that depend on assumptions about public transportation share and the fuel structure of gasoline and diesel.

Table 5-2 Public Transportation CO₂ Reduction Effect under Different Scenarios

Scenarios	Fuel Structure of Gasoline and Diesel	When Public Transportation Share Rises %	CO ₂ Emission Reduction Rang (10kton)	CO ₂ Emission Reduction Median (10kton)
Scenario 1	Public Transportation : Gasoline 40%, Diesel 60%	1%	1497~3168	2333
Scenario 2		5%	7631~15956	11794
Scenario 3		10%	15298~31940	23619
Scenario 4	Public Transportation : Gasoline 30%, Diesel 70%	1%	1533~3197	2365
Scenario 5		5%	7667~15985	11826
Scenario 6		10%	15334~31970	23652
Scenario 7	Private Cars :Gasoline 100%	1%	1570~3226	2398
Scenario 8		5%	7703~16014	11859
Scenario 9		10%	15370~31999	23685

5.2.3 Rail Transit Development

Rail transit lags far behind road transport in terms of route length, net coverage, and passenger weight-distance transport. Long distance rail also faces strong competition from air transport. China revised its *Long and Medium-Term Plan for Railway Development* during the 11th FYP and adopted a strategy to lengthen rail routes and diversify channels for financing rail infrastructure construction. As of 2009, China had 86,000 kilometers of rail, the second longest track length of any country in the world. Newly constructed track includes 5557.3 kilometers of new route, 4128.8 kilometers of double track (to facilitate simultaneous freight and passenger transport), and 8448.3 kilometers of electrified track, constituting the biggest railway development in history. Some of the newly constructed high-speed rail has already out-competed commuter flight routes – our interviews with experts in this field indicated that many experts believe China's high speed rail for passenger transport within 800 km has great potential to outperform air transport.

China committed historic investments in rail infrastructure under the 11th FYP: fixed-asset investment increased over 60% and infrastructure construction investment increased 80% in both 2008 and 2009.

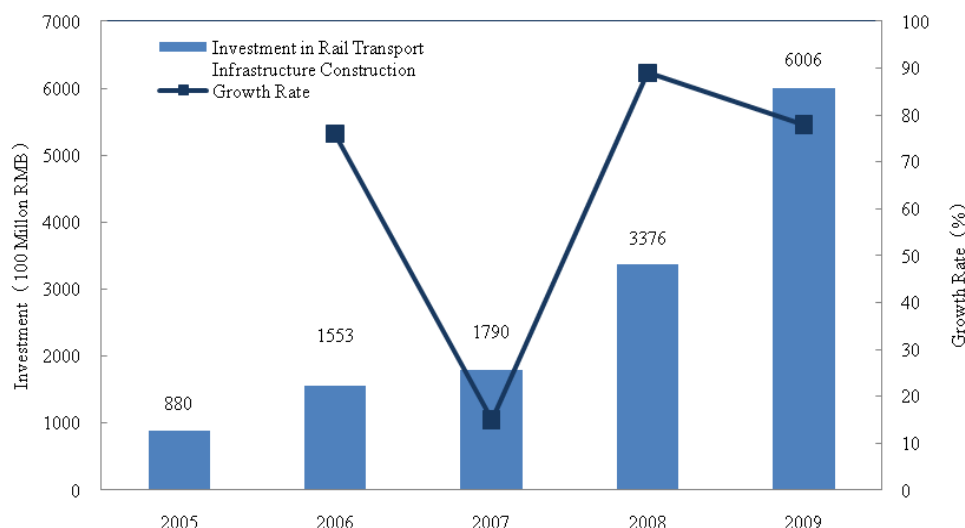


Figure 5-8 Railway Infrastructure Construction Investment

Transportation energy consumption and CO₂ emissions will continue to grow as the market for motor vehicles, especially private cars, grows in China. However, optimizing the transportation structure to ensure high and continued ridership of mass transit and long-distance rail, as well as controlling energy intensity through fuel economy regulations, have already proved to be effective means of energy conservation and CO₂ emissions reduction. Policies to control the structure of transportation and replace conventional fuels, such as the promotion of rail transit and new energy vehicles, saw preliminary development under the 11th FYP and are likely targets for further energy conservation and emissions reduction efforts.

