Chengdu's Low-carbon Urban Construction Present Situation Research

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ABSTRACT : The essay has made an empirical analysis about the present situation of Chengdu's low-carbon urban construction, revealed the features of Chengdu's carbon emission during Year 2001 and 2010: (1) Chengdu's emissions has been growing ,but the growth rates presented a repeated fluctuation trend; the fluctuation of decoupling elastic curve was comparatively large; (4) Chengdu's CO_2 emissions per capita and GDP per capita both were synchronously growing with a correlation coefficient of 0.98; (5) During the period of "11th Five-year Plan", the relationship between economic growth and carbon emissions has always been a weak decoupling state, but the decoupling degrees were fluctuating. Meanwhile, problems of Chengdu's low-carbon urban construction and corresponding strategies were put forward.

KEY WORDS: Low-Carbon City; Decoupling Theory; Carbon Emissions; Strategy

MAIN CONTENT（11point）

Introduction

At present, reducing energy consumption, improving energy utilization rate, decreasing CO_2 emissions, and the development of low-carbon economy, are the common pursuits of the countries all over the world. Cities are the center of various economic and social activities, but also places of intensive discharge of CO_2. The Cities' energy conservation and emission reduction are not only a great impact on the global climate change, but also deeply affect the sustainable development of human beings. Chengdu is one of the core cities of Western China, its development pattern has an important influence to the development of the western region. Therefore, in recent years, Chengdu actively promote low-carbon urban construction, has obtained the certain result, and has incorporated the low-carbon urban construction into the "12th Five-year Plan" (Year 2011-2015), and actively strive for the application of the state's development of low-carbon economy pilot city.

The study aims to use existing researching theories and methods of low-carbon cities, to carry on the qualification of CO_2 emissions of Chengdu during Year 2001-2010, reveal the decoupling state of Chengdu's economic growth, energy consumption and CO_2 emissions growth, and put forward corresponding measures according to the existing questions.

I. low-carbon urban construction connotation, model and evaluation index

1. The connotation of low-carbon city

An important indicator of Low-carbon city is: (2) Chengdu's GDP per capita and CO_2 emissions per capita basically presented increasing trend, of which the growth of GDP per capita basically was greater than the growth of CO_2 emissions per capita; (3) Chengdu's GDP per capita and CO_2 emissions per capita decoupling index had become gradually stable;

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the city's economic growth, energy consumption growth, and growth of CO_2 emissions are decoupling, its core lies in the technical innovation and system innovation [1]. In this regard, the construction of low-carbon city is to practice low carbon development mode in transportation, construction, production and living , the four major fields where carbon dioxide emissions are the largest, improving energy efficiency, reducing the consumption of energy, developing renewable energy, and reducing carbon dioxide emissions in the four major fields; moreover, increasing urban greening area and carbon sink, and improve abilities of carbon capture and carbon neutralization by means of forestation in urban areas, seeding, flowers raising, etc.

2. Urban CO_2 emissions estimation model

Urban CO_2 emissions estimation model is to estimate CO_2 emissions and the foundation of sources of CO_2 emissions. Urban CO_2 emission mainly comes from energy consumption in urban transportation, construction, production and living, according to the IPCC CO_2 emission calculation guide, urban CO_2 emissions can use Formula (1) to calculate:

$$CO_2 \text{ emissions} = \sum_{i=1}^{n} Ei \times Ci \quad (1)$$ [2]

In Formula (1): Ei is the consumption of the ith energy (tons of standard coal); Ci is the CO_2 emission coefficient of the ith energy (tons of CO_2/tons of standard coal), i.e. the CO_2 emissions of per unit of energy i. Various kinds of energy can be converted into standard coal. According to the National Development and Reform Commission (NDRC) Energy Research Institute's recommended value, the CO_2 emission coefficient of standard coal is 2.4567 (tons of CO_2 / tons of standard coal), which would be used in this study to estimate Chengdu's total CO_2 emission.

In order to estimate the total amount of CO_2 emissions more easily, Formula 1 can be evolved into [3]:

$$CO_2 \text{ emissions} = P \times \frac{GDP}{P} \times \frac{E}{GDP} \times \frac{CO2}{E} \quad (2)$$

In Formula (2), P is population; E is sum of all kinds of fossil energy's consumption which is converted into standard coal; $\frac{GDP}{P}$ is GDP per capita; $\frac{E}{GDP}$ is the energy consumption per unit of GDP; $\frac{CO2}{E}$ is energy E's CO_2 emission coefficient. The actual calculation in this study will use Formula (2) and its transformation to calculate Chengdu's total CO_2 emissions.

