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Low carbon transition in Beijing-Tianjin-Hebei Region Under Carbon Neutrality Scenario

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ABSTRACT

The new carbon emission reduction target proposed by the Chinese government is an important process for the international community to deal with climate change. Beijing-Tianjin-Hebei region is the representative region of the advanced region of China and it is important to analyze the low carbon transition in Beijing-Tianjin-Hebei region. This paper used a provincial China TIMES model to analyze the carbon emission, energy use and electricity transmission under low carbon scenarios. This paper established 3 scenarios which include reference scenario (REF), NDC (Nationally Determined Contribution) scenario which achieves China's carbon emission peaking target in 2030 and a carbon neutrality scenario which achieves China's carbon neutrality target in 2060. The results show that the carbon emission in Beijing-Tianjin-Hebei region will peak at 2035 and 2030 in the NDC_PEAK30 and CN60 scenario. In the low carbon scenarios, the proportion of electricity in the final energy consumption will continuously increase to achieve the low carbon transition target. The power sector will have negative emission in the carbon neutrality scenario and the Biomass Electricity plant with Carbon Capture and Storage (BECCS) will play an important role in carbon neutrality. The carbon neutrality is a big challenge to China especially in Beijing-Tianjin-Hebei region. It needs more effort in transport and building sector.

Keywords: carbon neutrality; energy; China; Beijing-Tianjin-Hebei region; TIMES model

1. INTRODUCTION

President Xi Jinping for the first time announced China's long-term goals to reduce carbon emissions on September 22th. Xi told the United Nations General Assembly that China would scale up its voluntary emissions targets under the Paris climate agreement, that it aimed to hit peak emissions before 2030, and to achieve carbon neutrality before 2060. Under China's Nationally Determined Contribution (NDC), the Chinese government proposed that the national CO2 emissions peaks at 2030 or in advance meanwhile the renewable energy should account for more than 15% in primary energy in 2020 and more than 20% in 2030[1]. When implementing China's response to climate change in the provinces, it should take into account the different situations such as economic development and energy reserves of the provinces.

The Beijing-Tianjin-Hebei region is one of the several economically and politically important regions in China. The low carbon transition in the Beijing-Tianjin-Hebei region is very important in the China's low carbon transition.

Some studies focused on the carbon emission in Beijing-Tianjin-Hebei region in different sectors. Guo and Meng [1] analyze the carbon emission in transportation sector and how to achieve the low-carbon transport development in Beijing-Tianjin-Hebei region. Wang, Zhan [2] calculated direct and indirect carbon emissions from both urban and rural residential consumption in the Beijing-Tianjin-Hebei region from 2002 to 2012, and then explored the main factors contributing to indirect carbon emissions from residential consumption using a structural decomposition analysis. Yan, Wang [3] focused on power sector and used generalized Divisia Index Method (GDIM) to decompose the dynamics in the CO2 emission in power sector.

This paper used a China's provincial TIMES model, China TIMES-30PE, to analyze the low carbon transition in Beijing-Tianjin-Hebei region under different scenarios.

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2. METHODOLOGY

The TIMES model, is a combination of the MARKAL (Market Allocation Model) and the EFOM (Energy Flow Optimization Model) which is developed and maintained by The IEA-ETSAP (Energy Technology Systems Analysis Program). The provincial China TIMES-30P model was developed based on the China TIMES[4-6] and China MARKAL[7] models. The provincial model contains 30 provincial administrative regions which include 22 provinces, 4 autonomous regions, 4 municipalities directly under the central government (Taiwan province, Tibet Autonomous Region, Hong Kong Special Administrative Region and Macao Special Administrative Region are not considered in the model due to statistical issue). The 30-region energy system model is built include energy supply, conversion, transmission and end-use technologies with a modeling period from 2010 to 2050 within a 5-year reporting period and described the flow of various energy carriers in the optimal mix of technologies. The historical data which the model calibrated based on is collected from various statistics, reports and official announcements from 2010 to 2015. Based on a given social economic development scenario in previous studies [8, 9], energy service demand in the model include five sectors which are agriculture, transportation, industry, commercial and residential. More details for the reference energy system and energy service demand considered in the model could be found in the literatures [10-12].

