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Regional Disaggregation of Energy Consumption Target: The Case of Henan Province

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Abstract

An approach to determine energy consumption control target allocation based on analytic hierarchy process, Ward's clustering algorithm, and differential adjustment method is proposed in this study. A case study of the allocation of control targets in Henan by 2020 is then conducted via the proposed method. The results show that: The per capita added value of the secondary industry is the primary factor for the increasing carbon emissions in provinces. Regions with high cardinality of energy consumption have to shoulder the largest reduction, whereas regions with low energy intensity and poor economic conditions met the minimum requirements for energy consumption in 2020.

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Keywords: Energy consumption; Analytic hierarchy process; Target allocation.

1. Introduction

China's energy consumption and related emissions have attracted attention worldwide. It is learned from 11th and 12th Five-Year Plan period that decomposing the energy intensity reduction targets to local areas and establishing a local supervising system are effective energy-saving means in China [1]. The cumulative reduction rate of energy intensity is 18.2% in 12th Five-Year Plan period, suppressing the original 16% target [2]. Apart from the energy intensity target, total energy consumption controlling has been put forward in the "Strategic action plan for energy development (2014-2020)" issued by General Office of the State Council issued, in which the national total energy consumption should be controlled at 4.8 billion tce by 2020. Therefore, it is necessary to set up the decomposition mechanism of total energy consumption target during the 13th Five-Year Plan period (2016–2020). With the increasing efforts in

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energy conservation and the challenging energy-saving targets proposed in China, the regional decomposition of energy-saving targets have attracted more and more domestic scholars to research. Zhou et al. analysed approaches for reducing carbon emissions and put forward a disaggregation model to decompose the China's national carbon intensity reduction target during 12th FYP period [1]. Yu et al. applied the PSO–FCM–Shapley method to solve the China's regional emission intensity reduction target allocation and suggest that provinces with large carbon emissions should bear the biggest burden [3]. Yi et al. constructed a top–down allocation approach based on emission abatement responsibility, capacity and potential to decompose the national carbon intensity reduction target [4]. Wang et al. used the analytic hierarchy process (AHP) approach to allocate the Sichuan's energy intensity target from province to city [5]. Sun and Tao allocated Jiangsu's energy intensity target in 2010 by setting a reduction benchmark based on the decomposition of total reduction target (20%) into basic and floating energy-saving rate [6]. However, most of these studies usually do not pay attention to the regional decomposition of energy consumption control targets that can comprehensively consider the regional circumstances in energy use, social economy and industrial structure. The aim of this paper is to address this gap by establishing comprehensive indicator evaluation system reflecting the regional development stage by taking Henan Province as a case.

The paper is structured as follows: section 2 illustrates the methodology of energy consumption target allocation. The results are discussed in section 3. Finally, the conclusion is given in Section 4.

2. Methodology

2.1. Comprehensive index construction

The comprehensive index ECI_i is constructed based on the three indicators of necessity, capacity and difficulty to quantify the energy consumption cap and allocate the controlled target of growth rate, providing overall analysis of all three indicators. Based on the standardized indicators and the corresponding indicator weights, the values of the comprehensive index of the 18 regions are obtained by the linear weighted method as following equation:

$$ECI_i = W_n N_i + W_c C_i + W_d D_i \quad (1)$$

Where ECI_i is the comprehensive index for i region; Ni, Ci, Di are the values of energy-saving necessity, capacity and difficulty respectively, which could also be calculated by the linear weighted method; i represents 18 regions of Henan (i=1,2,⋯,18); W_n, W_c, W_d are the weights for the three indicators the sum of which equals one.

2.2. Determining weights through the AHP approach

The basic thought of AHP is to decompose the research object into various factors by several levels according to the characteristics of the object and the research target [7-9]. Generally, the AHP method reflects people's basic characteristics of thinking: decomposition, judgment, and synthesizing. The range variation method is applied to standardize the evaluation indicators of 18 cities in Henan province [10].

2.3. Ward's hierarchical clustering method

To allocate the control target of energy consumption to various regions, this study proposes a Ward's hierarchical clustering algorithm considering the squared Euclidean distance as a measure of difference[11]. Detailed descriptions can be found in the literatures[12].The Ward's hierarchical