3. Low-carbon city evaluation index

This study has adopted the decoupling model and decoupling elasticity coefficient which were established by Tapio and other scholars based on the decoupling theory as evaluation index for Chengdu's low-carbon urban development level. The decoupling model is as Formula (3) shows:

$$e=(\%\triangle CO_2)/(\%\triangle GDP) \quad (3)$$ [4]

"e" in Formula 3 is the decoupling elasticity coefficient, $\%\triangle CO_2$ is the rate of percentage change of CO_2 emissions per capita per year, $\%\triangle GDP$ is the rate of percentage change of GDP per capita per year. According to the value of decoupling elasticity coefficient, the decoupling degree of urban economic development and CO_2 emission can be divided into 8 circumstances, as shown in Figure 1.

II. Empirical analysis of Chengdu's Low-carbon urban construction

According to the low-carbon model and evaluation index mentioned above, and combined with related Year 2001-2010 data of Chengdu, this research will make an empirical analysis of Chengdu's low-carbon urban construction.

1. Chengdu's total CO_2 emissions analysis

According to urban carbon emission Formula

(2) and "Chengdu Statistical Yearbook", after selecting and sorting out relevant data of Year 2001-2010, the CO_2 emissions of Chengdu during Year 2001-2010 are estimated (see Table 1).

According to Table 1, Chengdu's CO_2 emissions in Year 2001-2010 basically was increasing. Meanwhile, from Figure 2, the growth of Chengdu's CO_2 emissions had experienced a process of sharp drop – dramatic increase - sharp drop – mild drop off. .

