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Modeling the Energy Transition of China under Different Peaking Time Based on Global-TIMES Model

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ABSTRACT

Reaching the CO2 emission peak as soon as possible is significant to limit global warming to well below 1.5℃. Based on GTIMES model, this paper simulates the transition of China's energy system under scenarios of energy-related CO2 peaking in 2025 and 2030.The results show that the realization of peaking earlier mainly depends on the transition of energy structure. Accordingly, coal consumption will be significantly reduced from now on, and non-fossil energy such as solar and wind would increase significantly, while biomass also needs to be developed to meet the requirement of carbon neutrality. The power system needs to start de-carbonization as soon as possible. The realization of earlier peaking time can avoid some unnecessary carbon locking and lay a foundation for China to achieve carbon neutrality.

Keywords: energy-related CO2 emission, peaking time, energy transition, GTIMES

NONMENCLATURE

Abbreviations	
IPCC	Intergovernmental Panel on Climate Change
GTIMES	Global-TIMES
CO2	Carbon dioxide
NDC	National Determined Contribution
ESD	Energy service demand

1. INTRODUCTION

Both of the Global Warming of 1.5°C report and IPCC fifth Assessment Climate Change suggest that it was necessary to limit global warming to 2 or even 1.5 degrees relative to that before the industrial revolution at the end of this century. Achieving the 1.5 degree target requires the world to begin absolute reductions and reach emission peak as soon as possible. Since the CO2 has a long existing time, the earlier the peak is reached and the sooner the emission reduction is made, the better the temperature rise control will be.

As the largest emission country at present, China's peaking time has significant impact on the global carbon emissions. President Xi Jinping announced on Sept 22 while addressing the general debate of the 75th session of the United Nations General Assembly via video, that China aims to see carbon dioxide emissions peak before 2030 and achieve carbon neutrality before 2060. This goal will have a great contribution to realize the 1.5 degree target.

The peaking time will also have different impacts on China's energy transition. This paper models an aggressive scenario that the global carbon emission would peak at 2025; compare with a scenario has a peaking time of 2030; simulates the carbon pathways and energy transition of China, and discusses the primary energy consumption, final energy consumption and structure of electricity generation, to see the important of peaking as soon as possible.

2. METHODOLOGY

2.1 Global-TIMES model

Global-TIMES (The Integrated MARKAL-EFOM System) is a technology-rich model developed based on

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China-TIMES, which now has 14 regions including China. GTIMES is also a bottom-up optimization model that represents the whole integrated energy sector from primary to useful energy. This global model aims at exploring different possible energy futures based on the minimal-cost decision and try to describe how the future for the world energy sector may develop and the key factors that influence the future energy systems. In this research, the model only tracks emissions from CO2 from fuel combustion and processes.

GTIMES was developed with 5-year intervals extending from 2010 to 2050 based on a reference energy system (RES) which incorporates the full range of energy processes including energy trading, exploitation, conversion, transmission, distribution and end-use. The model contains explicit detailed description of more than 500 technologies and several hundreds of energy, emission and demand flows in each region.

2.2 Scenario settings

To meet the target of 1.5 degree, the energy-related CO2 emission is designed to peak at 2025 and 2030. 14 regions are free in carbon trading and all of them are willing and able to exploit local emission reduction potential as much as possible, based on the most cost-effective design.

Under the constraint of global emission peaking time, China will peak at 2025 and 2030 respectively, and has a correspondence with global peaking time. According to the result of the model, the CO2 emissions reach to a similar level in 2050.

Scenarios	Descriptions
PK-2025	Emission peak at 2025, the peaking emission is around 10.3Gt, and the cumulative emissions in 2020-2050 is around 164Gt.
PK-2030	Emission peak at 2030, the peaking emission is around 10.5Gt, and the cumulative emissions in 2020-2050 is around 199Gt.

