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Impacts of renewable energy quota system on China's future power sector

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Abstract

As the biggest carbon emitting sector which produces 44% of current national carbon emission in China, the coal-dominated power sector has a tremendous potential for CO_2 mitigation in the next two decades. Renewable energy quota system is currently discussed as a potential future policy instrument for the power sector, which requires certain fraction of renewable energy in total power generation for each province and grid zone. The quantitative studies on renewable energy quota for China are still very limited. Based on a least-cost and technology-rich power generation and transmission expansion model for China, this study examines the impacts of renewable energy quota system and carbon cap policy instruments on the future Chinese power sector. Various scenarios are examined toward 2030 and their future power generation mix, capacity installations and carbon emission are discussed. This study concludes that while the renewable quota alone would be drive significant increase of renewable generation in the long term, with slightly increase of system cost compared with carbon cap policy.

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Keywords: China; power sector; carbon emission; renewable energy quota; optimisation model

1. Introduction

China's energy demand increased rapidly in the past decades in line with high economic growth. The resulting large-scale power sector expansion contributed to massive air pollution, mainly due to the heavy reliance on coal in the country's power generation mix. With substantial potential for renewable electricity production available, it's essential to analyze and evaluate how to best integrate more renewable energy sources into China's coal-dominant power. Renewable energy quota system is currently discussed as a new policy instruments for China's power sector transition, which requires grid operators

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and provincial governments to obtain up to certain fraction of their energy from non-hydro renewable sources [1].This study examines the impacts of various renewable energy quotas and carbon cap policies on China's power sector. As the political process in defining this renewable policy instrument is ongoing, there is still a lack of research to evaluated impacts of renewable quota system in China. The results highlight potential impacts of different policy instruments on China's future power mix, renewable energy deployment and carbon emissions. The analysis develops and applies a least-cost expansion model of electricity generation capacity and transmission for China, based on the open-source power optimization model platform Balmorel.

2. Methodology

This study develops a Balmorel model for China's power sector. The model is developed at a provincial scale, consisting of 30 provinces in China. This model simulates a least-cost generation and transmission capacity expansion plan for China's future power sector, based on a recursive linear optimization approach. The optimization takes account electricity imports and exports for each province in each time slice, transmission constraints, natural resource endowment as well as emission constrains.

Balmorel model is designed as partial equilibrium model with assumption of perfect competition to analysis relevant energy policy questions in power sector [2]. The model finds the minimized-cost solutions for generation capacity expansion as well as transmission capacity in different regions, which includes the investment cost and operation cost meeting load of electricity, transmission constraint, technical maximum restrict among other policy-relevant targets. Satisfying these technical and policy constrains, the model finds the least-cost generation capacity from conventional fossil fuel technologies, renewable power and nuclear power. In addition, the model also integrates the transmission capacity expansion to analyze the deployment of renewable energy installation among different provinces. Renewable quota and carbon cap policy scenarios.

This study develops two renewable quota scenarios for China's power sector: a low quota and a high quota scenarios with 15% and 25% of non-hydro renewable energy penetration in total generation by 2030. Additionally, two associated carbon cap scenarios with same emission mitigation effect in 15% quota and 25% quota scenarios.

3. Results

Fig 1 presents the electricity generation mix in 2030 for the four scenarios with same projections of electricity consumption. The 15% renewable energy quota case has a modest effect on the generation mix from the low carbon cap case with same emission. If 25% renewable quota is implemented, there will

be significant increase of wind generation and solar generation compared with 15% scenario. The cap case with same emission with 25% quota will drive development of Coal CCS technology instead of renewable generation options, which results in low renewable penetration and nuclear penetration than 15% quota scenario. It indicates that Coal CCS is cost-efficient solution for carbon emission than renewable energy from national system view.