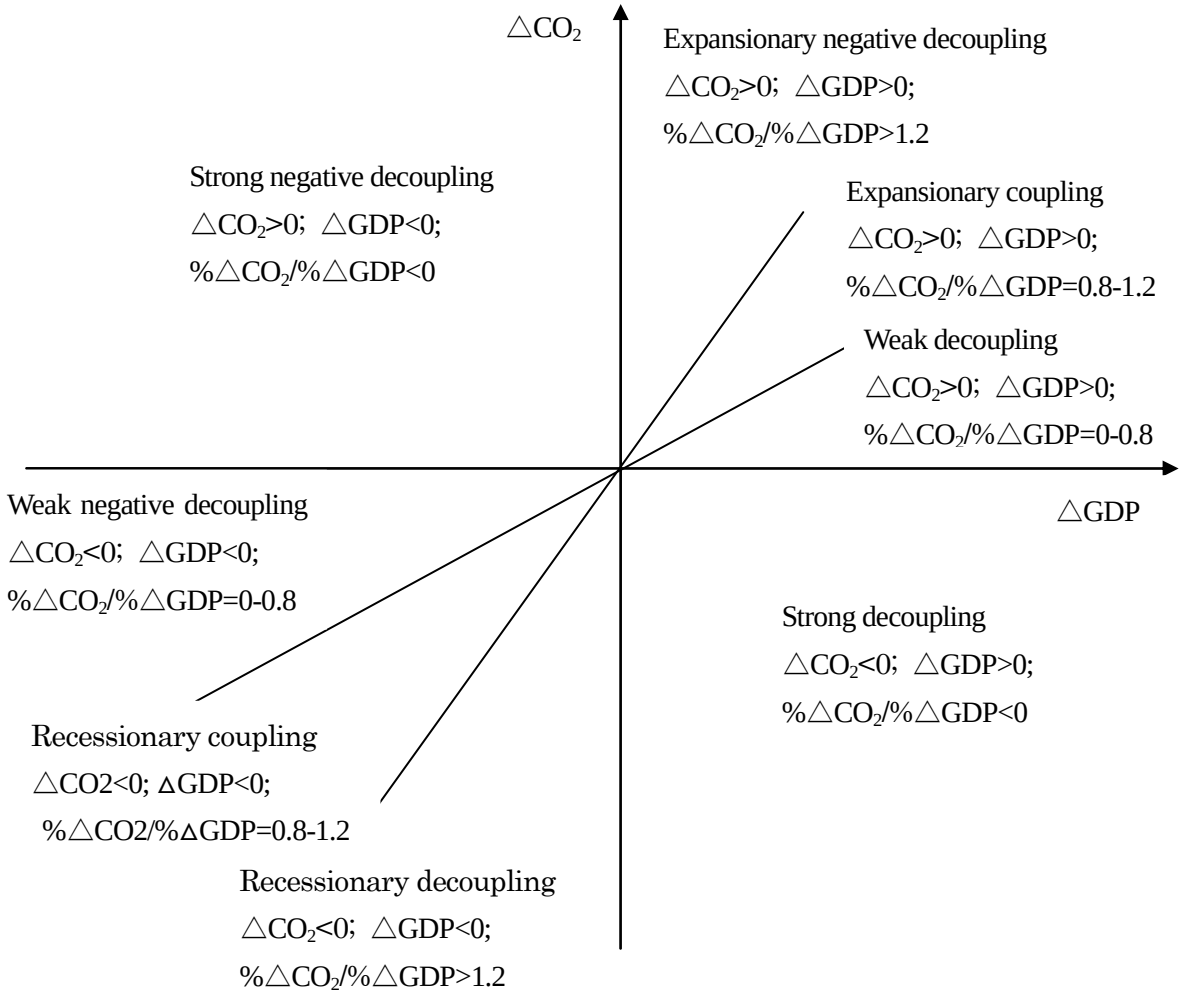


Figure 1: Low-carbon evaluation index

Table 1: Chengdu's CO_2 emissions in Year 2001-2010

Time/Year	GDP energy consumption (10^4tce)	CO_2 emissions (10^4t)	CO_2 emissions growth rate
2001	1850.00	4581.53	3.35%
2002	1727.00	4276.92	-6.65%
2003	1825.00	4519.61	5.67%
2004	2193.00	5430.96	20.16%
2005	2418.00	5988.18	10.26%

2006	2640.34	6538.80	9.20%
2007	2880.70	7134.05	9.10%
2008	3135.91	7766.08	8.86%
2009	3400.08	8420.30	8.42%
2010	3753.33	9295.12	10.39%

In Figure 2, CO_2 emissions is still comparatively large and is increasing at a speed of 9%, the reason lies in several aspects:

(1) Increasing energy consumption due to sustained economic development of Chengdu is the main reason for the increasing of CO_2 emissions year by year, such as shown in Table 2. Analyzing from the structure of energy consumption, electric power, coal, petroleum products, and other energy consumptions account for more than 80% of the total energy consumption, which is the main source of Chengdu's CO_2 emissions.

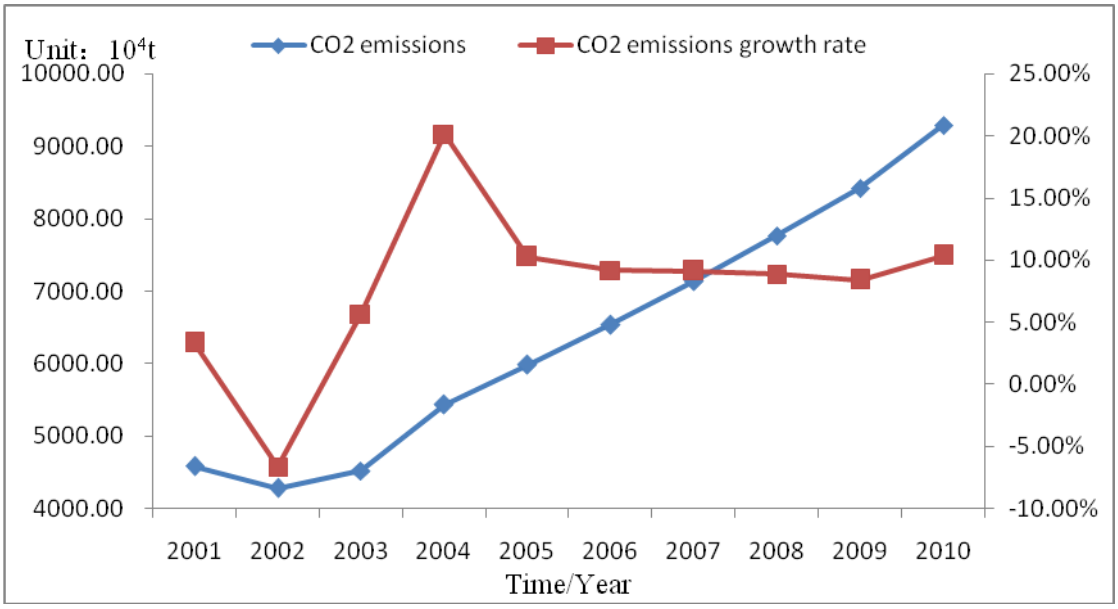


Figure 2: Growth trend of Chengdu's CO_2 emissions from Year 2001-2010

Table 2: Chengdu's total energy consumption and composition in Year 2001-2010

Time/Year	Total energy consumption (10^4tce)	Percentage of electric power consumption	Percentage of natural gas consumption	Percentage of coal and other consumption
2001	1850.00	25.00%	15.10%	59.90%
2002	1727.00	29.40%	17.50%	53.10%
2003	1825.00	35.50%	16.30%	48.20%
2004	2913.00	40.60%	15.10%	44.30%
2005	2418.00	45.60%	17.00%	37.40%
2006	2640.34	32.51%	13.76%	53.73%
2007	2880.70	33.64%	14.03%	52.33%
2008	3135.91	33.63%	14.13%	52.24%
2009	3400.08	35.18%	13.65%	51.17%

2010	3753.33	36.77%	13.15%	50.08%

(2) Sustainable increasing of the population in Chengdu is another major cause of the increasing of Chengdu's CO_2 emissions year by year. Chengdu's permanent resident population was continuously increasing from Year 2001-2010 (as shown in Figure 3). In addition to the permanent population, Chengdu has a large floating population which is not included in the statistics.

