Research on Economy of Clean Energy Power Generation Technology Based on CORE Method

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Abstract. Clean energy power generation has good economic and social benefits for promoting regional development. However, clean energy power generation is in the growth stage, and the difference of investment income is obvious. Therefore, it is of great significance to study the economy of clean energy power generation technology. In view of this, considering the influencing factors on economy of clean energy power generation technology, this paper proposes a technical economy evaluation and cost trend analysis model for clean energy power generation, which includes three modules: input, output and analysis calculation. Finally, taking Africa as an example, under the three scenarios of high utilization hours, medium utilization hours and low utilization hours, the paper analyzes the economy of photovoltaic power generation in Africa, and concludes that the cost of photovoltaic power generation in the northern and southern of Africa has a certain degree of network transmission economy.

1. Introduction

At present, the contradiction between energy demand and energy supply has become an important factor restricting social and economic development. In order to realize the sustainable development of energy, the development of clean energy is of great strategic significance to promote the revolution of energy production and consumption, and to establish a clean, low-carbon, safe and efficient modern energy system. With the development of clean energy power generation technology, countries all over the world are developing clean energy, which has good economic and social benefits for promoting regional development. However, the current clean energy power generation project is in the growth stage, affected by the regional resources, the investment income difference is obvious, so the research on the economy of clean energy power generation technology is very important. Firstly, this paper analyzes the influencing factors of clean energy power generation technology economy. Secondly, based on the basic model framework of LCOE method, a technical and economic evaluation and cost trend analysis model for clean energy power generation is established to realize the quantitative evaluation of technical and economic efficiency of clean energy power generation. Finally, the economy of photovoltaic power generation in Africa is analyzed based on different scenarios.

2. Factors influencing the technical economy of clean energy power generation

The main influencing factors of clean energy power generation cost include the basic parameters of the project, power generation cost and government incentive policies and measures and so on.

(1) Basic parameters

The basic parameters of the project include the life cycle of the project, utilization hours of power generation equipment, benchmark internal rate of return (IRR), financial parameters, etc. For the life cycle, the longer the life cycle is, the higher the ROI of the project will be, and the corresponding internal rate of return will also be improved without considering the renewal cost of the equipment and the same boundary conditions. The utilization hours of power generation equipment and clean energy power generation technology equipment are important indicators affecting power generation economy. Affected by the local resource conditions, equipment quality, management and operation and maintenance level, power grid capacity and so on. The benchmark internal rate of return is the discount rate when the total present value of capital inflow is equal to the total present value of capital flow and the net present value is equal to zero. It is particularly important to analyze clean energy power generation assets, which can be used to compare the operating costs of different clean energy power generation. Financial parameters mainly include loan proportion, loan

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repayment period, depreciation rate, depreciation period, residual value rate of fixed assets, formation rate of fixed assets, proportion of working capital, etc. The impact of financial parameters on the economy of clean energy power generation project is obvious.

(2) Power generation cost

The generation cost of clean energy power generation project includes initial investment cost (including unit), operation and maintenance cost, grid connection cost and other costs. The cost items included in the power generation cost have an internal impact on the project economy. The initial investment cost of clean energy power generation project is the most important factor to determine the total cost of the project, which has the greatest impact on the economy of the project. Generally, it includes the equipment cost, construction cost, financial cost, design and other miscellaneous items, and other expenses of the project.

(3) Policy measures

Policy measures are the external factors of power generation cost, but they will have a crucial impact on the cost. Electricity price policy, fiscal and taxation policy, financial policy, full guarantee purchase policy, green certificate trading mechanism and other policies, as well as development planning and scale objectives have an important impact on the cost of clean energy power generation technology.

3. Economic analysis model of clean energy power generation technology

In addition to the basic parameters, the most important factors affecting the economy of clean energy power generation are power generation cost, utilization level and policy measures. Among them, although the policy measures will not directly affect the cost of power generation, they will affect the basic parameters, grid connection cost, other costs and utilization level that determine the cost of power generation, which has an important impact on the economy of the project. Therefore, this paper takes policy measures as an important external influencing factor model into the model system, and analyzes its impact on the relevant factors and parameters of power generation economy.

3.1 Analysis steps

According to the above factors and components of clean energy power generation economy, based on the basic model architecture of LCOE method, this paper comprehensively considers the advantages and disadvantages of different technical and economic analysis methods and models, and establishes a economics evaluation and cost change trend analysis model (CORE) for clean energy power generation technology, so as to realize the quantitative evaluation of clean energy power generation technology economy. The specific analysis steps are as follows: firstly, the main cost factors such as initial investment cost, construction cost, operation and maintenance cost are determined according to the technology type and project scale. Then determine basic parameters such as lifetime, depreciation, and internal rate of return, and predict operating parameters such as the utilization hours of different types of clean energy power generation equipment based on historical data. Finally, according to the influencing factors of policies and measures, the impact of on grid electricity price, fiscal and tax policies, financial policies and other related parameters are determined, and the CORE value and IRR level of different clean energy power generation projects are calculated.

3.2 Model framework

The core model consists of three modules: input module, output module and analysis module. The input and output parts adopt custom data format, and the analysis module is the core module of the model.

(1) Input module

For a given clean energy power generation project, input the internal factors including technical parameters, economic parameters, operating parameters, and external factors including on grid electricity price, fiscal and tax policies, financial policies, and development planning objectives.

(2) Analysis and calculation module

Analysis and calculation module is the core function module of core model, which is divided into three parts: generation cost calculation module, internal rate of return calculation module and generation cost prediction module.

1) Power generation cost calculation module

According to the technical parameters, economic parameters, operation parameters and other internal influencing factors input by the input module, the cost, profit, cash flow and so on in the whole life cycle of clean energy power generation project can be calculated.

