Study on Ecological Environmental Impact Assessment Index System of UHV AC Transmission and Transformation Engineering-A Case Study of 1000kv UHV Transmission and Transformation Engineering from Zhangbei to Xiongan

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Abstract—Ultra-high voltage (UHV) power grid is a new transmission and transformation technology, which has the advantages of large transmission capacity, long transmission distance, low line loss, saving land resources and obvious economic benefits. Taking the Zhangbei-xiongan 1000kv AC high voltage power transmission and transformation project as an example, this paper constructs the eco-environmental index system of the UHV transmission and transformation project by using the pressure-state-response model, and constructs a set of 18 indexes eco-environmental index system, it mainly includes three aspects: the eco-environmental pressure index caused by the construction behavior in different construction stages of power transmission and transformation projects, and the eco-environmental state index given by on-the-spot investigation and study of projects, based on the construction unit on the ecological environment impact management response measures given indicators. The index system provides a basis for comprehensive and systematic evaluation of the impact of power transmission and distribution projects on the ecological environment, and finally draws the corresponding project construction evaluation conclusions. In this paper, the eco-environmental impact assessment index system of power transmission and transformation engineering has certain universality, and it has certain reference and guiding significance for the ecological environment evaluation of power transmission and transformation engineering.

1 Introduction

As a new transmission and transformation technology, UHV transmission and transformation has many advantages, such as large transmission capacity, low line loss and obvious economic benefit. However, the UHV transmission and distribution project is complex and has a long distance. The construction of the project will destroy the vegetation, landforms, biological resources and natural landscape along the route to different degrees, stress on the environment. In recent years, with the convening of the National Conference on ecological and environmental protection and the proposal of the national "14th five-year plan", the construction of ecological civilization and ecological and environmental protection have been placed in an important position in the governance of our country. It is very important and challenging to realize the coordination between power grid construction and environment, and to develop the social economy without damaging the ecological environment.

At present, there are many achievements and corresponding norms in the study of ecological environmental impact [1,2]. Ecological Impact Assessment [3] based on the ecological characteristics of the evaluation object, the qualitative and quantitative methods were used to predict and evaluate the main ecological functions of the region and the ecological processes necessary for the completion of the functions. The commonly used methods include Pressure-State-Response model (PSR) [4,5], Comprehensive Index Method [6,7], and Analytic Hierarchy Process (AHP) [8,9]. The contents and technical requirements of the ecological environmental impact assessment are laid down in the technical guideline for environmental impact assessment -ecological impacts. The code is commonly used in the ecological environmental impact assessment of construction projects in various industries, and lacks a certain degree of specialization in the ecological impact assessment of power transmission and transformation projects. "Technical code for environmental protection acceptance check of completed construction projects, power transmission and transformation"stipulates the technical requirements for the content, methods and other technical requirements of the environmental protection acceptance check of power transmission and transformation construction projects, the code only generally requires references to technical guidelines such

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as the Environmental Impact Assessment. It is necessary and important to study the eco-environmental impact and assessment of power transmission and transformation engineering for its large scale and wide area. Zhang Xiaoqing et al. [10] based on the three stages of power transmission and transformation project design, construction and Operation Maintenance, studied the technical system of ecological impact prevention and control, and put forward the corresponding technical measures of prevention and control. On the whole, there are still few achievements in the ecological environment evaluation of power transmission and transformation engineering construction, which need further study.

Taking the Zhangbei-xiongan 1000kv UHV AC transmission and transformation project as an example, this paper studies the impact of UHV transmission and transformation project construction on ecological environment. The eco-environmental Index System of UHV transmission and transformation project is constructed by using the pressure-state-response model. Based on the interaction and influence between construction and eco-environment, the pressure and influence of construction on eco-environment are analyzed, the corresponding countermeasures of ecological impact are put forward, and the index system of ecological environment of power transmission and transformation engineering is established.

2 Construction of Ecological Environmental Impact Assessment index system for UHV transmission and transformation engineering

Construction of eco-environmental assessment index system for power transmission and transformation project is an important content of eco-environmental assessment for power transmission and transformation project. Pressure-state-response (PSR) model was established in 1991 by the United Nations Organization for Economic Cooperation and Development. The basic idea is that human activities exert pressure on the environment and natural resources and affect the quality of the environment and resources, society through human consciousness and activities to formulate environmental, economic, land policies or measures in response to these changes, alleviate the pressure of human activities on the environment. Based on the interaction and influence between human and environment system, the PSR conceptual model organizes and classifies the environmental indicators, which is systematic and suitable for the components of environmental indicators, it has been widely used in the evaluation and establishment of environmental system.

