Towards a Low-Carbon Future for China's Power Supply Chain: Critical Sectors Identification and Scenario Analysis

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Author: Jin Yang
Co-Authors: Lin Tang

In recent years, China has witnessed a noteworthy increase in its carbon emissions, even amidst the COVID-19 epidemic. Increasing coal use in the electricity sector is the major contributor to China's CO2 emissions, accounting for 60% of the increase in emissions. Considering the substantial carbon emissions from the power sector, a new low-carbon electricity system with solar and wind as its primary energy sources was proposed at the ninth meeting of the Central Finance Committee in March 2021. It should be noted, however, that China's rapidly expanding renewable energy capacity in recent years has not kept pace with the constantly growing electricity demand. A certain number of thermal power installations are still required to guarantee the energy supply security. The total new capacity of coal-fired units is estimated to be 316 GW during the 14th Five-Year Plan (FYP) period even though the entry thresholds for new coal-fired plants are raised by the Chinese government. In light of China's high proportion of coal power installations, achieving a low-carbon transformation of the power structure has become an urgent topic.

Changes in the electricity mix will not only have an impact on direct carbon emissions, but also on indirect carbon emissions from the upstream sector due to the substantial differences in the supply chains associated with the various generation technologies. The indirect emissions should thereby be fully considered in the low-carbon transition of the electricity mix. Moreover, to achieve a low-carbon energy mix from a supply-chain perspective, special attention should be paid to identifying the key upstream sectors of different power generation technologies that have the highest carbon reduction potential. It is therefore necessary to reduce indirect CO2 emissions resulting from the growth of electricity supply and the restructuring of the electricity sector by identifying the critical sectors of different power technologies and implementing effective strategies.

In this study, a multi-regional input-output model based on disaggregation of power sectors was firstly used to assess the embodied carbon intensity of different power technology sectors in 30 provinces in China and identified major upstream carbon emitters and transmission nodes in the electricity supply chain. Further, scenario analysis based on provincial 14th Five-Year Plans and the Implementation Plan for Transforming and Upgrading Coal-Fired Power Plants was conducted. The results indicate that the solar power sector brings the highest carbon reduction benefits, with an average embodied carbon intensity of 1.25 t/10000 yuan, and significant differences in low-carbon technologies exist across provinces. Critical carbon emitting sectors along the power supply chain are concentrated in the energy sector and energy-intensive sectors, while the electrical machinery and equipment sector is also essential to alleviate environmental pressures as an important carbon transmission sector. Besides, the implementation of the "Replacing Small Generation Units with Large Ones" policy at the provincial level, especially in Western China, and â€œFurther Enhancing the Supply Capacity of Clean Energyâ€• can effectively promote the emission reduction of the whole supply chain in the power sector. The results presented in this paper may provide a reference for the provincial government to rationally plan future low-carbon transformation paths of the power sector.

This study makes the following contributions: (i) From a provincial rather than a national perspective, the power sector was disaggregated in provincial input-output tables according to power technology, and its direct and embodied emission intensity were accounted for to reveal the different levels of power generation technology in each province; (ii) The provincial carbon emissions inventories of different power generation technologies in the power sector were compiled based on point source data of coal-fired units, which served as the basis of this study to improve the accuracy of the division of the coal-fired power generation sector in the input-output table; (iii) To our knowledge, this is the first systematic identification of the critical upstream carbon sectors of different electricity technologies from both a consumption perspective and a betweenness perspective.