Factors affecting the benefit of the investment subjects of the Global Energy Internet

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Abstract. Investment decisions under Global Energy Internet(GEI) are characterized by complexity and diversity. The investment decisions under the GEI are influenced by resource system, market mechanism, economic technology, power investment environment and cooperation risk. In order to make better investment decisions, the following work is done in this paper. Firstly, the interaction between the electricity price system and the different income mechanism between different subjects is studied. Then, the relationship between the economic investment ability and the income of the market mechanism is analyzed. Finally, based on the foregoing research, the factors affecting the benefit of the investment subjects of the GEI are summarized.

1. Introduction

In the context of economic globalization, social informatization and energy electrification, the Global Energy Internet is increasingly moving from China's initiative to world action. At 2018 global energy Internet conference on march 28, Liu Zhenya[1] said, Building GEI is a path to change, a path to green, a road to prosperity, a path to harmony, a path to happiness, a change in the way energy is used, and a fundamental solution to climate change. The construction of GEI involves the energy, economic, social and environmental fields of the world, and the top-level design needs to be strengthened. Global planning should be formulated and implemented in stages under the guidance of planning.

Investment decisions under the global energy Internet have the following characteristics.

(1)   Intermittency and uncertainty of renewable energy(RE) output, differences in planning, operation and safety standards of various countries and regions, as well as the spatio-temporal inversion characteristics of renewable energy output and national and regional loads are the major problems faced by the investment decisions of power systems.

(2)   The coordinated decision-making of power supply and power grid needs to consider: diversity of transmission modes across time zones,different national power system planning principles, different clean energy policies, high degree of uncertainty in interregional tie lines.

(3)   Under the global energy Internet, countries and intercontinental networks have diversified the subject of investment. And the diversity of investment factors leads to complex decision-making.

In order to comply with the trend of global energy Internet, it is of great significance to study the factors that affect the benefit of investment subject. The interaction between different tariff systems and income mechanisms between the main regions and countries is studied. By analyzing the driving force of main regional and national GDP development levels to the construction of clean energy and transmission lines in global energy Internet investments, the correlation between economic investment

ability and income of major regions and countries in market mechanism is researched. Last, the factors affecting the benefit of the investment subjects of the GEI are extracted.

2. The interaction between the electricity price system and the different income mechanism between different subjects.

2.1. Electricity price system in major countries.

This paper defines the state as a different investment subject. The following is a brief introduction to the pricing system of six countries in Britain, the United States, Japan, China, France and Russia.

2.1.1. Electricity price system in Britain

The electricity price system in the UK includes the sale price of electricity, pool purchase price and transmission pricing.The current electricity price models adopted in the UK are showing in table1.

Table 1. Electricity price model adopted in the UK

Electricity price models	Introduction
Step tariff	Its pricing varies with the amount of electricity used. When the quantity of electricity is small, the unit electricity price is higher. Otherwise, its electricity price is cheap, and the structure is generally divided into three sections.
Two-part tariff	The electricity billing consists of two parts: fixed fee and electricity price. The former has nothing to do with whether power or electricity use size, only consider a voltage level of the user's access to users and user types. The latter is calculated according to the size of the electricity consumption. Such electricity prices are still widely used by British power users.
TOU price	Generally divided the day into two segments:①low time period from 7pm to 7am, the electricity price in this time period is about 70% of the day price.②low time period from 12 pm to 7 am. The UK for some big industrial users have taken every half an hour a electricity price, electricity price according to the production cost of power system real-time changes.

The electricity price model and competition mechanism of the British electricity market can be summarized as follows: the power plant will report second day's every half an hour of the equipment operation cost and the power of generating units per hour to the power transportation center one day in advance. Transport center will input the data into the computer, the running costs of each generator are ordered from low to high until all the generating capacity is included in the generation plan to meet the load forecasting results. So the cost of the last generator set to be included in the power generation plan is the marginal cost of the feed-in tariff, which is the unified "feed-in tariff" of the entire grid. As long as the unit is included in the power generation plan, the feed-in tariff is the same as the electricity price of the generator set, regardless of the cost.