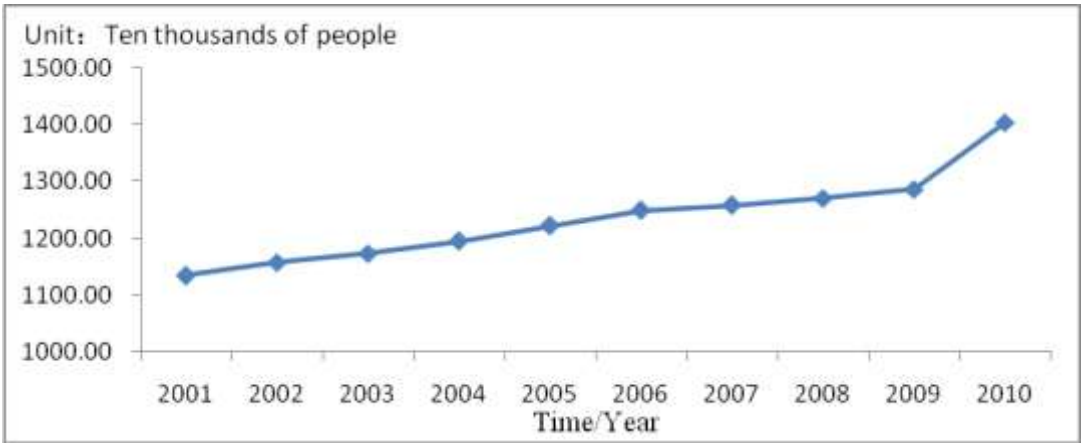


Figure 3: Chengdu's permanent population in Year 2001-2010

(3) The rising number of vehicles in Chengdu, especially the rapid growth of the number of private cars is an important reason of the increasing of Chengdu's CO_2 emissions year by year, as shown in Table 3.

Table 3: Total amount of motor vehicles in Chengdu from Year 2001-2010

Time/Year	Total amount of motor vehicles (Ten thousands)	Total amount of private cars	Percentage of private cars
2001	82.09	-	-
2002	109.66	27.90	25.44%
2003	124.92	34.52	27.63%
2004	139.98	41.69	29.78%
2005	148.13	46.62	31.47%
2006	161.04	55.55	34.49%
2007	177.94	68.13	38.29%
2008	193.85	82.77	42.70%
2009	235.90	109.80	46.55%
2010	259.90	139.60	53.71%

(4) The growth of Chengdu's CO_2 emissions during Year 2005-2010 had maintained a mild drop off process; this was due to continuously decreasing of Chengdu's energy consumption per unit of GDP and carbon emissions per ten thousands Yuan of GDP, as shown in Figure 4.