In the PSR model, the pressure indicators refer to the direct impact of human activities on environmental resources, and the state indicators refer to the current state of the ecological environment in the region, which is caused by the pressure, response indicators are those quantifiable components of environmental policy measures that directly or indirectly affect the other two. According to this theory, this paper constructs the eco-environmental assessment index system of UHV transmission and distribution project. As shown in Figure 1.

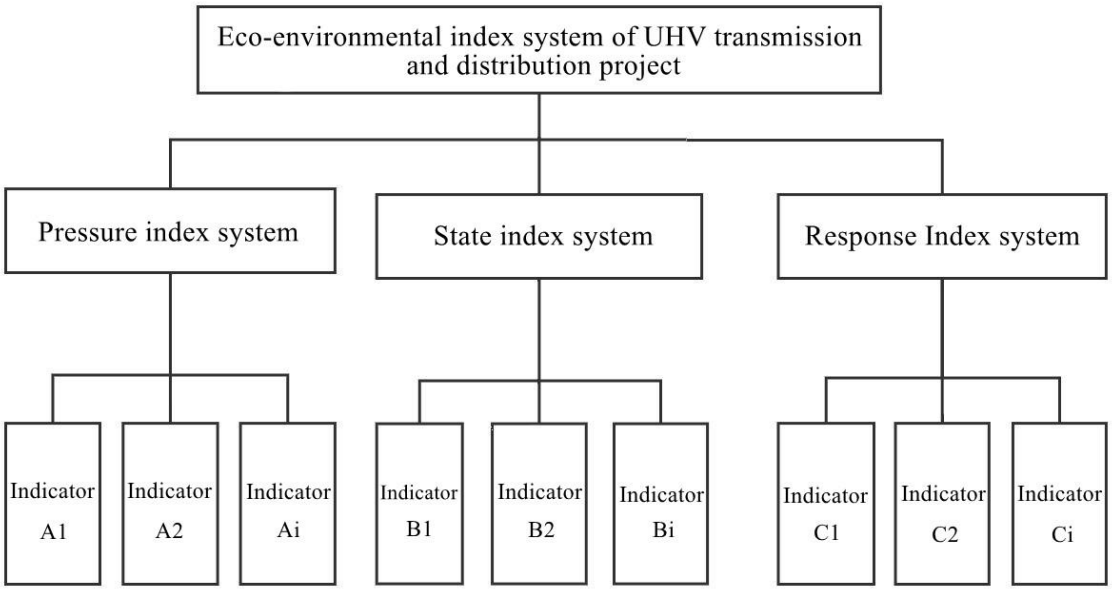

Fig.1 Eco-environmental assessment index system for UHV transmission and distribution project

3 1000kv AC power transmission and eco-environmental impact assessment from Zhangbei to Xiongan

3.1 Project Overview

Zhangbei to xiongan extra-high voltage project starts from the Zhangbei substation in Zhangjiakou Zhangbei County, Hebei province, and ends in Baoding in Dingxing County. The project comprises two parts, namely The Substation Project and the transmission line project.The xiongan transmission line from the Zhangbei substation in Zhangjiakou Zhangbei County to the xiongan substation in Baoding Dingxing County is 2 × 313.638 km long, of which 2 × 194.243 km are double-connected to the same tower, 2 × 119.395 km two single-loop construction. A total of 792 base towers were built, 89 stretching fields were laid, 94 sites were crossed, and 48.03 km of new construction access roads were built.

Zhangbei-xiongan high-pressure project spans a long region, involving Zhangbeiba Hauts Plat., hilly and plain three types of landforms. As shown in Fig. 2, the elevation along the line is between 42m and 2100m, and the overall trend is high in the north and low in the south. The climate types of the project area are mainly temperate continental climate and warm temperate semi-humid semi-arid continental monsoon.

(a) Geomorphology of Hauts Plat (b) Hilly landform (c) Plain landform

Fig.2 Geomorphologic types along the project line

Ultra-high voltage transmission and transformation projects include transmission line construction and transformer installation projects. The selection and determination of the ecological environmental impact factors should be aimed at the ecological impact factors existing in substations and transmission line projects, the study is carried out from many aspects such as landform, animal population, plant population and landscape.

