



# Research on the Evaluation Index System of Pumped Storage Power Station's Contribution to Rural Revitalization

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**Abstract.** This paper considers the objective factors of national rural revitalization strategy and pumped storage power station construction and operation. Then, based on the principle of index system construction, the evaluation index system of pumped storage power station's contribution to rural revitalization is constructed from five dimensions, namely industrial prosperity, ecologically livable, rural culture civilization, effective governance and live in plenty. Finally, it puts forward some suggestions on the promotion of pumped storage power station to help rural revitalization.

**Keywords:** Pumped storage, Rural revitalization, Evaluation index system.

## 1 Introduction

In 2017, General Secretary Jinping Xi first proposed the implementation of the rural revitalization strategy in his report at the 19th National Congress of the Communist Party of China. He clearly stated that the overall requirements should be implemented in accordance with the principles of thriving industries, livable ecology, civilized rural culture, effective governance, and affluent living, with "thriving industries" being the foremost priority, highlighting that the development of rural industries is the primary focus of this strategy. On February 21, 2021, the "Opinions of the Central Committee of the Communist Party of China and the State Council on Comprehensively Promoting Rural Revitalization and Accelerating Agricultural and Rural Modernization" pointed out that the revitalization of the nation requires the revitalization of rural areas. Zhide Luo (2024) believes that the development of ecological animal husbandry tourism industry can improve infrastructure construction, improve the rural environment, attract professionals, promote industrial transformation and upgrading, and then help the countryside achieve comprehensive revitalization [1]. Ahlmeyer F (2023) conducted a study on the development of rural areas in Europe and believed that under the background of sustainable transformation, renewable energy, emergence of new technologies and increasing awareness of environmental impact, rural areas have more opportunities for revitalization [2]. Pumped-storage power stations, which are often built in rural areas,

can create employment opportunities for rural residents, improve rural infrastructure, promote the development of impoverished areas, and have significant benefits for local economic, social, and ecological development. Based on this context, this paper aims to develop an evaluation index system for assessing the contribution of pumped-storage power stations to rural revitalization. This will help to more comprehensively and systematically understand the impact of pumped-storage power stations on rural revitalization, identify any shortcomings, and provide theoretical guidance for supporting the national rural revitalization strategy through the development of pumped-storage power stations.

Pumped storage power stations, as fundamental energy infrastructure, are characterized by large investment scales and strong industrial driving forces. While serving the energy transition and upgrade, they can effectively boost local economic development and promote rural revitalization. Many scholars have conducted a series of studies based on this. Ying Wang and Xiaonan Han (2024) believe that pumped storage unit is the most mature energy storage technology with the largest power and energy capacity in the current power system. With its flexibility, high capacity and low cost of construction and operation per unit capacity [3]. Wan Wengong et al. (2024) took Luxi pumped storage Power Station as the research object, and discussed the installed capacity and key influencing factors of pumped storage power station with built reservoirs and good terrain conditions. [4]. Lu (2021) and others proposed that renewable energy supported by pumped storage can provide long-term and considerable environmental benefits [5]. Chinese scholars summarized the driving forces of pumped storage power station construction on rural revitalization, pointing out that the construction of these stations can not only stimulate local employment and drive the development of local service industries but also help improve the local ecological environment. Based on the landscape trinity theory, Binyi Liu (2013) proposed that comprehensive regional planning should include "tourism," "landscape," and "ecology" trinity planning, which can effectively guide the study of the impact of pumped storage power stations on rural revitalization [6]. Jian Huang (2021) and others, based on the "Two Mountains" theory, pointed out that developing industrial tourism for pumped storage power stations is a vivid practice to aid rural revitalization, providing new ideas for the development of industrial tourism for pumped storage power stations in the new era [7].

Some studies focus on the issue of rural revitalization in power station relocation villages, analyzing the main problems in the current planning of relocation sites and proposing several considerations for the planning of relocation sites. Lifeng Zheng (2023) believes that the six pumped storage hydropower projects currently under development in Scotland will more than double the UK's pumped storage capacity to 7.7GW by 2035, while creating nearly 15,000 jobs and bringing in £5.8 billion in benefits [8]. Yuhan Liu (2017), using the Zhiri Pumped Storage Power Station in Inner Mongolia as an example, analyzed the climate and crop planting in the areas involved in the land acquisition for the construction of the pumped storage power station, the composition of regional industries, the composition of income for farming and herding households, and the characteristics of self-employed production resettlement methods, concluding that the self-employment-based production resettlement method is more suitable for the Zhiri Pumped Storage Power Station [9]. Peng Jia (2018) combined the

planning and requirements of relocation sites for pumped storage power stations with the characteristics of new rural construction, analyzing the main problems in the current planning of relocation sites and proposing several considerations for the planning of relocation sites [10].