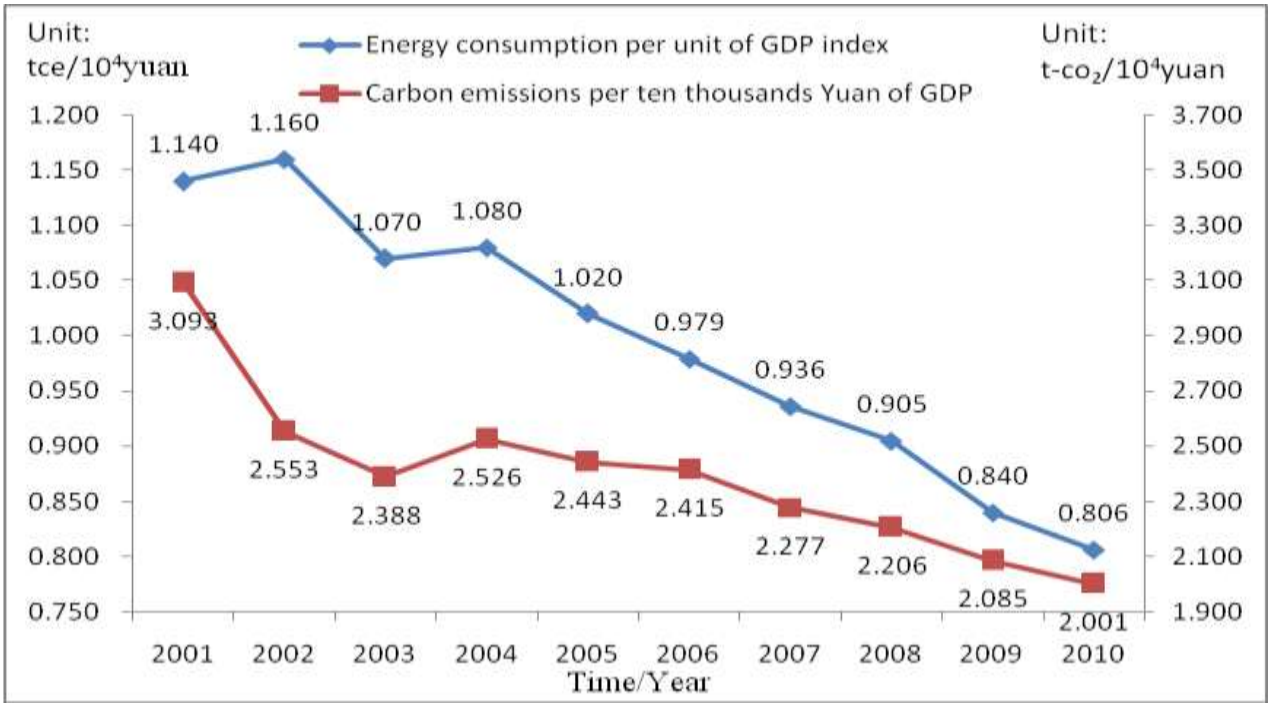


Figure 4: Chengdu's energy consumption per unit of GDP index and carbon emissions per ten thousands Yuan of GDP

2. Decoupling analysis of Chengdu economic growth and CO_2 emissions

The essay uses the decoupling degree of economic growth and CO_2 emissions to decide whether the city is low-carbon. According to Year 2001-2010 "Chengdu Statistical Yearbook" and other relevant data, the value of GDP per capita and CO_2 emissions per capita of Chengdu from Year 2001-2010 was calculated (see Figure 5).

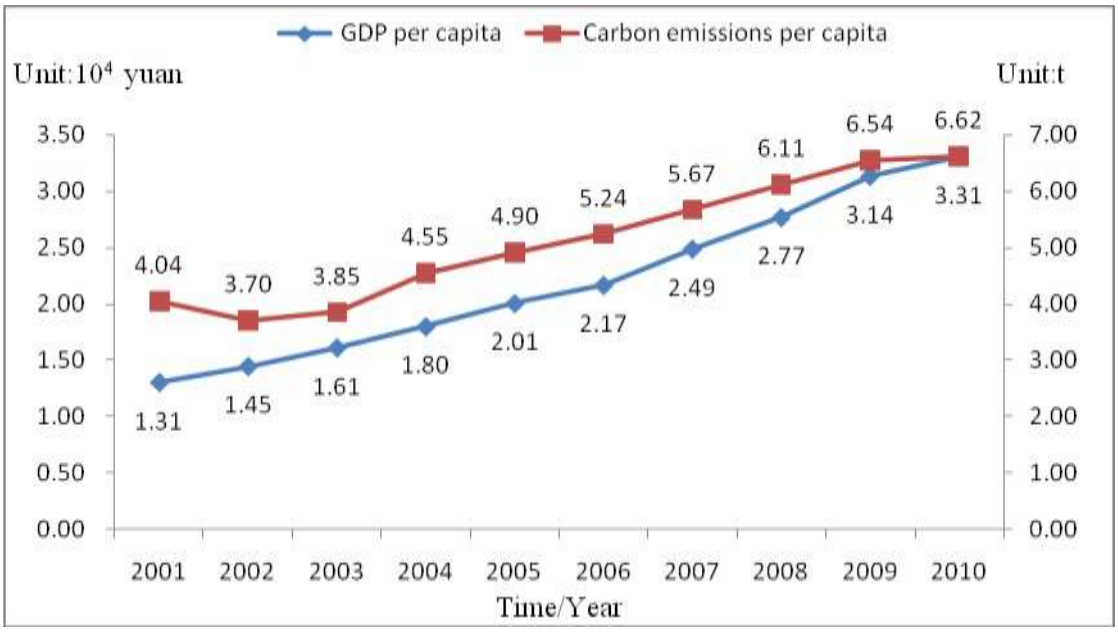


Figure 5: Chengdu's Per capita GDP and CO_2 emissions per capita

With the help of Figure 5 and calculation of correlation coefficient of Chengdu's CO_2 emissions per capita and GDP per capita, it is known that with a correlation coefficient of 0.98, Chengdu's CO_2 emissions per capita and GDP per capita presented a synchronous growth trend. Thus it can be seen, in the process of the economic growth, environmental protection situation of Chengdu is severe.