6 THE AGRICULTURE AND FORESTRY SECTOR

The Agriculture and Forestry sectors are relatively small consumers of energy, but their impact on CO₂ emissions is significant. Agriculture is the only sector in which direct energy-related emissions declined during the 11th FYP period. While non-CO₂ greenhouse gas emissions were stable, CO₂ emissions embedded in fertilizer production grew, leading to a small net increase in overall agriculture-related greenhouse gas emissions. China's forestry development, especially large-scale afforestation, contributed significantly to the building of carbon sinks, adding 420MtCO₂ per year on average to the current stock, an amount nearly four times the CO₂ emission from direct fossil fuel combustion in agriculture and forestry. In 2009, forest coverage reached 20.4%, which enabled China to achieve its 11th FYP target for forest coverage ahead of time. Carbon sequestration projects expanded accordingly. The 7th general survey for forestry (2004~2009) showed that China's carbon sink in forestry amounted to 22,290MtCO₂, an increase of 10.4% compared to the 6th survey period (1998~2003).

6.1 GHG Emissions from Agriculture and Forestry

Greenhouse Gas (GHG) emissions from the agriculture and forestry sector do not merely include fossil energy related CO₂, but also methane (CH₄) and nitrous oxide (N₂O) emissions. In addition, the use of fertilizers, pesticides, and agricultural machinery promotes the development of upstream industries and results in indirect embodied CO₂ emissions (Figure 6-1).

Complicating the picture further, properly managed forests and agricultural land can serve as carbon sinks, actually absorbing CO₂. Therefore, analysis of the climate impacts of the agriculture, grassland, and forestry sector must include both direct and indirect CO₂ emissions, CO₂ absorption, and other GHG emissions. China's agriculture and forestry sector made notable progress in both the reduction of GHG emissions and an increase of carbon sinks under the 11th FYP, during the period of 2006 to 2008.

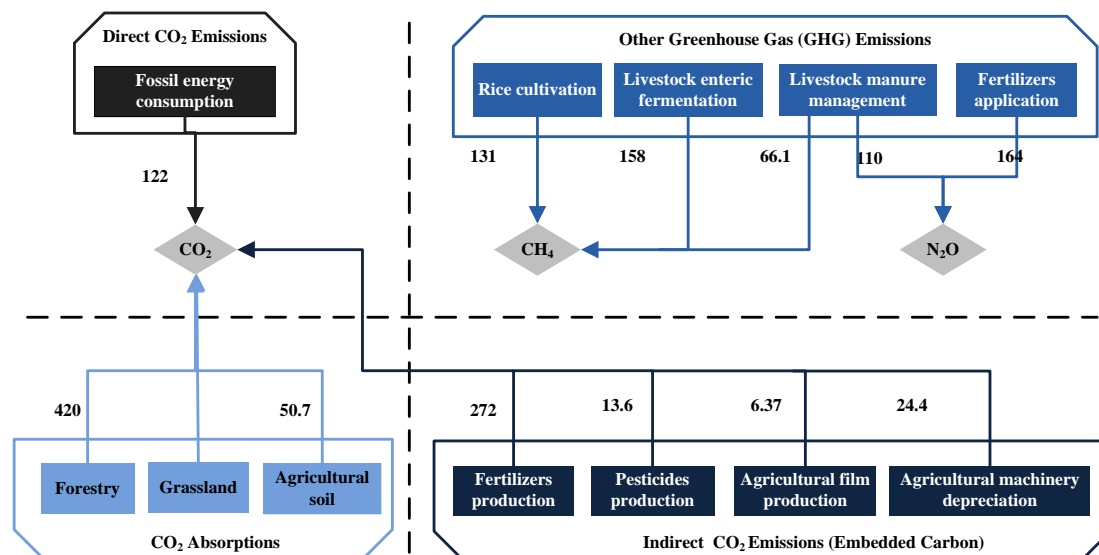


Figure 6-1 GHG emissions and absorptions of the agriculture and forestry sector

Note: The numbers in the figure represent the GHG emissions or CO₂ absorption associated with various aspects of the agriculture and forestry sector in China in 2008. Unit: MtCO₂-eq.