## **2 The Significance of Studying the Evaluation Index System for the Contribution of Pumped Storage Power Stations to Rural Revitalization**

### **2.1 Contributes to Identifying the Impact of Pumped Storage Power Stations on Rural Revitalization**

Pumped storage power stations involve large investments and long construction periods, and they can significantly drive medium to long-term economic growth in regions, playing an important role in facilitating domestic circulation, stabilizing investment, ensuring employment, and improving people's livelihoods. During the construction phase, pumped storage power stations can stimulate economic growth through direct investment, enhance the level of infrastructure such as electricity and transportation, promote employment, and improve livelihoods. After completion, pumped storage power stations can stimulate the development of industries such as tourism and upgrade the industrial structure, increasing local fiscal revenue.

### **2.2 Contributes to Ensuring the Stability and Sustainability of Poverty Alleviation Efforts by Pumped Storage Power Stations**

This paper combines the content of the rural revitalization strategy to analyze the key elements of rural revitalization and the impact of pumped storage power stations on rural revitalization. It helps to timely identify shortcomings of pumped storage power stations in promoting rural development, summarize the experience of power stations in assisting rural revitalization, clarify the future work priorities of pumped storage power station construction and operation, and provide reliable advice for subsequent investment decisions.

### **2.3 Contributes to Harnessing the Potential of Pumped Storage Power Stations in Implementing the National Rural Revitalization Strategy**

This paper combines the content of the rural revitalization strategy and selects indicators that effectively reflect the contribution of pumped storage power station construction and operation to rural revitalization to construct an evaluation indicator system. This helps to further grasp the role of pumped storage power stations in the rural revitalization strategy, promote high-quality rural economic development, and ensure that pumped storage power stations contribute their due strength to the implementation of the national rural revitalization strategy.

### **3 Principles for Constructing the Evaluation Index System of Pumped Storage Power Station's Contribution to Rural Revitalization**

#### **3.1 Principle of Science**

The evaluation indicators should scientifically and objectively reflect the contribution of pumped storage power stations to rural revitalization in all aspects, and avoid being selected according to individual subjective opinions. During the investigation, the structure of the index system should be reasonable, and the collected data can scientifically reflect the actual construction situation.

#### **3.2 Principle of Comprehensiveness**

As for the principle of comprehensiveness, the evaluation index system should reflect all aspects of pumped storage power station's contribution to rural revitalization as far as possible, based on the national rural revitalization strategy.

#### **3.3 Systematic Principle**

As the comprehensive evaluation index system consists of multiple subsystems and the overall structure is complex, the index system should be systematically compared and analyzed, to avoid a lack of logic in the hierarchy. Systematically constructing the index system, the overall contribution of pumped storage power station to rural revitalization can be reflected from different respects in clear hierarchy and reasonable structure.

#### **3.4 Principle of Comparability**

During the selection of indicators, the caliber and scope should meet the requirements of the industry specification to ensure the comparability of indicators. By horizontal comparison of the index value, the gap between different projects can be reflected. By vertical comparison of the index value, the promotion of the same project can be evaluated, so as to take measures to improve the project in the future.

#### **3.5 Principle of Simplicity**

When selecting indicators, it should be noted that the selected indicators should be simple and clear, and easy to statistics. On the premise of meeting the evaluation requirements, the representative main indicators are selected to obtain the corresponding evaluation results, so as to avoid the cross-overlap of indicators and increase the difficulty of evaluation.

## 4 Objective Weighting Model Based on Entropy Weight Method

In 1850, the German physicist Clausius proposed a new physical quantity - entropy; In 1948, the American scientist Shannon used entropy to indicate the uncertainty of the signal in the information source. The greater the amount of information, the smaller the uncertainty, and the smaller the entropy; Conversely, the smaller the amount of information, the greater the uncertainty and the greater the entropy. Therefore, according to this property, the degree of dispersion of a specific index can be judged by calculating the entropy value. Entropy weight method is an objective weighting method to determine the weight according to the above principles. It determines the weight according to the relationship between the original data, and the weighting result has strong mathematical theory and logic basis. This paper has collected a large number of real data through investigation. The entropy weight method can effectively avoid the deviation caused by human factors, with higher accuracy and greater objectivity. The specific steps for determining index weights by this method are as follows:

Data standardization processing. First of all, each index is de-dimensionalized. Suppose  $m$  indexes are given:  $X_1, X_2, \dots, X_m$ , where  $X_i = \{x_1, x_2, \dots, x_n\}$ . Suppose that the normalized values of each index data are:  $Y_1, Y_2, \dots, Y_m$ , so there is:

$$Y_{ij} = \frac{X_{ij} - \min(X_i)}{\max(X_i) - \min(X_i)} \quad (1)$$

Find the ratio of each index under each scheme.

$$P_{ij} = \frac{Y_{ij}}{\sum_{i=1}^n Y_{ij}} \quad (2)$$

Find the information entropy of each index.

$$E_j = -\ln(n)^{-1} \sum_{i=1}^n P_{ij} \ln(P_{ij}) \quad (3)$$

$E_j \geq 0$ , if  $P_{ij} = 0$ ,  $E_j = 0$  is defined.