Based on Year 2000 data, the growth rate of Chengdu's per capita GDP and the growth rate of CO_2 emissions per capita of Chengdu were calculated (see Table 4). Then Chengdu's decoupling elastic index was worked out according to the ratio of CO_2 emissions' growth rate and per capita GDP's growth rate (see Table 4, Figure 6).

Table 4: CO_2 emission elastic characteristics of Chengdu during Year 2001-2010

Time/Year	Growth rate of per capita GDP	Growth rate of CO_2 emissions per capita	Decoupling elasticity coefficient	Carbon emission characteristics
2001	10.48%	1.22%	0.12	Weak decoupling
2002	10.83%	-8.52%	-0.79	Strong decoupling
2003	11.46%	4.23%	0.37	Weak decoupling
2004	11.63%	18.08%	1.55	Expansionary negative decoupling
2005	11.43%	7.77%	0.68	Weak decoupling
2006	8.08%	6.85%	0.85	Expansionary coupling
2007	14.83%	8.28%	0.56	Weak decoupling
2008	11.28%	7.77%	0.69	Weak decoupling
2009	13.28%	7.08%	0.53	Weak decoupling
2010	5.32%	1.10%	0.21	Weak decoupling

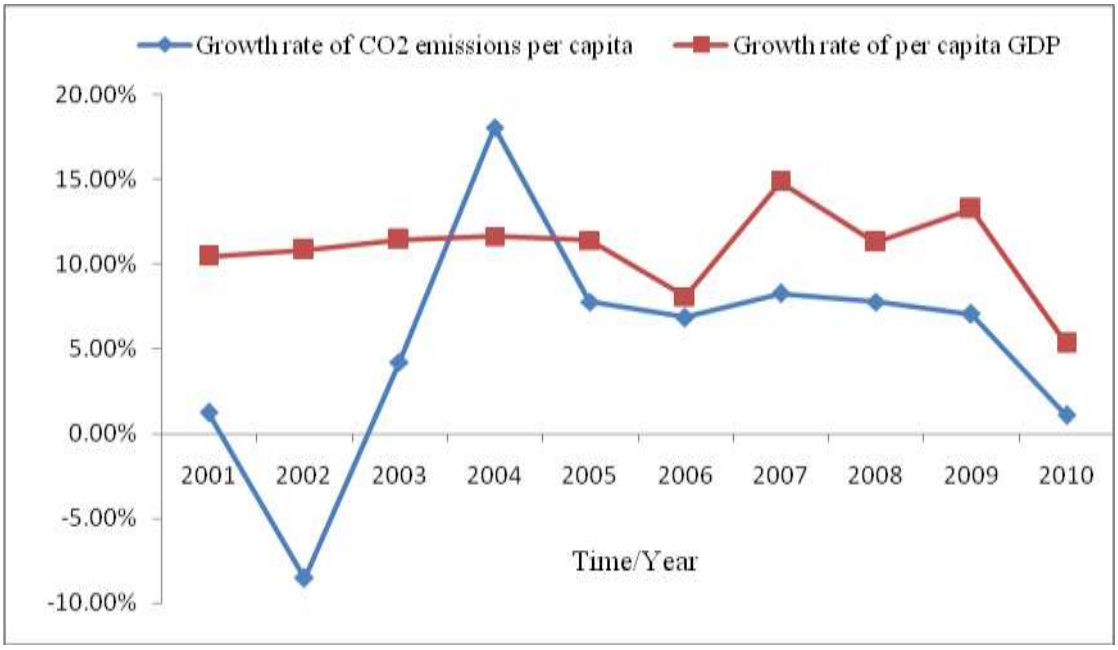
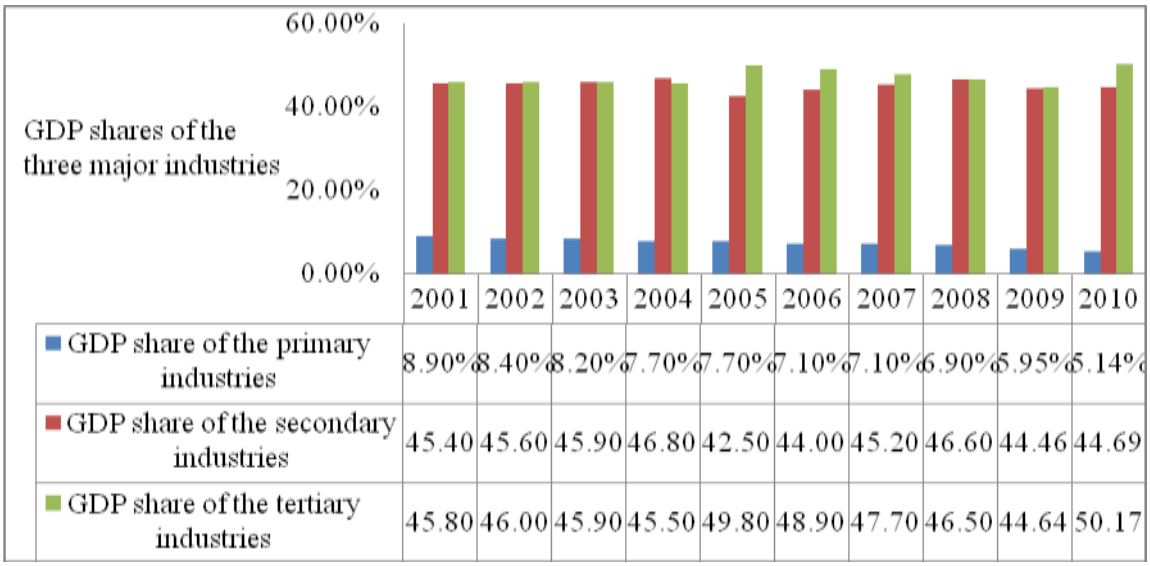