3. SCENARIOS AND ASSUMPTIONS

In this study, 3 scenarios were designed to study the pathway of carbon emission in Beijing-Tianjin-Hebei region. The reference scenario is a baseline scenario using the existing energy and economic policies at the national and provincial levels from the 13th Five-year Plan, such as those for industrial structure adjustment, increasing non-fossil energy substitution and reducing carbon intensity and coal consumption. This scenario addresses the current status of the energy system and the policies needed to meet the goals and commitments for near-term development.

Two low carbon scenarios were designed to study the pathway of low carbon transition in Beijing-Tianjin-Hebei region. The NDC scenarios is designed to simulate the target that China's carbon emission peak at 2030 or in advance. In NDC_PEAK30, to achieve the NDC target and carbon emissions peak at 2030, the cumulative emissions constraint from 2010 to 2050 was 380Gt.

The carbon neutrality scenarios include CN60. The CN60 was established to study the low carbon transition pathway in Beijing-Tianjin-Hebei region under the carbon neutrality target. According to our colleague's study on carbon mitigation burden sharing model and energy system optimization model GTIMES[13], the

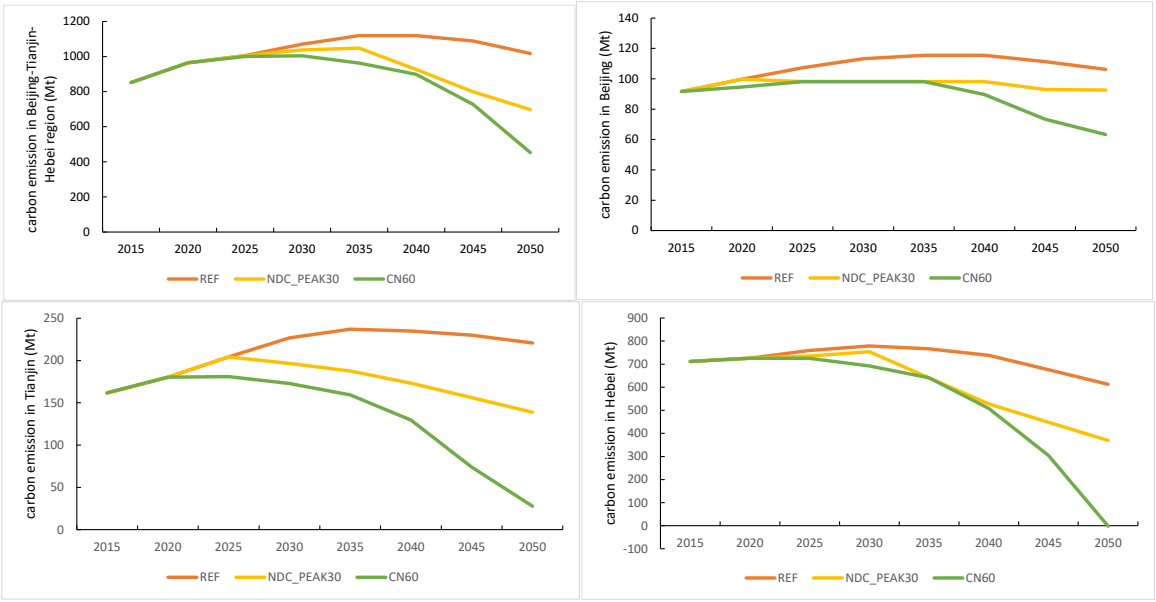

Fig 1 Carbon emission in Beijing-Tianjin-Hebei region under different scenarios

carbon emission in 2050 assumed as 1327Mt to achieve the carbon neutrality target.

Table 1. Scenarios in China TIMES-30PE

Scenarios		Description
Reference	REF	Reference scenario with existing energy policies
Low carbon development scenarios	NDC_PEAK30	NDC scenario: Emissions peak at 2030, cumulative emissions in 2010-2050 380Gt
	CN60	China achieve carbon neutrality before 2060, China's carbon emission in 2050 assumed as 1327Mt

4. RESULTS AND DISCUSSIONS

4.1 Carbon emission in Beijing-Tianjin-Hebei region

Fig1 shows the carbon emission from 2015 to 2050 under different scenarios.

