
Analyzing Energy Conservation and Carbon Emissions Reductions of China's 11th FYP Plan

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Abstract

Energy security remains high on the Chinese central government agenda to ensure sustained social and economic development because the dependency rate of (the share oil import in total oil consumption) got to 56% in 2010. To reduce energy import dependency and maintain stability of the international energy market, China adopted measures to encourage the exploitation of domestic energy resources, especially increased usage of natural gas and renewable energies to combat climate change. Consequently, the self-sufficiency rate of energy supply has remained at about 90% since 2000, which implies a majority of its energy supply comes from domestic sources. Meanwhile, China has been conducted policies of energy conservation and carbon emissions reductions in the 11th FYP Plan and made great progress.

Keywords

Energy conservation • Energy dependency • Energy structure • Energy security

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2.1 General Assessment on Energy Development and Emissions Reductions During 11th FYP Period

During the 11th Five Year Plan (2006–2010) China witnessed rapid development in the energy sector. While its energy supply capacity reached historic levels, the nation made significant progress in energy-savings, pollutant emissions reductions and realized steady improvement of energy technologies.

Global energy cooperation with the PRC has entered a new stage of boosting domestic energy supply, as well as new opportunities and development for other countries.

2.1.1 Enhanced Energy Supply Capacity

Energy security remains high on the central government agenda to ensure sustained social and economic development.

To reduce energy import dependency and maintain stability of the international energy market, Beijing has adopted measures to encourage the exploitation of domestic energy resources, especially increased usage of natural gas and renewable energies to combat climate change.

Total energy production has risen from 2.16 billion ton of coal equivalent (tce) in 2005 to 2.97 billion tce in 2010 (see Fig. 2.1), which has made the country the largest energy producer in the world since 2008.

Consequently, the self-sufficiency rate of energy supply has remained at about 90 % since 2000, which implies a majority of its energy supply comes from domestic sources.

According to energy statistical institutions, China holds the lowest energy dependency among the world's large economies (see Table 2.1), although its dependency rate for petroleum has risen in recent years.

2.1.2 Optimized Energy Structure

Another effective approach to fight climate change would be to develop low-carbon or carbon-free energy. Policies and actions have been adopted to promote efficient and clean energy development.

Significant progress has been made in adjusting the energy mix and developing clean or renewable energies such as hydropower, nuclear power, wind and other modes.

Since China entered into the stage of rapid industrialization and urbanization, energy demand has risen dramatically. To meet booming demand for energy, coal still plays a dominant role from the viewpoint of domestic resources.

Coal can meet short-term demands: Coal production has increased from 2,350 Mt in 2005 to 3,235 Mt in 2010 (see Fig. 2.2), the share of coal is above 76 % in the primary energy production structure (see Table 2.2).

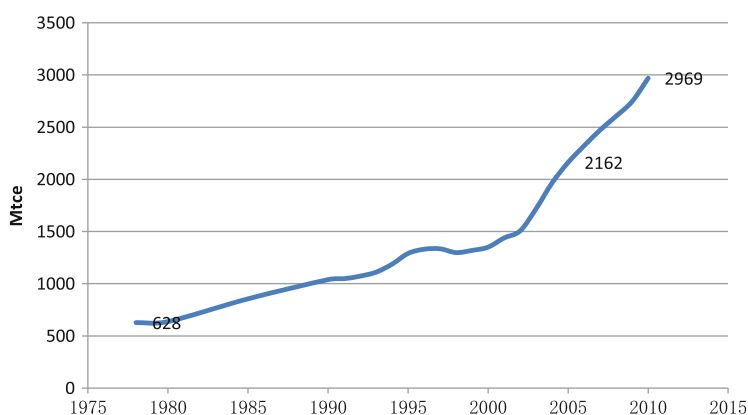


Fig. 2.1 China's primary energy production from 1978 to 2010 (Source: China Energy Statistical Yearbook)

Table 2.1 Energy self-sufficiency rate and net imported energy in selected countries

	Energy self-sufficiency rate (%)			Net imported energy/Mtoe		
	2000	2008	2010	2000	2008	2010
China	96	92	91.4	47.2	193.5	368
US	72.8	74.7	77.8	607.7	631.6	534
Japan	20.1	17.7	19.5	427.8	415.7	409
Germany	39.4	39.8	40.1	205.7	211.4	203
UK	116.5	80.5	73.5	-40.1	56.7	61
France	51.9	51	51.7	132.6	140.5	132
Italia	16.3	15.5	17.5	152.4	154.9	148
Russia	157	183	184.3	-408.8	-544.4	-579
India	79	76	74.8	31.7	150.0	181
Brazil	77	92	92.9	38.9	24.8	-
Korea	18.3	19.7	18.0	165.7	194	221
OECD	71.8	70.8	71.8	1532	1774.3	3879

Source: IEA, Energy Balances of OECD Countries, Energy Balances of Non-OECD Countries

Note: TOE is the abbreviation of ton of oil equivalent

Nevertheless, natural gas and renewable energies have grown quickly while petroleum production remains stagnant, due to limited resources.

The share of natural gas has increased from 3 % in 2005 to 4.2 % in 2010 in the mix of energy production, and the share of primary electricity consisting of hydropower, nuclear power and renewable energy such as wind and solar has increased from 7.4 % in 2005 to 9.4 % in 2010.

The share of low-carbon and carbon-free energy in the production structure increased by 3.2 % (see Fig. 2.3).

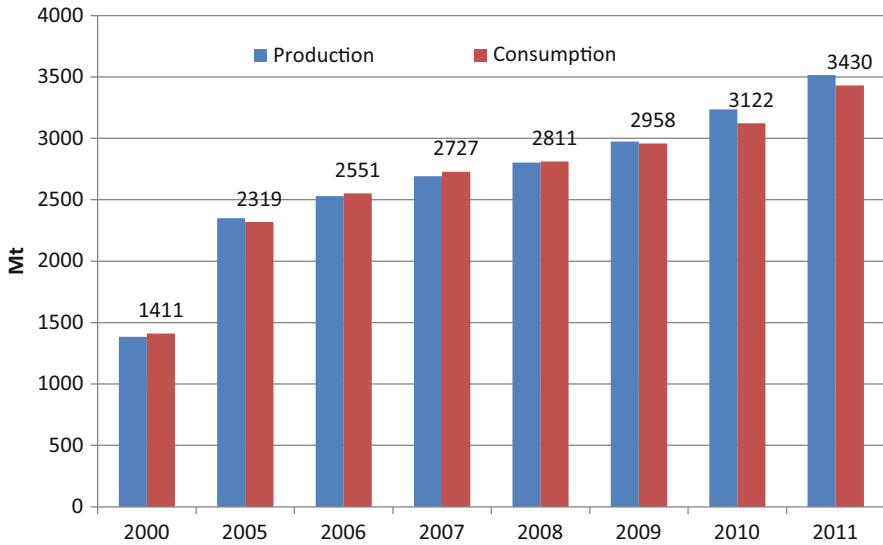


Fig. 2.2 Coal production and consumption from 2000 to 2010 (Source: China Energy Statistical Yearbook [2])

Table 2.2 Coal share of primary energy production and consumption structure

	Coal share of primary energy production structure (%)	Coal share of primary energy consumption structure (%)
2000	73.2	69.2
2001	73.0	68.3
2002	73.5	68.0
2003	76.2	69.8
2004	77.1	69.5
2005	77.6	70.8
2006	77.8	71.1
2007	77.7	71.1
2008	76.8	70.3
2009	77.3	70.4
2010	76.6	68.0
2011	77.8	68.4

Source: China Energy Statistical Yearbook [2]

During the 11th FYP, the capacity of under-construction and installed hydropower expanded rapidly; total installed capacity has exceeded 200 GW. The construction nuclear power capacity has reached 30.97 GW, 40 % of the world total.