3. RESULTS

3.1 Primary energy consumption

The primary energy consumption will peak around 2025 and 2030 respectively. The primary energy consumption will have a relatively large increase of 25%, from 2020 to 2030 under the PK-2030 scenario, compared with an increase of 12% under PK-2025 from 2020 to 2025. And they just have a little difference in 2050 due to the similar CO2 emissions under two scenarios.

However, the coal consumption under PK-2025 will fall rapidly, from 68% in 2020 to 20% in 2050. While under the scenario of peaking in 2030, the proportion of coal consumption just changes little between 2020 and 2030, and begins to decline rapidly after 2030.

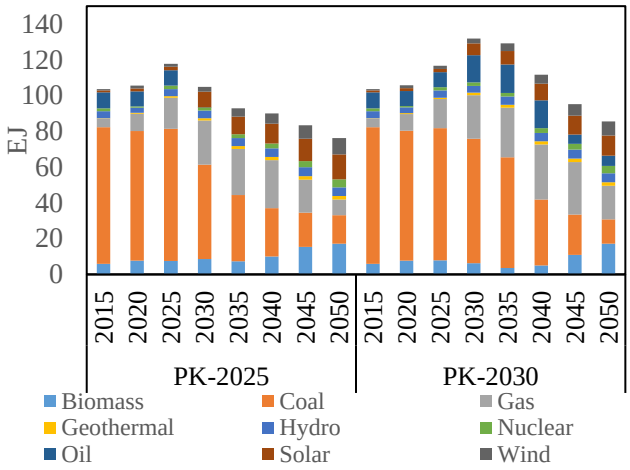

Fig 1 Primary energy consumption by fuel

Reduction of fossil energy is one of the most important measures in climate mitigation, as a result, the proportion of fossil energy in the primary energy drop significantly, the share of fossil fuel will fall 86% in 2020 to 32% and 44% in 2050 respectively under two scenarios. Since China has proposed the carbon neutrality target of 2060, it is necessary to deploy negative emission technology in advance to meet the requirement of carbon neutral from now on. Therefore, the proportion of biomass consumption will gradually increase under the two scenarios.

The proportion of solar energy is quite different in different peaking time. Under the PK-2025 scenario, the proportion of solar energy is significantly higher than that of PK-2030 in 2050, accounting for 18% and 13% respectively. This may be due to the fact that the power system chooses more non-fossil energy power generation technologies under the requirement of reaching an earlier peaking time, while in the PK-2030 scenario, solar energy accounts for a relatively low proportion in 2050 due to the locking effect of traditional energy technologies.

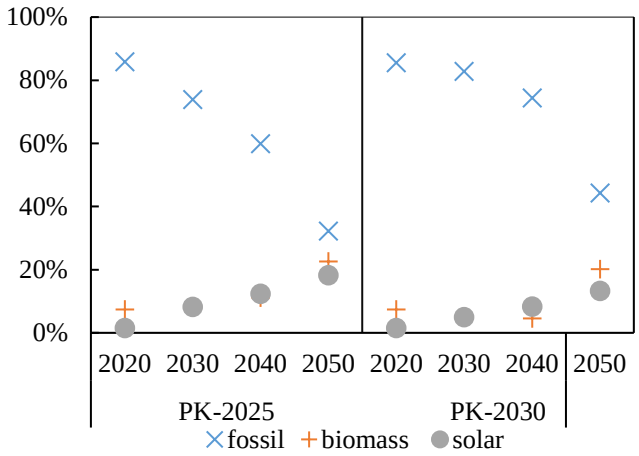

Fig 2 Comsuption proportion of fossil, biomass and solar in primary energy

3.2 Final energy consumption

The trends of final energy consumptions are basically the same under two scenarios, both reaching the peak around 2030 to 2035, and the final energy use under PK-2025 is just slightly lower than that of PK-2030. Since the energy consumption in the GTIMES model is driven by ESD, reaching the peak in advance has little impact on the demand for energy services, so there is unsignificant change in the final energy demand. However, the electrification rates under PK-2025 and PK-2030 are quiet different, from 23% in 2020 to 42% and 30% respectively. Earlier peaking time will promote the deployment of electrical equipment in end-use sectors.

