Evaluation, Risk and Prospect for Electricity Investment in Five South American Countries

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Yuxi Liu*, Yiming Feng, Hongli Jiang, Yuxi Li and Baozhong Zhou

HUADIAN Electric Power Research Institute Co., LTD, Hangzhou, China

*Corresponding author: yuxi-liu@chder.com

Abstract. South America is the natural extension of the "One Belt, One Road" initiative and has now become one of the important destinations for Chinese companies' overseas investment. South America is rich in renewable energy resources, but has a large power gap and has good investment potential. This paper selects 20 factors of five major factors: politics, economy, law, society, and resources, and uses the entropy method to evaluate and compare the electricity investment environment of the five countries in South America. Combined with the regional power development and planning, the priority investment countries and industries are obtained. In addition, we put forward investment suggestions such as seizing opportunities, building brands, strengthening cooperation, and initiating change.

Keywords: South America, Electricity Investment, The Entropy Method.

1. Introduction

South America is the fourth largest continent by land area, with a relatively large population, including 12 countries such as Brazil, Argentina, Chile, Colombia, and Peru. As the natural extension of the “Belt and Road” initiative, South America has become a resources supplier, an energy and intermediate productor, a receiver of superior products and production capacity, and an implementer of innovative technologies and standards of China. It is an important destination for Chinese companies to deploy overseas one.

Investment evaluation refers to the integration of internal and external factors that have an impact on investment in a certain area within a certain period of time, including various factors such as natural geographic environment, economy, law, humanities and infrastructure [1]. The assessment of the investment environment is generally to find out the deficiencies in the investment environment of specific industries and regions by comparison, such as backward infrastructure, low economic levels and invalid economic policies, and then adjust the industrial structure and economic policies to improve the investment environment and promote the growth of the local economy or the coordinated development of the regional economy.

Therefore, in order to maintain the unique objective attributes of the electricity investment evaluation itself, this paper uses five South American countries as the research sample, starting from the five aspects of politics, economy, law, society, and resources, and uses the entropy method to determine the weight. The objective empirical analysis and indexation evaluation of electricity investment can be used as a reference for companies investing in power in South America.

2. Overview of South America

2.1. The situation of society and economy

As of the end of 2019, the total GDP of South America was approximately $3.47 trillion, accounting for 4.01% of the world's total economy [2]. The per capita GDP was approximately $8163.1, and the economic growth rate was approximately -3.47%, showing a downward trend. In the past five years, the economies of many South American countries have shown a declining trend. In particular, the economic conditions of major regional countries such as Brazil and Argentina are worrying. Some countries have weak economic growth, and some have even fallen into negative growth again. Many South American countries rely too much on resource exports. In the context of a slowdown in the world economy, declining demand for resources and increasing volatility in the international financial market, regional economic growth momentum is obviously insufficient.

2.2. The development of electricity

South America is rich in energy and has a good power generation basis. However, in recent years, some countries in South America have been affected by economic recession, inflation, and high unemployment. The local power grid system has become overwhelmed. The established energy policy cannot adapt to the current national conditions of the country. Range blackouts also occur from time to time, and countries are facing the challenge of "power shortage". In response to the "power shortage", most countries in South America continue to increase hydroelectricity construction and actively hold auctions of renewable energy. At the same time, some large international power companies withdraw from the South American market or reduce their business in South America. In this context, it is very forward-looking to seize the opportunity to invest in the South American power industry and vigorously expand the South American power market. According to the World Energy Data Statistics for 2020 released by BP [3], the power generation of South American countries in 2019 is shown in Table 1.

Table 1. Five South American countries' power generation in 2019 (unit: 100 million kw)

Country	Total	Hydroelectricity	Thermal power	Renewable	Nuclear	Others
Agentina	1399	371	858	82	84	4
Brazil	6256	3993	1177	925	162	-
Chile	839	209	414	216	-	-
Columbia	752	515	215	22	-	-
Peru	573	316	217	40	-	-
Total	9819	5404	2881	1285	246	4

Generally speaking, the power generation in South American countries is dominated by hydroelectricity and thermal power. With the exception of Brazil and Chile, South America's abundant renewable energy such as solar, wind, geothermal, and biomass remains to be developed.

2.3. The development of industry

2.3.1. The thermal power. Thermal power accounts for a relatively large proportion of the power structure in Argentina, Chile, Colombia, and Peru. South America is rich in fossil resources. Argentina's shale gas prospects are considered second only to the United States. However, most of Argentina's shale gas has not been developed, so South America is still a net importer of natural gas at this stage. In the future, thermal power can supplement electricity when South American countries are transitioning to a "low-carbon grid" [4] and when hydroelectricity generation cannot meet demand in the dry season, but due to the impact of resources and climate policies, the development space is limited.