In the past 5 years, installed capacity of wind power grew to 44.7 GW in 2010 from 12.7 GW in 2005 and only 3.4 GW in 2000. With explosive growth of the

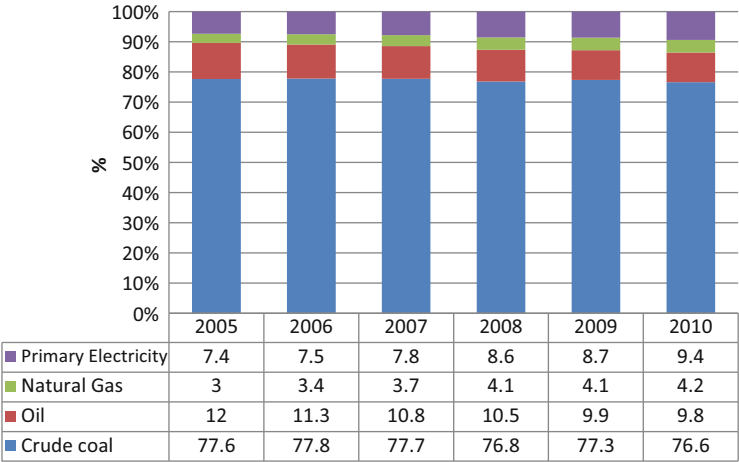


Fig. 2.3 Primary energy production structure for 11th FYP (Source: China Energy Statistical Yearbook [2])

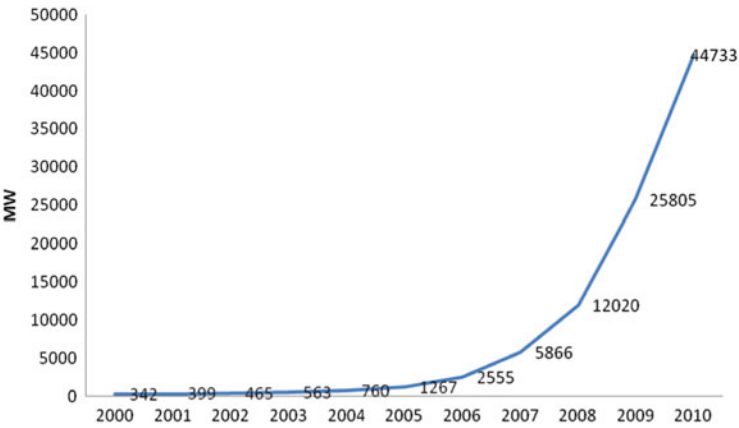


Fig. 2.4 The development of wind power in China (Source: China Wind Energy Association (CWEA))

wind industry, it has become the largest country for installed wind capacity (see Fig. 2.4).

According to statistical data from the China Electricity Council, wind power capacity connected to the power grid has reached 31 MW.

However, to slow down carbon emissions of carbon, more efficient energy has been consumed to decrease the coal share in primary energy consumption structure.

The nation has imported more than half of its total oil consumption, which accounts for 19.0 % of primary energy consumption in 2010, 9.2 % age points more than its share of primary energy production (see Fig. 2.5).

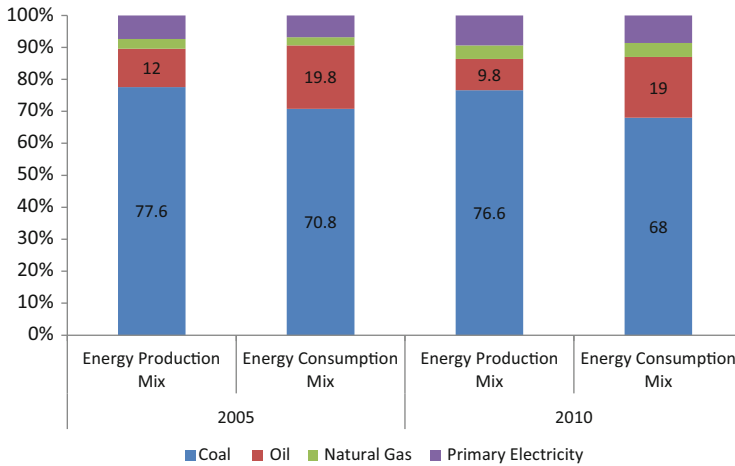


Fig. 2.5 Comparison of energy production and energy consumption mix in China (Source: China Energy Statistical Yearbook [2])

The corresponding coal share of primary energy consumption in 2010 was 8.5 % points lower than its share of primary energy production.

The optimization of energy production and consumption structure has contributed much to the realization of energy-savings and emissions reductions targets.

2.1.3 Energy Conservation and Environmental Protection Achievements

The national economy grew at an average rate of 11.2 % during the 11th FYP period, while the growth rate of energy consumption was only 6.6 % (see Fig. 2.6). The energy consumption elasticity coefficient¹ declined from 0.93 in 2005 to 0.57 in 2010 (see Fig. 2.7).

In contrast, the energy consumption elasticity coefficient in developed economies always exceeded 1 during the historical period when they entered into a stage of rapid industrialization and urbanization.

The lower growth rate of energy consumption supported the strong expansion of economic activities, which has alleviated a contraction of energy supply and demand, reversing trends of increased energy intensity of GDP that occurred in

¹ Energy consumption elasticity coefficient is an indicator to reflect the relation of energy consumption and economic activities expansion, which is the ratio of the growth rate of energy consumption and GDP. If the energy consumption elasticity coefficient is more than 1, it means the growth rate of energy consumption is faster than that of GDP.

