Feasibility Analysis of New Energy Development under the Asian-African-European Grid Interconnection Mode

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Abstract. The power area of Asia-Africa-European power transmission is rich in new energy resources such as wind resources and solar resources. West Asia and Africa have the potential to build large-scale renewable energy power generation bases. Based on the basic idea of Levelized Energy Cost Analysis (LCOE), this paper proposes an improved feasibility analysis model of new energy power generation technology, comprehensively considering the impact of policies, technology, politics and other factors on the cost of power generation. Feasibility of power transmission from large renewable energy bases in West Asia and Africa to Europe are measured under inter-regional grid interconnection. The results show that: the wind and solar power generation bases in West Asia and Africa are feasible of transferring electricity to Europe, and solar intercontinental interconnected transmission is more feasible than wind power.

Keywords: new energy power generation; feasible; intercontinental interconnected transmission.

1. Introduction

In the context of low-carbon energy development for global response to climate change, large-scale development of large-scale renewable energy bases and long-distance power transmission across regions have become a possible model for the development and utilization of new energy in the future. Overall planning of new energy resource endowments and electricity demand characteristics in Africa, Europe and West Asia, and construction of energy interconnected backbone channels can realize the optimal allocation of resources within and across continents. Intensive development of hydropower in the Congo and Nile river basins in Africa and solar power generation in northern Africa and western Asia can enable complementary and efficient use of multiple types of energy and achieve low-carbon clean development of cross-region energy use.

The economic analysis of new energy power generation technology mainly includes the learning curve model and the standardized energy cost analysis (LCOE) method. The learning curve model mainly analyzes the relationship between the cost of energy technology and various influencing factors, and predicts the trend of cost changes. Using the modified model to measure the cost of new energy power generation technology requires a large amount of historical data as the basis. The Levelized Energy Cost Analysis (LCOE) can comprehensively analyze the feasibility of new energy power
generation throughout the life cycle, and calculate the unit cost of electrical energy produced during the entire life cycle of power generation technology. Based on the basic idea of the LCOE method, this paper comprehensively considers the costs caused by internal and external risk factors such as fiscal and taxation, financial policies, and geopolitical risks, and establishes a method model suitable for the economic analysis of new energy power generation technology. This model can realize the analysis and comparison of the cost of different types of new energy power generation and the feasibility of intercontinental multinational interconnected transmission.

2. New energy resources and development potential in Asia, Africa and Europe

Asia's new energy resources are rich and unevenly distributed. The theoretical reserves of wind energy and solar energy both account for 25% of the world. The degree of development is relatively low. The proportion of wind and solar resources development is less than 1 in 10,000. The development potential is huge. Wind energy resources are mainly distributed in Russia, China, Kazakhstan and other countries. Russia's wind energy resources are mainly concentrated in the Siberian Arctic rim area, especially the Kara Sea and Bering Strait. China's wind energy resources are mainly concentrated in the "Three North" region, the southeast coast and nearby islands. Kazakhstan is the country with the most abundant wind energy resources in Central Asia. The average annual wind speed in 50% of the regions is more than 4 meters/second. High-quality wind energy resources are concentrated in the central, southern and Caspian regions. Solar energy resources are mainly distributed in China, Saudi Arabia, Kazakhstan and other countries. China's solar energy resources are mainly concentrated in the Qinghai-Tibet Plateau, northern Gansu, northern Ningxia, and southern Xinjiang. The annual radiation intensity is more than 1600 kWh/m², and some parts of the Qinghai-Tibet Plateau exceed 2300 kWh / m²; Saudi Arabia is about Half of the country's land area is desert, and its annual irradiation intensity exceeds 2200 kWh / m²; Kazakhstan's annual irradiation intensity is mostly between 1300 and 1800 kWh / m².

Africa's new energy resources are very rich. Wind energy resources rank first in the world, accounting for 32% of the global theoretical reserves of wind energy, mainly distributed in Sudan, Somalia, Egypt and other countries. Among them, Sudan has the most abundant wind energy resources. The average annual wind speed of more than half of the country's land area is more than 5 meters per second, and the theoretical installed capacity is 2.83 billion kilowatts. Solar energy resources also rank first in the world, accounting for 40% of the global theoretical reserves of solar energy, and theoretical installed reserves of 40.9 billion kWh, mainly distributed in Sudan, South Africa, Tanzania and other countries. Among them, Sudan, South Africa and Tanzania have an annual irradiation intensity of 1500-2000 kWh / m², accounting for 20%, 25%, and 18% of the country's land area, and an annual irradiation intensity of 2000-2500 kWh / sq.m. The area of rice accounts for 56%, 8%, and 5% of the national land area, respectively.

