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Analysis of air pollution reduction and climate change mitigation in the industry sector of Yangtze River Delta in China

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ABSTRACT

China is now undergoing a fast process of industrialization, with the industry sector playing an important role in the overall economy. Among the many economic areas in China, Yangtze River Delta (YRD) takes the lead. The macro economy development and energy use status quo of both China and YRD are depicted, the past and current situation of air pollution and GHGs emissions is presented, and detailed national and local policies are reviewed. GAINS-China model is deployed in this study to evaluate the air pollution reduction and climate change mitigation achievements in the industry sector under the current policy of the three areas (i.e. Jiangsu, Zhejiang and Shanghai) in YRD from 2005 to 2030. According to the simulation results, the total population would grow marginally while the economy of YRD will keep booming in the next two decades. The total energy consumption of Jiangsu, Zhejiang and Shanghai in 2030 would be 2.36, 2.61 and 1.81 times that of 2005, with the industry sector still playing the biggest part. SO_2 emissions would be well under-control by 2030. The NO_X emissions all show steady growing trends, while the $PM_{2.5}$ emissions show different trends for three areas. The ensemble average years of life lost has a complex correlation with the total population and the $PM_{2.5}$ concentration. CO_2 emissions are still in predominant position among all the GHGs emissions, showing a steady growing trend towards 2030. All GHGs emissions amount in YRD would be 1.76 times that of 2005. The differences among the emissions in the three areas may due to reasons like economy scale, industrial composition, energy structure, and enforcement rate of policy. The uncertainties of this study may come from inaccurate prediction of scenario parameters and the expected policy changes in the future, and the emissions from the restructure of industry should be considered as well. In terms of achieving sustainable industrial development, YRD's governments should restrict the scale of energy-intensive industries, improve the primary energy structure, and take co-benefits concepts and methods more into policy-making processes.

1. Introduction

Despite the fact that most industrialized countries are now highly concerned about global warming and are making great efforts to cut down on their carbon emissions, less developed countries such as China and India are now right on their way of rapid industrialization and urbanization, which will be the predominant impetus for the global energy consumption in the coming decades. With a total population reaching 1.36 billion and the gross domestic products (GDP) reaching 9181.38 billion USD (7.7% more than 2012), China's urbanization rate has climbed up to a new level of 53.73%, by the end of 2013 (National Bureau of Statistics of China, 2014). To maintain the high speed of economic growth and social development, a great amount of energy, resources and materials have been consumed in China over the last decades. It is estimated that the primary energy consumption amount of China, by 2035, will almost match that of the OECD countries, and the CO_2 emissions will increase by 47% and account for 30% of world total, with per capita emissions overtaking the EU in 2017 and surpassing the OECD average in 2033 (BP, 2014a).

Although the proportion of the added value of tertiary industry (46.1%) in China has firstly exceeded that of second industry (43.9%) in 2013 (National Bureau of Statistics of China, 2014), the industry sector still holds the largest share (approximately 70%) in the

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energy consumption structure (Fig. 1) (National Bureau of Statistics of China, 2013) and remains the biggest contributor in terms of air pollutants emissions (Fig. 2) (National Bureau of Statistics of China and Ministry of Environmental Protection of China, 2013). Global climate change and local air pollution, two major issues which are usually studied and addressed separately, are actually closely related to each other, for greenhouse gases (CO_2, CH_4, N_2O, HFCs, etc.) and air pollutants (SO_2, NO_X, PM, VOCs, etc.) are emitted simultaneously from the combustion of fossil fuels, in spite of their temporal and spatial differences (Bollen et al., 2009a; Dulal et al., 2013). Even though it is projected that the coal share in China's primary energy consumption will decline from 69% (2012) to 52% (2035) with the highest renewables growth rate in the world (BP, 2014b), regarding the fact that China is still on the highway towards industrialization, the industry sector will still play as the biggest energy consumer among all the sectors. Therefore, China will be faced with increasing pressure to tackle the problem of air pollution reduction as well as climate change mitigation.