With the low carbon transition policies, the carbon emission will peak at 2030 and 2025 under NDC_PEAK30 and CN60 scenarios, respectively. The carbon emission in Beijing-Tianjin-Hebei region will peak at 2025 and reach 1004.2Mt under carbon neutrality scenario. The carbon emission in Beijing-Tianjin-Hebei region is projected to reach 1017.5 Mt, 697.5 Mt and 451.92 Mt in 2050 under the REF, NDC_PEAK30 and CN60 scenarios, respectively. The carbon emission in Beijing-Tianjin-Hebei region is projected to reach 106.3 Mt, 92.6 Mt and 63.2 Mt in 2050 under the REF, NDC_PEAK30 and CN60 scenarios, respectively. Beijing need to find a pathway to achieve low carbon development in transport sector and building sector. The carbon emission in Hebei is projected to peak at reach 613.1 Mt, 369.2 Mt and -1.8 Mt in 2050 under the REF, NDC_PEAK30 and CN60 scenarios, respectively. In carbon neutrality scenario, Hebei will have negative carbon emission in 2050.

4.2 Carbon emission in Beijing-Tianjin-Hebei region

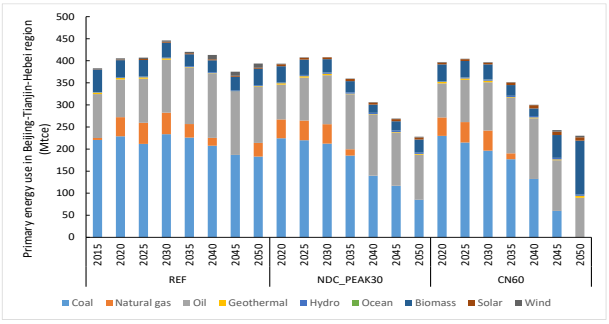

Fig 2 Primary energy use in Beijing-Tianjin-Hebei region

Fig2 shows the primary energy use from 2015 to 2050 under different scenarios.

Compared with reference scenario, the coal use in the primary energy use will continued decrease in the low carbon scenarios. The primary energy use in Beijing-Tianjin-Hebei region is projected to reach 393.3 Mtce, 228.0 Mtce, and 230.3 Mtce in 2050 under the REF, NDC_PEAK30, CN60 scenarios, respectively. Besides, The non-fossil fuel energy use in the primary energy use will be 25.7%, 32.7%, and 77.7% in 2050 under the REF, NDC_PEAK30, CN60 scenarios, respectively. In the same time, biomass will play an important role and reach 121.9 Mtce in the carbon neutrality scenario.

4.2 Final energy consumption in Beijing-Tianjin-Hebei region

Fig3 shows the final energy consumption from 2015 to 2050 under different scenarios. The results showed that the final energy consumption in Beijing-Tianjin-Hebei region will reach 254.4 Mtce, 227.8 Mtce, and 156.9 Mtce in 2050 under the REF, NDC_PEAK30, CN60 scenarios, respectively. Because of the elastic energy service demand, the final energy consumption is projected to decrease with the low carbon constraint.

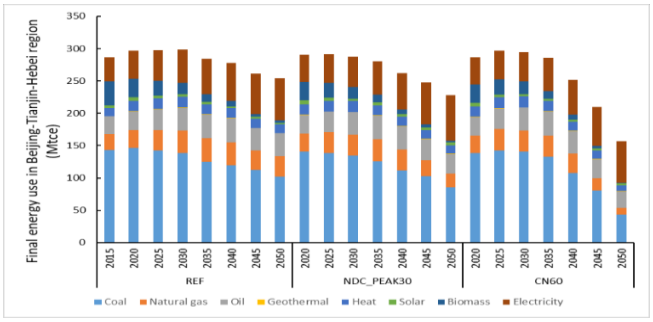

Fig 3 Final energy consumption in Beijing-Tianjin-Hebei region

4.4 Electricity consumption in Beijing-Tianjin-Hebei region

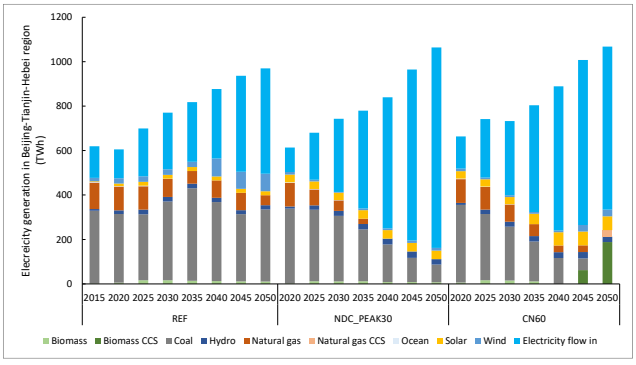

Fig 4 the electricity generation (include electricity flow in) from 2015 to 2050 under different scenarios.

