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# Carbon dioxide mitigation target of China in 2020 and key economic sectors

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## HIGHLIGHTS

- China's energy demand and $CO_2$ emission in 2020 are predicted.
- Integrated impacts of three factors can achieve $CO_2$ mitigation target in 2020.
- Twelve key sectors for China's $CO_2$ mitigation are identified on a life cycle basis.
- In the short term, China's $CO_2$ mitigation highly depends on technology development.
- In the long term, it relies on reshaped structure changes and new energy sources.

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## ABSTRACT

China proposed a $CO_2$ mitigation target in 2020 to deal with anthropogenic global climate change. Chinese policy makers mainly focus on three factors comprising consumption structure changes, energy technology development, and new energy increments. In addition, sectoral $CO_2$ reduction is increasingly concerned in the world. Thus, it is significant to investigate integrated impacts of three factors to China's $CO_2$ mitigation target as well as to identify key economic sectors for achieving this target. In this study, energy demand and $CO_2$ emission in 2020 are predicted. Five scenarios are generated to illustrate the contributions of three factors. In addition, twelve key economic sectors for reducing energy demand and $CO_2$ emission are identified from both production and final demand perspectives. Under integrated impacts of three factors, China's $CO_2$ intensity per unit gross domestic product in 2020 will decrease by about 43.9% in 2020 than 2005 level. In the short term, China's $CO_2$ mitigation will be highly dependent on energy technology development. In the long term, it will mainly rely on reshaped consumption structure changes and new energy development. In addition, China's future policies should focus on 12 identified key economic sectors.


## 1. Introduction

China has become the world's largest $CO_2$ emitter (Gregg et al., 2008). $CO_2$ emission is regarded as the primary anthropogenic driver of climate change (Gregg et al., 2008). In order to deal with anthropogenic global climate change, the concept of low carbon economy is introduced (STI, 2003). A low carbon economy means decoupling economic growth from $CO_2$ emission (STI, 2003). China is struggling for the low carbon economy to mitigate anthropogenic global climate change.

In China, the general public and policy-makers are increasingly considering climate change mitigation in their consumption activities and policy decisions. Chinese central government mainly focuses on three factors in the eleventh and twelfth five-year plans to achieve the low carbon economy: consumption structure changes, energy technology development, and new energy increments. Consumption structure changes are reflected by different growth rates of each sector's final demand. They aim to promote economic growth and to limit surplus and backward productivity simultaneously. Energy technology development, which means the decrease in energy consumption per unit of each sector's total output, focuses on improving energy usage efficiency. New energy increments change energy structure of production and consumption activities. They aim to reduce fossil fuel demands and $CO_2$ emission as well as to seek new economic growth opportunities. Based on efforts of these three factors, China expects to reduce its $CO_2$ intensity per unit gross domestic product (GDP) by 40%–45% in 2020 than 2005 level.

Subsequently, a question appears: can China achieve this target in 2020 under integrated impacts of these three factors? According to previous studies (Liang and Zhang, 2011a, 2012), there are interactions among various policies. This means that

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integrated impacts of various policies does not simply equal to the sum of impacts of each individual policy. Thus, in order to achieve China's $CO_2$ mitigation target in 2020, it is important to investigate integrated impacts of these three factors on $CO_2$ emission. Moreover, sectoral reduction of $CO_2$ emission is increasingly concerned (UNFCCC, 2007). National $CO_2$ mitigation target will mainly be achieved by key economic sectors. Thus, identifying key economic sectors can provide the emphasis for policy decisions on $CO_2$ mitigation. Key economic sectors should be identified on a life cycle basis (Allen et al., 2009; Foran et al., 2005; Liang et al., 2012b, 2013a, 2013).

Many studies on China's $CO_2$ emission have been conducted. The contribution of urban areas and main regions to China's $CO_2$ emission is investigated (Dhakal, 2009; Liang et al., 2007; Liu et al., 2012). Zhang and Cheng (Zhang and Cheng, 2009) discussed that China can pursue conservative $CO_2$ mitigation policy in the long run without impeding economic growth. The drivers for China's $CO_2$ emission change from 1957 to 2006 are analyzed (Chang, 2010; Fan et al., 2007; Feng et al., 2009; Liang and Zhang, 2011b; Peters et al., 2007; Wang et al., 2005; Zhang et al., 2009a, 2009b; Zhang, 2000, 2009). Energy efficiency improvements are identified to be the largest contributor to $CO_2$ mitigation, while the contribution of $CO_2$ intensity and structural changes is relatively small. Moreover, economic growth, urbanization and population growth are regarded to have negative contribution to $CO_2$ mitigation. The integrated impacts of three main factors (including consumption structure changes, energy technology development and new energy increments) on China's $CO_2$ emission, however, have not been analyzed. In addition, key economic sectors for achieving China's $CO_2$ mitigation target in 2020 have not been identified on the life cycle basis.