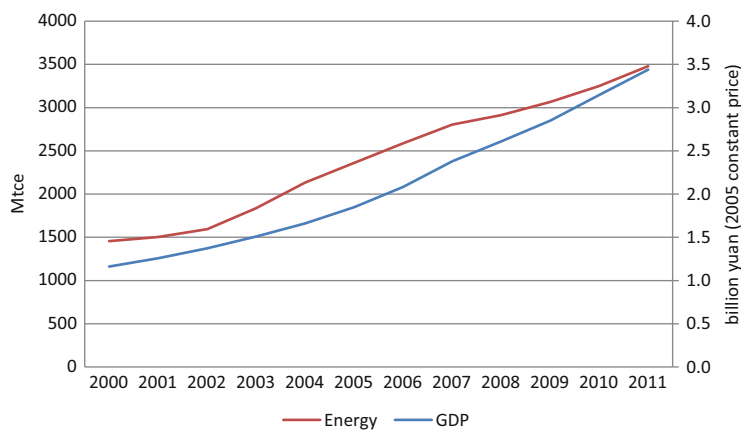


Fig. 2.6 Comparison of energy consumption and GDP in China from 2000 to 2011 (Source: China Energy Statistical Yearbook [2])

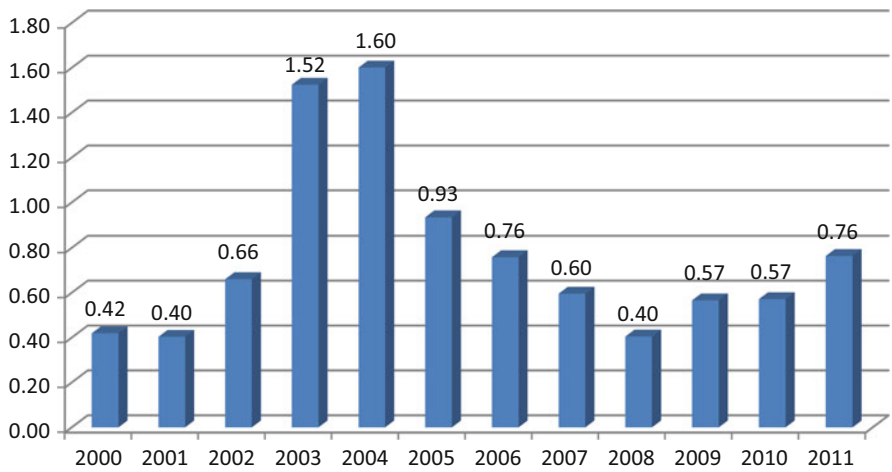


Fig. 2.7 Energy consumption elasticity coefficient in China from 2000 to 2011 (Source: China Energy Statistical Yearbook [2])

the last 3 years of the 10th FYP and slowed down the growth rate of carbon emissions as well.

According to the statistical data, the energy intensity of the economy decreased from 1.28 tce/10,000 RMB in 2005 to 1.03 tce/10,000 RMB in 2010, based on constant 2005 prices, and the decrease in energy intensity during the 11th FYP was about 19 %, meeting the anticipated target of about 20 % set by Beijing.

Table 2.3 Accumulated energy-saving and fixed energy-saving during the 11th FYP

	GDP ^a (billion RMB Yuan)	Energy (Mtce)	Energy intensity (Tce/10K RMB Yuan)	Energy-saving (Mtce)
2005	18.49	2,360	1.276	–
2006	20.84	2,587	1.241	72.3
2007	23.79	2,805	1.179	148.1
2008	26.08	2,914	1.117	160.8
2009	28.48	3,066	1.077	116.6
2010	31.43	3,250	1.033	137.3
Accumulated energy-saving during the period of 2006 and 2010				635
Fixed energy-saving of 2006 and 2010				765

Source: China Energy Statistical Yearbook [2]

Note: ^aUsing 2005 constant prices

The accumulated amount of energy savings² amounted to 635 Mtce, while fixed energy savings³ amounted to 765 Mtce (see Table 2.3, the difference of accumulated energy-savings and fixed energy-savings could be shown in Fig. 2.8).

Accumulated carbon reductions totaled 1.46 billion tons CO₂, which made great contributions for tackling global climate change and won widespread praise.

In terms of local environmental quality improvements, emissions of sulfur dioxide decreased 14 % by the end of 11th FYP and the Chemical Oxygen Demand (COD) COD decreased 10 % compared with 2005; which exceeded established targets.

2.2 Quantitative Analysis of Energy-Savings Targets

Beijing launched an ambitious target of 20 % of energy-savings and pollution reductions for the 11th FYP as a mandatory indicator for local governments.

The Chinese government has utilized command, law and economic measures to promote energy conservation and efficiency improvements as well as pollution reductions.

This section will evaluate the fulfillment of established energy-intensity and pollution reduction indicators to sort out the factors of influence and analyze the main contributors and roles of selected policies and actions to achieve energy and environmental targets.

²The accumulated energy-saving is calculated as the following formula: $ES_{i \sim n} = \sum_{i=1}^n (EI_i - EI_{i+1}) * GDP_{i+1}$, here $ES_{i \sim n}$ is referred as the accumulated energy saving during the period of year i to year n , EI_i is referred as the energy intensity of year i , GDP_{i+1} is referred as the GDP of year $i+1$.

³The fixed energy-saving is calculated as the following formula: $ES_{2005-2010} = (EI_{2005} - EI_{2010}) * GDP_{2010}$, here the equals to the fixed energy-saving during the period of 2005 and 2010, equals to energy intensity of 2005 and 2010 respectively, GDP_{2010} equals to the GDP of 2010.

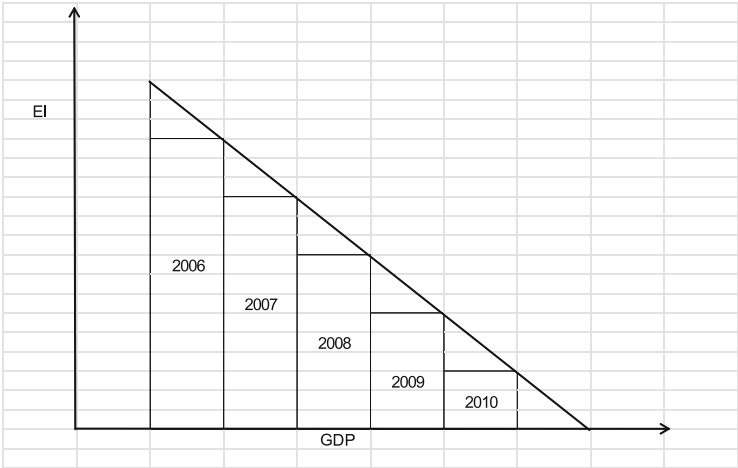


Fig. 2.8 Schematic map of accumulated and fixed energy-savings of 11th FYP. Note: the accumulated energy-saving is the sum of square 2006 to square 2010, while fixed energy-savings is the triangle of 2006 to 2010. The horization axis is the GDP and the vertical axis is referred as energy intensity

2.2.1 Actual Performance of Energy Intensity

Since the energy intensity indicator is a function of energy consumption and the GDP, whether the energy-intensity target for the 11th FYP was achieved depends on GDP and energy consumption from the year before.

In early 2011, Beijing released the 2010 Statistics Bulletin of the National Economic and Social Development of the People’s Republic of China.

The National Development and Reform Commission (NDRC) launched the preliminary assessment of energy intensity and carbon emission indicators of the 11th FYP in March 2011 and the State Council issued the *Energy Conservation and Emission Reduction Planning of 12th FYP* in August 2012.