Fig4 shows the electricity generation (include electricity flow in) from 2015 to 2050 under different scenarios.

The electricity generation (include electricity flow in) will reach 979.0 TWh, 1073.1 TWh and 1072.7 TWh in 2050 under the REF, NDC_PEAK30, CN60 scenarios, respectively.

Compared with reference scenario, the proportion of electricity import in the electricity consumption will increase in the low carbon scenarios. In carbon neutrality scenario, Hebei will construct more Biomass Electricity plant with Carbon Capture and Storage (BECCS) which will decrease the proportion of electricity import.

5. CONCLUSIONS

This study used a provincial China TIMES model to analysis the low carbon transition in Beijing-Tianjin-Hebei region. Four scenarios were established to analysis the low carbon transition pathways in Beijing-Tianjin-Hebei region.

The carbon emission in Beijing-Tianjin-Hebei region will peak at 2025 and reach 1004.2Mt under carbon neutrality scenario. Beijing proposed that the government would force carbon emission at 2020. The carbon emission of Tianjin and Hebei will peak at 2025 and 2030.The energy structure will change a lot in the carbon neutrality scenario. The proportion of non-fossil fuel energy in primary energy use in Beijing-Tianjin-Hebei region will be 25.7%, 32.7%, and 77.7% in 2050 under the REF, NDC_PEAK30, CN60 scenarios, respectively. The proportion of electricity in final energy use of Beijing-Tianjin-Hebei region will continuously increase.

In Beijing and Tianjin, the large energy service demand in transport and building sector make it hard to achieve carbon neutrality in Beijing and Tianjin. The Biomass Electricity plant with Carbon Capture and Storage will play an important role in the carbon neutrality process, the province with rich biomass like Hebei can achieve negative emission in 2050.

The results suggest that the policy on EV and low carbon building is important for carbon neutrality. Besides, it is very hard to achieve zero emission in all sectors which shows the importance of Biomass Electricity plant with Carbon Capture and Storage.

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REFERENCE

[1] Guo M, Meng J. Exploring the driving factors of carbon dioxide emission from transport sector in Beijing-Tianjin-Hebei region. Journal of Cleaner Production. 2019;226:692-705.

[2] Wang C, Zhan J, Li Z, Zhang F, Zhang Y. Structural decomposition analysis of carbon emissions from residential consumption in the Beijing-Tianjin-Hebei region, China. Journal of Cleaner Production. 2019;208:1357-64.

[3] Yan Q, Wang Y, Li Z, Baležentis T, Streimikiene D. Coordinated development of thermal power generation in Beijing-Tianjin-Hebei region: Evidence from decomposition and scenario analysis for carbon dioxide emission. Journal of Cleaner Production. 2019;232:1402-17.

[4] Chen W, Li H, Wu Z. Western China energy development and west to east energy transfer: Application of the Western China Sustainable Energy Development Model. Energy Policy. 2010;38:7106-20.

[5] Chen W, Wu Z, He J, Gao P, Xu S. Carbon emission control strategies for China: A comparative study with partial and general equilibrium versions of the China MARKAL model. Energy. 2007;32:59-72.

[6] Chen W, Yin X, Ma D. A bottom-up analysis of China's iron and steel industrial energy consumption and CO2 emissions. Applied Energy. 2014;136:1174-83.

[7] Chen W. The costs of mitigating carbon emissions in China: findings from China MARKAL-MACRO modeling. Energy Policy. 2005;33:885-96.

[8] Li N, Chen W. Energy-water nexus in China's energy bases: From the Paris agreement to the Well Below 2 Degrees target. Energy. 2019;166:277-86.

[9] Li N, Chen W. Modeling China's interprovincial coal transportation under low carbon transition. Applied Energy. 2018;222:267-79.

[10] Li N, Ma D, Chen W. Quantifying the impacts of decarbonisation in China's cement sector: A perspective from an integrated assessment approach. Applied Energy. 2017;185:1840-8.

[11] Ma D, Chen W, Yin X, Wang L. Quantifying the co-benefits of decarbonisation in China's steel sector: An integrated assessment approach. Applied Energy. 2016;162:1225-37.

[12] Yin X, Chen W. Trends and development of steel demand in China: A bottom–up analysis. Resources Policy. 2013;38:407-15.

[13] Huan W. Modeling of global energy system transition and co-benefit under Paris Agreement: Tsinghua University; 2019.