The overall mode of transmission pricing in the UK is price control and partition price. The transmission rate is calculated using the megawatt - kilometer method, and the long - term marginal cost method is adopted for the use of transmission grid.The net cost is adopted accounting cost method.

2.1.2. Electricity price system in the United States.

PJM power market, North America's largest power pool, has an independent operating system that provides transmission and ancillary services. The PJM power market is currently composed of the power market, futures market and real-time market. Transmission costs in the U.S. PJM electricity market are in the form of rates, and transmission costs are charged according to the type of transmission service.

Transmission pricing in the United States is diverse in content and form. Transmission prices in the U.S. state of California include Internet access, royalties and network operations. ISO-NE uses the contract path method and stamp act. Company internal use of stamps, cross - company contract path method. ERKOT uses a stamp method of 70 % of fixed costs, and 30 % for a DC - based megawatt - kilometer method.

The forms of ownership of American power enterprises are complex, including private, federal, local and cooperative camps, and their electricity prices vary from state to state. The main tariff patterns in the United States are as follows in table 2:

Table 2. Tariff patterns in the United States

Tariff patterns	Introduction
TOU price	Some power companies have two schemes for small and medium users with TOU price and non-TOU price. For large users, it is required to adopt the TOU price for all two periods. In addition to executing 3 time periods of TOU price in industrial and commercial users, some companies also perform peak and low time TOU price in 2 periods for residents. This has a good effect on reducing peak load, adjusting charge and reducing power cost.
Seasonal price	Many power companies have adopted this pricing model, such as the use of seasonal difference for industrial and commercial users and residents, and a large difference in price, in order to correctly reflect the cost of power supply in different seasons and reduce the peak load in summer.
Lifeline price	An electricity price that the government pays special attention to the low-income residents. A lower electricity price is stipulated for each monthly electricity consumption below the life line of the lifeline, and the user who exceeds the limit of the lifeline consumption is charged at a reasonable price, and the charge is higher than the reasonable electricity price when the limit of a certain electricity consumption is exceeded.

2.1.3. Electricity price system in France
The French power company has long been operated by the French power company. In terms of electricity price, French electricity price is based on marginal cost method, and its sales price and transmission price are very characteristic.

The price of electricity in France is classified by the combination of user capacity and voltage level. It is divided into three main categories: Blue price, yellow price and green price.

Table 3. Classification of electricity price in France

Classifications	Application
Blue electricity prices	3 kVA ~ 36 kVA low-voltage users
Yellow electricity prices	36kVA-250kVA low-voltage users
Green electricity prices	more than 250 kVA medium-voltage, high-voltage and ultrahigh-voltage users

Transmission prices are set by voltage level and by hour. It is estimated that the use of stamp method, namely electricity transmission price is independent of the power transmission distance, and the transmission tariff is not allocated to the generator, which is borne by the consumers.

The classification of transmission electricity price is divided into two categories: 130kV-350kV and 40kV-130kV. Secondly, according to the grid utilization hours classification. Power grid utilization hour is equal to the transmission amount divided by the application capacity. Its power has a higher state monopoly.

2.1.4. Electricity price system in Japan
The current electricity price in Japan is based on social welfare and energy saving. It is mainly divided into the following table:

Table 4. The current electricity price in Japan

Tariff patterns	Brief Introductions
Three-stage tariff system	①The power limit is 120 kWh/month, and its price is the lowest.②The power limit is 120 kWh/month to 200 kWh/month, the price is about the average of the first and third sections.③Consumption is more than 200 kWh/month, the price is the highest. This system has a certain regulating effect on energy saving and high consumption.
Special tariff system	It is a kind of incremental electricity prices, it is reference to historical determining of electricity use all kinds of users of electricity, The low price for the part of the contract power and electricity consumption is not exceeding the benchmark, otherwise, the higher electricity price is adopted, and the new users adopt the higher electricity price.
Seasonal tariff system	A large number of equipment and lines are needed to meet seasonal peak demand. The reduction of power load due to the change of seasons, the utilization rate of equipment drops sharply, so that the operation and maintenance costs are increased. Eventually lead

	to change in electricity prices. In addition, for any season, there are diurnal peaks and valleys, so there are also daytime and night peaks and valleys.
Dual tariff system	In all kinds of electricity prices, except the quota lighting price is set by one electricity price system.The rest of the electricity price is the dual tariff system of basic electricity price(capacity price)and the electricity price.

Transmission prices are set by the ministry of economy, trade and industry. In Japan, the price of electricity is mainly based on the classification of voltage level and load rate, and then the method of classification and pricing by use. For low-voltage users such as residents, the sale price is mainly classified according to the nature of electricity. For high-voltage users such as industry, it is mainly classified by voltage grade and power capacity. All users have two sets of electricity prices, and the higher the load rate, the cheaper the electricity price.

2.1.5. Electricity price system in China
The electricity price classification in China is as follows

Table 5. The electricity price classification in China

Classification Standard	Brief Introductions
Production and circulation link	Pool purchase price,the price of online power settlement for power generation enterprises with independent accounting; Internet-work power price: the settlement price of power and power supply between the power grid and the power grid through the contact line; Sale price: the price of selling electricity to the end user.
Capacity	Unitary system price;two-part tariff. Among them, the basic electricity price reflects the capacity cost of the power enterprise, namely the fixed cost part, the electricity price reflects the electricity cost of the power enterprise, namely the variable cost part.
Time	TOU price. Using economic means to stimulate customers to cut peak and fill the valley, relieve the situation of peak electricity consumption, and improve power grid efficiency and power consumption. The division of peak valley time and the implementation scope of peak valley electricity price are the key of the electricity price system.
Sales mode	Direct and wholesale electricity prices.

At present, the domestic electricity price bidding mode: the limited quantity bidding mode, the price difference contract bidding mode, the dual tariff system price bidding mode. The transmission and distribution price is made up of the power plant that is connected to the power grid and the the power plant and user payment that is connected to the grid.

2.1.6. Electricity price system in Russia
Russian Federation pricing department is responsible for pricing monopoly services at the national level, and supervising the price of distribution services. The electricity price is calculated according to the price parameters of the economic commission of Russia. Russia adopts two-part tariff for industrial users whose capacity is over 750 kVA, and electricity price for other users.

According to various unit capacity investment, coal price, gas price, utilization hour number, annual operation and maintenance fee, water power station inundation compensation and other factors, the prices of different energy in Russia are calculated and calculated in detail, as shown in table 6.

Table 6. Different kinds of electricity prices

Type	Hydropower	Coal power	Gas power
Price(￥/kWh)	0.4312～0.627	0.627	0.6

In the formulation of the transmission price, the current capacity of 5% ~ 15% is set by the exchange, the coexistence of state control and wholesale market.

After the first electricity reform, the wholesale market and retail market were formed. The Federal Energy Commission controls the power generation price, transmission cost and inter regional electricity price in the unified power system. The regional energy committee sets the local electricity price, including the household tariff rate.

It is divided into several electricity price areas within the geographical boundaries of wholesale market. Unified electricity price is applied to all buyers in each area in each price area.