![Figure 1. Global wind energy resources](image-url)
There are relatively few new energy resources in Europe. Wind energy resources account for 8% of the global wind energy theoretical reserves, mainly distributed in Denmark (including Greenland), Norwegian countries, the entire European continent, except for central Iberia, northern Italy, Romania and Bulgaria and other parts of Southeast Europe and Turkey. In addition, the wind speed in most other areas is basically above 6-7 meters/second. Solar energy resources only account for 1% of the global theoretical solar energy reserves, and the theoretical installed reserves are 10.9 billion kWh, far lower than other regions of the world. European solar resources are mainly distributed in southern European countries such as Spain, Italy, and Portugal. More than 60% of Spain's land area, Italy's more than 50% land area, and Portugal's more than 70% land area have annual radiation intensity of 1600-1800 kWh/m².

Figure 2. Global solar energy resources

3. Economic Analysis Model of New Energy Power Generation Technology under Intercontinental Interconnection Mode

3.1. Influencing factors of economic analysis of new energy power generation technology under intercontinental interconnection mode

The main factors influencing the technical and economic analysis of new energy power generation include the basic parameters of the project, the cost of power generation, government incentive policies and measures, and the ownership and capital structure of the project.

(1) Basic parameters

The basic parameters of the project include the life cycle of the project, the hours of power generation equipment utilization, the benchmark internal rate of return, and financial parameters.

Project life cycle: The life cycle of a new energy power generation project is also an important factor affecting feasibility. At present, the life cycle of global wind power projects is about 20-25 years, and the life cycle of photovoltaic power generation projects is about 25-30 years.

Utilization hours of power generation equipment: The utilization hours of new energy power generation technology equipment are an important indicator that affects the feasibility of power generation. It is affected by local wind resource conditions, equipment quality, management and operation and maintenance levels, and grid acceptance capacity.

Benchmark Internal Rate of Return (IRR): The benchmark internal rate of return (IRR) is one of the most important exogenous parameters in cost calculation. It is the expected return or cost per unit of capital and represents the estimate of the time value of the funds in the project investment. The discount rate can be adapted to different financing structures and varies with capital markets. Generally speaking,
the nominal interest rate available for financing new energy power generation projects in the financial market is about 8%, while in the stock market that can accept higher risks, the nominal interest rate for financing is about 13%.

Financial parameters: Financial parameters mainly include loan ratio, loan repayment period, depreciation rate, depreciation period, fixed asset residual value rate, fixed asset formation rate, liquidity ratio, etc. The influence of financial parameters on the feasibility of new energy power generation projects is more obvious.

(2) Power generation cost
The power generation costs of new energy power generation technology projects include initial investment costs, operation and maintenance costs, grid connection costs, and other costs. The cost items included in the cost of power generation all have an inherent impact on the feasibility of the project. Among them, the initial investment cost has the greatest impact on the feasibility of the project, and the initial investment cost per kilowatt has also become one of the important indicators to measure the feasibility of the project.

(3) Policy measures
In addition to the factors influencing the cost of power generation, external policy influencing factors such as electricity pricing policies, fiscal and tax policies, financial policies, full-guaranteed acquisition policies, and green certificate trading mechanisms, as well as development planning, scale targets, and geopolitics also have implications for the cost of new energy power generation technologies.

(4) Ownership and capital structure
Ownership and capital structure also affect the cost or benefit of the project. In the economic analysis model, a series of potential ownership and capital structures can be defined, which can be assumed to be used when modeling. Decision-makers’ choice of appropriate ownership and capital structure will have a significant impact on the availability of new energy power generation technology and financing conditions.