2.3.2. Hydroelectricity. Hydroelectricity has an absolute advantage in the power structure of Brazil, Colombia, and Peru. Hydroelectricity is the most important method of power generation in South

America. Since the 1990s, the share of hydroelectricity in South America has gradually declined. Due to global warming and severe and prolonged drought, the power generation of existing hydroelectricity stations has been greatly reduced, many new hydroelectricity stations in South America do not have large-capacity storage capacity, making them very vulnerable to drought. At the same time, the construction of new dams has become increasingly difficult (especially the construction of large dams) due to environmental protection and local residents' resettlement issues. Due to residents' protests, local court charges, frequent government review activities and other factors, many large dams under construction cost much more than expected and finally had to stop construction. Despite the difficulties in hydroelectricity construction, the abundant water resources in South America and the development potential of nearly 300 million kilowatts of hydroelectricity resources in the Amazon basin make hydroelectricity the first choice for power generation in the Amazon River basin for several years [5].

2.3.3. Renewable power. South America has become one of the fastest growing markets for renewable energy [6]. In recent years, increasingly severe regional droughts have forced South American countries to develop alternative energy sources. For those in power in many countries, the top priority is to break the electricity pattern that is overly dependent on hydroelectricity. South American countries are rich in renewable energy. At present, most countries have put forward the concept of giving priority to the development of renewable energy power. Brazil is one of the top ten renewable energy investors in the world. Argentina has the potential to become the largest renewable energy market in South America. Chile’s renewable energy power generation is second only to Brazil. Peru is the first South American region to promote wind and solar power on a large scale. One of the countries of the project. Almost all countries are trying to develop solar energy, biomass energy and geothermal energy, and in the past few years, the technical cost of wind power and solar power generation has dropped significantly. Fierce price competition has made South American governments pay more and more attention to renewable energy.

2.3.4. Nuclear power. At present, due to various factors such as geography, technology, economy, politics, etc., except Brazil and Argentina, there is no nuclear power development in other countries. South American countries have considerable reserves of nuclear raw materials. Brazil's uranium resource reserves ascertained by surveys of one-third of the country's land area has ranked sixth in the world, and its national uranium resource reserves may rank second in the world. But for South American countries with more safe and clean energy options, nuclear power has no obvious competitive advantage [7].

2.4. The power developing plan

South America has the world's most active renewable energy market. More than a quarter of primary energy comes from renewable energy, which is twice the global average. The region’s power generation is characterized by its high dependence on hydroelectricity and the ability to make full use of the complementarity between hydroelectricity and renewable energy. Most countries have formulated plans for accelerating the development of electricity. Generally speaking, hydroelectricity is still the target of vigorous development and investment in South American countries. In addition, many countries put the development of wind energy, photovoltaics, biomass and other renewable energy on the agenda. Table 2 is the power developing plan of five South American Countries.

Table 2. The power developing plan of five South American Countries.

Country	The Plan	The main content
Agentina	'The Agentina 2020 energy plan' Argentina Renewable Energy Program	1. By 2020, the installed power capacity will reach 39.005 million kw. 2. Construction of a number of large hydropower stations such as Nestor Kirchner; renovation of old nuclear power stations such as Atucha II; construction of thermal power stations such as Belgrade II; construction of transmission and transformation grids and fuel procurement projects. 3. Encourage foreign investment in electricity, actively develop renewable energy projects, and increase the proportion of renewable energy in Argentina's power structure to 20% by 2025, so that the scale of renewable energy power generation exceeds 10 million kw.
Brazil	'2013-2022 mid-term plan' '2030 long-term plan' '2050 long-term plan'	1. By 2030, 4 new nuclear power plants will be built. 2. By 2030, non-aqueous renewable energy power generation will account for 23% of total power generation. 3. By 2020, the total installed capacity will reach 185 million kw, of which wind power will account for 7% of the total installed capacity. 4. Continue to increase the scale of hydropower development.
Chile	'257 Promotion of Non-traditional Renewable Energy Law' '2016 Energy Strategy'	1. Develop non-traditional renewable energy. By 2024, the proportion of non-traditional renewable energy will reach 10%. By 2025, the power generation of non-traditional renewable energy will reach 20% of the total power generation. By 2035, it will reach 50% and by 2050. Up to 70% annually. 2. Set the renewable energy power generation ratio of all power generation companies, impose fines on companies that do not reach the ratio or purchase power generation capacity from renewable energy power generation companies. 3. Develop large and medium-sized hydropower, and the proportion of hydropower will reach 45%-48% by 2022. 4. Do not develop nuclear power, but will continue to promote its research and technical exchanges with developed countries to lay the foundation for the possible use of nuclear power in the future.
Columbia	'2027 National Power Plan' 'New Renewable Energy Law (Act 1715)'	1. Install approximately 3.1 million kw of installed capacity by 2027 and invest more than $2 billion in transmission facilities. Construction of the second phase of a large hydropower station Ituango, two new hydropower stations, two gas-fired combined cycle thermal power plants and a coal power plant. 2. For the non-hydropower renewable energy industry, developers can be provided with preferential tax policies, open financing to fund projects, and exempt foreign investment projects from tariffs, thereby promoting investment in the emerging non-hydropower renewable energy industry.
Peru	'2013-2022 Rural Power Development Plan'	1. The government invested $294 million and $42.5 million in the construction of photovoltaic and wind power generation. 2. Achieve 100% electrification coverage by 2021, aiming to narrow the gap in rural areas. 3. By 2030, renewable energy will account for 15% of the energy structure.

