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ENVIRONMENTAL AND CLIMATE CHANGE CO-BENEFITS ANALYSIS OF WIND POWER GENERATION IN CHINA

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Abstract

In China, the fossil energy consumption in electricity generation leads to a large quantity of greenhouse gas (GHG) and air pollutant emissions. Along with the rapid development of renewable power generation technologies, especially wind power, substantial environmental emissions were avoided due to the substitution of fossil fuel combustion. The co-benefits approach, which uses resources efficiently to solve multiple environmental problems, provides a new angle for the power generation and deployment. In this paper, the environmental co-benefits of wind power penetration in China were calculated. The regional distribution of environmental co-benefits was also mapped. Based on the co-benefits analysis results, the wind power deployment pathways are designed to enlarge the environmental co-benefits in the whole country level.

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Keywords: Wind power; Environmental co-benefits; Regional distribution

Nomenclature

Q_{j,i,CO_2}	CO_2 emissions from fuel i of region j
$E_{j,i}$	Fuel i consumption of region j
$COEF_{j,i,CO_2}$	CO_2 emission coefficient of fuel i in region j

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$Q_{j,i,e}$ SO_2 and NO_x emissions from fuel i of region j

$COEF_{j,i,e}$ SO_2 and NO_x emission coefficients of fuel i in region j

$\gamma_{e,n}$ The average removal efficiency of air pollutant e by pollutant removal equipment n

$s_{e,n,j}$ The share of production capacity installed with pollutant e removal equipment n in the total production capacity in province j

$\alpha_{e,n,j}$ The operation rate of pollutant e removal equipment n in province j.

$Q_{j,i,w}$ Water consumption of power generation using fuel i of region j

$\theta_{j,el}$ Water consumption coefficient of power generation using fuel i of region j

El Electricity generation

Q_{g,i,CO_2} Total CO_2 emissions from power generation using fuel i in grid g

$Q_{g,i,e}$ Total environmental emissions from power generation using fuel i in grid g

$Q_{g,i,w}$ Total water consumption from power generation using fuel i in grid g

R Environmental co-benefits

1. Introduction

To fill in the gap between shrinking supply and expanding demand of energy, the Chinese government has been dedicated on exploiting renewable energy to supplement existing energy services. Among these renewable alternatives, wind power is growing in an incredible speed and has ranked the third power source in China with total installed capacity of 91GW in 2013 [1]. Increasing wind power deployment to stabilize energy supply is likely to have a wide variety of environmental benefits besides reducing conventional energy consumption, e.g., providing health, environmental, and climate benefits by displacing conventional generators and therefore reducing emissions of carbon dioxide (CO_2) and criteria air pollutants, which include sulfur dioxide (SO_2), nitrogen oxides (NO_x), and fine particulate matter ($PM_{2.5}$). The quantification of regional environmental co-benefits of wind power generation in China is an important indication of power generation structure and deployment in China.

In the current stage, extensive co-benefit analyses were conducted on either a specific wind farm or a region using different methods [2-5]. In this paper, both the direct environmental co-benefits and indirect environmental costs of wind power generation in China are mapped. Also, scenarios on enlarging the environmental co-benefit and balancing the regional discrepancy of co-benefits are set to shed light on future wind deployment in China. The reminder of this paper is organized as follows: In Section 2, the