Based on the official assessment on Energy-saving and Emission Reduction Efforts during the 11th FYP, the energy intensity reduction amounts to 19.1 % (see Fig. 2.9); the accumulated energy savings exceeded 0.6 billion tce, which amounts to 1.4 billion tons of CO₂ reductions.

As mentioned-above, the energy intensity was reduced by 19.06 % in 2010 compared with 2005 and the accumulated energy-savings was about 635 Mtce, based on the latest data from the China Statistical Yearbook of 2012.

Looking at year-on-year energy intensity improvements based on the latest information,⁴ it can be found that the nation reversed its backward momentum of energy intensity obviously in 2006, when it declined by 2.72 %; in the next 2 years,

⁴ China Energy Statistical Yearbook [2].

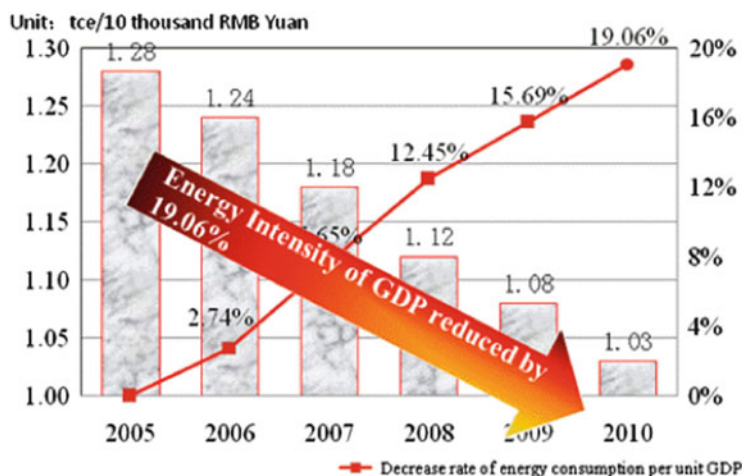


Fig. 2.9 Improvement of energy intensity of GDP during the 11th FYP (Source: National Bureau of Statistics of China [3])

the energy-intensity improvement rate advanced to 5.02 % and 5.23 % decline rates in 2007 and 2008, respectively.

Affected by the global financial crisis, Beijing implemented a stimulus spending package worth 4 trillion RMB, mainly flowing to infrastructure and manufacturing projects.

This contributed to a slowdown in the rate of decline in energy intensity to only 3.66 % in 2009 and 4.05 % in 2010 (see Fig. 2.10).

Nevertheless, the energy-intensity improvement target has been achieved. No matter whether it is 19.06 % or even lower, it is still in the 20 % range.

Moreover, the 20 % energy-intensity reduction target was in the context of an expected annual GDP growth rate of 7.5 % for the 11th FYP. Accomplishing a 19 % decline in energy intensity appears more remarkable since the actual GDP growth rate stood at 11.2 %.

It is shown in Table 2.4 that fixed energy-savings under 7.5 % GDP and 20 % energy-savings were about 678 Mtce while fixed energy-savings were 760 Mtce under the real case, i.e., with average annual GDP growth of 11.2 %.

Compared to estimates in the 11th FYP, an additional 87 Mtce must be saved to achieve a 19.1 % reduction that was achieved in reality.

Energy consumption per unit produced was decreased, along with unprecedented reductions in energy consumption per unit production for copper smelting and caustic soda (both reduced by 35 %), cement and crude oil (both reduced by 28 %), standard coal consumption for power plants, steel, electrolytic aluminum, and ethylene (all dropped by more than 10 %).

Calculating by unit product energy consumption reductions, energy savings exceeded 0.3 billion tce. Making technical improvements in energy intensive industries has contributed much to the realization of meeting energy-savings and emissions reductions targets.

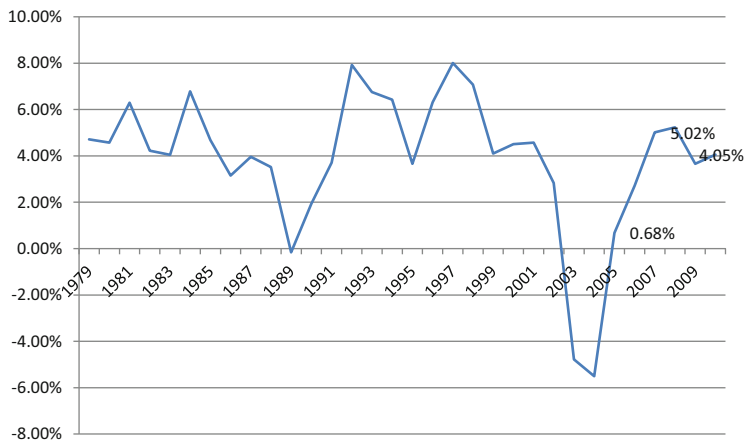


Fig. 2.10 Annual energy intensity improvement from 1979 to 2010 (Source: China Energy Statistical Yearbook [2])

Table 2.4 Comparison of target and current status for 11th FYP

	11th FYP target	Reality
Annual growth rate of GDP (%)	7.5 %	11.2 %
GDP in 2005 (trillion RMB)	18.49	18.49
Energy intensity in 2005 (tce/10k RMB)	1.276	1.276
Improvement rate of energy intensity (%)	20	18.96
GDP in 2010 (based on 2005 constant price, trillion RMB Yuan)	26.55	31.46
Energy intensity in 2010 (tce/10k RMB Yuan)	1.021	1.033
Total fixed energy-savings (Mtce)	678	765

2.2.2 Methodology on Potential Energy-Savings Analysis

The potential energy-savings is based on the improvement of energy intensity of GDP or energy consumption per unit GDP, which is the ratio of energy consumption to GDP.⁵

Various factors can affect energy intensity, including economic and social factors, as well as the energy consumption structure and local condition such as climate and land area [6].

Many incomparable elements could impact energy intensity among different countries and regions due to a different economic development phase, energy consumption structure, natural conditions and even the foreign exchange rate.

Two approaches could be taken to improve energy efficiency or energy savings—structure optimization and technical improvements.

⁵ Dai, Yande. et al. [5].

Economic optimization can be divided into structures of economic, industrial, sector and products.

Potential energy savings come from the adjustment of the energy-efficient industry/sector/product replacing the energy-intensity industry/sector/product and increasing its share.

Technical improvements could be taken as the direct method to improve energy efficiency and save energy based on the manufacture/product level. It could be shown as the following Formula (2.1):

$$e = \frac{E}{G} = \frac{E_G + E_R}{G} = \sum \left(\frac{E_i}{G_i} * \frac{G_i}{G} \right) + \frac{E_R}{G} = \sum (ie_i * p_i) + \frac{E_R}{G} \quad (2.1)$$

Where,

e = Energy intensity or energy consumption per unit GDP

E = Energy consumption

G = GDP

E_G = Energy consumption of industrial sector

E_R = Energy consumption of residential sector

ie_i = Energy intensity of subsector i

p_i = Share of subsector i 's GDP relative to national GDP

From the decomposition of energy intensity, it can be determined that three factors can affect energy intensity: the energy intensity or energy efficiency level of individual subsectors, GDP share of individual sectors and residential energy consumption status.