2.5. The summary

South America has abundant development conditions such as water resources, sunlight, biomass, and has a huge energy gap. Currently, South American energy demand is growing steadily, with an estimated annual growth rate of about 3% [8]. However, the infrastructure in South America is obviously lagging behind, which severely restricts the region's own development. Overseas electricity investment is complicated and risky. Therefore, scientific evaluation is essential for overseas electricity investment. This paper selects 20 factors of five major factors: politics, economy, law, society, and resources, and uses the entropy method to evaluate and compare the electricity investment environment of the five countries in South America. The main process and results are shown in the third part.

3. Evaluation of Electricity Investment in Five South American Countries

A good investment environment is the basis for a country or region to attract foreign investment and enhance economic vitality. The investment environment includes many factors such as geographic location, natural resources, economic development, human resources, infrastructure, laws and regulations, and political situations that directly or indirectly affect investment. Therefore, the use of quantitative index evaluation systems and evaluation methods to evaluate the investment environment has become the most common method [9].

3.1. The evaluation method and index selection

In order to eliminate the interference of subjective factors as much as possible, in order to make the evaluation results more accurate and objective, this paper selects the entropy method for index weighting [10]. On this basis, the weighted sum method is used to calculate the comprehensive scores of the power investment environment of the five South American countries. Considering the quantification of comprehensive indexs and the availability of data, this paper selects five first-level indexs, 11 second-level indexs, and 20 third-level indexs that are closely related to power investment in politics, economy, law, society, and resources, and building a power investment index evaluation system. Table 3 is the indexs and sources.

Table 3. Related indexs and sources.

1st index	2nd index	3rd index	Sources
Politics(A)	Political stability(A_1)	Public-sector performance(A_{11})	'The Global Competitiveness Report 2019'
		Happiness index(A_{12})	'World happiness report 2020'
	Future development (A_2)	Future orientation of government(A_{21})	'The Global Competitiveness Report 2019'
Economy(B)	Economy(B_1)	Macroeconomic stability(B_{11})	'The Global Competitiveness Report 2019'
		Foreign direct investment, net inflows (% of GDP) (B_{12})	World Bank
	Finance(B_2)	Financial system(B_{21})	'The Global Competitiveness Report 2019'
Law(C)	Legal force(C_1)	Rule of law index(C_{11})	'World Justice Project Rule of Law Index 2020'
	Clean-government(C_2)	Corruption Perceptions Index(C_{21})	'Corruption Perceptions Index 2019'
Society(D)	Infrastructure(D_1)	Transport infrastructure(D_{11})	'The Global Competitiveness Report 2019'
		Utility infrastructure(D_{12})	'The Global Competitiveness Report 2019'
	Culture(D_2)	Ease of doing business(D_{21})	World Bank'Doing Business 2020'
		School enrollment, tertiary (% gross) (D_{22})	World Bank
	Security(D_3)	Security(D_{31})	'The Global Competitiveness Report 2019'
		Crime Index(D_{32})	Knoema'World Crime Index Rank2020'
Resource(E)	Human resource(E_1)	The age of 15-64 Population(E_{11})	World Bank
		Educational attainment, at least completed primary, population 25+ years, total (%) (cumulative) (E_{12})	World Bank
	Natural resources (E_2)	Fossil energy (E_{21})	BP
		Hydroelectric resources (E_{22})	World Bank
		Renewable resources (E_{23})	IRENA
		Mineral resources (E_{24})	Global mineral resources information platform

