

Renewable Energy Investment Project Evaluation Model Based on Improved Real Option

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Abstract:Constructed a real option valuation model that the risk could be adjustable based on the characteristics of renewable energy projects and the idea of the Capital Asset Pricing Model.Using this model to value the renewable energy projects considering selling green electricity certificate revenue. And then verified the effectiveness and rationality of this model through the investment projects of the wind power.

Keywords: Capital Asset Pricing Model; real option; renewable energy

1.Introduction

As the main body of the social economy, enterprise plays a vital role in the renewable energy popularization and the industry development. For the renewable energy power generation industry in China is in the early stages of the industry, there are still many uncertainties. All of those factors, such as policy, economy, technology, energy and resources, will affect the evaluation of the value of renewable energy power generation projects. The scientific and prudential evaluation of the project value will be related to the interests and development of the enterprises and the whole society. Traditional investment decision methods are difficult to accurately assess the value of the project due to the uniqueness of energy and its industry development. Real option theory which is a quantitative tool of the option value of investment project makes an effective mining to the value of the management flexibility and the strategic value of the investment. At present, there have been some researches which make an application of real option concept in making an evaluation to renewable energy investment project in foreign. Lee et al (2010) made a point that "the policy effectiveness evaluation model", it integrated the cost-effective curve which was brought by renewable energy technology innovation with the real options model. The model quantified the effectiveness of the policy through the analysis of the uncertainty in fossil fuel prices and policy-related factors, and studied the current renewable energy policies in Taiwan through empirical analysis^[1]. Through a study of ethanol expanded reproduction investment, Pederson et al (2009) established a model which embedded the risk factors of market price into investment decision and made use of the available historical market price data, using real options method and Monte Carlo simulation method to evaluate investment decisions of expanding ethanol reproduction problems^[2]. Cheng et al (2011) revealed the changes about clean energy investment strategic choices and strategic value which due to the lead time of power generation equipment investment and uncertainty of future electricity demand with the binomial real options model which based on continuous compound option^[3]. However, the current studies had a lack of analysis about systemic risks which can not be distributed and outside the enterprise. In general, we always directly divide the value into two parts (the discounted value of future cash flows and option value of investment projects) when we use the real options to value the value of investment projects, we mainly use the risk-free rate to discount future earnings without taking the market risk factors that can not be dispersed into account, and to some extent, resulting in partial distortion about the option value of the project. This paper which is based on analyzing the investment characteristics of renewable energy projects and drawing the idea about Capital Asset Pricing Model brings the non-dispersed

systemic risks into the assessment of the project value, and builds a improved real option valuation model with the risk-adjusted. Then, this paper will make an evaluation of renewable energy investment projects which are under the quota system, we can verify the effectiveness and feasibility of the model through analyzing a typical case of wind power industry, and then make some proposals on the investment and operation of renewable energy projects.

2 Model construction

2.1 Investment characteristics of renewable energy project

According to the provisions on the type of renewable energy under the "Renewable Energy Law" and "renewable energy quota management approach (draft)", Renewable energy generation projects mainly refers to wind power, solar power, biomass power, geothermal, ocean energy power generation and other non-hydro renewable energy generation projects. There are obvious differences between renewable energy generation project investments and traditional thermal power project investments. Firstly, renewable energy generation project has a characteristic of investment irreversibility. Because of the higher degree of specialization of renewable energy generation equipment, the majority or all of the initial investment may become a sunk cost as long as making a decision to invest in a renewable energy project that makes the investment irreversible. Secondly, renewable energy return on investment is more uncertainty. Many factors will have an enormous impact on the financial income of renewable energy power generation projects, such as policy changes, international and domestic market environment, technological innovation, etc. Huge differences may exist between the actual yield and the expected yield of investments in renewable energy projects since there are many uncertainties. On the one hand, the investment may generate spillover benefits in a good external environment and internal management; On the other hand, if the risk bring an assault on the project, and the manager could not manage risk well, it will certainly bring losses of the project; Third, renewable energy generation projects are more strategically. The exhaustion conventional fossil fuels and increasing awareness of social environment will make renewable energy get a huge development although all kinds of uncertainties exist in renewable energy industry. The current renewable energy investment may not bring corporate large amount of cash incomes, but as the situation developing, the rise of renewable energy sources will make the value of the project gradually reflected, and early investments also lay the foundation for future competition of companies in related fields. Meanwhile, it can promote local employment and local investment, establish good relations with government departments and social image and can also bring more potential revenue for enterprises, if the enterprise take actively participate in renewable energy project investments. So, companies should analyze the impact of renewable energy generation projects for the future development of enterprises, from a strategic point of view.

