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Assessing the low-carbon effects of inter-regional energy delivery in China's electricity sector

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ABSTRACT

In China, the electricity sector consumes approximately 50% of the coal and emits 40% of the CO_2 from fossil fuel combustion. The unbalanced spatial distribution between energy resources and demands and the remarkable differences in power-generation capabilities among regions are important factors that impede decarbonization of China's electricity sector. Utilization of the abundant low-carbon energy resources in the central and western regions is restricted by limited local demand. Energy demand in these regions accounts for approximately 26% of the entire nation's demand. By comparison, the regions have more than 45% of the energy resources. However, long-distance energy delivery incurs considerable losses. At present, approximately 80% of inter-regional energy delivery uses primary coal transport and 20% travels by secondary electricity transmission. The Chinese government is planning to build an ambitious inter-regional transmission grid for energy delivery. We demonstrate that this plan would significantly change the current delivery patterns and improve delivery efficiency. Approximately 40% of inter-regional energy delivery would travel by secondary electricity transmission and a 25% improvement in the delivery efficiency of the entire system is expected. Therefore, utilization of low-carbon energy resources would be promoted and overall carbon emission would be reduced. Using a fine-grained electricity dispatch model to simulate and optimize the operation of the power system, the carbon emission mitigation potential is quantitatively assessed based on real planning data. The results indicate a significant 10% reduction in CO_2 emissions in 2030, amounting to 0.49 Gt. This reduction should be included as an important component for the sector's low-carbon budget. Finally, we assess the potential for further reductions in carbon emissions by making modifications to the planned transmission grid.

Contents

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1. Introduction

China is one of the major contributors to the recent emission surge, and the electricity sector is the largest single source of carbon emissions, consuming approximately 50% of China's coal and emitting more than 40% of China's CO_2 from fossil fuel combustion [1,2]. Considering the rapid increase in electricity demand, the scale of overall CO_2 emissions from the electricity sector would still experience a rapid increase in the future despite the installation of large-scale generation capacity based on renewable resources [3–5] and remarkable improvements in technology efficiency [6–9]. Several studies have estimated that the scale of annual incremental emission between 2010 and 2030 would be approximately 1.5–2.0 Gt [3,8,10]. This emission is roughly equivalent to Russia's annual CO_2 emissions in 2010 (the world's fourth largest emitter) [11]. Therefore, the electricity sector would be confronted with great challenges in the low-carbon era.

An important factor impeding the decarbonization of China's electricity sector is the unbalanced spatial distribution between energy resources and demands [12]. For example, the exploitable energy resources in the east region account for only 3% of the resources for the entire country, whereas the proportion of energy demand is up to 25% of the national demand. By contrast, the northwest region and Tibet account for approximately 22% of the total energy resources and only 8% of the total energy demand. Approximately 80% of coal reserves are located in the north and northwest regions [1]. Therefore, at present, long-distance energy delivery in the form of coal transport is necessary to support the energy demands in the east, south, and northeast regions. In 2010, inter-regional transport carried approximately 25% of the national coal consumption for power generation [1,3,13]. This situation incurs considerable energy losses and associated carbon emissions, which are estimated to be 0.17 Gt of CO_2, or 5% of the sector total in China [1].

Fig. 1. Division of regional power grids in China.