Determine the weight of each indicator.

$$w_j = \frac{1 - E_j}{m - \sum E_j} \quad (4)$$

## 5 Design of Evaluation Index System of Pumped Storage Power Station's Contribution to Rural Revitalization

Through field research on pumped storage power stations and the surrounding rural areas, this paper comprehensively defines the specific contribution of pumped storage

power stations to the implementation of the rural revitalization strategy from the following five aspects.

### **5.1 Rural Revitalization Is the Focus**

During the period of construction and operation, pumped storage power stations can promote the prosperity of the surrounding rural industries, including the large investment and long construction period of the project construction itself, and the construction requires a large number of construction materials, machinery and manpower, which directly promote the development of related industries in the surrounding areas, and a large number of construction workers are consumed locally. It will greatly promote the development of surrounding rural industries (such as hotels, hotels, planting, etc.). In addition, the power station will directly help the village to develop primary industries, such as new agricultural irrigation facilities. Therefore, pumped storage has played an important role in promoting the increase of output value of the primary, secondary and tertiary industries in the surrounding areas, the improvement of agricultural labor productivity, the increase of leisure agriculture and the increase of rural tourism arrivals.

### **5.2 Ecologically Livable Is the Key of Rural Revitalization Strategy**

The construction of pumped storage power station involves land requisition and resettlement in the surrounding villages. During the construction of the new village for migrants, the power station invests in greatly improving the living ecological environment, carrying out village greening, centralized disposal of garbage, and renovation of sanitary toilets, etc., to promote the construction of beautiful villages, and continues to provide financial assistance to improve the rural environment during the operation period. Therefore, the contribution of power stations can be reflected by indicators such as the change of village green coverage area, the change of domestic waste disposal volume, the change of rural sanitary toilets and the change of rural domestic sewage treatment volume.

### **5.3 Rural Culture Civilization Is the Guarantee of Rural Revitalization Strategy**

Through the construction of new villages for migrants and the construction of roads into mountains, pumped storage power stations have greatly increased the convenience and quality of villagers' transportation, schooling, medical treatment, employment and entertainment, and significantly increased the information exchange between villagers and the outside world. Through assistance, direct donations and other forms, pairs help and finance students to go to school, the construction of village comprehensive cultural centers and other cultural entertainment venues; Through the grass-roots form, regularly publicize the knowledge of fire protection and safe electricity to the villagers. Therefore, the number of comprehensive cultural service centers in the village, the number of undergraduate students in the village, the change of the convenience of the

village students to go to school, the change of the proportion of education, culture and entertainment expenditure of rural residents, and the change of neighborhood communication frequency are selected to reflect the contribution degree of the power station in rural culture and civilization.

#### 5.4 Effective Governance Is the Foundation of Rural Revitalization Strategy

Pumped storage power station through the construction of migrant new villages in the construction period, in the operation period, the construction of village-level comprehensive service station, greatly improve the efficiency of villagers, help to give full play to the village-level government service capacity. In addition, some power stations have greatly promoted the development of rural tertiary industry and promoted the development of rural collective economy through the development of tourist attractions. Therefore, the effective dimension of governance includes two indicators: whether there is a village comprehensive service station and the annual income of the village collective economy.

#### 5.5 Live in Plenty Is the Fundamental Goal of Rural Revitalization Strategy

Engineering construction (such as upper and lower reservoirs, water transmission systems, underground workshops, transportation roads, etc.) and logistics (such as canteens, cleaning, security, etc.) require a large number of labor forces to provide jobs and increase incomes for villagers; In the process of the construction of new villages for immigrants, the construction of rural internal infrastructure such as roads, power supply, communication and water supply is promoted. At the same time, land expropriation and immigration improve the housing conditions of villagers, and the compensation cost of immigrants increases the income of villagers. In this dimension, the specific indicators include the per capita disposable income of rural residents, the number of jobs driven by power stations, the direct subsidy funds for immigrants, the change of per capita housing area, the stability of rural electricity consumption, the change of the grade of external transportation roads and the change of rural broadband coverage.