We could see the option property of renewable energy projects after we analyzed the investment characteristics of renewable energy projects, the option value can be expressed as a function $V = f(S, X, \delta, T, r)$, here: S is the present value of expected future cash flows of a renewable energy project; X is the exercise price which is the initial investment to get this option; δ is the uncertainty about the value of renewable energy projects; T is the validity of the option; r is the risk-free rate. According to the investment decision criteria, investors will decide to carry out the execution when the present value of cash flow of the project and the option value are greater than the value of the initial investment. In general, the value assessment of the investment project are directly divided into two parts that the discounted value of future cash flows and the option value of the investment projects in the current value assessment research which based on the real options. Among that, it uses the risk-free rate for discounting future earnings when calculates the net present value, and the option value is calculated based on a point of project risk management, using the risk rate, so risk-caliber is inconsistent in the calculation of different parts of the same project value. The reasons for analyzing this contradiction is that, the non-fragmented market risk

factors are not taken into account in the calculation of the net present value of the project, and the option value of the project depends on the project NPV calculations, this also causes partial distortion of the project option value to a certain extent. Therefore, this thesis draws on Lenos' (2007) the analysis of market risk theory to make a risk adjustment for the expected return on investment project. A real investment market can be obtained through an analogy with financial market, if, making Analysis of the real assets from a financial market perspective we bring related investment data into model when calculating financial assets with CAPM, and the obtained expected returns on investment should be the basis of the discounting of investment projects, if not, company can choose other more competitive projects to invest. This also avoids the situation with market segmentation among projects in the market and yet contradiction that calculated Caliber of different values appears unified in the same project. We need to identify types of options that the project contains and select the appropriate real option pricing method when evaluating the option value of energy power generation projects. Considering that renewable energy power generation investment projects have growth value and strategic value and management flexibility value, the option type that project contains can be defined as growth option. According to the optional time characteristic and the convenience of data acquisition of the renewable energy power generation project, this thesis adopts the B-S option model for renewable energy power generation projects to evaluate the option value. In February 2012, the National Development and Reform Commission issued a "renewable energy quota management approach (draft)", the quota system would affect renewable energy generation projects valuation, this study considered the benefits that he relevant provisions of green electricity certificate could produce for the projects. Consequently, this study holds that the total value of renewable power generation project is consist of three parts including the risk-adjusted net present value, the option value and the income of selling green electricity certificate. What must be clear is that, there hasn't a corresponding market which can carry out the relevant certificate transaction and the "draft" only gives a rule on corresponding quota proportion of 2015. This study brings the sale of green power certificate into the evaluation of the total value of the project in order to have a better reflect on a good growth in the future of the renewable power generation project.

2.2 Model Construction

(1) Risk-adjusted NPV

Firstly , considering the project's net present value of expected cash flows in the case that items are not adjusted for risks. According to NPV (Net Present Value), risk-adjusted NPV formula is (1):

$$NPV_t = \sum_{t=1}^n CI_t / (1+r)^t - \sum_{t=1}^n CO_t / (1+r)^t \quad (1)$$

Where, n is the investment period; CI_t is the cash inflows in t year; CO_t is the cash outflows in t year; r is the discount rate. Further in reference of the idea of CAPM, achieving the desired rate of return on investment projects through the risk analysis of the renewable energy industry, and making risk adjustment, then getting (2):

