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The impact of technical progress and fuel switching on building sector's decarbonization in China

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Abstract

During the recent decades, China's building energy consumption has been growing rapidly. And the energy structure also changes quickly with more natural gas & electricity and less coal. Meanwhile, the technology used in building sector is improving towards higher energy efficiency. In this paper, the impact of technical progress and fuel switching in building sector are analyzed. China TIMES model is used to model the future energy consumption in building sector. The modelled results indicate that energy consumption grows up to around 39EJ in 2050 while the energy intensity still stays in a reasonable level in building sector. And with a stricter policy on fuel switching, building sector can reach a relatively low-carbon future with more clean and low-carbon fuel used in this sector, but it's still very hard to access the emission peak before 2050.

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Keywords: Building sector; China-TIMES model; CO_2 emissions;

1. Introduction

Building sector is one of the most important final energy sector in China. The historical trends in developed countries show that China's building energy consumption will continually increase for a long time. [1] The traditional biomass used in rural China have rapidly decreased from the peak of 8EJ in 2006 to about 5.3EJ in 2009, and more commercial energy like coal and liquefied petroleum gas (LPG) are substituting traditional biomass in rural China. [2][3] Meanwhile in urban residential buildings, coal is gradually replaced by other clean and convenient energy, such as LPG and natural gas, with a significant drop from 1.27EJ in 2005 to 0.69EJ in 2010 (National Bureau of Statistics of China (NBSC), 2006-2011).[2] With urbanization in China, the fuel switching will continue in building sector in the next

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decades. On the other hand, more and more renewable energy can be used in buildings due to the technical progress, for example, about 145million m^2 solar heat panel were on processing in 2009, and more than 0.5EJ solar energy was used for water heating. [3]

In this paper, we take the technical progress and fuel switching into account using China TIMES model to analysis the impact on building sector. We also compare two scenarios to see different pathways of CO_2 emissions in building sector.

2. Methodology and Data

2.1. Brief introduction of China TIMES

China TIMES is an energy technology system model we establish based on the TIMES (The Integrated MARKAL-EFOM System) model and developed in 5-year intervals extending from 2010 to 2050 based on China's reference energy system (see, Chen [4]). In China TIMES, building sector is divided into three parts, urban residential, rural residential and commercial buildings, covering all the energy services. Advanced end-use technologies, such as Building Integrated Photovoltaic (BIPV) and air or water source heat pump, are also considered in this model.

2.2. Data

Based on the energy consumption data of residential and commercial sectors from NBSC, renewable energy and traditional biomass used in buildings from Wang (2011) are added. In the residential and commercial sector, some statistics like gasoline which are actually not used in buildings are cancelled and some other statistics like diesel are seldom used in residential buildings are reallocated based on Wang (2007).[5] We estimate the share of building energy consumption in final energy is 18.8% in 2010, which is close to the simulation results from Tsinghua University Building Energy Research Center (THUBERC).[6] Detailed data about the building energy services is collected mainly from the research by THUBERC (2013) and then the base year 2010 of China TIMES in building sector is calibrated.

The main assumptions of China TIMES, such as GDP, Population and Urbanization rate, come from Chen (2013). Besides, we also consider the future building floor space from Yin (2013). [7] These assumptions and the data of floor space are shown in table 1.

Table 1. Assumptions and simulation results in building sector

		2010	2020	2030	2040	2050
GDP annual growth rate (%)		8	6	4.5	3.5	-
Population (million)		1359.82	1432.87	1453.3	1435.5	1384.98
Urbanization rate (%)		49.95	57	62.5	67	70
Per capita floor space (m^2)	Urban	21.5	30	36.5	40.3	42.1
	Rural	36.4	42.5	46.6	49	50
	Commercial	5.8	9.4	12.6	15.4	18.8

