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A Comprehensive Economic Benefit Evaluating Method of Grid-connected Wind Power Generation under Demand Response

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Abstract

The phenomenon of abandoning wind power in China is very severe. Promoting the demand side response management vigorously become the key measures in North China. Overall efficiency evaluation of the wind farm connected with grid under demand response is necessary to solve the problem. At the same time National Energy Board of China called for a full launch of the carbon emissions trading in 2017. The carbon-emissions reduction is conducive to both environmental protection and economic benefits increasing. This article analyses six aspects of economic efficiency and low carbon benefits of the impact on the system ,including the wind power station construction, operation and maintenance, scheduling cost of demand response, generation benefit, peak-load following benefit and network loss improvement benefit. Taken low carbon trading regulations as the basis, the paper come up with the establishment of a comprehensive economic benefits model in carbon emissions trading mechanism with comprehensive economic benefits of the system. The overall test system is quantified through calculation, which proves the validity of the evaluation method.

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Keywords: demand side response; wind power curtailment; carbon emissions trading; low carbon benefits; comprehensive economic benefit

1. Introduction

Wind power has become the number one in new energy. By 2016, the wind power generation in China was 241 billion kWh, accounting for 4% of the total generating capacity[1]. And China signed "The Paris Agreement" which is an agreement on Climate Change dealing with greenhouse gases emissions mitigation. Chinese carbon emissions

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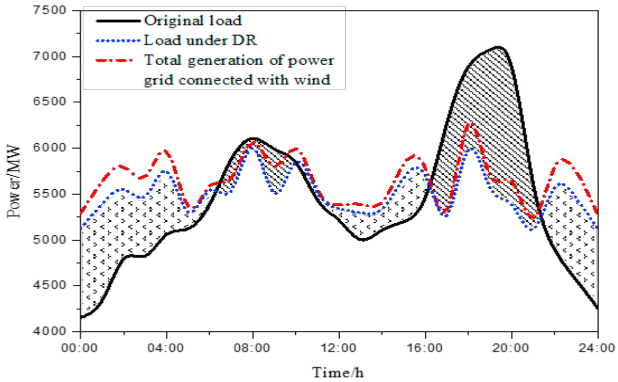
trading will cover eight industries including electricity. Wind power will become an important way to respond to the climate change of our country. But the wind curtailment rate in China is very high. The national average wind curtailment rate is 19% in 2016. Therefore, using the demand response (DR) to improving the comprehensive utilization efficiency of wind power has attracted more and more attention.

The evaluation idea of [2] combined low carbon with economic characteristic, but didn't consider the peaking cost of grid. Low carbon evaluation model of power planning was established in [3] and [4] which didn't consider the low carbon cost brought by ancillary services for wind farm.

This paper analyses six aspects of wind power under DR from economic and low-carbon two perspectives. Taken low carbon trading regulations as the basis, the paper comes up with the establishment of a comprehensive economic benefits model in carbon emissions trading mechanism with comprehensive economic benefits of the wind power under DR. Finally, basing on the typical data, it verifies the validity of the comprehensive economic benefits model in the IEEE 14-node system.

2. Assessment ideas



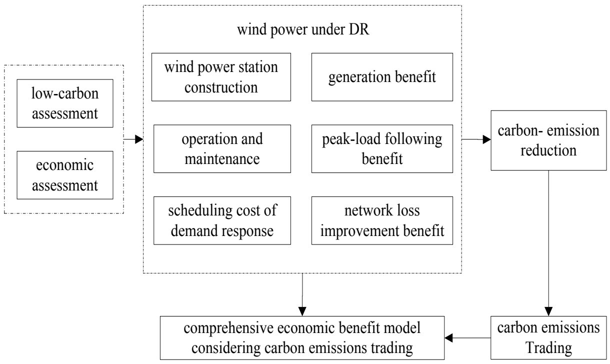


Fig.1 implementation effect of demand response; Fig.2 assessment framework of comprehensive economic benefits

The DR in this paper is mainly to change the using time of the transferable load, so that the load and the wind power generation are closer in time sequence. Implementation effect of demand response is shown in fig.1. And this paper argues that the comprehensive economic benefits of wind power under DR include both economy and low carbon benefits, transform low carbon benefits into economic efficiency through the carbon emissions trading, and establishes the comprehensive economic benefits model. The assessment framework is shown in fig.2.

3. Analysis of factors influencing the comprehensive economic benefits of wind power under DR

3.1. The influence of wind power station construction

The construction of wind power station requires a lot of capital investment which is negative effect of economy.

$$E_1 = IP_{\mathrm{w}} \tag{1}$$

Where E_1 is the construction cost, I is the unit cost of wind farm, P_{w} is the capacity of wind farm.
The manufacturing of wind-driven generators, the material transportation and the power station construction, will produce carbon emissions. Thus, the construction of wind power station has negative effects of low carbon.

$$C_1 = \sum_{i=1}^{m} \lambda_i W_i + Ggs + \sum_{j=1}^{n} \lambda_j W_j \tag{2}$$

where m is the varieties of manufacturing materials of wind power generator, λ_i is the carbon intensity of the i-th material, W_i is the weight of the i-th material, G is the total weight of the material transported. g is the transportation emissions intensity, s is the transportation distance, n is the varieties of construction materials.