$$k = E(R_i) = r + \beta_i [E(R_m) - r] \quad (2)$$

Here, k is the risk-adjusted discount rate, which means the discount coefficient of the return on investment at the market average level; $E(R_i)$ is the expected equilibrium returns on asset i; $E(R_m)$ represents the expected return on the market portfolio of all assets; β_i indicates the system risk of assets i that is the sensitivity of asset i when facing with the changes of market m; r is the risk-free rate. If we brought the risk-adjusted discount rate into the project NPV calculations, we can get the formula (3):

$$NPV_k = \sum_{t=1}^n CI_t / (1+k)^t - \sum_{t=1}^n CO_t / (1+k)^t \quad (3)$$

Looking at the meaning of the coefficients in formula (3), in addition to NPV_k and k , the other coefficients are the same meanings as formula (1). NPV_k represents the risk-adjusted NPV, k is the risk-adjusted discount rate.

(2) Risk-adjusted option value of the project

Through NPV risk-adjusted, we will post the data on behalf of the related adjustments into B-S option pricing model, calculating the option value of the projects included. Obtained by partial differential equations are derived, and finally get simplified model formula is:

$$C = SN(d_1) - Xe^{-r(T-t)}N(d_2) \quad (4)$$

$$\text{Here: } d_1 = \frac{\ln(S/X) + (r + \delta^2/2)(T-t)}{\delta\sqrt{T-t}}, \quad d_2 = d_1 - \delta\sqrt{T-t}.$$

The representative meanings of coefficients in these three formulas are: C is the option value of the project; S is the market value of the underlying asset; X is the option exercise price; δ is the price volatility of the underlying asset; r is the risk-free rate; T is the expiration date of the option, t is the current time, $T-t$ is maturity of the option; $N(\bullet)$ is the cumulative normal distribution density function. Calculating the option value of depends on the net present value calculations,

$$\text{here: } S = \sum_{t=1}^n CI_t / (1+k)^t, \quad X = \sum_{t=1}^n CO_t / (1+k)^t.$$

(3) Assessing incomes from selling green electricity certificates of the project

The income from sale of green electricity certificates W_c is affected by some variables, such as the annual generation capacity Q , the proportion of green electricity quota ρ , the certificates price P_c and so on, it can be expressed as the formula(5):

$$W_c = Q*(1-\rho)*P_c / 1000 \quad (5)$$

Thus, the NPV of income form selling green electricity certificates during the full life cycle projects period of the renewable energy generation can be expressed as the formula(6):

$$NPV_{W_c} = \sum_{t=1}^n W_c / (1+k)^t \quad (6)$$

(4) The total value of the project

Finally, adding the project's risk-adjusted net present value, option value and the present value of the project to sell green electricity certificate together, incorporating into the calculation of the total value of the project, we can get the total value assessment model of renewable energy project based on improved real options, as the formula (7):

$$\begin{aligned} W &= C + NPV_k + NPV_{W_c} \\ &= SN(d_1) - Xe^{-r(T-t)}N(d_2) + \sum_{t=1}^n CI_t / (1+k)^t - \sum_{t=1}^n CO_t / (1+k)^t + \sum_{t=1}^n W_c / (1+k)^t \end{aligned} \quad (7)$$

3. Case Analysis

Company A is a large listed enterprise which specializes in new energy development, design, construction investment, and the development, promote, application of low-carbon technologies, it was successfully listed in Hong Kong in late 2010. It is ready to invest a wind power project W which is located in province H and plans an installed capacity of 49.5MW. The wind power project is in line with our strategic planning for renewable energy power development, it plays great significance and positive role in the optimization of the structure of H provincial power source, increasing the reliability of supply and servicing for local economic development, achieving

sustainable development, therefore, the selected case here is representative and typical one. The whole cycle of wind power project W will last 21 years, the construction period is 1 year, and the completed full productive capacity is 49.5MW, the production period is 20-year, the annual full-load running time is 2500-hour. Initial investments are 5.00 million yuan, the total funds invested in the first year of which 4.33 million yuan are in fixed assets investment, and the rests are liquidity and others. According to state regulations, the acquisition subsidized electricity prices is 0.62 yuan / KWh when power generation equipment operates within 30,000 hours, exceeding 30,000 hours, the acquisition may refer the local average price 0.41 yuan / KWh, the project run higher cash inflow in the first 12 years. The residual rate of fixed assets is 5 percent in the end of project operations, approximately converting into 21.65 million yuan, withdrawing liquidity 1.49 million yuan, and the annual generating capacity of the wind farm is expected to 1.2375 billion KWh.