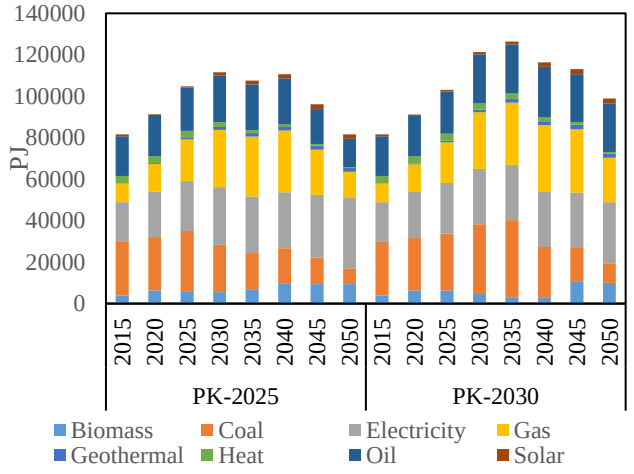

Fig 3 Final energy consumptipn by fuel

3.3 Electricity generation

The de-carbonization of power sector is the key to achieve emission peaking and carbon neutrality. A significant change in electricity capacity is that coal power will decline rapidly under the two peaking scenarios, with the proportion dropping from 60% in 2020 to 3% and 4% respectively in 2050. However, under the PK-2030 scenario, coal power capacity shows slightly decrease from 2020 to 2030, which due to the fact that China has newly approved the construction of coal power units in the past two years. However, after 2030, the share of electricity capacity by coal also began to fall rapidly under PK-2030.

Under the constraint of earlier peaking, solar and wind power have a fast developed. It is related to the continuous decrease of their generation costs, and also can meet the need of low-carbon transition.

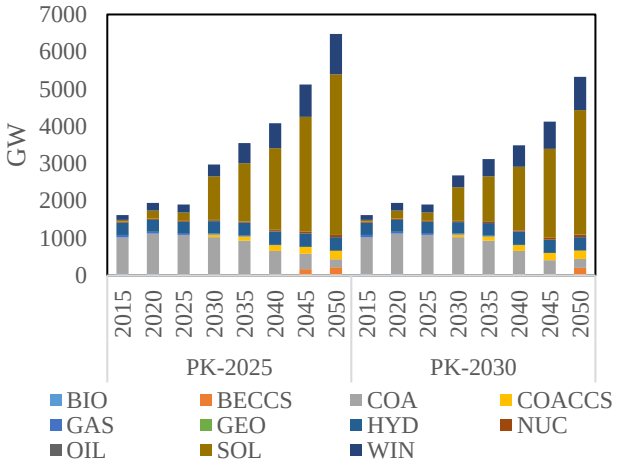

Fig 4 Electricity capacity by technology

4. CONCLUSION

Based on GTIMES model, different peaking-time of carbon emissions will have a greater impact on the transition of China's energy system. However, the primary energy would peak around 2025 and 2030 respectively, but under an earlier peak scenario, coal consumption would decrease sharply from now to meet the falling of carbon emissions. Non-fossil fuels such as solar and wind power will expand dramatically with their cost reduction. Meanwhile, as the main demand for future negative emissions, biomass consumption will also grow from now on.

The constraint of reaching the peak in advance has little impact on the final energy consumption, while the electrification rate under PK-2025 will greatly increased. To peak earlier, it is mainly depend on the transition of energy structure. However, the goal of carbon neutrality cannot be achieved only by energy structure transforming, the energy consumption patterns is equally important. Therefore, it is also necessary to

improve energy efficiency and reduce energy service demand.

The realization of peaking earlier is conducive to reducing the pressure in achieving carbon neutrality of China. Therefore, China should to take action on reaching the emission peak before 2030 as soon as possible.

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