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The air quality co-benefit of coal control strategy in China

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ABSTRACT

Coal keeps dominating the primary energy consumption in China, and is highly-related to the carbon emission and air quality challenge. Recently, China has submitted its Intended Nationally Determined Contribution (INDC) and committed to peak the carbon emission around 2030, and reduce the emission intensity by 60%–65% in 2030 compared to the 2005 level. Moreover, severe haze problem blanketed China in recent years and tends to getting worse, which is directly related to fossil fuel combustion, especially coal consumption in China. To address these challenges, this study carried out an analysis on effect of coal control strategy to energy system and local pollutant reduction. A bottom-up model of China-MAPLE is developed, linking the carbon emission and local pollutant emissions to the coal control policy scenarios. Four scenarios are designed for the energy system and co-benefit study. Three main conclusions can be drawn based on the study: first, the deep energy conservation measures including coal control has apparent effect on the energy system optimization, and the coal peaking year is near 2020 which is highly related and consistent with the carbon peaking. Second, the end-of-pipe control measures will significantly reduce the local pollutant emission, however the reduction is not sufficient enough to achieve the air quality standard. Energy conservation measures, especially coal control strategy, are essential for the source control side. Third, for the co-control from both source control and end-of-pipe control, emission of SO_2, NO_X and $PM_{2.5}$ in 2030 will be reduced by 78.85%, 77.56% and 83.32% compared to the level of 2010, which fits the air quality targets, together with carbon peaking target achieved. In electricity generation sector, the source control measures will contribute 10%–35% in future and coal control measures contributes 17%–40% to the local pollutant reduction. The strategy of coal control is of high importance for carbon mitigation and also local pollutant control.

1. Introduction

In contrast with many developed countries, coal has hitherto remained the dominant energy source in China and accounted for more than 70% of the total energy consumption for the past 20 years, and 67.5% in 2013. The coal consumption in China achieved 2.75 billion tce (tons of standard coal) in 2013, which is about half of the global coal consumption (International Energy Agency, 2014). Among the coal consumption, about 52% of coal is consumed in the electricity generation sector, while this share is lower than most of the developed countries (NBSC, 2014). The large amount of coal consumption has caused serious concerns on various social and environmental issues, such as the carbon emissions, aggravating local air pollution and other problems. China has submitted its INDC (NDRC, 2015) and committed to peak its carbon emission around 2030. Compared to 2005 level, the carbon emission per unit of GDP will be reduced by 60–65% in 2030. And the share of non-fossil fuel consumption in total primary energy consumption should rise to roughly 20% in 2030.

Besides of the carbon mitigation, air pollution in China became a major economic and social issue across the country, especially in Beijing-Tianjin-Hebei area and Yangtze River Delta. The coal combustion contributes 91.18% of total SO_2 emission, 68.56% of NO_x emission, and 52.74% to the primary $PM_{2.5}$ emissions in 2012 (MEIC, 2013). According to the study of World Health Organization, the air pollution accounts for more than one quarter of premature death and more than 23% of the health disease in China (WHO, 2015). The local air pollutant emissions are highly related to fossil fuel combustion, especially coal consumption in China. Actions of energy conservation to reduce carbon emissions also reduce co-emitted air pollutants like SO_2, NO_x and $PM_{2.5}$, bringing co-benefits for air quality (Fig. 1).

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Under these multiple challenges, China takes the coal control as the core target of low carbon development, and has taken a series of policies and measures in recent years. In 2014, the state council issued the National Energy Development Strategy Action Plan (2014–2020), and clearly stated that, up to year 2020, the total coal consumption should be controlled to 4.2 billion tons, and among the primary energy consumption the share of coal should be below 62%. And in the National Air Pollution Control Action Plan issued by Ministry of Environmental Protection, National Development and Reform Commission and other key ministries, the detailed coal consumption control target is further explicitly stated for key provinces and cities. The coal control in China is of high importance not only for carbon mitigation to achieve the peaking target, but also very critical for local pollutant reduction and air quality improvement.

This paper focusing on the coal relevant policies and technologies, aims to further study the air quality co-benefits of coal control and energy conservation measures based on China-MAPLE model. In Section 2, literature review of coal related policy research and co-benefit study is carried out. In Section 3, an overview of China-MAPLE model and its difference with other bottom-up model is introduced, with coal resources and local pollutant module highlighted. In Section 4, scenario analysis is carried out and based on the results, several issues including carbon peaking, local pollutant reduction and source control measures' contribution to air quality co-benefits are discussed. Section 5 draws the conclusion.

2. Literature review

Studies on coal related policy research in China keeps increasing in recent years, especially after the coal-control cap regulations published. First, on coal consumption in key sectors, Yuan et al. (2016) projected the trend of coal used for power generation in China till 2030 based on electricity demand, fuel mix and generation efficiency, and reach the conclusion that coal used for power could reach the peak at around 1280 Mtce by 2020. Wang and Li (2016) quantify the driving forces and drivers of coal consumption intensity, and found that the coal intensity and economic output of secondary industry is the leading contributor to change of coal consumption intensity. Bhattacharya et al. (2015) developed an integrated growth model to explain coal demand in China, and Li et al. (2015) predicted effects of five methods for China's coal demand and compared their forecast efficacy.