Among these, energy intensity or energy efficiency level could be the technical improvement factor and the GDP share of the individual sector could be taken as the structural factor.

For the industrial sector, potential energy-savings could be analyzed by the following formula:

$$\begin{aligned} \Delta E_m &= (G_m) * [(ie_m)_0 - (ie_m)_t] \\ &= \sum_{i=1}^n \{ (P_{mi})_t * [(pe_{mi})_0 * (pe_{mi})_t] \} \\ &\quad + \sum_{i=1}^n \{ (v_{mi})_0 * (ie_m)_0 - (pe_{mi})_0 * [(pe_{mi})_t * (pe_{mi})_0] \} \\ &\quad + \sum_{i=1}^n \{ (ie_m)_0 * [(v_{mi})_t - (v_{mi})_0] * (pe_{mi})_t \} \end{aligned} \quad (2.2)$$

Where,

ΔE_m refers to the energy-savings of industry m

G_m refers to GDP of individual industry m

ie_m refers to energy intensity of individual industry m

P_{mi} refers to the production of product type i of individual industry m

pe_{mi} refers to per unit energy consumption of product type i of individual industry m

v_{mi} refers to the embodied GDP of product type i of individual industry m

t refers to the forecast year

0 refers to the base year

The energy-savings of industry m is composed of three items from Formula 4.2: the technical energy-savings from the variation in the energy efficiency⁶ of individual product type i , the last two items being the energy-savings from structural change of industry m , one item being the energy-savings from the change of product structure of industry m and the other item being the energy-savings from the change of embodied GDP of product type i of individual industry m .

For the residential sector, it could be calculated by the following Formula 2.3:

$$\Delta E_{\text{Res}} = (G_t) * \left[\left(\frac{E_R}{G} \right)_0 - \left(\frac{E_R}{G} \right)_t \right] \quad (2.3)$$

Where,

ΔE_{Res} refers to the energy-savings for the residential sector

$\frac{E_R}{G}$ refers to the ratio of residential energy consumption of GDP

t refers to the forecast year

0 refers to the base year

2.2.3 Potential Energy-Saving Analysis

The contributors and roles in realizing the energy-savings target for the 11th FYP were analyzed by domestic agencies⁷ in early 2011 based on above-mentioned methods.

According to their research, accumulated energy-savings was about 638 Mtce. Structural adjustment contributed 28.8 % of total energy-savings; the rest came from technological improvements (see Fig. 2.11).

For energy-savings through structural adjustments, the contributor from the industrial structure optimization stood at only 7.9 % (see Table 2.5), since the share of the secondary industry only declined by 0.5 % in 2010 compared with 2005 (see Fig. 2.12).

Meanwhile contributions from the structural adjustment of internal secondary industry, the internal tertiary industry and the internal major industry subsector are significant: 26.6 %, 29.6 % and 24.7 % respectively.

For energy-savings through technical improvements, the decline of energy consumption per unit output of major energy-intensive industrial products such as iron and steel, cement, electricity, chemical products, paper and so on is the largest contributor, accounting for 65.5 % of total technical energy-savings.

Accumulated energy-savings from improvements of energy efficiency of the above-mentioned industrial products amounted to 297.8 Mtce.

⁶ i.e., energy consumption per unit production.

⁷ Energy Research Institute (2011), Study on energy-saving evaluation of 11th FYP and perspective on potential energy-saving for 12th FYP, internal report.

Fig. 2.11 Contributors for energy-savings during the period of the 11th FYP

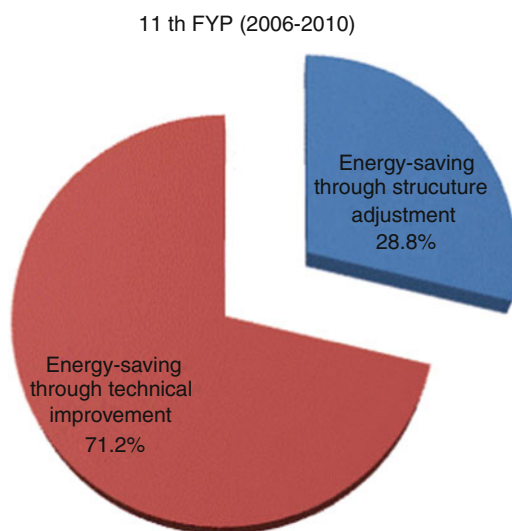


Table 2.5 Energy-savings and its contributions from structure change during 11th FYP

	Energy-savings (Mtce)	Contribution rate (%)
Industrial structure	1,451	7.9
Internal secondary industrial structure	4,896	26.6
Internal tertiary industrial structure	5,441	29.6
Internal industry sector structure	2,065	11.2
Internal industry subsector structure	4,538	24.7
Total	18,392	100

Note: The industrial structure is the mix of primary, secondary and tertiary; the internal secondary industrial structure is the mix of industrial sector and construction sector; the internal tertiary industrial sector structure is the mix of transportation, commercial and other service; the internal industry sector structure is the mix of 39 subsectors

Analyzing the energy-savings contribution by sector shows that the industrial sector played a key role in realizing the energy-savings target for the 11th FYP.

According to research results by ERI, accumulated energy-savings from the industrial sector amounted to 372 Mtce, a share of 58.3 %, while the structural adjustment, the commercial and residential sector, and the agriculture and construction sector contributed 18.5 %, 18.9 % and 5.2 %, respectively (Table 2.6).

Since the boom of the domestic auto market during the 11th FYP (see Fig. 2.13), road transportation fuel consumption, especially fuel use from the private car has increased dramatically. The annual growth rate of private car petroleum use grew by 16.4 % during the 10th FYP (see Table 2.7), 5.2% higher of GDP growth rate. Energy use from other transportation modes, which includes air transportation, also increased very quickly.