6.2 Performance evaluation of GHG emissions reduction

6.2.1 Energy consumption and energy related CO₂ emissions

In 2008, the agriculture and forestry sector in China consumed 35.1Mtce of fossil energy, 2.17% less than that consumed in 2005. Direct energy-related CO₂ emissions were 122MtCO₂ in 2008, the same level as that in 2005. In terms of energy intensity, an obvious reduction was observed. Energy intensity per agricultural added value decreased 15% in three years, from 160kgce/10⁴RMB in 2005 to 136kgce/10⁴RMB in 2008 (Figure 6-2).

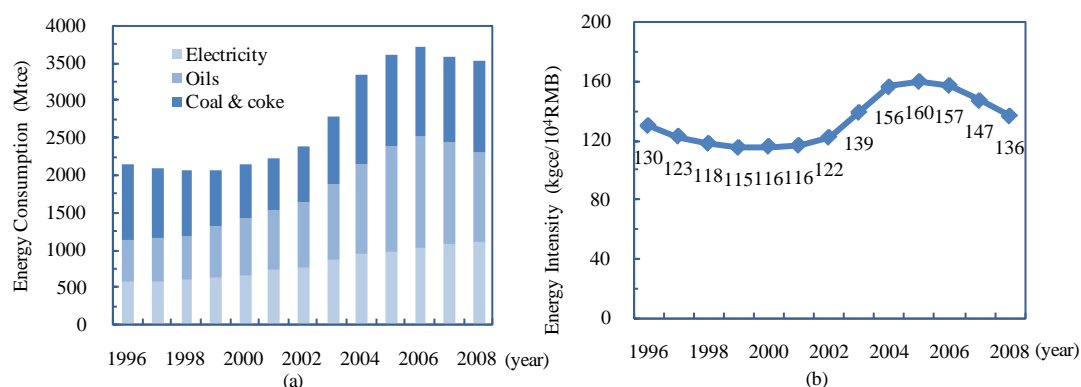


Figure 6-2 Energy consumption and intensity of the agriculture and forestry sector in China (a) Energy consumption; (b) Energy Intensity

6.2.2 CH₄ and N₂O emissions

Total CH₄ and N₂O emissions remained stable from 2000 to 2008. Total emissions were 629MtCO₂-eq in 2008, 5.2 times the level of direct energy related CO₂ emissions. Absolute emissions of CH₄ and N₂O have increased slowly, by 0.35% per year between 2000 and 2008. The slight decrease in CH₄ emissions is attributable to a reduction of livestock enteric fermentation of CH₄. By contrast, N₂O emissions increased rapidly, by 11.9% between 2000 and 2008. This growth in N₂O emissions is primarily due to increased use of fertilizers (Figure 6-3).

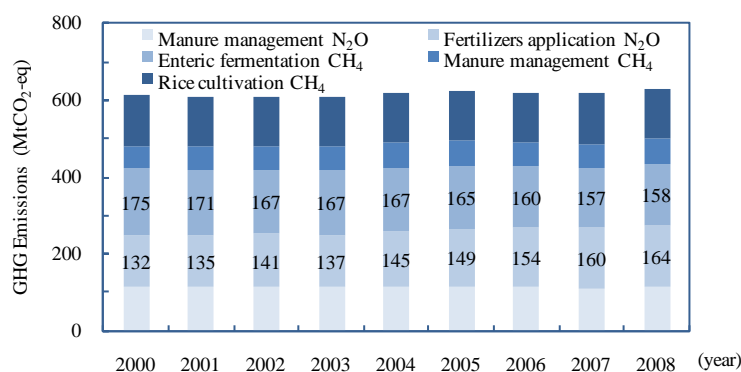


Figure 6-3 CH₄ and N₂O emissions from various sources of the agriculture and forestry sector in China

(Note: Rice cultivation CH₄ emissions adopted for Wang et al. (2009)⁷. Calculation methods of the others adopted for Tier1 in “2006 IPCC Guidelines for National Greenhouse Gas Inventories”.)

⁷ Wang Ping et al., 2009. Estimates of Methane Emission from Rice Paddies in China over the Period 1955-2005. *Advances in Climate Change Research*, 5(5): 291-297(Chinese).