3.2. Determining the indexes weight

3.2.1. The original matrix. Suppose there are m evaluation objects and n indexs, where M=(M_1, M_2,..., M_m); D=(D_1, D_2,..., D_n), the value of the evaluated object M_i to the index D_j is recorded as X_{ij}(i =1, 2, ..., m; j=1, 2, ..., n), which represents the value of the j-th index of the i-th object. The original matrix is:

$$\begin{pmatrix} X_{11} & \cdots & X_{1n} \\ \vdots & \ddots & \vdots \\ X_{m1} & \cdots & X_{mn} \end{pmatrix} \quad (1)$$

3.2.2. Standardization. Processing method of positive indexs:

$$V_{ij} = \frac{X_{ij} - \min(X_j)}{\max(X_j) - \min(X_j)} \quad (2)$$

Processing method of negative indexs:

$$V_{ij} = \frac{X_{ij} - \max(X_j)}{\min(X_j) - \max(X_j)} \quad (3)$$

3.2.3. Feature weight. Calculate the feature weight of the i-th evaluation object and the j-th index. For the i-th evaluation object, the feature weight of the j-th index is P_{ij}, then:

$$P_{ij} = \frac{V_{ij}}{\sum_1^m V_{ij}} \quad (4)$$

$0 \le V_{ij} \le 1$, $0 \le P_{ij} \le 1$

3.2.4. Entropy. Calculate the entropy value of the jth index:

$$E_j = \frac{-1}{\ln m} \sum_1^m \left(P_{ij} \times \ln P_{ij} \right) \quad (5)$$

3.2.5. Diversity factor. Calculate the diversity factor D_j of the jth index

$$D_j = 1 - E_j \quad (6)$$

The greater the D_j, the greater the amount of information provided by the index, and the greater the weight of the index should be given.

3.2.6. Entropy weight. Determine the entropy weight of each index:

$$W_j = \frac{D_j}{\sum_1^n D_j} \quad (7)$$

3.2.7. Evaluation value. Calculate the comprehensive evaluation value of each evaluation object:

$$V_i = \sum_1^n W_j P_{ij} \quad (8)$$

3.3. The evaluation results

3.3.1. Original data. This paper mainly uses five countries in South America as analysis samples, namely Argentina, Brazil, Chile, Colombia, and Peru. The original data are shown in Table 4. In order to achieve uniform requirements, all data processing is in the range of 1-100.

Table 4. The original data of five South America countries.

Country / Index	Agentina	Brazil	Chile	Columbia	Peru
Public-sector performance(A_{11})	39.9	45.7	58.2	51.3	44.5
Happiness index(A_{12})	59.75	63.76	62.28	61.63	57.97
Future orientation of government(A_{21})	48.7	49.1	64.1	44.7	44.9
Macroeconomic stability(B_{11})	33.9	69.4	98.0	90.0	95.0
Foreign direct investment, net inflows (% of GDP) (B_{12})	15	40	42	44	39
Financial system(B_{21})	52.9	64.6	82.0	64.6	61.4
Rule of law index(C_{11})	58	52	67	50	50
Corruption Perceptions Index(C_{21})	45	36	67	37	36
Transport infrastructure(D_{11})	47.7	45.6	56.6	43.8	42.4
Utility infrastructure(D_{12})	88.9	85.3	95.9	84.9	82.2
Ease of doing business(D_{21})	59.0	59.1	72.6	70.1	68.7
School enrollment, tertiary (% gross) (D_{22})	93	51	70	55	61
Security(D_{31})	69.8	43.0	83.7	45.1	59.6
Crime Index(D_{32})	62.26	68.31	49.60	54.94	65.65
The age of 15-64 Population(E_{11})	20	100	10	25	15
Educational attainment, at least completed primary, population 25+ years, total (%) (cumulative) (E_{12})	92.7	80.3	87.5	78.9	81.9
Fossil energy (E_{21})	12	42	8	16	10
Hydroelectric resources (E_{22})	60.00	96.95	65.15	86.75	78.10
Renewable resources (E_{23})	60	90	53	53	63
Mineral resources (E_{24})	90	100	90	80	95

3.3.2. The evaluation results. According to the content of section 3.2, the data related to the investment environment of the five South American countries were processed to obtain the comprehensive scores of power investment evaluation (Table 5).