3.2. Principle of Economic Analysis of New Energy Power Generation Technology under Intercontinental Interconnection Mode
Based on the basic model framework of the LCOE method, this paper comprehensively considers the costs caused by internal and external risk factors of fiscal taxation and financial policy changes, and establishes a model suitable for the economic analysis of new energy power generation technology to achieve different types of new energy power generation costs and intercontinental The analysis and comparison of the feasibility of interconnected transmission, the basic principles of the model are as follows:

In addition to basic parameters, the main factors affecting the feasibility of new energy power generation technology are the cost of power generation and policy measures. It is known that the value \( F \) of each future period is lower than the value of the current period, and this difference is measured by the discount rate \( r \), namely

\[
P = F(1+r)^{-n}
\]  

The net present value NPV is a collection of multiple periods of value, usually referring to all periods within the life cycle of a project. The definition of economic analysis model of new energy power generation technology comes from the identity that the net present value of revenue equals the net present value of cost, ie

\[
\sum_{n=0}^{N} C_n (1+r)^{-n} = \sum_{n=0}^{N} (A_n P_n + B_n)(1+r)^{-n}
\]

In the formula, \( C_n \) is the total expenditure; \( A_n \) is the electricity produced; \( B_n \) is the income from other sources, such as possible tax subsidies.
\[
CORT = \frac{I_0 + V_R (1 + r)^{-T} + \sum_{i=0}^{T} (C_e - B_a)(1 + r)^{-i} + R_I + R_E}{\sum_{i=0}^{T} A_i (1 + r)^{-i}}
\]

In the formula, \(I_0\) is the initial investment; \(V_R\) is the residual value of the system; \(R_I\) is the internal factor risk cost, mainly including, for example, the cost caused by the change of population management expenses in operation and maintenance, or the generation of electricity due to unexpected events in the operation of new energy technologies. The cost caused by the change of risk, and the risk cost of internal factors. \(R_E\) is the risk cost of external factors, mainly including costs caused by changes in external factors such as fiscal, taxation, financial policy changes and political risk.

4. Economic analysis of non-European new energy development and interconnected transmission

According to the analysis of non-European new energy resources and development potential, it can be seen that Africa and Asia have the world's most abundant new energy resources such as wind energy and solar energy. It has a sparse population and low electricity demand. It has the potential to build a large-scale renewable energy power generation base. The development potential of new energy resources is low, with a dense population and large demand for electricity. Therefore, in the future, UHV transmission technology can be used to carry out intercontinental long-distance, large-scale clean power transmission to the European load center area. This section studies the feasibility of constructing large-scale renewable energy bases in Africa/Asia and developing non-European interconnected power transmission in the future from the perspectives of new energy development costs.

4.1. Economic analysis of wind power

(1) Introduction of boundary conditions and analysis scenarios

The analysis of the feasibility of wind power in West Asia and Africa in 2025 mainly considers the basic influencing factors such as initial investment cost and financial parameters, and is divided into three scenarios: high utilization hours, medium utilization hours, and low utilization hours. Show:

| Boundary conditions and analysis scenarios of economic analysis of African wind power in 2025 |
|-----------------|-----------------|-----------------|
| North Africa    | South Africa    | West Asia       |
| Initial investment cost | 1000USD/kW    | 880USD/kW     |
| Operation and maintenance cost | 24000 USD /MW/year | 18000 USD /MW/year |
| Effective use of hours | 2200-2400 hours | 1800-1900 hours | 1800-2000 hours |
| Lending rates    | 10%             | 20%             |
| Capital ratio    | 10%             | 20%             |
| Benchmark IRR    | 8%              |

(2) Results of economic calculation

1) High utilization hours scenario: According to estimates, in high utilization hours scenario, the cost of wind power in West Asia is 0.35 RMB / kWh; the cost of wind power in North Africa is about 0.38 RMB / kWh; the cost of wind power in South Africa is about 0.43 RMB / kWh.

2) Mid-use hours scenario: After calculation, in the mid-use hours scenario, the cost of wind power in West Asia is 0.38 RMB / kWh; the cost of wind power in northern Africa is about 0.40 RMB / kWh; the cost of wind power in South Africa is about 0.46 RMB / kWh.
3) Low utilization hours scenario: According to calculations, under low utilization hours scenario, the cost of wind power in West Asia is 0.46 RMB / kWh; the cost of wind power in North Africa is about 0.49 RMB / kWh; the cost of non-South Africa wind power is about 0.52 RMB / kWh.