3.2 Construction of eco-environmental pressure index evaluation system for the construction of Zhangbei-xiongan UHV transmission and transformation project

3.2.1 Construction of pressure index of substation construction on eco-environmental assessment

The impact of UHV transmission and transformation project on ecological environment is mainly in the construction stage, so this paper mainly focuses on the construction period. The transmission and transformation project is mainly divided into substation project and transmission line project to analyze the impact of ecological environment. By analyzing the engineering behavior in each stage of construction, the ecological environment influencing factors are obtained, and the corresponding pressure index evaluation system is established.

The construction period of substation can be simply divided into three construction stages: construction preparation stage, civil construction stage and equipment installation stage. After screening and analysis, seven indexes are selected as pressure indexes: temporary construction site layout, earth-rock balance, land occupation, landform change, sewage discharge, Tower Pole and foundation design, wiring mode. Table 1 gives the construction behavior of power transmission and distribution projects and the corresponding eco-environmental impact pressure index.

Table 1 construction behavior and pressure index of power transmission and transformation project

Construction phase	Construction behavior	Pressure indicators	subindicators	Actual situation of the Zhangbei to xiongan on transmission and transformation project
Construction preparation phase	① Entry of construction personnel ② Materials and construction equipment	①Temporary site arrangement for construction	Material Station	Rent local houses and do not build new ones
			Fetch field	A total of 89
			Construction camp	Rent local houses as much as possible and set up construction camps in no-man's land

	transportation ③ Substation area construction		Construction road	Use or widen the existing road as far as possible
Civil construction phase	①Earthwork excavation ② Concrete pouring, wall masonry and other construction activities	②Earth-stone balance		The excavation is 44.9,000 m^3, the filling is 173,100 m^3, and the remaining soil is 271,800 m^3
		③Land occupation		The total area is 260.85 hm^2, of which 66.26 hm^2 is permanent and 194.59 $hm^2$is temporary
		④Topographic change		Disturbing the original geomorphology and damaging the area of soil and water conservation facilities
		⑤Effluent discharge		The discharge amount of construction sewage is very little, and the domestic sewage is used for station greening after being treated.
Equipment installation phase	① Equipment transportation ② Equipment installation ③Tower pole and foundation design, stringing	⑥Design of Tower and foundation	Foundation design	Rugged terrain and mountainous areas with high and low legs; flat terrain with flat push
			Tower design	Tower design features
		⑦Stringing mode		The conductor is one to draw four; the ground wire is one to draw one

3.2.2 Construction of eco-environmental Assessment State Index system for UHV power transmission and transformation project

The state index of this project is used to describe the state of ecological environment in power transmission and transformation project, and it is a comprehensive reflection of the space-time coupling of driving factors of ecological environment change. Through the practical investigation and analysis of the power transmission and transformation projects, the state indexes which represent the ecological environment are condensed, including the following indexes:

(1) Soil erosion

Soil erosion has an important influence on ecological environment and is an important index of ecological environment evaluation. In this paper, the classification of soil and water loss intensity in soil erosion classification standard is divided into mild, mild, moderate, intensive, extremely strong and severe erosion.

(2) Changes in biological resources

With the destruction of surface vegetation, the above-ground biomass is reduced and the actual carrying capacity of livestock is weakened. Based on the design of substations and line corridors, the loss of biomass is estimated, which can be used as a reference index for the impact of project construction on ecological environment.

(3) Impact on ecologically sensitive areas

The ecological fragile zone means that the ecosystem is easy to be destroyed and not easy to recover.

(4) Ecological landscape impact

Degree of impact on natural landscape, List of national parks of China, etc. after construction and construction.

(5) Water environmental quality

Refers to the impact of power transmission and transformation project construction on the quality of surrounding water environment. The water quality index corresponding to each environmental function area in surface water environmental quality standard is taken as the evaluation standard.

(6) Habitat function

It refers to the impact of the project construction on the habitat area. The more the vegetation continuity is damaged, the more the habitat is threatened, and the weaker the habitat function is not good for the stability of the ecosystem.

(7) Permafrost environment

There are a lot of permafrost regions in plateau region, and the ecological environment of permafrost region is relatively fragile.

According to the on-site investigation, the indices of the Zhangbei to hung on UHV AC transmission and transformation project are calculated as shown in Table 2.