In response to the multiple challenges, China has adopted comprehensive strategies in terms of energy conservation, climate change mitigation, and air pollution control. *The Twelfth Five-Year Plan on Energy Development* is the blueprint to guide China's energy development during 2011–2015. It sets goals including at least 16% decline on energy intensity (i.e. the energy consumption amount per unit of GDP), and 17% decline on carbon emission intensity (i.e. CO_2 emission per unit of GDP), compared to that of 2010, as well as reducing NO_X and $PM_{2.5}$ concentration (The state council of the People's Republic of China, 2013a). *Twelfth Five-Year Plan on Greenhouse Gases Emissions Control* sets even more detailed reduction targets to different provinces and regions (The state council of the People's Republic of China, 2011). *Climate Change Adaptation Program of the Industry sector (2012–2020)* targets that the CO_2 emission per unit value-added of industry, in 2015 and 2020, would be 21% and 50% less than that of 2010, respectively (Ministry of Industry and Information Technology of China et al., 2012). *China's Policies and Actions for Addressing Climate Change (2013)* reviews China's efforts in 2013 on industrial structure adjusting, energy structure optimizing, energy conserving and forests carbon sinks increasing, etc. (National Development and Reform Commission of China, 2013). *Air Pollution Control Action Plan* sets the target that the PM_{10} concentration will drop by no less than 10% in 2017, compared to 2012, with Beijing–Tianjin–Hebei Area, Yangtze River Delta Area and Pearl River Delta Area decrease 25%, 20% and 15% respectively (The state council of the People's Republic of China, 2013b). *Twelfth Five-Year Plan on the Air Pollution Control of Key Areas* addresses the co-control measures of air pollutants in 13 key areas of China (Ministry of Environmental Protection et al., 2012). Determined to tackle the issue of both climate change and air pollution, China is now getting aware of achieving co-benefits by designing and implementing a smart mix of more cost-effective policies.

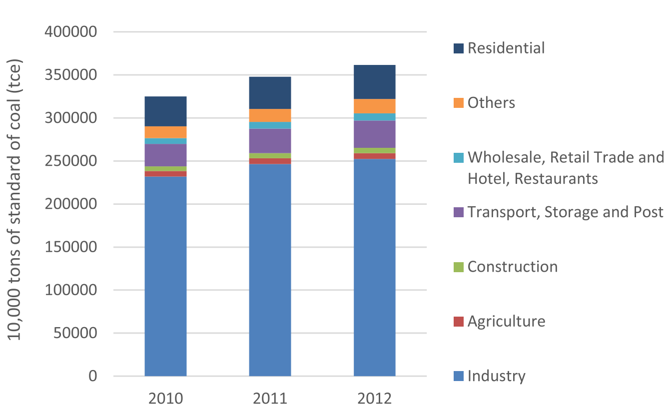

Fig. 1. Energy consumption amount and structure of China (by sector), 2010–2012.

Fig. 2. Air pollutants emissions from different sectors of China, 2010–2012.

The study of co-benefits is becoming popular in recent years. Quite a few researches focus on finding out to what extent the co-benefits are brought about by certain interventions (laws, policies, programs, projects, etc.). Jiang et al. (2013) examined China's policies related to co-benefits in different sectors and selected two industrial areas as case studies to assess the co-benefits achieved by local mitigation measures. Oliveira et al. (2013) presented the magnitude of the co-benefits achieved by certain sectors in Asian cities. Ministry of the Environment of Japan (2009) has been making great efforts on promoting co-benefits approach and has developed a set of indicators and calculation equations to evaluate the co-benefits approach in terms of environmental projects such as CDM, by different categories. Relevant models are being utilized more frequently in co-benefits assessment as well. For instance, Geng et al. (2013) and Mao et al. (2012) used different models to project the carbon dioxide emission and air pollutants emission under different policy scenarios in the transport sector. Chen et al. (2006) forecasted the energy consumption and explored the co-benefits under 3 different energy policy scenarios in Shanghai by using MARKAL model. Xu and Toshihiko (2009) simulated the impacts on local air pollutant emission reduction and ancillary CO_2 emission reduction of SO_2 control policies in China based on AIM/CGE model. Bollen et al. (2009b) reviewed the literatures on the estimates of the co-benefits and then used the extended MERGE model to make a new estimate in a global scale. Markandya et al. (2009) compared the health benefits resulted from GHGs reduction measures in EU, India and China by adopting POLES model, GAINS model and a WHO recommended model. He et al. (2010) combined 4 models, i.e. an energy projection model (LEAP), an emission estimation model (TRACE-P), an air quality simulation model (CAMQ) and a health benefit evaluation model (BenMAP) to assess the co-benefits from China's energy policies. Cao et al. (2008) made an integrated modelling analysis after a thorough methodology review on all the top-down and bottom-up models that have been used in co-benefits estimation. All these aforementioned quantitative analysis, especially through modeling methods, is now gaining its significance for in-depth research on co-benefits approach.

Yangtze River Delta (YRD) is the largest economic zone in China, with its industry sector playing an important role in the national economy. The main purpose of this study is to assess the co-benefits of GHGs reduction and air pollution reduction in YRD's industry sector through the application of GAINS-model, so as to give feasible suggestions to local and national policy-makers.

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