The mathematical formula for calculating the cost of clean energy power generation is as follows:

It is known that the value F of each future period is lower than that of the current period. The discount rate r is used to measure the difference.

$$P = F(1+r)^{-n} \tag{1}$$

$$NPV = \sum_{t=1}^{n} \frac{C_t}{(1+r)^t} - C_0 \tag{2}$$

$$\sum_{n=0}^{N} C_n (1+r)^{-n} = \sum_{n=0}^{N} (A_n P_n + B_n)(1+r)^{-n} \tag{3}$$

$$LCOE = \frac{I_0 + V_R(1+r)^{-n} + \sum_{n=0}^{N}(C_n - B_n)(1+r)^{-n} + R_I + R_E}{\sum_{n=0}^{N} A_n (1+r)^{-n}} \tag{4}$$

Where NPV is the net present value; C_0 is the initial investment; C_t is the cash flow of year t; R is the discount rate; N is the life cycle of the investment project; C_n is the total expenditure; A_n is the electric energy produced; B_n is income from other sources; I_0 is the initial investment; V_R is the system residual value; R_I is the internal factor of risk cost; R_E is the risk cost of external factors.

2) Internal rate of return calculation module

IRR can be obtained by the following formula:

$$IRR(NPV)=\sum_{t=0}^{n}(CI-CO)_t(1+IRR)^{-t}=0 \quad (5)$$

Criterion: if the benchmark discount rate is i_0 , if $IRR \geq i_0$, the economic effect of the project is acceptable; If $IRR < i_0$, the economic effect of the project is not acceptable.

The solution process is as follows: firstly, the present value coefficient of annuity $(p/A,IRR,n)=K/R$ is calculated; secondly, look up the table of annuity present value coefficient, find two adjacent coefficients $(p/A,i_1,n)$ and $(p/A,i_2,n)$ and corresponding i_1、i_2 , which satisfy $(p/A,i_1,n)>K/R>(p/A,i_2,n)$; finally, the IRR is calculated by interpolation: $(IRR-I)/(i_1-i_2)=[K/R-(p/A,i_1,n)]/[(p/A,i_2,n)-(p/A,i_1,n)]$.

3) Generation cost prediction module

According to the given future forecast period, combined with the basic input parameters of the input module, the future development scale, planning objectives and other external factors, the medium and long-term power generation cost of clean energy power generation project can be calculated, and the future cost change trend is analyzed, and the cost decline curve and cost change roadmap are given. In addition, the core analysis and calculation module of the CORE model also has the function of uncertainty analysis, which can analyze the sensitivity of input parameters for the economy of clean energy power generation technology, and also analyze and calculate the break even hours, break even payback period, etc.

(3) Output module

According to the input parameters of the input module, through the analysis and calculation of the core functions of the calculation module, the economic analysis results and power generation cost prediction results of the clean energy power generation project are output. Including power generation cost (LCOE), IRR, profit margin, etc; medium and long-term power generation cost, cost change trend, etc. In addition, according to the calculation of uncertainty analysis function, the results of break even analysis and sensitivity analysis can be output.

3.3 Example analysis

Taking Africa as an example, the analysis of power generation economy mainly considers the initial investment cost, financial parameters and other basic factors, and is divided into three scenarios: high utilization hours, medium utilization hours and low utilization hours. The specific boundary condition parameters are shown in Table 1.

Table 1. Boundary conditions and scenarios for economic analysis of photovoltaic power generation in Africa

Boundary condition	**Northern Africa**	**Southern Africa**
Initial investment cost	1120$/kW	
Operation and maintenance cost	35000$/MW/year	
Effective utilization hours corresponding to resource conditions	1800-2000	1700-1800
Lending rate	11%	
Capital ratio	21%	
Benchmark IRR	8%	
Scenarios	**Northern Africa**	**Southern Africa**
High utilization hours	2000	1800
Medium utilization hours	1900	1750
Low utilization hours	1800	1700

The economic calculation results are as follows:

1) High utilization hours scenario: the cost of photovoltaic power generation in northern Africa is about 0.51 yuan / kWh; The cost of photovoltaic power generation per kilowatt hour in southern Africa is about 0.58 yuan / kWh.

2) Medium utilization hours scenario: the cost of photovoltaic power generation in northern Africa is about 0.54 yuan / kWh; The cost of photovoltaic power generation per kilowatt hour in southern Africa is about 0.61 yuan / kWh.

3) Low utilization hours scenario: the cost of photovoltaic power generation in northern Africa is about 0.58 yuan / kWh; The cost of photovoltaic power generation per kilowatt hour in southern Africa is about 0.63 yuan / kWh.

To sum up, the per kilowatt hour cost of photovoltaic power generation in northern Africa is about 0.51-0.58 yuan / kWh; About 0.58-0.643yuan / kWh in the south.

At present, in Europe, Germany, Italy, Britain and other countries, the cost of photovoltaic power generation is about 0.63-0.80 yuan / kWh. Compared with European photovoltaic power generation, the cost of photovoltaic power generation in Northern and Southern Africa has certain transmission economy, but considering the transmission cost, the economy is not prominent.

4. Conclusion

The economy of clean energy power generation technology is a practical problem to be further studied. Based on the analysis of the economic factors of clean energy power generation technology and the basic model framework of LCOE method, this paper establishes a economics evaluation and cost trend analysis model for clean energy power generation technology. Through setting different scenarios, this paper analyzes the economy of photovoltaic power generation in Africa, and draws the conclusion that the cost of photovoltaic power generation in Northern and Southern Africa has a certain degree of network transmission economy, but the

economy is not prominent after considering the transmission cost. This model can more comprehensively compare and evaluate the economy of clean energy power generation.

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