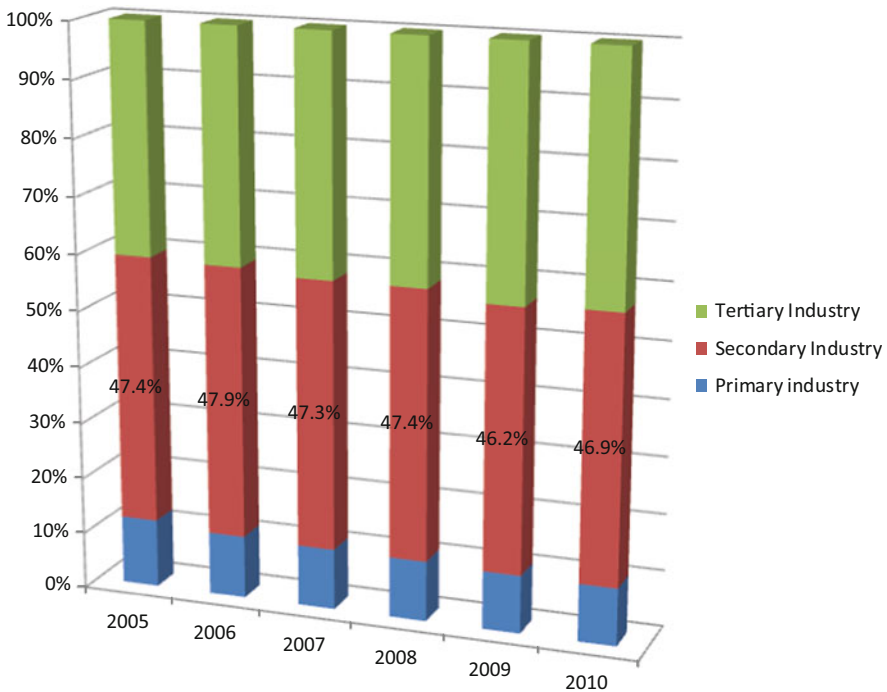


Fig. 2.12 Change of industrial structure from 2005 to 2010

Consequently, contributions from the transportation sector are negative, about -0.8% , although there is slight energy-savings from transportation mode optimization.

It should be emphasized that energy-savings from the industrial or sector levels included two components: energy-savings from structural adjustments and energy-savings from technical improvements.

Accumulated energy-savings from the industrial sector amounted to 372 Mtce; the contribution from energy efficiency improvements, i.e., technical innovations, amounted to 305.7 Mtce, taking a share of 82.2 %; the rest came from internal industrial sector and sub-sector adjustments (see Fig. 2.14).

Beijing implemented nation-wide energy-saving projects such as phasing out backward production capacity, carrying out Ten Key Energy Conservation Projects and Implementing Energy Conservation Action in Top 1,000 Enterprises.

According to evaluation results,⁸ energy-savings from the implementation of Ten Key Energy Conservation Projects amounted to 340 Mtce.

The energy-savings capacity of 180 Mtce was formed through the input of special funds on energy-savings and emissions reductions allocated by the central

⁸ Dai Yande and Bai Quan's [9].

Table 2.6 Energy-saving by sectors for 11th FYP

	Energy-savings (Mtce)	Contribution rate (%)
Industrial structure ^a	117.88	18.5
Industrial sector	371.78	58.3
Commercial & residential Sector	120.53	18.9
Agriculture & construction sector	33.09	5.2
Transportation sector	−5.13	−0.8
Total	638.15	100

Note: ^aEconomic structural adjustments only cover the industrial structure, internal secondary industrial structure and internal tertiary industry structure

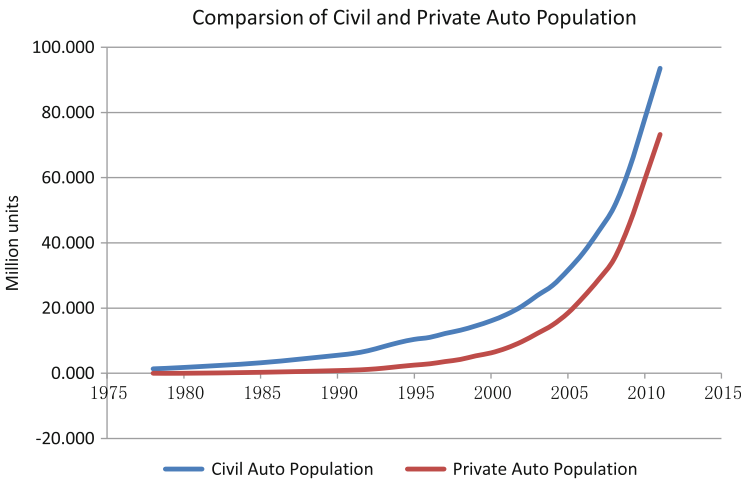


Fig. 2.13 Comparison of civil vehicle and private auto population growth (1978–2011) (Source: China Energy Statistical Yearbook [2])

government and energy-savings from eliminating backward production capacity amounted to 80 Mtce (see Fig. 2.15).

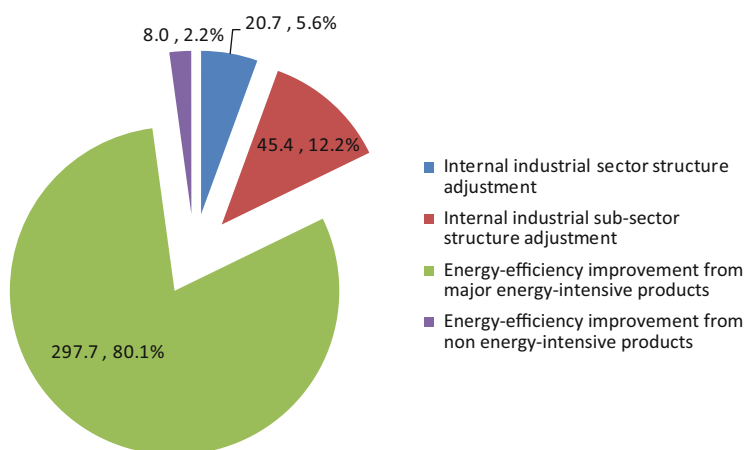
2.3 Analysis on Carbon Emission Reductions Target

Although the reduction of the carbon intensity indicator has not been set as a binding target in the 11th FYP, China has made great progress in improving carbon intensity, with energy efficiency enhanced and energy consumption structure optimized, accordingly, the carbon intensity improvement rate was higher than that for energy intensity during the 11th FYP.

Table 2.7 Private car populations and its petroleum consumption (1995–2010)

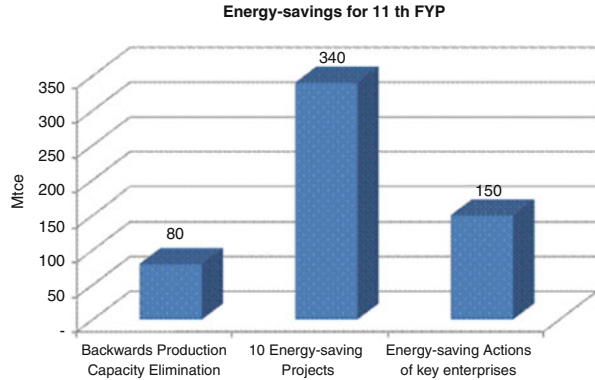
	Private car population (million)	Sum of gasoline & diesel (Mt)	Gasoline (Mt)	Diesel (Mt)
1995	2.5	0.80	0.64	0.16
1996	2.897	2.88	1.79	1.09
1997	3.584	3.13	1.94	1.19
1998	4.237	3.53	2.07	1.46
1999	5.339	3.89	2.21	1.68
2000	6.253	4.06	2.28	1.78
2001	7.708	4.44	2.45	1.99
2002	9.69	4.88	2.74	2.14
2003	12.192	5.87	3.39	2.48
2004	14.817	8.30	4.57	3.74
2005	18.48	9.30	5.24	4.06
2006	23.33	10.85	6.16	4.70
2007	28.76	13.24	7.78	5.45
2008	35.01	14.47	8.55	5.92
2009	45.75	16.52	9.99	6.53
2010	59.39	19.84	12.14	7.71

Source: China Statistical Yearbook [8]

**Fig. 2.14** The contribution to energy-savings of industrial sector during the 11th FYP

As known, carbon intensity was not listed into national statistical system, academic research institutions still strived to conclude a nearly true current carbon intensity improvement rate. Their efforts made it possible to estimate that the carbon intensity was decreased by the rate of 21–23 % from 2005 to 2010.