In summary, the cost of wind power in West Asia is about 0.35-0.46 RMB / kWh in 2025, the cost of wind power in North Africa is about 0.38-0.49 RMB / kWh; the cost of wind power in South Africa is about 0.43-0.52 RMB / kWh. The cost of wind power in Europe is about 0.30-0.45 RMB / kWh. Compared with the cost of wind power in Europe, wind power in West Asia and North and South Africa has a certain degree of economical transmission.

4.2. Economic analysis of solar power

(1) Introduction of boundary conditions and analysis scenarios

The analysis of the feasibility of photovoltaic power generation in West Asia and Africa in 2025 mainly considers the basic impact factors such as initial investment costs and financial parameters, and is divided into three analysis scenarios: high utilization hours, medium utilization hours, and low utilization hours. The specific boundary condition parameters are as follows. As shown:

| Table 2. Boundary conditions and analysis scenarios of economic analysis of African solar power in 2025 |
|-------------------------------------------------|---------------------|-------------------|
| Boundary conditions                              | North Africa        | South Africa       | West Asia         |
| Initial investment cost                          | 750 USD/kW          | 680 USD/kW         |                  |
| Operation and maintenance cost                   | 25000 USD /MW/year  | 20000 USD /MW/year |                  |
| Effective use of hours                           | 2200-2400 hours     | 1800-1900 hours    | 1680-1860 hours  |
| Lending rates                                    | 10%                 |                   |                  |
| Capital ratio                                    | 20%                 |                   |                  |
| Benchmark IRR                                    | 8%                  |                   |                  |
| Analysis scenario                                | North Africa        | South Africa       | West Asia         |
| High utilization hours                           | 2100                | 1900              | 1850             |
| Hours in use                                     | 2000                | 1850              | 1750             |
| Low utilization hours                            | 1900                | 1800              | 1680             |

(2) Results of economic calculation

1) High utilization hours scenario: According to calculations, under high utilization hours scenario, the cost of photovoltaic power generation in West Asia is about 0.47 RMB / kWh; the cost of photovoltaic power generation in North Africa is about 0.38 RMB/kWh; the cost of photovoltaic power generation in southern Africa is about 0.42 RMB/kWh.

2) Mid-use hours scenario: According to calculations, under the mid-use hours scenario, the cost of photovoltaic power generation in West Asia is about 0.50 RMB/kWh; the cost of photovoltaic power generation in North Africa is about 0.43 RMB / kWh; the cost of photovoltaic power generation in southern Africa is about 0.46 RMB / kWh.

3) Low utilization hours scenario: Under the low utilization hours scenario, the cost of photovoltaic power generation in West Asia is about 0.54 RMB / kWh; the cost of photovoltaic power generation in North Africa is about 0.46 RMB/kWh; the cost of photovoltaic power generation in southern Africa is about 0.48 RMB / kWh.

In summary, the cost of photovoltaic power generation in West Asia is about 0.47-0.54 RMB / kWh, the cost of photovoltaic power generation in North Africa is about 0.38-0.46 RMB / kWh; the cost of photovoltaic power generation in southern Africa is about 0.42-0.48 RMB / kWh. The cost of photovoltaic power generation in Europe, Germany, Italy, the United Kingdom and other countries is about 0.43-0.49 RMB / kWh. Compared with European photovoltaics, the cost of photovoltaic power generation in southern and northern Africa has a certain degree of interconnected transmission feasibility,
and the cost of photovoltaic power generation in West Asia does not have the feasibility of Asia-Europe interconnection transmission.

5. Conclusion
Based on the basic idea of Levelized Energy Cost Analysis (LCOE), combined with the analysis of influencing factors of new energy power generation costs, this paper proposes an economic analysis model of new energy power generation technology, which effectively solves the incomplete and influential factors of existing research methods. This paper analyses and estimates the feasibility of constructing large-scale renewable energy bases in Africa and carrying out non-European interconnected transmission in the future from the perspectives of new energy development costs and interconnected transmission feasibility. The results of the study show that: compared with the cost of European wind power, wind power in West Asia and Africa have a certain degree of interconnected transmission feasibility; solar power in Asia does not have the interconnected interconnection transmission feasibility.

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