(1) Risk-adjusted net present value and net present value calculations are not risk-adjusted

If we use risk-free rate for the expected future net cash flows discounted items without considering environmental risk factors, according to formula (1), we will get the NPV of the project is 132.53 million yuan. Now, the NPV is greater than zero, we should invest in this project in accordance with judgment criterion of investment decision.

If considering the impact of systemic risk factors that the project faces, we should use a risk-adjusted discount rate k on risk adjusted NPV. As the long-running cycle of the project, and the entire operating period is 20-year, so we refer to the Ministry of Finance issued 20-year bonds in the recent years, choosing the 20-year half year interest-bearing debt which was published in 2007 by the ministry of finance, national debt code 010713, and taking its 4.52% annual interest rate as the risk-free interest rate r of this case. We can obtain the coefficient $\beta_i = 1.155$ while using the method in reference [5]. Then selecting the difference between the closing price of Hang Seng Index 17668.83 in September 23, 2011 and the closing price of Hang Seng Index 19411.46 in June 29, 2012 as a return on investment, on this basis, we can obtain the return on investment in this period $R_m = 9.86\%$. Taking the above parameter values into formula (2) to calculate the expected return of investment assets is the risk-adjusted discount rate:

$$k = E(R_i) = r + \beta_i [E(R_m) - r] = 10.69\%$$

The risk-adjusted net present value is obtained -82.93 million yuan when we put k into formula (3) to calculate. At this point, the risk-adjusted net present value is less than zero, the investor should invest in the project according to the investment decision criterion. Through the Comparison between NPV_r and NPV_k you can see, the net present value of the project is reducing when we consider the systemic risk of the project, this is because taking no account of systemic risk, and investors expect the same investment returns, lower risk will increase the expected returns of investors, and relatively higher risk will lead to lower expected returns. When the systemic risk was brought into reward system, according to the thought of discounted cash flow, investors would reduced a certain level expectations of expected cash flows because of the increased risk. Seen from the difference between the results, we need to take environment and systemic risks that the investment faces into account when calculating the net present value of the project, otherwise, that poses a potential danger to project operation without considering the risks to make the investment value artificially high.

(2) Option Value of the Project

Here, we use B-S option pricing model to evaluate option value of the project, this model needs to definite the volatility of the underlying asset. This study selects the stock's closing price of company A between February 15, 2012 to July 10, 2012, then using historical volatility method to

forecast the volatility of revenue growth of this investing enterprise, the day volatility of assets δD is obtained 2.15%, so the annual volatility δY is 34.11%. According to the formula of B-S option model, and bringing the above parameters into the formula (4), obtaining that: $d_1 = 1.2728$, $N(d_1) = 0.8985$; $d_2 = 0.2903$, $N(d_2) = 0.3858$; The option value of project $C = 300050000$ yuan.

(3) Green electricity certificate revenue

At present, although there are no specific detailed rules for the implementation of renewable energy quota index, but the practice of renewable energy quota system has been set, so the evaluation of the renewable energy power generation project investment need to consider the increased revenue that the quota brings for the enterprise. "Renewable energy power quota management approach (draft)" provides the quota proportion of large-scale renewable energy generation enterprises accounted for 6.5% for their own, while a prescribed amount of green electricity certificates is 1000 K/Wh. The price of the certificate must be defined if you would have revenue from energy renewable green electricity certificates inserted into the value evaluation of the project. Ideally, the price of green electricity certificates should be the difference between the marginal cost of renewable and conventional electricity power. Selecting the average of the lower limit 0.15 yuan/KWH and the upper 0.5 yuan/KWH of wind power green electricity certificate

