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Implementation method of energy and environmental protection based on desert control

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Abstract: With the aggravation of global desertification and the prominent problems of energy and environment, this article is committed to exploring the collaborative implementation method of energy and environmental protection based on desert control. Through the study of desert control, energy and environment related theory and multidisciplinary integration theory, this article analyzes the synergy principle between desert control, energy development and environmental protection, and makes clear its feasibility in resource conditions, technological development and policy support, and analyzes the technical, economic and social challenges it faces. Based on this, a large-scale centralized and distributed solar energy development model and a wind energy development method based on the distribution of wind resources are designed, and environmental protection measures such as vegetation protection and cultivation and rational utilization of water resources are put forward. By reasonably integrating and optimizing these implementation methods, it is expected to realize the coordinated development of desert control, energy development and environmental protection. This article puts forward specific implementation methods of energy development and environmental protection, and emphasizes the importance of integration and optimization, which provides theoretical basis and practical reference for realizing the coordinated development of energy, environment and ecology in desert areas.

1. Introduction

With the deterioration of the global ecological environment and the increasing demand for energy, desertification, energy shortage and environmental pollution have become major problems to be solved urgently in the world today [1]. The area of desertified land is expanding at an alarming rate, which has a serious negative impact on the ecological system, human living environment and social and economic development in the surrounding areas [2-3]. At the same time, the excessive dependence on traditional energy sources has caused a series of environmental problems, such as global warming caused by greenhouse gas emissions and rapid consumption of limited resources, which makes it urgent to seek sustainable energy and environmental protection strategies [4].

Under this background, it is of great theoretical and practical significance to explore an implementation method of energy and environmental protection based on desert control for

realizing the coordinated development of ecology, energy and economy [5]. Although the natural conditions in desert areas are harsh, they are rich in renewable energy resources such as solar energy and wind energy, which provides great potential for energy development [6]. If desert management can be organically combined with energy development and environmental protection, it is not only expected to alleviate the problem of energy shortage, but also effectively improve the ecological environment in desert areas and form a virtuous circle. This article focuses on the research on the implementation methods of energy and environmental protection based on desert control, aiming at constructing a scientific, reasonable and practical implementation system through theoretical analysis and exploration.

2. Related theoretical basis

The formation of desert is mainly due to factors such as climate drought, loose materials on the surface and wind force. Desert control aims at improving the desert ecological environment through human intervention [7]. The theory of vegetation sand fixation emphasizes that by planting drought-tolerant plants and using plant roots to fix sand, the wind speed can be reduced and the sandstorm activity can be reduced. The theory of engineering sand fixation focuses on the use of sand barriers, sand retaining walls and other engineering measures to directly stop sandstorms and create conditions for vegetation restoration. At the same time, the theory of soil improvement is devoted to improving the structure and fertility of desert soil and improving the survival rate and growth quality of vegetation.

In terms of energy, the theory of energy sustainable development requires that the development and utilization of energy should meet the needs of the present without damaging the ability of future generations to meet their needs [8]. The theory of renewable energy substitution advocates that traditional fossil energy should be gradually replaced by renewable energy such as solar energy and wind energy to reduce environmental pollution and resource consumption. In the field of environmental protection, the theory of ecological balance points out that all parts of the ecosystem are interdependent and mutually restricted, and their balance needs to be maintained to ensure the stability of the ecosystem. The theory of environmental carrying capacity emphasizes that the intensity of human activities should not exceed the environmental carrying capacity to avoid environmental deterioration.

The synergy between desert control, energy and environmental protection involves multidisciplinary integration. Ecological theory guides the evaluation of the ecological impact of desert ecological restoration and energy development to ensure the health of the ecosystem [9]. Engineering theory helps to design efficient energy development facilities and desert control projects. Economic theory is used to analyze cost-benefit and ensure the economic feasibility of collaborative projects. Through multidisciplinary integration, it can provide comprehensive and systematic theoretical support for the implementation methods of energy and environmental protection based on desert control.