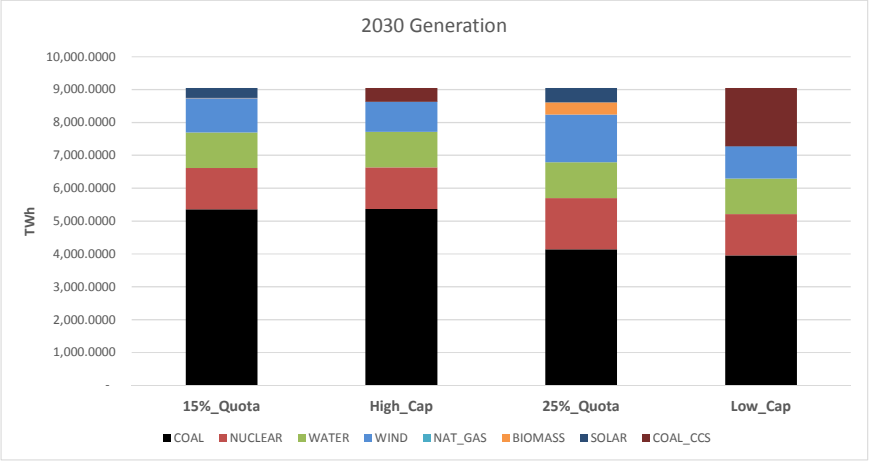

Fig. 1. Electricity mix for the four scenarios in 2030

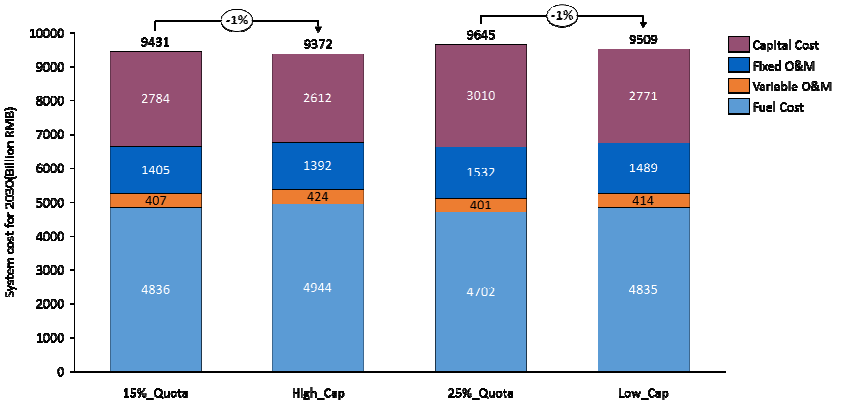

Fig. 2. System cost for the four scenarios in 2030

Fig 2 shows the annual system cost for four scenarios. The comparison outlines that there is slightly decrease of system cost in carbon cap scenario from renewable energy quota scenario, which means carbon emission cap is more cost-efficient to achieve mitigation target since renewable energy quotas overlook option of CCS and natural gas. In addition, increase of renewable energy quota don't result in significant increase of energy system since cost of renewable energy is decreasing. Fig 2

indicates that the additional cost for highly renewable quota scenario is lower than 1% from system perspective.

4. Summary and Conclusion

Although renewable quota system is designed to improve the renewable energy integration in China, there is strongly interaction between renewable penetration and carbon emission mitigation in China's power sector since the quota policy will drive achievement of emission target. As modelling results show, renewable quota system will contribute the increase of renewable generation while carbon cap policy can transfer to CCS instead in the long term towards 2030, which means renewable quota system can provide extra certainty to the market and relevant industries. As conclusion, this study finds that renewable energy quotas system could drive significant increase of renewable generation while the additional system cost to achieve certain target of carbon emission is very limited compared with carbon cap policy. Based on the same modelling tool, more discussion about future policy instruments could be implemented and evaluated.

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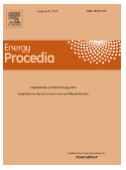

Biography

Weiming Xiong is currently pursuing his Ph.D studies at Tsinghua University, one of the top-ranked universities of China. His research interests at the Institute of Energy, Environment, and Economy include renewable energy policy, energy system modelling and district heating. He received his B.S. degree in electrical engineering in 2011.