2.2. The relationship between transmission price, pool purchase price and user electricity price.
The calculation of the price to the grid includes the calculation of the pool purchase price, the transmission price and the line loss electricity price that reflects the transmission loss. The pool purchase price is the price that the electricity generation enterprise and the electric power purchase party to carry on the net power to settle the price; Transmission price is the price of transmission service provided by the power grid of dc engineering and supporting communication engineering, and it is calculated by a reasonable internal rate of return. The line loss price shall be calculated according to the principle of balance of electricity charges. It is assumed that the price of the grid is the local purchase price. The calculation formula is as follows:

$$p_l = p_p \cdot r_l / (1 - r_l) \tag{1}$$

$$p_g = p_p + p_t + p_l \tag{2}$$

Where, p_l is line loss price, p_p is pool purchase price, p_g is the price to the grid, r_l is line loss rate, p_t is transmission price.

Based on the estimated results of the pool purchase price of sending end, the electricity price and the line loss price are calculated, and get the electricity price of receiving end. Compared with the stake electrovalence of receiving end, the competitiveness of grid price is analyzed. The competitiveness of price is the difference between stake electrovalence and net electricity price.

The electricity price shall be calculated on the basis of the principle of the electricity price plus fixed. Intercontinental transmission projects across many countries need to consider tariff tariffs of different countries when crossing the border. It is possible to analyze the competitiveness of the electricity price by comparing the price of the net electricity with the pole price of the electric energy dissipation. The greater the difference between the two, the stronger the competitiveness of the clean electricity is. The calculation results of literature [2] show that the exchange rate is inversely proportional to the competitiveness of RE sale price. The loan interest rate is in direct proportion to the cost of electricity.

3. The relationship between economic investment capability and profit under market mechanism.

3.1. The promotion of GDP development level to clean energy
The electric power industry is an important basic industry of the national economy. The index of power generation and consumption has always been regarded as an important reflection of the economic operation. Power demand and GDP can be indicators of each other. There are a number of domestic and foreign scholars[3,4] studied the internal relationship between power industry and economic growth. There are also papers[5,6] directly using electricity consumption data or from the power elasticity coefficient to explore the relationship between electricity consumption and GDP . All these indicate the state's direct response to the development level of power generation investment and power consumption in the power industry, while the continuous development of GDP promotes more power consumption, thus promoting investment in power generation enterprises.

Renewable energy as the main way of the power investment under the GEI environment, studying different countries' GDP level of development of GEI investment in renewable energy, can provide decision support for renewable energy investments.

According to the report issued by Pugh Charity Foundation in 2016, Global investment in renewable energy reached $328.9 billion by 2015. The total amount of renewable energy investment in major regions and countries is shown in the table below.

Table 7. Total investment in renewable energy

2013 rankings/GDP rankings	Country/region	2013 total investment	2012 total investment	2012 rankings/GDP rankings
1/2	China	54.2	57.9	1/2

2/1	America	36.7	40.3	2/1
3/3	Japan	28.6	15.9	5/3
4/6	Britain	12.4	11.0	7/6
5	Other EU countries	11.5	22.0	4
6/4	German	10.1	22.4	3/4
7/11	Canada	6.5	4.5	12/11
8/8	India	6.0	7.1	8/10
9/29	South Africa	4.9	5.7	10/28
10/12	Australia	4.4	4.4	13/12

It can be seen from the above table, developing countries' investment in renewable energy is already pushing Europe's developed countries. With economic growth slowing, Europe's renewable energy investment has fallen sharply. A sudden rise in Africa's investment in renewable energy.

The current situation of clean energy financing in major regions and countries is described from asset financing, open market financing, venture capital and private equity investment.

Table 8. Assets financing of different countries

Country	China	America	German	Brazil
Assets financing (hundred million$）	287	133	62	69

Solar energy is the most widely absorbed sector of the open market, absorbing a total of $4 billion 200 million.Energy efficiency and low-carbon technologies are the biggest beneficiaries of venture capital and private equity, with $2.1 billion in total and $500 million in wind power.

So GDP growth means more demand for electricity and energy. However, with fossil energy depletion and the implementation of national renewable energy plans, countries will increase their investment in renewable energy to promote the construction of renewable energy.