3. Synergistic principle of energy and environment based on desert control

3.1. Synergy analysis

There is a close and mutually reinforcing synergistic relationship between desert control, energy and environmental protection. On the one hand, desert control creates favorable conditions for energy development and environmental protection. Successful desert control can increase the vegetation coverage on the surface, reduce the wind speed, reduce the erosion and damage of energy facilities caused by sandstorms, and ensure the stable operation of energy facilities such as

solar energy and wind energy. At the same time, the sand-fixing function of vegetation can effectively improve soil quality and provide a more stable foundation for infrastructure construction related to energy industry. On the other hand, energy development and environmental protection have positive feedback effects on desert control. Reasonable energy development, such as the construction of large-scale solar and wind power generation projects, can feed back desert control through economic benefits. Part of the power generation income can be used for desert control measures such as expanding vegetation planting area and optimizing irrigation system. Ecological monitoring and restoration measures in environmental protection work are helpful to find ecological problems in the process of desert control in time, adjust control strategies and improve the effectiveness of desert control.

3.2. Synergistic feasibility

From the perspective of resource conditions, the desert area is rich in solar energy and wind energy resources, with long sunshine time and stable wind power, which has the innate advantage of developing new energy on a large scale. At the same time, the vast desert land provides sufficient space for the construction of energy facilities. From the perspective of technical development, the current solar photovoltaic technology and wind power generation technology are progressing continuously, the energy conversion efficiency is continuously improved, and the cost is gradually reduced, which makes the energy development in desert areas technically feasible. In addition, desert control technologies such as drip irrigation technology and drought-tolerant plant cultivation technology are becoming more and more mature, which provides technical support for the synergy between desert control and energy development. On the policy support level, governments all over the world have issued policies to encourage the development of renewable energy and ecological environment protection, and given subsidies and tax incentives to energy and environment collaborative projects in desert areas, creating a good policy environment for their implementation.

3.3. Challenges facing synergy

Although desert control, energy and environment have many advantages and feasibility, they also face some challenges. On the technical level, the integration of energy development and desert control technology still needs to be further optimized. For example, how to design energy facilities that can adapt to the harsh desert environment and combine with desert ecological restoration is an urgent problem to be solved. Economically, the initial construction investment is large and the return period is long, so enterprises and investors face great economic pressure. Take a typical collaborative project of solar power generation in desert and desert control as an example (see Table 1). In the early stage of the project, the costs of land lease, equipment purchase and installation, and early investment in desert control are high, while the power generation income grows slowly in the early stage of the project operation, and it will take several years to achieve balance of payments and start making profits.

At the social level, local residents' lack of awareness and participation in the project may lead to resistance in the process of project promotion. At the same time, the ecological risk assessment and response mechanism in the process of project implementation is not perfect, which may have an unpredictable impact on the fragile ecosystem in desert areas.

Table 1 Planning Table of Solar Energy Development Project in Desert Area

Project Phase	Cost (ten thousand yuan)	Revenue (ten thousand yuan)
Year 1	Equipment purchase and installation: 5,000; Land lease: 500; Vegetation planting and irrigation facility construction for early - stage desert management: 1,000	Power generation revenue: 0
Year 2	Desert management maintenance and optimization: 500	Power generation revenue: 800
Year 3	Equipment maintenance: 300; Continuous input for desert management: 300	Power generation revenue: 1,200
Year 4	Equipment upgrade: 500; Ecological monitoring and adjustment for desert management: 200	Power generation revenue: 1,500
Year 5	Daily operation and maintenance: 300	Power generation revenue: 1,800

4. Energy and environmental protection implementation method design

4.1. Energy development method based on desert control

In desert areas, solar energy and wind energy have great development potential. For solar energy development, the mode of combining large-scale centralized solar photovoltaic power station with distributed photovoltaic power generation can be adopted. Large-scale centralized power stations can use vast desert land to lay photovoltaic panels on a large scale, generate a large amount of electricity and connect to the national grid. Distributed photovoltaic power generation can be installed in small facilities around the desert, such as weather stations and forest protection stations, to meet their own electricity demand.