Table 5. Five South American countries' electricity investment evaluation scores.

Country	Score	Rank
Agentina	0.17	4
Brazil	0.24	1
Chile	0.21	3
Columbia	0.23	2
Peru	0.14	5

3.4. The result analysis

From the results, Brazil ranks first in the evaluation of electricity investment in the five South American countries, followed by Colombia, Chile, Argentina and Peru. There is little difference in electricity investment evaluation scores within the region, and the variance is less than 0.01. In general, South American countries have low electricity investment evaluation scores. It is worth noting that the impact of the five first-level index in the evaluation of power investment is society, economy, law, resources, and politics in order. The weight scores are 0.48, 0.17, 0.16, 0.11, and 0.08 respectively. It shows that the social environment has the greatest impact on electricity investment evaluation. In addition, the economic environment and legal environment also play an important role. In contrast, the resource environment and political environment have no significant impact on electricity investment. It can be concluded that a good electricity investment environment is formed by a variety of factors, among which the social environment has an important influence on the overall rating.

In general, Brazil has good conditions in all aspects, especially social stability, large economic volume and market size, rich natural resources, and great development potential. It is recommended as a priority investment country. Secondly, Colombia and Chile have a stable social and economic environment and a high degree of marketization. They are recommended as alternative investment countries. Argentina has experienced financial volatility in recent years, with certain restrictions on imports and profit control, and the development of trade investment and engineering contracting businesses must face certain risks; Peru has certain social security issues and the market is small; in summary, it is recommended that Argentina and Peru are listed as an observing country and invest carefully.

4. The electricity investment proposals of five South American countries

4.1. Seize the opportunity of rapid regional power development and plan the construction of a South American green energy base.

Highlight green and enter lightly. South America has abundant renewable resources and good electricity prices. Most countries are vigorously developing renewable energy. It is recommended that enterprises take the "short, flat, and fast" wind and photovoltaic projects as "first movers", take the lead in opening the South American market, and choose opportunities to invest in hydropower projects around the Amazon Basin; Focus on the key points and enter the best ones. The selection of countries should not only focus on the size of the country, but must analyze the country's political, economic, and social status quo and trends. Focus on mergers and acquisitions and take multiple measures simultaneously. After the economic crisis, the form of greenfield investment in South America has decreased, and the form of mergers and acquisitions has increased significantly [11]. Due to the long distances, large cultural differences, and large exchange rate fluctuations in South America, political and social stability and continuity in some countries are poor, consider mergers and acquisitions in the form of short time, low policy impact, and low management difficulty to invest in hydropower and gas power projects, and strive for Avoid benefit risks in contract negotiation. In addition, you can also choose to invest in shares based on the actual conditions of the project [12].

4.2. Focus on building a corporate brand image, based in South America, benefiting the region, and sharing development.

Place corporate brand building and publicity in a more important position [13], adhere to the concept of shared development, help the host country increase power supply, ensure energy security, promote local employment, and promote local social and economic development. Actively fulfill social responsibilities, strengthen public relations construction, optimize localized employment management, support public welfare undertakings, actively give back to the society, share development results, and build excellent brands.

4.3. Strengthen collaboration between enterprises and promote complementary advantages.

Several companies have been cultivating in South America for many years, and they have explored and formed a relatively complete "South American Strategy". In addition, power generation groups, power grid companies, general engineering contractors, power equipment companies, technical support units and other parties have their own characteristics and advantages. It is necessary to fully coordinate the role of the industry, give play to the advantages and characteristics of various units, and jointly study Carry out cooperation models of energy and power projects, overseas project development strategies and plans, etc., to achieve complementary advantages and common progress [14].

4.4. Optimize decision-making and management processes, actively seek changes to adapt to the new environment and new rules.

The subject research found that an important reason why some companies failed to open the market in South America is that they failed to adjust the corporate decision-making management process in time

according to market requirements. Currently, most countries in South America use renewable energy auctions for resource allocation. This form requires the investment unit to quickly and accurately measure the technical and economic benefits of the project and make a quick business response. The excessively lengthy internal decision-making process is obviously not suitable for market development. In addition, domestic and foreign energy investment companies bid for projects in the form of consortiums to achieve complementary internal advantages of investors (for example, power generation companies and equipment companies combine to have capital advantages, equipment price advantages, etc.) and improve project benefits. Therefore [15], it is recommended that the group company further optimize the internal decision-making process of overseas projects, achieve precise response by region and category, and actively seek strategic partners of the consortium to achieve a win-win situation.

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