CHINA'S ENERGY SYSTEM OPTIMAZATION UNDER INDC COMMITMENTS: STUDY BASED ON CHINA-MAPLE MODEL

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Key words

Energy system optimization, INDC, carbon mitigation, China-MAPLE model

Overview

China has stepped into the stage of new normal development, with GDP growth rate slowing down. And in 2015, China has submitted its Intended Nationally Determined Contribution (INDC) to UNFCCC, and committed to reduce the emission intensity per unit of GDP by 60%–65% from its 2005 level in 2030, and also peak the carbon emission around 2030. At the same time, the local pollutant problem and haze problem keeps getting worse in China.

This paper focuses on these challenges and critical research topic on co-control of carbon emission and local air pollutants, and aims to explore China's energy system optimization in the 2 degree world, specifically following the carbon mitigation trajectory as the INDC documents committed. This paper is highlighted from three aspects: first, to get the carbon mitigation trajectory and carbon emission allocation in China under the constaints of INDC documents; Second, to get the the carbon mitigation trajectory evaluated based on China-MAPLE model, and explore the energy system transformation pathway; Third, the work is based on China-MAPLE model framework, a partial equilibrium model with linkage between carbon emission and local air pollutants at technological level.

Methods

The study is based on China-MAPLE model. China-MAPLE (China-Multi-pollutant Abatement Planning and Long-term benefit Evaluation) model is developed to evaluate the minimum system cost of energy system based on linear programming, and optimize the energy structure based on constraints of mitigation policies and technology. The model carries out multi-sectoral bottom-up evaluation on national level, including resource supply, oil refinery, electricity generation, transportation, industry and building sector. The base-year energy service demands are exogenous and are projected for the future using drivers such as GDP, population, household, value-added by sectors etc. The model output includes China's future energy consumption, carbon dioxide emissions in different scenarios, major conventional pollutant emissions, and co-benefits of the carbon mitigation actions.

China-MAPLE differs from other versions of bottom-up model in three aspects: First, local pollutant control and co-benefit module has been integrated into the energy system framework, the local pollutant emission control measures and technologies are implemented for main sectors in China-MAPLE. Second, instead of based on fuel consumption or activity level, the end-of-pipe technologies are implemented on all the relevant technologies with different application rate and emission factor. This approach can help distinguish the local pollutant reduction due to energy conservation and end-of-pipe control measures. Third, China-MAPLE introduces energy supply curve into the energy supply module. The coal, oil and gas supply includes both domestic production and importation, thus can reflect the reality approaching result of primary energy consumption, and avoid the possible deviation caused by fixed energy cost.

Based on the peaking constraints in the INDC documents, the contraints are directly injected into the China-MAPLE platform for evaluation, to get the main results of energy system optimazation, including primary energy structure adjustment, technological improvement among sectors, electricity mix, and local pollutant mix in China up to year 2050.

Results

Based on the first step rough simulation with China-MAPLE model, the total energy-related carbon emission will peak around year 2030, and then decrease to year 2050. Large amount of carbon mitigation can be fulfilled. Compared to reference scenario, the total carbon emission in 2030 is declined from 11.88 billion tons CO_2 to 10.58 billion tons CO_2, around 1.30 billion tons CO_2 with 12.4% of reduction. The growth rate during 2010-2030 is around

1.52%, which is 0.64% lower than reference scenario, and after peaking in 2030, the decreasing rate during 2030-2050 is about 1.55%, about 0.81% higher than the REF scenario. The carbon intensity in 2030 is about 12.32% reduced compared to the reference scenario, and the reduction rate will increase to 43.14% in 2050.

When comes to the distribution of carbon emission among sectors, electricity generation and industries dominate the carbon emissions, which are also the main coal consumption sectors. Besides, the rural residential building sector also has large amount of bulk coal consumption for heating in winter. The three sectors together take account of 85% in reference scenario and 83% in INDC mitigation scenario in year 2030.

At sectoral level, for electricity generation, the energy conservation has strong effect on the total carbon mission. Respectively, in the INDC mitigation scenario, the carbon emission will peak around year 2020 at 3.107 billion tons CO_2, and then decrease to year 2050. During the period 2020-2050 by 10-year step, the carbon emission is reduced by 4.19%, 33.57%, 48.80% and 82.13% compared to reference scenario.

In the industry sector, the demands of main energy-intensive products will peak around year 2020, with the carbon emission peaking around year 2020 at 4.63 billion tons CO_2 in the INDC mitigation scenario. During 2020-2050 by the 10-year step, the industry sector carbon emission is reduced by 1.38%、2.71%、6.52% and 11.35%, compared to reference scenario. In the building sector, the carbon emission peaking year is around 2030 in INDC mitigation scenario compared to 2040 in reference scenario. The carbon emission in building sector in 2020, 2030, 2040 and 2050 compared to reference scenario, is reduced by 2.92%, 5.52%, 15.41% and 24.98%.

The carbon peaking year of electricity generation sector and industry sector is around 2020, which are also the dominant sectors of coal consumption. The peaking year is closely consistent with the coal peaking year. Thus the carbon mitigation is highly related to coal conservation measures and technologies application, together with increasing application of renewables.

Conclusions

The concept of INDC is a real game changer to climate negotiation which ask host countries to consider their possible contribution from a bottom up perspective.The carbon mitigation measures has large effect on the energy system optimization. The coal consumption can peak around 2020, and respectively the carbon emission peaking around 2030, which has achieved the INDC target. Among the sectors, the electricity sector and industry sector contributes most, and with the coal consumption concentrated to electricity generation, the coal efficiency can be largely improved, the main local pollutant emissions will also be significantly reduced for key sectors. When comes to the local pollutant among sectors, SO_2 reduction mainly comes from the industrial sector (46%) and the power sector (19%) in 2030. NO_x emission reduction is mainly from the industrial sector (35%), the power sector (22%) and transportation sector (21%), and PM2.5 emission reduction mainly comes from the household sector (49%), the industrial sector (32%) and electricity sector (6%), in the household sector the emissions reductions are mainly due to the improvement of energy mix in rural area. The INDC commitment is possible to be acheved for the carbon intensity reduction of 60%-65% in 2030 compared to 2010, and carbon peaking target around or even earlier than 2030. Besides, the local pollutant reduction can be observed together with the INDC target, as a result of the energy structure adjustment and technological improvement.