

Analysis on the Estimation of Consumption of Carbon Emission in Urban and Rural Residents in Liaoning Province

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Abstract—carbon emission research is mostly concentrated on the field of industrial production, but ignore the role of residents' consumption in promoting carbon emissions. So this paper estimates the carbon emissions from urban and rural residents in Liaoning Province via input-output method. The conclusions are as follows: consumption of direct carbon emissions from urban and rural residents in Liaoning Province shows a tendency to decrease first, then rise while indirect still rising. What's more, the urban residents' direct and indirect carbon emissions are both much higher than that of rural. Indirect carbon emissions from urban residents in Liaoning are the main source of carbon emissions from residents' consumption, which is the focus of carbon emission control at the same time. According to the results, then we could suggest the relevant departments in Liaoning province take the effective measures.

Keywords—household consumption; direct carbon emissions; indirect carbon emissions; input-output analysis

I. INTRODUCTION

With the rapid development of the world economy, people's life has changed with each passing day. While enjoying all the benefits brought by economic development, humans have also paid the cost of the destruction of the natural environment. According to the results of CO₂ emission monitoring, carbon emissions from combustion of fossil fuels are the most important, reliable and representative greenhouse gas sources^[1]. Statistics show that during 1990 to 2015, China's coal carbon accounts for 64.0%-76.2% of total energy consumption, coal accounted for 61.2%-83.7% of the total energy consumption in Liaoning. In the considerable future, coal is still the major part of the energy consumption.

Research on carbon emissions is mostly concentrated on the field of industrial production for a long time, but it has ignored the role of residents' consumption in promoting carbon emissions. In recent years, many countries researches show growth rate of energy consumption and CO₂ emissions caused by private consumption has exceeded that caused by industrial energy consumption, which become the new major growth point. The main factor driving the growth of carbon emissions is the growth of personal consumption, which has far offset the emission reduction effects caused by technological progress and industrial upgrading^[2]. If American families can take

effective energy conservation actions, the US CO₂ emissions after 2018 should be expected to reduce by 7.4% in 2008^[3].

In view of the research content, this paper presents the existing results both in and abroad from the following aspects: the research level of carbon emissions from household consumption and the method of calculation. The former contains the global and local analysis. Further the local analysis includes the aspects of direct carbon emissions of residents as well as indirect carbon emissions. The latter involves kinds of calculation, such as the input-output analysis.

There are three levels in the study of carbon emissions from household consumption: national level, regional level and family level. At present, the domestic research results include the Yangtze River Delta region^[4], Northwest China^[5], Yunnan Province^[6], Qinghai Province^[7], Taiyuan^[8], Wuhan^[9], Shanghai^[10], Beijing^[11], and Tianjin^[12].

Carbon emission from residents' consumption is divided into direct carbon emissions and indirect carbon emissions. The direct carbon emission of resident consumption refers to the carbon emission produced by the direct use of energy in the household, and the carbon emission coefficient method^[13,14] is generally used in the calculation. The indirect carbon emission of resident consumption refers to the indirect carbon emissions of non-energy goods and services in its raw materials, production, transportation and sales caused by production energy consumption, the measurement methods are divided into two categories: the input-output analysis method^[15,16] and life cycle analysis method^[17,18]. Domestic scholars mainly use input-output analysis to calculate indirect carbon emissions of resident consumption.

As a typical cold area, Liaoning province has a longer heating period every year, so it is necessary to study the consumption of carbon emissions from urban and rural residents. Considering there are no research findings about carbon emissions of urban and rural residents consumption in Liaoning province (hereinafter referred to as Liaoning residents carbon emissions) currently, we provide reliable and basic information for formulating highly individualized policy recommendations to constitute, based on estimating Liaoning residents carbon emissions (especially for the indirect carbon emission).

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II. MEASUREMENT AND ANALYSIS OF DIRECT CARBON EMISSIONS OF LIAONING RESIDENTS

According to the data of Liaoning statistical yearbook and relevant formulas, the results of calculating direct carbon emissions by residents in Liaoning are shown in Table I .

TABLE I. DIRECT CARBON EMISSION OF RESIDENTS IN LIAONING PROVINCE

Unit: 10000 tons

year	urban	rural	resident	year	urban	rural	resident
2000	818.5	239.2	1057.7	2008	681.5	148.7	830.2
2001	852.8	222.9	1075.7	2009	701.9	145.6	847.5
2002	848.3	208.5	1056.8	2010	921.5	198.1	1119.6
2003	890.7	192.2	1082.9	2011	1042.4	233.7	1276.1
2004	849.4	163.6	1013.0	2012	1188.4	272.6	1461.0
2005	844.5	235.9	1080.4	2013	1008.8	234.7	1243.5
2006	833.7	195.6	1029.3	2014	1183.1	243.8	1426.9
2007	820.3	179.8	1000.1				

III. MEASUREMENT AND ANALYSIS OF INDIRECT CARBON EMISSIONS OF LIAONING RESIDENTS

Indirect carbon emissions were measured by the input-output table in 2002, 2007 and 2012 (results are shown in Table II).