6.2.3 Indirect embedded CO₂ emissions

Indirect embedded CO₂ emissions from agricultural means of production continued to increase between 2000 and 2008. Indirect embedded CO₂ emissions from the agriculture and forestry sector in China were 317MtCO₂-eq in 2008, 10.1% higher than 2005 levels and about 2.6 times higher than direct CO₂ emissions from the sector. Agricultural machinery and fertilizers accounted for the vast majority, or 93.7%, of total embedded CO₂ emissions (Figure 6-4).

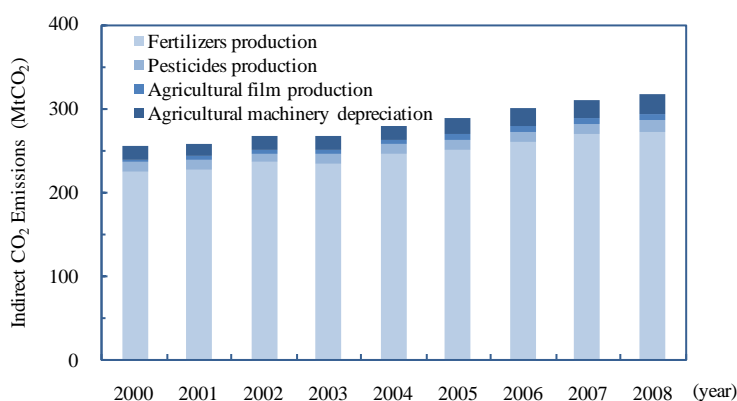


Figure 6-4 Indirect embedded CO₂ emissions of the agriculture and forestry sector in China

6.2.4 GHG emissions from fertilizers

GHG emissions from fertilizers are the leading source of agriculture and forestry sector emissions. This includes both indirect embedded CO₂ emissions from fertilizer production as well as N₂O emissions from fertilizer application. Fertilizer-related GHG emissions topped 436MtCO₂-eq in 2008, or roughly 40% of the total emissions from the agriculture and forestry sector, representing an 8.71% increase between 2005 and 2008. Nevertheless, the emissions intensity of fertilizer-related GHG emissions dropped in recent decades, from 9.85tCO₂-eq/t in 1980 to 8.32tCO₂-eq/t in 2008, a decrease of 15.5% during the 28-year period. This emissions intensity decrease is attributable to the falling percentage of nitrogen fertilizers as a share of total fertilizer application (Figure 6-5).

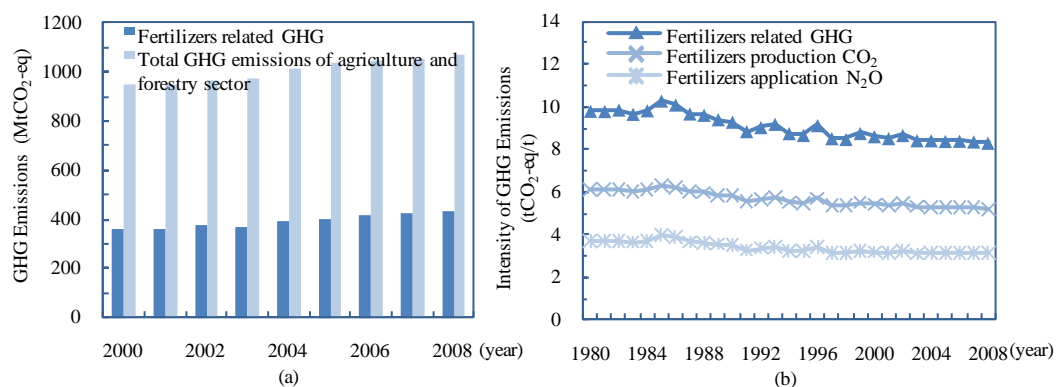


Figure 6-5 Fertilizer-related GHG emissions and corresponding intensity (a) Fertilizer-related GHG emissions; (b) Intensity of fertilizer-related GHG emissions