In order to fill this gap, this study mainly contributes to two points. First, integrated impacts of China's three main factors to $CO_2$ mitigation target in 2020 are investigated. Second, key economic sectors for achieving this $CO_2$ mitigation target are identified on a life cycle basis.

## 2. Methodology and data

### 2.1. Methodology

The hybrid input–output (HIO) model is used to predict future possibilities under integrated impacts of China's three main factors. Some sectors in the HIO model are expressed in physical units, which can partly reduce errors brought about by the assumption of unique sectoral prices (Liang and Zhang, 2013; Weisz and Duchin, 2006). The framework and functions of the HIO model as well as both behavior and structural validity of the HIO model are shown in Liang and Zhang's study (Liang et al., 2012a, 2012c, 2013b, 2013; Liang and Zhang, 2011a, 2013). Economic sectors of the economic system are divided into two categories: energy sectors and other sectors. Energy sectors are expressed in energy units (terajoule, TJ), and the other sectors are expressed in monetary units. Methods using the HIO model to predict future energy demand and $CO_2$ emission are described in Liang and Zhang's study (Liang and Zhang, 2011a). Consumption structure changes, energy technology development, and new energy increments are inputs of the HIO model. Consumption structure changes are illustrated by different growth rates of each sector's final demand. Energy technology development is illustrated by changes in elements of rows representing energy sectors in the direct requirement coefficient matrix of the HIO model. New energy increments are illustrated by changes in proportions of energy sources in each column of the direct requirement coefficient matrix of the HIO model. In order to investigate impacts of uncertainties of input data on results, sensitivity analysis is also conducted.

In addition, key economic sectors for achieving China's $CO_2$ mitigation target are identified on a life cycle basis. The life cycle basis in this study means investigating each sector's $CO_2$ emission from both production and final demand perspectives. The production perspective reflects direct sources producing $CO_2$ emission, not considering indirect $CO_2$ emission throughout whole supply chains. The final demand perspective analyzes both direct and indirect $CO_2$ emission accumulated throughout whole supply chains (Liang et al., 2013a; Liang and Zhang, 2011b; Peters et al., 2007). The final demand perspective can identify underlying drivers of $CO_2$ emission besides direct drivers from the production perspective. Equations calculating $CO_2$ emission from production and final demand perspectives can be found in Liang et al.'s study (Liang et al., 2013a).

### 2.2. Data and scenarios

Five scenarios are constructed to illustrate the contribution of consumption structure changes, energy technology development, and new energy increments to China's $CO_2$ emission. Each sector's $CO_2$ emission is calculated by methods of the *Intergovernmental Panel on Climate Change* (IPCC, 2006), comprising $CO_2$ emission from energy combustion and that from production processes. Economic sectors of the HIO model are classified into 58 categories. In particular, energy sectors are disaggregated into 16 energy sub-sectors, including coal, crude oil and natural gas, petroleum products and coke, coal-fired power, fuel gas, biodiesel, bioethanol, hydroelectric power, wind power, nuclear power, photovoltaic power, ocean power, biomass power, solar heat, geothermal heat, and biomass heat. The sector named *Transport, storage and post* is further disaggregated into 3 sub-sectors: *Transport, Storage, and Post*. Detailed disaggregation method is shown in Lindner et al.'s study (Lindner et al., 2012). Data for consumption structure changes, energy technology development and new energy increments during 2007–2020 are based on Liang and Zhang's study (Liang and Zhang, 2011a).

The base year is set to be 2007. According to data published by *National Bureau of Statistics of China*, economic growth rates in 2008, 2009, 2010, and 2011 are 9.63%, 9.20%, 10.30% and 9.2%, respectively, which are higher than the target in the eleventh five-year plan (7.50%) but lower than growth rates in 2006 (12.68%) and 2007 (14.16%). Moreover, expected annual economic growth rate of the twelfth five-year plan is 7%. This situation indicates that: China's economic growth rate is slowing down, which is consistent with economic development trends in this study's assumption. Moreover, the estimation of three factors is based on China's eleventh and twelfth five-year plans as well as *The Guideline Catalogue for Industrial Restructuring of China*. Descriptions of five scenarios are shown in Table 1. Detailed parameters for five scenarios are listed in the Supporting Information (SI).

## 3. Results and discussion

China's energy demand and $CO_2$ emission in 2020 are calculated. The contribution of three factors to China's $CO_2$ mitigation target is analyzed. Moreover, key economic sectors for China's $CO_2$ mitigation are identified. Sensitivity analysis is also presented to illustrate impacts of parameter changes on results. Finally, policy implications of results are discussed.

### 3.1. Energy demand and $CO_2$ emission in 2007 and 2020

China's energy demand and $CO_2$ emission in 2007 and 2020 are calculated (Table 2). According to proportions of the first row