Taking a planned solar energy development project in desert area as an example (see Table 2 "Planning Table of Solar Energy Development Projects in Desert Area"), photovoltaic power stations of different scales are set up in different areas through reasonable layout. The large-scale centralized photovoltaic power station is planned to cover an area of 500 hectares, with an estimated installed capacity of 500MW and an annual power generation capacity of 800 million kWh after completion. Distributed photovoltaic power generation is aimed at five small stations around, each with an installed capacity of 100kW, which can meet the daily equipment operation and domestic electricity consumption.

Table 2 Planning Table of Solar Energy Development Projects in Desert Area

Power Station Type	Occupied Area (hectares)	Installed Capacity (MW)	Estimated Annual Power Generation (billion kWh)
Large-scale Centralized PV Power Station	500	500	8
Distributed PV Power Station (Single)	0.1	0.1	-
Distributed PV Power Stations (Total 5)	0.5	0.5	-

For the development of wind energy, it is necessary to build a wind farm at a reasonable location according to the distribution of wind resources in desert areas. Through the preliminary wind monitoring, determine the main wind direction and wind speed stability area, and install the appropriate type of wind turbine. For example, in a desert area with abundant wind resources (see

Table 3 "Selection and Layout Table of Desert Wind Farm Units"), fans with different powers are selected according to the wind parameters in different areas. In the strong and stable wind area, install 30 large fans with 5MW; In the area with relatively weak wind power, 50 medium-sized fans with 2MW will be installed.

Table 3 Selection and Layout Table of Desert Wind Farm Units

Area	Wind Parameter (Average Wind Speed m/s)	Turbine Model	Quantity (units)	Total Installed Capacity (MW)
Strong Wind Stable Area	8 - 10	5MW Large Turbine	30	150
Relatively Weak Wind Area	6 - 8	2MW Medium Turbine	50	100

4.2. Environmental protection method based on desert control

In the process of desert control, environmental protection is very important. First of all, we should strengthen the protection and cultivation of desert vegetation. Establish a strict vegetation protection system, and prohibit illegal logging and destruction. At the same time, according to the soil conditions and climate characteristics in different regions of the desert, suitable drought-tolerant plant varieties are selected for planting. For example, in sandy soil areas, plants with strong sand-fixing ability such as Haloxylon ammodendron and Salix psammophila are given priority; In areas with relatively light salinization, trees with strong adaptability such as Populus euphratica are planted. Secondly, we should pay attention to the rational utilization and protection of water resources. Water resources are scarce in desert areas, so efficient water-saving irrigation technologies, such as drip irrigation and micro-sprinkler irrigation, need to be adopted. Establish a water resources monitoring system to monitor the changes of groundwater level and water quality in real time to prevent over-exploitation and water pollution. The wastewater generated in the process of energy development needs to be treated strictly and used for vegetation irrigation or other ecological purposes after reaching the discharge standard.

4.3. Integration and optimization of implementation methods

The proposed strategy integrates energy development and environmental protection methods to form an integrated implementation system. In the planning stage of energy projects, the strategy fully considers the needs of environmental protection and desert control, and reserves space for ecological protection and vegetation restoration. For example, in the construction of solar photovoltaic power station, low sand-fixing plants can be planted between photovoltaic panels, which will not affect the efficiency of photovoltaic power generation, but also play a role in sand-fixing and improving ecology.

In the operation stage of the project, a joint monitoring mechanism is established to comprehensively monitor energy production, ecological environment change and desert control effect. The implementing agency should, based on the monitoring data, adjust the energy development strategy and environmental protection measures in a timely manner to realize the dynamic optimization of energy and environmental protection. Simultaneously, the agency should strengthen cooperation with local communities and governments, enhance public awareness and participation in the project, and ensure its sustainable development.