Figure 6: Chengdu's per capita GDP growth rate and per capita CO_2 emissions growth rate

It is known from Table 4 and Figure 6 that the decoupling index of Chengdu's per capita GDP and

per capita CO_2 emissions during Year 2001-2005 presented an unstable status, of which it appeared to be decoupling from Year 2001-2003, and reached a strong decoupling state in 2002. This may be due to the situation that between Year 2001-2003, the GDP of Chengdu's tertiary industries always sharing a bigger part of Chengdu's total GDP than that of the secondary industries (see Figure 7); the secondary industries are the main sources of CO_2 emission; With respect of energy consumption, coal and other fossil energy consumptions during this period gradually reduced at a rapid rate (see Table 2), and in 2002, per capita CO_2 emissions presented a negative growth. It indicates that industrial structure and energy structure may have influenced the decoupling state of per capita GDP and per capita CO_2 emissions. Expansionary negative decoupling state presented in 2004: the growth of GDP per capita was slower than the growth of CO_2 emissions per capita, and the ratio of the two was greater than 1.2. According to Figure 7 and Table 2, in 2004, the secondary industries' output value had exceeded that of the tertiary industries and created a great increase in the carbon emissions of the secondary industries; the growth rate of power consumption was also comparatively higher in 2004, meanwhile, in 2004, energy consumption per unit of GDP had also increased, these may have caused the negative decoupling state of Chengdu's per capita GDP and per capita CO_2 emissions in 2004. Since 2005-2010, Chengdu's per capita GDP growth rate is higher than that of per capita CO_2 emissions, the ratio of the two was always more than 0 and less than 0.8, and maintained in the weak decoupling state, except that in Year 2006. This may be because that during the period of "11th Five-year Plan", the tertiary industries' output value in this period always greater than that of the secondary industries; during the same period, Chengdu had adopted a series of measures to promote adjustment of industrial structure, eliminated a lot of outdated capacity, and continuously reduced the energy consumption per unit of GDP.



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
GDP share of the primary industries	8.90%	8.40%	8.20%	7.70%	7.70%	7.10%	7.10%	6.90%	5.95%	5.14%
GDP share of the secondary industries	45.40	45.60	45.90	46.80	42.50	44.00	45.20	46.60	44.46	44.69
GDP share of the tertiary industries	45.80	46.00	45.90	45.50	49.80	48.90	47.70	46.50	44.64	50.17

Figure 7:Chengdu's industry composition in 2001-2010

III. Conclusions and measures

According to the relevant data of Chengdu in Year 2001-2010, have studied the carbon emission characteristics and the relationship between Chengdu's carbon emissions from energy consumption and economic growth in 2001-2010, have drawn the following conclusions:

(1) CO_2 emissions kept growing, but the

growth rate presented a fluctuation trend: during 2001-2004, the growth rate continued to accelerate, in Year 2005-2009, the growth rate gradually slowed down, and the growth rate again increased in 2010.

(2) Per capita GDP and per capita CO_2 emissions basically presented an increasing trend, of which the growth rate of GDP per capita basically was greater than the per capita CO_2 emissions growth.

(3) The decoupling index of per capita GDP and per capita CO_2 emissions had become gradually stable from an unstable state; the fluctuation of decoupling elastic curve was comparatively large; the fluctuation of decoupling trend performed as: weak decoupling - strong decoupling - weak decoupling – expansionary negative decoupling - weak decoupling - expansionary coupling - weak decoupling.

(4) Per capita CO_2 emissions and per capita GDP was synchronously growing at a correlation coefficient of 0.98.