TABLE II. INDIRECT CARBON EMISSIONS OF URBAN AND RURAL RESIDENTS IN LIAONING PROVINCE

Unit: 10000 tons

Energy type	Urban resident			Rural resident		
	2002	2007	2012	2002	2007	2012
coal	5768.7	11192.8	12884.4	1737.7	1717.6	1651.6
coke	262.5	2445.6	3497.3	77.6	388.2	490.3
crude oil	2268.9	4715.9	7054.0	673.9	741.5	973.0
gasoline	203.8	475.9	829.5	63.4	89.7	129.7
kerosene	15.5	33.6	36.6	4.3	5.8	5.2
diesel oil	260.5	694.1	1387.0	86.9	129.2	215.3
fuel oil	142.6	212.4	444.3	44.4	33.2	60.2
Natural gas	143.4	147.2	286.5	43.7	22.3	34.8
Total emission	9065.8	19917.6	26419.7	2731.9	3127.5	3560.2

From Table II we can see that: from 2002-2012, the indirect carbon emissions of urban and rural residents in Liaoning province continue to rise; the indirect carbon emissions of urban residents is greater than the indirect carbon emissions of rural residents, the former is about 7 times more of the latter in 2012; in addition, the highest proportion of indirect carbon emissions is from coal consumption; followed by crude and coke the third.

IV. MEASUREMENT AND ANALYSIS OF CARBON EMISSIONS OF LIAONING RESIDENTS

Table III is sorted and calculated according to Table I and Table II .

TABLE III. CARBON EMISSIONS AND AVERAGE ANNUAL GROWTH RATE OF LIAONING RESIDENTS

Index name	Carbon emission (10000 tons)			Average annual growth rate (%)			
	2002	2007	2012	2002-2007	2007-2012	2002-2012	
urban resident	Direct carbon emission	848.3	820.3	1188.4	-0.7	7.7	3.4
	Indirect carbon emission	9065.8	19917.6	26419.7	17.0	5.8	11.3
	carbon emission	9914.1	20738.9	27608.1	15.9	5.9	10.8
rural resident	Direct carbon emission	208.5	179.8	272.6	-2.9	8.7	2.7
	Indirect carbon emission	2731.9	3127.5	3560.2	2.7	2.6	2.7
	carbon emission	2940.4	3307.3	3832.8	2.4	3.0	2.7
resident	Direct carbon emission	1056.8	1000.1	1461.0	-1.1	7.9	3.3
	Indirect carbon emission	11797.7	23045.1	29979.9	14.3	5.4	9.8
	carbon emission	12854.5	24045.2	31440.9	13.3	5.5	9.4
carbon emissions in Liaoning		39884.2	59010.7	75857.9	8.1	5.2	6.6

According to Table III and Table IV, we can see that:

In 2002, 2007 and 2012, Liaoning residents carbon emissions and Liaoning carbon emissions continue to rise, the growth of carbon emissions are lower than the growth of residents carbon emissions during the same period; the proportion of carbon emissions from residents is rising, the more increase of the carbon emissions in Liaoning, which the carbon emissions of residents increased during the same period also increase, and the increasing carbon emissions from residents is the main reason for the increase in carbon emissions in Liaoning.

TABLE IV. LIAONING RESIDENTS CARBON EMISSION RATIO (%)

Proportion index	2002	2007	2012
Indirect carbon emissions of urban residents account for carbon emissions of residents	70.5	82.8	84.0
Indirect carbon emissions of residents account for the carbon emissions of residents	91.8	95.8	95.3
Carbon emissions of urban residents account for carbon emissions of residents	77.1	86.2	87.8
Carbon emissions of residents account for carbon emissions in Liaoning	32.2	40.7	41.4

From 2002 to 2007, from 2007 to 2012, the indirect carbon emissions of residents accounted for more than 91.8% of the total carbon emissions of residents, and increased year by year. The indirect carbon emissions of urban residents accounted for more than 70.5% of the total carbon emissions of residents, and increased year by year. This indicates that the carbon emissions of Liaoning residents mainly come from indirect carbon emissions of urban residents.

In conclusion, reducing the carbon emissions of Liaoning can't ignore the carbon emissions of residents; to reduce the carbon emissions of residents needs to control indirect carbon emissions of urban residents, and the indirect carbon emissions of urban residents are the key points of control.

V. CONCLUSIONS AND RECOMMENDATION

A. Conclusions

Through the measurement of carbon emissions of residents in Liaoning Province, and then the study on influencing factors of direct carbon emissions and indirect carbon emissions of urban and rural residents in Liaoning Province, and the comparison analysis between urban and rural areas was analyzed, we draw the following conclusions:

1) The direct carbon emissions of Liaoning residents showed a trend of decreasing first and then rising, while the indirect carbon emissions were rising continuously. Meanwhile, the direct and indirect carbon emissions of urban residents were much higher than those of rural residents.

2) The carbon emission of urban and rural residents in Liaoning province has been increasing and the proportion of carbon emission in the province has been increasing while the indirect carbon emissions increasing constantly, which accounts for more than 90% of carbon emissions of residents. It indicates that the main source of carbon emission of residents is the indirect carbon emission, and the growth rate of urban residents' carbon emission is higher than that of rural residents. Therefore, the indirect carbon emissions of urban residents are the key point of control.

B. Recommendations

Through the analysis above, we can see that the carbon emissions caused by household consumption, especially indirect carbon emissions, can't be ignored. From the perspective of energy security and environmental protection, it is suggested that the relevant departments of Liaoning province take the following emission reduction measures: improve the energy consumption structure, reformed energy price, advocate low-carbon lifestyle, optimize energy utilization efficiency, coordinate the relationship between population growth and economic growth and consumption of carbon emission, tax on carbon and environment and strengthen energy statistics work

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