2.3. Scenario description

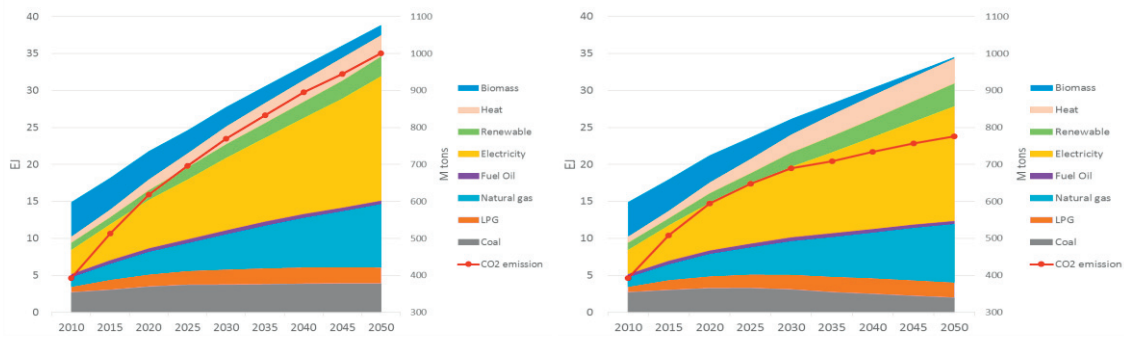
The impact of technical progress and fuel switching are both under consideration in the model. The reference (REF) scenario is designed with an assumption that no more coal is used in commercial and urban residential buildings. The traditional biomass is reduced to only one third of the quantity in 2010 concerning the energy use in the remote area. Furthermore, due to the serious air pollution in China recent years and the pressure to reduce CO_2 emissions, it's necessary for coal and traditional biomass to accelarate to be replaced by other low-carbon energy. An enhanced policy scenario (EPO) is designed with a challenging goal that no coal can be used in urban residential and commercial buildings in 2050.

3. Model results and Comparison

As an input in the model, energy service demand projection in building sector is generated by the Energy Service Demand Projection Model(ESDPM) for a given social economic development scenario.[4] The ESDPM considers current and future potential policies which may affect the building energy consumption. For example, new standards for buildings, such as Design Standard for Energy Efficiency of Public Buildings (2012 edition) and Standard for Lighting Design of Buildings (2013 edition) have been underway to be more suitable for energy conservation of building sector. The policy of improving existing residential buildings by Chines government shows great energy reduction potentials. Only in northern China, about 3.5 billion m^2 buildings need to be refurbished and it means a huge decrease of service demands especially space heating in future. Policies like these are considered in ESDPM.

3.1. Future trends of building energy consumption and emissions in China

In the REF scenario (see Fig. 1(a)), energy consumption continues to grow from 14.9EJ in 2010 to about 38.8EJ in 2050 and CO_2 emissions gradually increases to more than 1 billion tons in 2050. The share of natural gas goes up to about 22% in 2050, which is higher than the level of Japan in 2010. [8] In the EPO scenario (see Fig. 1(b)), coal and LPG substitute more traditional biomass and less than 0.2EJ of traditional biomass consumed in 2050. The share of renewable rises to about 9%, and the percentage of heat using for space heating increases from only 5% in 2010 to more than 10% in 2050. Coal used in urban and commercial buildings decreases a lot and CO_2 emissions have a large decay for about 25% drop comparing with REF scenario



(a) REF (b) EPO

Fig. 1. Energy consumption by fuel and CO_2 emissions in building sector, 2010-2050

3.2. Comparison

We choose the building energy data in USA, Japan, Canada and UK to make comparisons with China in 2010 and the modeled results of REF scenario in 2050, to know the energy consumption of different services in a global perspective.[8-11] The comparison results show that energy consumption in residential buildings grows from 8.4GJ per capita in 2010 to about 13 GJ per capita in 2050, which is still much lower than the level of developed countries in 2010. Japan consumes the least in these four developed countries for about 20GJ per capita in 2010. Commercial buildings consume double energy per floor space in 2050 due to a large increase in water heating, cooking and electrical appliances, however, the energy intensity still stays in a relatively low level. And because of the new building standard which decreases the energy service demand and technical progress, the energy intensity of building sector still much lower in 2050 than developed countries in 2010.

4. Conclusion

This study specifically models the energy consumption in China's building sector with consideration of the current and potential policies and building technology trends. China TIMES suggests that energy use in building sector will have a large increase in the next several decades even considering the impact of technical progress and fuel switching. And CO_2 emissions in building sector have a large growth to more than 1 billion tons in 2050 in the reference scenario. The enhanced policy scenario shows that fuel switching can make a reduction of CO_2 emissions down to about 770 million tons in 2050 with a certain purpose of no coal in urban residential and commercial buildings. It also gives us a relatively low-carbon future in building sector while it may put a large pressure to the supply side, especially natural gas and heat. The import and unconventional natural gas may solve this problem to some extent. And a lot of combined heat and power (CHP) in power sector may need to be built for the demand of heat. This is a great challenge in the future and an upfront planning needs to be down as soon as possible. The modelled results from China TIMES shows that though efforts, the energy intensity in China's building sector can still stay in a low level in 2050 with the growing energy service demands.

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