(5) The low-carbon urban construction had obtained certain achievements: during the period of "11th Five-year Plan", the relationship of economic growth and carbon emissions had always been a weak decoupling state, but the decoupling degrees were fluctuated.

Coordinating the relationship between economic development and growth of carbon emission is the most significant priority in the construction of low-carbon city. In order to speed up Chengdu's construction of low-carbon city, combined with the present situation of Chengdu, the following suggestions are put forward:

(1) Promoting the up gradation of industrial structure; vigorously develop a low carbon economy. First of all, speed up the adjustment of industrial structure and the development of new energy, new materials, electronic business, cultural creativity and other low-carbon and environmental friendly industries. Secondly, promote utilization of renewable energy and new energy exploitation, especially the comprehensive utilization of biomass energy, methane, geothermal heat, and other renewable energy. Third, strengthening technical innovation, on the one hand, promoting innovation and achievements transformation of low-carbon technology, and on the other hand, actively introduce relevant advanced foreign low-carbon technologies.

(2) Strengthening energy conservation and emission reduction; reducing carbon emissions. Above of all, optimizing the industrial enterprise structure, improving industrial technologies level, eliminating outdated capacity, process, and technology, and strengthening industrial enterprise for energy conservation and emission reduction. Secondly, strengthening energy efficiency of buildings and promote low-carbon constructions; strictly carrying out design standards of 50% energy saving for new buildings, and put utilization of geothermal energy and other energy saving technologies into priority; for existing constructions, employing multiple ways to speed up its energy efficiency reform. Third, developing green transportation, vigorously develop public transportation and rail transit, improve urban and rural public transportation integration, promote multiple means of transportation and no-slot joint traffic connecting the inside and outside of a city; improving traffic management level, adopt strategies like traffic control of non public transport vehicles in specific area at a certain time to enhance traffic efficiency and traffic organization efficiency; promote electric vehicle's development and popularity. Fourth, strengthening energy efficiency of public institutions and promote energy saving lighting products.

(3) Establish the concept of low-carbon,

construct low-carbon society. First, enhance publicity of low-carbon concept, raising citizen's awareness of low-carbon, and encourage people to cultivate good low-carbon life and consumption habits. Second, put forward strategic transition of urban and rural patterns, according to the develop requirement of low-carbon city, carry out urban planning , control the size of city center, optimize small and medium-sized cities' functioning , conduct well planning of tree belt and rural green belt, and lessen energy consumption and reduce carbon emissions with the help of planning. Third, vigorously develop carbon sink ability, on one hand, vigorously expand cities' forest coverage, forest stock volume, and urban and rural green space to increase biological carbon sequestration; on the other hand, build ecological barrier in Min-jiang River valley, protecting prime farmland and Chengdu plain.

(4) Carry out tests and demonstrations; lead low-carbon development. First of all, sets up low-carbon demonstration area (city) county, such as Low-carbon Economic Zone of Qingbaijiang District, Chengdu High-tech Zone, WenJiang District Low-carbon Economic Zone, etc. Secondly, build zero-carbon agricultural demonstration park, in which, employ methane electricity generation technology and leading energy-saving technology to promote the comprehensive utilization of methane, and strive to achieve self-sufficiency in the agricultural park with the help of methane. Third, construct zero-carbon tourism industry demonstration zone, make use of the surrounding forests and other vegetation to neutralize carbon dioxide, and promote electric vehicles, free bicycles, and other energy saving products to reduce carbon emissions, such as Dujiangyan Longchi - Hongkou tourism zone, northern Wenjiang ecological tourism district . Fourth, implement green lighting project, on one hand, vigorously spread usage of LED energy-saving lamps, carry out a number of demonstration projects of LED lighting application, popularize and apply 400000 LED lights by the end of 2012; on the other hand, rationally divide urban lighting levels, optimize the operation of lighting system, improve urban lighting energy utilization efficiency. Fifth, launch "free bicycle" action. First pilot "free bicycle" action in the southern new district, provide convenience to citizens for transferring to public transit, encourage people in low-carbon trip.

(5) Innovation system and mechanism. First of all, optimize the statistical monitoring system of energy consumption, speed up the implementation of reward and punishment measures to inspect energy consumption per unit of GDP and watershed pollutant emission; Secondly, deepen forest right reform, promote natural forest protection project, and put non-commercial forest compensation approach into practice; Third, improve the regulatory system of energy conservation, strengthen the construction of energy-saving monitoring team, and carry out the "Energy Conservation Law"; Fourth, actively promote the energy performance contract, form energy performance contract trading scheme, and apply market power to motivate energy-saving; Fifth, establish Southwest Environmental Exchange, carry out emission permits exchange for sulfur dioxide and other emissions, and promote exchange of Clean Development Mechanism (CDM) projects, etc.

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