6.2.5 Forest and agricultural soil carbon sinks

Forest coverage increased from 13.9% of China's total area in 1994 to 20.4% in 2009. Data from China's Seventh Comprehensive Forest Survey (2004-2009) showed that forest carbon sequestration was approximately 22,290MtCO₂, 10.4% higher than levels estimated during the Sixth Forest Survey (1998-2003). The average annual carbon sequestration rate was roughly 420MtCO₂/a during the period from 2004 to 2009, or about 3.4 times the direct energy-related CO₂ emissions of the agriculture and forestry sector in 2008. China has one of the highest rates of afforestation in the world – China's afforestation rate topped 30% during the Seventh Forest Survey. Carbon storage associated with afforestation efforts reached 3723MtCO₂/a during the period of 2004 to 2009, with a 177MtCO₂/a carbon sequestration rate.

Research suggests that no-till farming practices and straw management can increase the levels of organic matter in agricultural soil as a form of carbon sequestration. Total carbon sequestration of agricultural soil under no-till farming reached 16.5MtCO₂ in 2008, a 95.4% increase over 2005. Organic carbon sequestration due to straw return management reached about 34.2MtCO₂ – a 17.5% increase from 2005 to 2008.

6.3 Policies in the Agriculture and Forestry Sector

The use of fertilizers and agricultural machinery – considered indicators of agricultural modernization – are major drivers of GHG emissions from the agriculture and forestry sector. While there were no climate-specific policies targeting this sector, national policies on environmental protection and agricultural land conservation may have had an effect on GHG emissions reductions. Further, improvements in the energy efficiency of agricultural machinery, replacing draft animals with mechanized alternatives, and increased use of compound fertilizers replacing nitrogen fertilizers, were all important in the effort to reduce GHG emissions from this sector (Figure 6-6).

6.3.1 Six major forest projects

Over the last decade, China's government has greatly increased efforts to protect the environment, ecology, and natural resources, with particular emphasis on the forestry sector. Six major forest projects – the Natural Forest Protection Project (NFPP), Conversion of Farmland to Forests Project (CFFP), Wind and Sand Storm Source Control Project (WSSSCP), Three Northern and Yangtze River Basin Shelter Forest Systems Project (TYRBSFSP), Fast Growth, High Yield Forests Project (FHFP), and Wildlife and Nature Reserve Establishment Project (WNREP)—achieved a total afforestation area of 38 million hectares from 2000 to 2008. As a result, between 2006 and 2008 alone, CO₂ sequestration from afforestation projects averted a cumulative 407MtCO₂ emission.

6.3.2 Conservation tillage and straw return policy

The Chinese government has energetically promoted conservation tillage (primarily consisting of no-till farming) as well as straw return management since 2005. China's no-till farming area has grown from 5.83 million hectares in 2005 to 11.4 million hectares in 2008, nearly doubling in just 3 years. Farming acreage employing straw return management techniques grew from 19.3 million hectares in 2005 to 22.8 million hectares in 2008. Our estimates suggest that cumulative soil carbon sequestration achieved through no-till farming and straw return management were 39.3MtCO₂ and 98.3MtCO₂ during the period of 2006 to 2008, respectively.

6.3.3 Agriculture mechanization

China faces a dual challenge of modernizing agricultural production while striving to prevent growth in energy intensity and emissions from the agricultural sector. In order to promote mechanization in agriculture, the Chinese government has extended a number of subsidies for agricultural machinery purchases since 2004. The subsidy policy incentivizes the purchase of machinery that is versatile (multi-use), large-scale, and highly efficient. National government statistics indicate that intensity of diesel fuel consumption per kilowatt for diesel engines decreased from 26.2kgce/kW in 2005 to 18.4kgce/kW in 2008. Based on 2005 levels, this suggests that the promotion of agriculture mechanization with improved efficiency diesel engines created a cumulative energy savings of 7.75Mtce diesel fuel and cut 16.7MtCO₂ emissions between 2006 and 2008. Although the promotion of agricultural machinery increased total energy consumption in the agriculture and forestry sector, mechanization does help to cut CH₄ and N₂O emissions via a reduction in the population of draft animals, which are replaced by agricultural machinery. The motive power of agricultural machinery increased 120% between 1996 and 2008, while the draft animal population decreased by 40%. Using 1996 GHG emissions as a baseline, agricultural machinery increased energy-related CO₂ emissions by an estimated 39.2MtCO₂ while reducing draft-animal-related GHG emissions by 51.6MtCO₂-eq in 2008.