3.2. The effect of electricity price on investment income

Electricity price competitiveness is an important index to evaluate the feasibility of transmission engineering. The more competitive the electricity price, the higher the revenue of the transmission project, so it is necessary to increase the power price competitiveness, mainly through the reduction of the feed-in tariff and the transmission price. Geographical latitude, topography, temperature and so on will have an impact on economic benefits. Some countries have high environmental protection requirements, difficulty in land acquisition and high cost of manpower and material resources, which affect static investment. Economic factors will also affect the ratio of static private investment in developed and underdeveloped regions, reflecting differences in engineering investment.

As an important factor restricting the economy, the tariff of the GEI transmission project may significantly increase the price of electricity, reduce the internal rate of return on capital and the internal rate of return of its own funds, and extend the period of investment recovery. When the tariff is constant, the decrease of feed-in tariff is more obvious to optimize the economic index of transcontinental transmission. In addition, it is suggested to strengthen the support of the routes along the route through international cooperation, so as to further reduce the project cost and the electricity price, and then optimize the economic indicators.

4. The factors affecting the benefit of the investment subjects of the GEI

4.1. The factors

Based on the foreword, this paper extracted the factors affecting the investment subject from three aspects: investment, performance and economic benefit.

The benefit of investors is affected by the performance of power supply and power grid. The performance factors include: transmission line loss rate, power grid transient performance, reserve ratio, grid voltage stability, RE utilization rate, RE stability , RE penetration, Power supply technology and power grid technology. Investment factors include: resource system, energy policy, grid investment, power investment, RE power generation type, RE base area and RE power generation

scale. The economic factors include: tax, loan rate, transmission loss, transmission and distribution cost, unit electricity cost and unit capacity cost.

4.2. The correlation of the factors

The performance indexes of power supply and power grid are determined by the specific content of investment. RE source type investment in power supply, such as the Complementarity of renewable energy, and the correlation of regional time difference of power base, will directly affect the stability of RE power supply. The more stable the RE source, the more stable the voltage of the grid.The greater the investment scale of RE power plant, the higher the RE energy permeability.

The investment of the power grid will affect the transient performance and transmission line loss rate of the power grid. The transient performance of the power grid and the stability of the grid voltage determine the reserve rate of the system together. The system reserve rate directly affects the unit capacity fee. The relationship between investment, performance and economic factors is shown below.
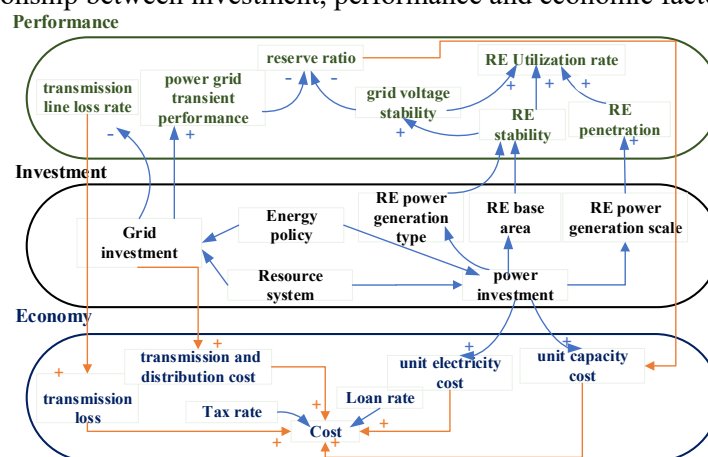

Figure 1. The relationship between investment, performance and economic factors

5. Conclusion

Through the investigation of electricity price system in different countries, the relationship between transmission price, pool purchase price and user electricity price is studied. The proportion of clean energy investment to GDP in different countries is investigated, which proved that GDP can promote the development of clean energy.The influence of electricity price on investment benefit is analyzed, and some suggestions are given. Based on the foregoing research, the factors affecting the investment subjects from three aspects: investment, performance and economic benefit are introduced.

Acknowledgments

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