Based on the above analysis, the evaluation index system of pumped storage energy contribution to rural revitalization is established, as shown in Table 1.

**Table 1.** Evaluation index system of contribution to rural revitalization.

First index	Second index
Industrial prosperity	Change in output value of primary industry
	Change in output value of secondary industry
	Change in output value of tertiary industry
	Change in agricultural labor productivity
	Leisure agriculture and rural tourism
Ecologically habitable	Change in village green coverage area
	Change in domestic waste disposal capacity
	Change in sanitary toilets number

	Changes in the total amount of rural domestic sewage treatment
Rural culture civilization	Change in number of comprehensive cultural service centers
	Change in number of undergraduate students in the village
	Change in convenience of the village students to go to school
	Change in proportion of education, culture and entertainment expenditure of rural residents
	Change in neighborhood frequency
Effective governance	Whether there is a village comprehensive service station
	Change in village collective economic annual income
Live in plenty	Change in per capita disposable income
	Change in number of jobs created
	Direct immigration subsidies
	Change in per capita housing area
	Change in rural electricity stability
	Change in grade of external traffic highway
	Change in rural broadband coverage

## 6 Suggestions on the Promotion of Pumped Storage Power Station to Help Rural Revitalization

In addition to constructing the evaluation index system of pumped storage power station's contribution to rural revitalization, this paper further explores ways for power station to promote rural revitalization benefits. It includes the following two aspects.

### 6.1 Vigorously Implement Industrial Assistance and Rely on Market Forces to Form Sustainable Development

At present, due to the objective needs of the project, pumped storage power stations are mostly built in rural areas with relatively backward economy, and the local industrial structure is single, which cannot provide enough jobs. In addition, the pumped storage power stations can directly provide jobs for villagers during the operation period, most of which are in the logistics of the power station (such as canteen, cleaning, security) and other positions with low technical requirements, and the age structure of the absorbed labor force is relatively large. At the same time, pumped storage power stations are currently restricted from expanding tertiary industry-related businesses, and the development of tourism in surrounding villages is relatively slow. Therefore, in the medium to long term, it is not sustainable to attract young people to work back home.

Therefore, the top-level planning and design of industrial tourism of pumped storage power stations should be carried out in the future, so that the power stations can fully consider their geographical advantages, industrial resource characteristics, ecological and environmental red line protection and other factors, develop industrial tourism industry according to local conditions, make full use of market mechanism, effectively



promote the development of rural leisure agriculture, thus achieving industrial transformation and upgrading, and effectively extend the industrial chain. With three production and one production, to promote the diversification of local characteristic agricultural products sales channels, and then drive the development of agriculture, forestry, husbandry and non-fishery industry. To promote the sustainable development of villagers' incomes and livelihoods, let green mountains give full play to their economic and social benefits, and effectively improve their economic, social and ecological benefits simultaneously.

## **6.2 Make Overall Planning for the Assistance System, Carry Out Scientific Planning from Top to Bottom, and Realize Advanced Layout**

At present, pumped storage power stations lack long-term industrial planning to support the industries after resettlement and relocation, and their future development is limited by the lack of rural industries. At the same time, during the operation of pumped storage power stations, the direct assistance and donation of each power station to the countryside needs to be approved by the superior company, which requires a long period. And the power station service for rural revitalization and development has not been included in the work assessment task of the power station.

Therefore, it is suggested that in the future resettlement work of power station construction, the requirements of rural revitalization as well as the advantages of local characteristic tourism, agriculture, culture and ethnic characteristics should be considered comprehensively, the layout should be planned in advance, the rural industry of the settlement should be planned and implemented in advance, and the corresponding supporting facilities should be constructed. During the operation period of pumped storage power stations, the list of projects donated by the power stations to help the villages should be unified, the approval process should be optimized, and the benefits of the power stations serving rural revitalization should be included in the assessment tasks of the power stations, and scientific assessment rules should be formulated.

## **7 Conclusion**

The construction and operation of pumped storage power stations play an important role in promoting the implementation of the rural revitalization strategy. In order to better evaluate the contribution of pumped storage power stations to rural revitalization, this paper systematically explains the significance of the research on the evaluation index system of pumped storage power stations to promote rural revitalization, and is based on the principles of scientific, comprehensive, systematic, comparable and concise principles. Indicators that can reflect the role of pumped storage are selected from five aspects: industrial prosperity, ecological livability, village style civilization, effective governance and prosperity, and an evaluation index system of pumped storage's contribution to rural revitalization is constructed. The paper also puts forward suggestions for pumped storage power stations to better serve rural revitalization: 1) Vigor-

ously implement industrial support and rely on market forces to form sustainable development; 2) Overall development of the help system, top-down scientific planning, to achieve advanced layout.

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