Fig. 2.15 Evaluation on energy-savings from major actions during the 11th FYP



2.3.1 Status of Domestic Carbon Emissions

Although carbon intensity was not covered in the 11th FYP, Beijing has issued a carbon intensity target for 2020 at the Copenhagen Conference held in 2009 and proposed a 17 % declining target for the 12th FYP this year.

It is essential to calculate and analyze carbon emissions, especially from 2005 since it is the base used to evaluate progress to combat climate change.

According to the National Communication on Climate Change of China and other sources, total carbon emissions increased from 5.35 billion ton in 2005 to 7.26 billion tons in 2010.

The average growth rate of 6.3 % is much lower than the GDP growth rate of 11.2 % and slighter lower than energy consumption growth (6.6 %) for the 11th FYP (see Fig. 2.16). By contrast, the annual average growth rate of carbon emissions reached its highest level, about 9.3 %, during the period of the 10th FYP (2000–2005).

This reflects Chinese government efforts on carbon reductions.

From the contributions of carbon emission by sector in China, it is reported by the National Communication on Climate Change that carbon emissions from fossil fuel combustion were 72 % of total GHG emission in 1994.

The share increased to 93.9 % in 2005, among which energy production and transformation processes contributed 46.5 %, the secondary industry including manufacturing and construction sector contributed 38 %, and the rest came from transportation, commercial and residential sectors (See Fig. 2.17).

2.3.2 Methodology on Analysis of Carbon Emissions

The Kaya Identity, which was developed by Japanese energy economist, Yoichi Kaya, in 1990, has been widely used for analyzing and forecasting major factors that affect carbon emissions.

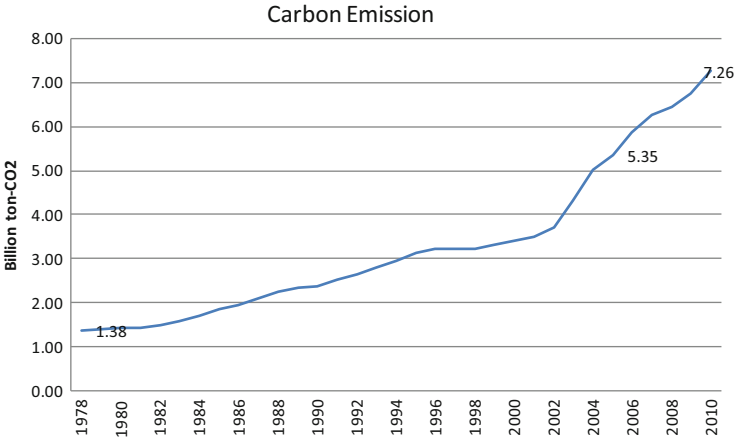


Fig. 2.16 Carbon emission from fossil fuel combustion (1978–2010) (Source: the emission from 1978 to 2004 is based on the recommended emission factor [The emission factor of Coal, Oil and gas is 0.732, 0.565 and 0.445 t-carbon/tce respectively])

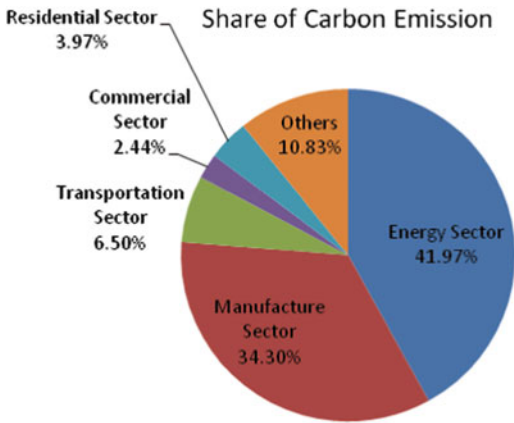


Fig. 2.17 Mix of carbon emissions by sector in 2005 (Source: National Communication on Climate Change of China)

The Kaya Identity (Kaya, 2009) looks back upon the IPAT Model [7] as a Formula 2.4:

Anv.Impact = Population * Affluence* Technology or

$$I = P * \frac{Y}{P} * \frac{I}{Y} \tag{2.4}$$

Where:

I = Environmental Impact (CO₂ emission),

P = Population,

G = Income (GDP).

The identity could be expressed in the form as Formula 2.5:

$$I = P * (G/P) * (E/G) * (F/E) = P * A * T1 * T2 \quad (2.5)$$

Where:

I = CO₂ emissions from energy consumption,

P = Population,

G = GDP,

E = Primary energy consumption,

(G/P) = Per-capita GDP or could be abbreviated as Activity

(E/G) = Energy intensity of GDP or could be as T1

(F/E) = Carbon intensity of energy or could be as T2.

To analyze the effect of structural changes on carbon emissions, the Kaya Identity was adapted as the following Formula 2.6:

$$CO_2 = P \cdot \left(\sum_i A_i \cdot E_i \cdot I_i + F \cdot E_r \cdot I_r \right) \quad (2.6)$$

Where,

CO₂ stands for carbon emissions

P stands for population

A_i stands for the GDP from the industrial sector i

E_i stands for the energy intensity of GDP in industrial sector i

I_i stands for carbon intensity of energy in industrial sector i

F stands for per capita income

E_r stands for residential energy consumption of per capita income

I_r stands for carbon intensity of energy in residential sector

2.3.3 Analysis on Carbon Emissions for 11th FYP

Since no energy consumption data at the sector level for 2010 is available, the research team of ERI only analyzed contributions on carbon emissions from 2005 to 2009.⁹

Calculation results show that the dominant driving force for carbon emissions in the country during the first 4 years of the 11th FYP was the booming per capita GDP of the secondary industry, which contributed 41.7 % (see Fig. 2.18), much higher

⁹ Study Team of Energy Research Institute [4].