5. Conclusions

This article focuses on the implementation methods of energy and environmental protection based on desert control. By combing the relevant theoretical basis, the theoretical basis of desert control, energy development and environmental protection and the importance of multidisciplinary integration are clarified. In the analysis of synergy principle, it is found that there is a close relationship between the three, and the feasibility of synergy is demonstrated from the aspects of resources, technology and policy, but the challenges of technological integration, economic cost and social cognition cannot be ignored.

In the design of implementation methods, targeted energy development and environmental protection measures are put forward. In terms of energy development, the specific development modes of solar energy and wind energy are planned, such as the layout and scale of large centralized and distributed photovoltaic power stations in a solar energy development project in a desert area, and the selection and layout of wind turbines according to wind parameters. In terms of environmental protection, it emphasizes the protection and cultivation of vegetation and the rational utilization of water resources.

On the whole, the effective integration and continuous optimization of energy development and environmental protection methods is of great significance to realize the coordinated development of ecology, energy and economy in desert areas. In the future, it is necessary to further deepen technology integration, reduce economic costs, increase social participation, and improve the ecological risk assessment and response mechanism, so as to better promote the coordinated development of energy and environmental protection based on desert control and provide feasible paths for solving the problems of desertification, energy shortage and environmental pollution facing the world.

References

[1] Bai Haifeng, He Xubo, Zhang Hongqiang, et al. Seasonal Variation of the Phytoplankton Community in Hongjiannao Desert Lake and Its Relationship with Environmental Factors [J]. Wetland Science, 2024, 22(2): 155-168

[2] Yu Jianan, Liu Sitong, Shi Xiaorong, et al. The Theoretical Logic, Business Model and Experience Enlightenment of Enterprises' Participation in Desertification Control under the Multi-stakeholder Co-governance Model [J]. Journal of Desert Research, 2024, 44(4): 244-252.

[3] Liu Shuqin, Bai Cunlin, Bian Zhen, et al. Land Use Change and Its Ecological and Environmental Effects in the Fragile Area at the Edge of the Desert: A Case Study of Yanchi County on the Southern Margin of the Mu Us Desert [J].Pratacultural Science, 2020, 37(11): 2175-2184.

[4] Wu Along, Deng Yousheng, Dong Chenhui, et al. Research on Economic Construction and Ecological Governance in Desert Areas [J]. Environmental Science and Management, 2024, 49(3): 168-173.

[5] Sun Jiayi, Tan Deqing. Research on the Differential Game Model and Macro Environmental Governance Strategy in Areas Adjacent to Deserts [J]. Operations Research and Management Science, 2022, 31(4): 49-54.

[6] Han Feng, Liu Zhibo, Yin Wenhua, et al. Ecological Risk Assessment and Optimal Selection Research of Desert Expressways Based on the Two-dimensional Cloud Model [J]. Journal of Safety and Environment, 2023, 23(10): 3774-3783.

[7] Meng Huicong, Hu Guangyin, Dong Zhibao, et al. Grain Size Variation Characteristics of Surface Sediments before and after the Control of Mobile Sand Dunes in the Zoig ê Basin [J]. Journal of Desert Research, 2024, 44(3): 96-107.

[8] Li Qingyun, Yang Guang, Yang Yongqiang, et al. Zonal Analysis of the Ecological Environment Quality in Aksu City Based on Landsat Data [J]. Southwest China Journal of Agricultural Sciences, 2020, 33(01): 168-174.

[9] Dong H, Cheng J, Ma B, et al. Characteristics of wind-sand transportation along railways in the eastern fringe of the Taklimakan Desert and sand control system[J]. Transportation Safety and Environment, 2024, 6(3): 042-056.