Table 2 Identification of eco-environmental quality state index of power transmission and transformation project

Index layer	Subindex	Actual situation of the Zhangbei to xiongan on transmission and transformation project	Degree of impact on ecological environment
Soil erosion	Disturbed land remediation rate	97.76%	It has reached the target value of soil and water loss and has little influence on ecological environment
	Soil loss control ratio	1.07	
	Slag retention rate	97.20%	
	Recovery rate of forest and grass vegetation	98.70%	
	Coverage of forest and grass	42.37%	
	Degree of total control of soil and water loss	The total control rate of soil and water loss was 97.64% (target 95%)	
Changes in biological resources	Biodiversity	Construction had little impact on biodiversity	Basically no effect
	Biological abundance	The loss of biomass in engineering construction is small	Minor effect
Impact on ecologically sensitive areas		The route does not involve ecologically sensitive areas	Basically no effect
Ecological landscape impact	Natural landscape	The natural landscape was destroyed to a certain extent, and the landscape sensitivity was 10% ~ 45%	Apparent influence
	Landscape of power transmission and transformation engineering itself	The tower body of the power transmission and transformation project is optimized to coordinate with the landscape	Minor effect
Water environmental quality		Engineering construction does not change the environmental quality of water body	Basically no effect
Habitat function		Habitat fragmentation < 3	Minor effect
Permafrost environment		The proportion of frozen soil in plateau area is small	Basically no effect

3.2.3 Construction of eco-environmental Assessment Response index system for UHV transmission and transformation project

In order to reflect the improvement measures taken by the construction units of the Zhangbei to Xiongan on power transmission and transformation project to address the impact of the project on the ecological environment, this article mainly from the environmental protection investment proportion, construction optimization, ecological compensation, construction supervision level of several aspects of evaluation, and the construction of the index system.

(1) Proportion of investment in environmental protection

The total investment in civil construction of the Zhangbei-xiongan power transmission and transformation project is 127381 million yuan, of which 24.41 million yuan is invested in environmental protection.

(2) Optimization of construction scheme

This project carries on a series of construction optimization according to the terrain condition, the construction characteristic and so on, minimizes the land

disturbance and the vegetation destruction. The major enhancements include:

① Carrying out heavy-duty ropeway transportation, greatly reducing ecological damage. For mountainous areas, the main use of cableway transport, the cumulative length of 90 km, effectively reduce the destruction of 60 hectares of mountains, reduce tree felling 150,000.

② Adopting the technology of horizontal arm holding pole and tower crane, avoiding the disturbance of the inner suspension and outer holding pole, reducing the area of each base iron tower by 1600 square meters on average, and reducing the disturbance of the land and the destruction of the vegetation by 126 hectares.

③ By using the technology of aerial stringing of initial guide rope by unmanned aerial vehicle (UAV) , the disturbance and vegetation destruction of the guide rope stringing passage for ground stringing can be reduced by 6,000 square meters per kilometer, and the total area of disturbance can be reduced by about 190 hectares.

Fig. 3 shows the working status of heavy cargo ropeway and uavs on site respectively.

(a) Heavy cargo ropeway (b) Drone wire

Fig.3 optimization of construction scheme

(3) Ecological compensation

In view of the difficulty of piling up surplus soil and the shortage and barren of topsoil in mountainous and hilly areas, the planting bag planting and planting bag planting were adopted in the taji slope of mountainous and hilly areas to restore the slope vegetation effectively. The area of ecological restoration was 110.51 hm^2, and the recovery rate of forest and grass vegetation was 98.70%, which exceeded the target of 98%.

Fig. 4 is the construction effect diagram of ecological compensation measures.

(a) Slope protection with planting bag (b) Grass planting

Fig.4 Ecological compensation measures

(4) Level of construction supervision

The construction unit entrusts the supervision company to carry out the special ecological environment supervision work, combining the on-line monitoring system, the remote real-time monitoring system and the natural disaster warning system, to implement the ecological environment supervision measures. The supervision problem of traditional UHV power transmission and transformation mode, such as “Can’t reach, can’t see all, low efficiency and low precision”, is solved, the supervision level is raised, and good effect is achieved. Fig. 5 shows the on-site remote sensing monitoring of the UAV.

Fig.5 Construction control measures

4 Conclusion

In this paper, the pressure-state-response model is used to construct the index system for the eco-environmental assessment of power transmission and transformation projects, and the construction period of UHV power transmission and transformation projects is divided, the eco-environmental impact caused by its construction behavior is analyzed and the eco-environmental pressure index is constructed. According to the state of ecological environment caused by the pressure of ecological environment in construction, the index of Ecological Environment State is summarized. Finally, based on the ecological environment state and the construction characteristics, the ecological environment protection measures are proposed to effectively protect the ecological environment in the region where the construction project is located, and the ecological environment measures are given. In this paper, the Environmental Impact Assessment index system of power transmission and transformation engineering has certain universality, and it has certain reference and guiding significance for the ecological environment evaluation of power transmission and transformation engineering.

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