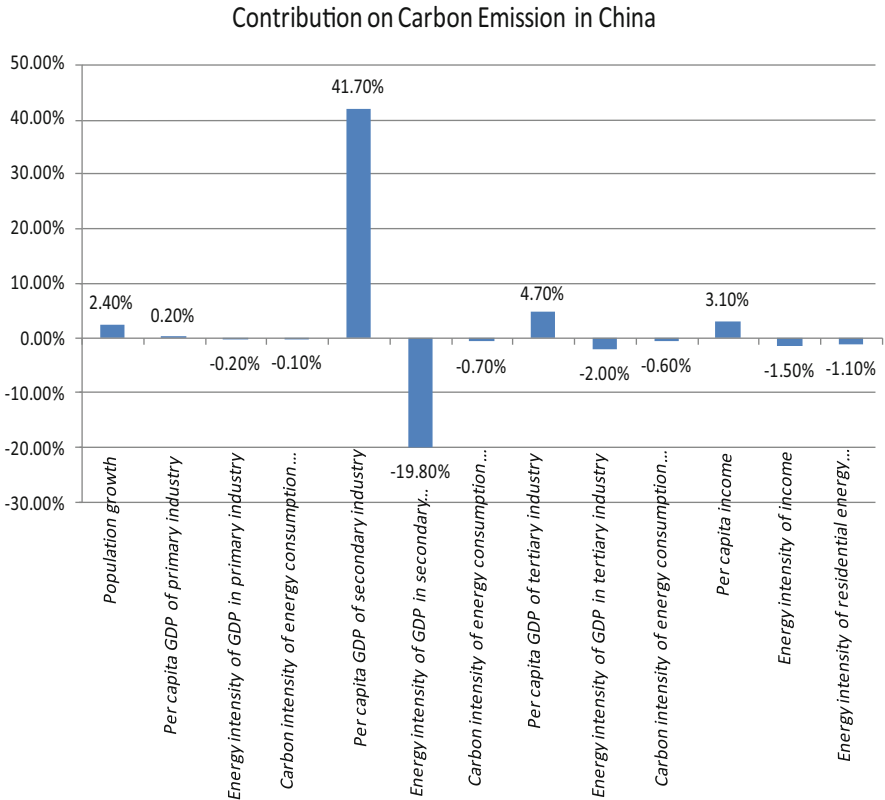


Fig. 2.18 Contributions of carbon emission by sector from 2005 to 2009

than the per capita GDP of the primary industry (0.2 %), per capita GDP of the tertiary industry (4.7 %), and per capita income (3.1 %).

Energy intensity improvements by individual industrial sectors played a positive role on carbon intensity reductions during the 11th FYP period, among which, the energy intensity of GDP from the secondary industry played the biggest role with its contribution at 19.8 %.

Renewable energy has developed dramatically. The annual growth rate of renewable energy consumed was about 10.5 %, which is higher than the average growth rate of total energy consumption.

However due to a relative lower base of renewable energy consumption, the optimization of the energy consumption structure played only a slight role in slowing down the growth rate of carbon emissions.

Looking at the contribution from energy consumption structural adjustment, the impact was not significant during the first 4 years of the 11th FYP; it is shown in Fig. 4.18 that the carbon intensity improvement of energy consumption in the primary, secondary and tertiary industry only contributed -0.1 %, -0.7 % and -0.6 % for carbon emissions.

Based on socio-economic data from the China Statistical Abstract of 2011 [1], keeping frozen the development pattern of 2005—i.e., assuming there is no progress in energy intensity of GDP, and no change for structural optimization—total carbon emissions would be 9.1 billion tons of CO₂, which will be 25.2 % higher than actual emissions.

The analysis shows that the effect on slowing down the increase of carbon emissions from optimization of the energy consumption structure is not significant: keeping frozen the energy consumption structure of 2005, carbon emissions in 2010 would be 7.6 billion ton-CO₂, which is 1.6 % higher than current emissions.

Accumulated carbon emissions reductions amounted to 1.4 billion tons of CO₂ during the 11th FYP, due to the integrated influence from energy-savings and energy efficiency improvements for energy structure optimization and economic structure adjustments.

To evaluate the impact of macro policies on slowing down carbon emissions, the following equation was adopted:

$$Y = \sum_i X_i \cdot E_i \cdot I_i + EI/GDP \quad (2.7)$$

Where:

Y stands for carbon intensity of GDP

X_i stands for the share of i industry of total GDP

E_i stands for energy intensity of i industry GDP

I_i stands for carbon intensity of energy consumption from i industry

EI stands for residential carbon emissions

Since energy consumption data by sector in 2010 is not available, we analyze carbon intensity improvements from 2005 to 2009.

If there were no special measures or actions on energy efficiency improvements and carbon emissions reductions during the first 4 years of the 11th FYP, total carbon emissions in 2009 would amount to 8.08 billion tons of CO₂, which would be 1.34 billion higher than actual emissions in 2009.

Based on Eq. 4.7, the contributions of specific policies in improving carbon emissions from 2005 to 2009 are shown in Table 2.8.

It can be determined that the contribution from the adjustment of the economic structure on the carbon intensity of GDP was negative, −10.28 %, reflecting the difficulty and challenges in optimizing the economic structure during its rapid industrialization and urbanization.

In the first 4 years of the 11th FYP, the annual average carbon intensity improvement rate of residential energy consumption stood at 4.6 %.

But with the enhancement of residential living quality, the averaged growth rate of residential energy use was about 7 % from 2005 to 2009, which offset improvements of residential carbon intensity; which stands as a negative contribution.

Table 2.8 Contribution of key policies on carbon intensity improvement of GDP (2005–2009)

	Added carbon-emission in 2009 without policy intervention (Mt-CO ₂)	Contributions on carbon intensity improvement (%)
Structural adjustment	–138.03	–10.28
Energy-saving and efficiency improvement of industrial sector	1,361.73	101.46
Energy structural optimization of industrial sector	143.23	10.67
Improvement of residential living standard	–24.76	–1.84

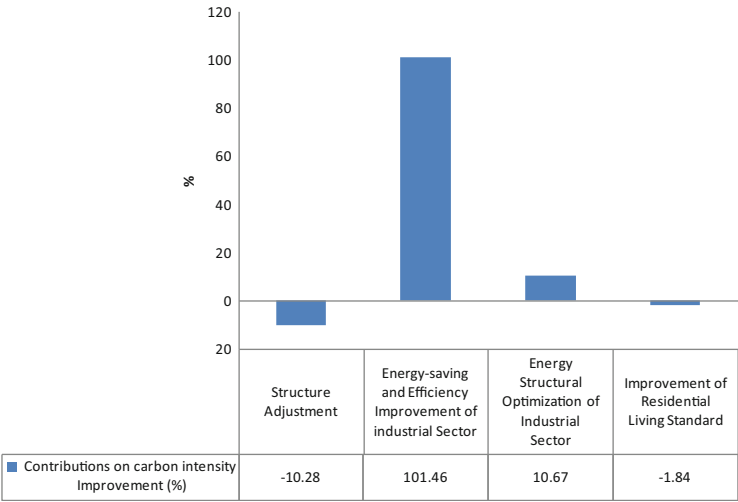


Fig. 2.19 Contributions of specific policies on improvements of carbon emissions (2005–2009)

The main contributions came from energy-savings and energy efficiency improvements, along with the optimization of the energy consumption structure from 2005 to 2009, which contributed 101.46 % and 10.67 % respectively (see Fig. 2.19).

However, the projections on potential energy-savings have been lowered in the next few decades amidst increasing political and economic uncertainties.

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