6.3.4 Soil testing and formulated fertilization

China has promoted an aggressive campaign for soil testing and formulated fertilization since 2005, whereby agricultural extension gives farmers detailed technical information about how to most effectively address their soil conditions. Farmers are enthusiastic about this program, as it enables them to fertilize rationally, save expenditure, and increase food production while reducing N₂O emissions. China's government has greatly increased support and expanded the scope of subsidies for this program in recent years – from 10 million families (3.33 million hectares) in 2005 to 150 million families (66.7 million hectares) in 2009. We estimated That, between 2006 and 2008, this program averted 2.8 million tons of unnecessary fertilizer application, representing a GHG emissions reduction of 24.1MtCO₂-eq.



National policy on energy saving & emission reduction

A notification in respect of doing the recent work well of building energy saving society (State Council [2005] No.21)

A decision in respect of enhancing energy saving work (State Council [2006] No.28)

A notification in respect of issuing "Energy saving & emission reduction comprehensive task" (State Council [2007] No.15)

Energy Conservation Law of the People's Republic of China (Presidential Order No.77, implemented on 04/01/2008)

Sector policy on energy saving & emission reduction

Policy fighting against climate change

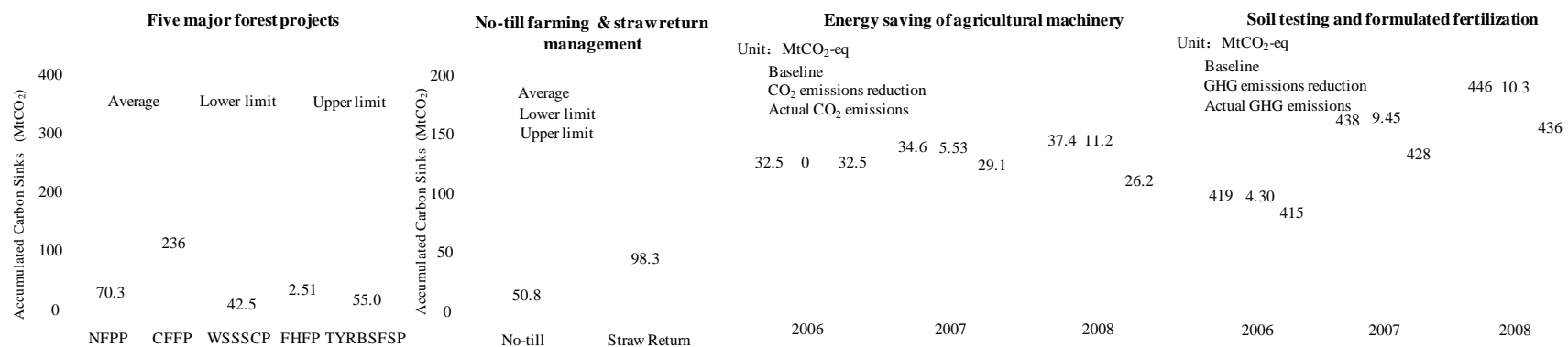


Figure 6-6 Major policies related to energy saving, emission reduction, fighting against climate change and the policy evaluation results, 2006 – 2008

Descriptors

CPI Area of Focus: Low-Carbon Growth

Sectors: Power, Industry, Building, Transport, Agriculture and Forestry

Region: China

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About CPI

Climate Policy Initiative (CPI) is a policy effectiveness analysis and advisory organization whose mission is to assess, diagnose and support the efforts of key governments around the world to achieve low-carbon growth. CPI is headquartered in San Francisco and has research centers around the world which are affiliated with distinguished research institutions. Research centers include: CPI at Tsinghua, affiliated with the School of Public Policy and Management at Tsinghua University; CPI Berlin, affiliated with the Department for Energy, Transportation and the Environment at DIW Berlin; CPI Rio, affiliated with Pontifical Catholic University of Rio (PUC-Rio); and CPI Venice, affiliated with Fondazione Eni Enrico Mattei (FEEM). CPI is an independent, not-for-profit organization which receives long-term funding from George Soros.

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