Focusing on the coal based technologies, Tang et al. (2015) analyzed the challenges and policy implications of clean coal use in China. Furthermore, Na et al. (2015) discussed the penetration of clean coal technology and its impact on China's power sector and summarized the future trend of clean coal power. Also, lots of studies focusing on the price elasticity of coal demand, like Burke and Hua (2015) estimated the price elasticity of coal demand and proved China's coal market is becoming more suited to price-based approaches to reducing emissions. Du and Mao (2015) estimated the environmental efficiency and marginal CO_2 abatement cost of coal-fired power plants in China, and found that subsidies can reduce environmental inefficiency but increase shadow price. When related to environmental pollutants, Zhu et al. (2016) studied the potentials of process control of heavy metals emissions from coal-fired power plants in China. Lots of the studies explored the coal demand drivers and future consumption, with highly consistent results, also studies on clean coal technologies and related emissions provide evidences of high relationship between coal combustion and carbon emission. Therefore, it is essential to further comprehensively study the relationship of between carbon mitigation from coal combustion and local pollutant reduction, to explore the air quality co-benefit from coal control policy.

Studies on co-benefits come to be a hot research topic in developed countries (Burtraw et al., 2003; Dessus and O'Connor, 2003; Jakob, 2006; van Vuuren et al., 2006), and especially in China studies starts emerging a lot in recent years (He et al., 2010; Xu and Masui 2009; Aunan et al., 2004; Creutzig and He 2009; Mao et al., 2011; Ma et al., 2016; Yang et al., 2013a,b). The main tools used include CGE model, GAINS model, MERGE model and TIMES-MARKAL model. For example,

For example, as one of the typical economic evaluation study on co-benefits, Aunan et al. (2004) studied the coal industry in Shanxi province, and figured out the effect of carbon mitigation policies on environment and human health. He et al. (2010) analyzed carbon mitigation policies and found evidences that these policies have positive effect on the local pollutant reduction. Creutzig and He (2009) took the transportation sector in Beijing as an case study, calculated the environmental co-benefits based on provincial level. Xu and Masui (2009) used the AIM/CGE model to analysis the local pollutant reduction, focusing on the SO2 tax policy and the effects. In recent years, Mao et al. (2011) studies the co-benefit of electricity sector in China and Ma et al. (2016) worked on China's iron and steel sector to explore co-benefits on national level. The paper authors (Yang et al., 2013a, 2013b) also looked into the cement sector, calculated the co-benefits of SO2, NOx and PM emission reduction due to the energy conservation technologies, and carried out evaluation of co-benefits based on provincial level in China. The results show that the national average co-benefit is around 3 $/t CO2 to 39 $/t CO2, which fit well of the estimation from study of Hasanbeigi et al. (2010), in Hasanbeigi's study 37 peer-reviewed studies on co-benefits are included. Therefore, the studies on co-benefit in China keep emerging and turn to change from qualitative analysis to quantitative analysis. However, most of the studies focused on single sector or based on activity level, more research focusing the full-economy sector and technological level is required.

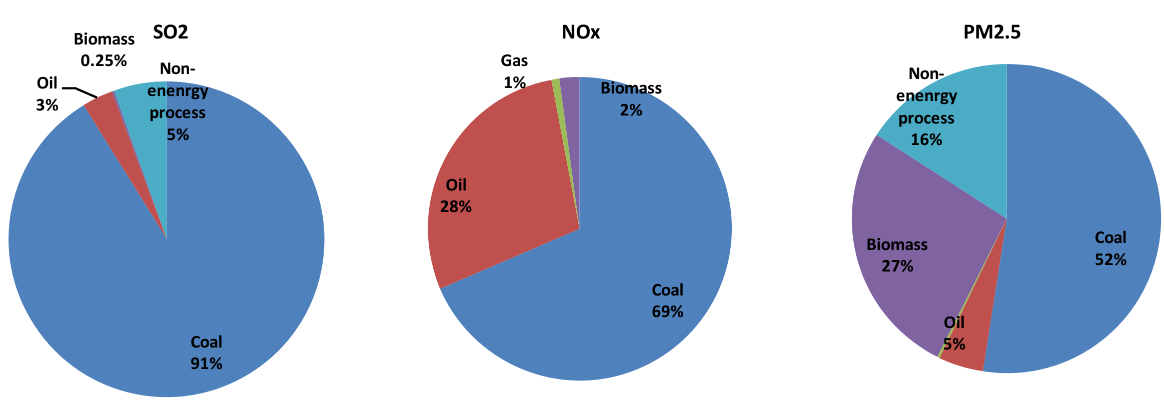

Fig. 1. Contribution of coal combustion to the SO_2, NO_x, and $PM_{2.5}$ emissions in 2012.
Data Source: MEIC model database (MEIC, 2013).

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