Uncertain	Rate of	Change rate	Sensitivity
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estimates in literature [6] to value the price for green power certificate^[5] and the price of a green electricity certificate is obtained 325yuan. According to the basic data of wind farms, when the annual generating capacity is 1.2375 trillion KWH, the

number of green power certificates that companies can sell is 115706 besides the need for companies to meet their quota for the proportion of renewable energy. Due to the differences between the marginal cost of different renewable energy relative to conventional electricity, you can use multiple certificates to be adjusted for different green electricity certificate designing different weights, for instance, A certificate of solar green electricity can be used for five copies and wind power is one, the multiple choice of this paper for wind power project certificate is double which conforms to cost expectation of current wind power electricity. Taking the data into the calculation formula(6) of green power certificate revenue, we can get the project sale income of green electricity certificates is 37.6 million yuan a year, if the project run 20 years, the total net present value is RMB 343.19 million.

(4) The total value of the project

Making C 、 NPV_k 、 NPV^{w_c} into addition, the project's final value is obtained 560,310,000 yuan. According to the investment decision criterion, we should invest in the project. Based on risk adjustment of interest rate and the evaluation of the option value, you can dig deeper into the value of the project and avoid overestimate risk returns and the impact of systemic risk is also brought into the project evaluation.

(5) Sensitivity analysis

Further, finding out the sensitivity factors of project financial data to make reference for investment decisions. This study selected annual full-load generation time, initial investment and feed-in tariff these three indicators which affect prime operating revenue of the project, then we use a single sensitivity analysis to separately calculate the sensitive degree of the whole project value when index increase or decrease by 5%, 10%. The specific calculation results as shown in table (1).

Table (1) Sensitivity analysis

factors	change	of the project value	coefficient
Original scheme	0%	0%	0%
Annual full-load generation time	-10%	-44.78%	4.48
	-5%	-22.44%	4.49
	5%	22.53%	4.51
	10%	45.15%	4.51
Initial investment	-10%	22.66%	-2.27
	-5%	11.30%	-2.26
	5%	-11.26%	-2.25
	10%	-22.47%	-2.25
Feed-in tariff	-10%	-43.30%	4.33
	-5%	-21.70%	4.34
	5%	21.80%	4.36
	10%	43.67%	4.37

As shown in the table, the uncertainly factor which affects the project value most is annual full-load generation time, its sensitive coefficient is around 4.5, followed by a feed-in tariff with sensitivity coefficient of about 4.35, the last is the initial investment, sensitivity coefficient of around -2.25. Trough break-even analysis of the project, we can get the break-even annual full-load generation time of the project is 1937.8 hours, feed-in tariff level of profit and loss balance is the current 76.73% of feed-in tariff level. In the operation of the project, therefore, people need to strengthen the maintenance and repair of wind turbine in order to ensure the benefits and the value of the project, to ensure that the unit can carry on the production capacity according to the plan without loss due to the equipment failure, at the same time, it also shows that projects face a greater uncertainty when it is the insufficient run caused by the natural environment. The sensitivity coefficient of the initial investment is relatively smaller, enterprises need to reasonable

budget and strictly controlled to ensure that the project will not appear larger initial investment increases, and yet minimize the amount of investment. Although the feed-in tariff is not controllable, but it can reflect the sensitivity of project value when the project faces price level fluctuations, so the influence of electricity price fluctuation to the project value cannot be ignored due to the primary business of project is electricity sales.

4 Summary

The investment value of renewable energy projects is affected by multiple internal and external factors, considering the non-diversifiable systemic risk and selling green electricity certificate revenue in the quota system, this study constructed a real option valuation model that the risk could be adjustable improvements to evaluate the value of renewable energy projects. This model brings potential losses which can be created by external systemic risk of the firm into value assessment system, providing a new idea for value assessment of that type of investment projects to effectively reduce investment risks. Besides, there remains be inadequate. Firstly, in the determination of the model coefficients, as we can not build an efficient market in real investment environment like the financial markets that can measure a variety of assets returns, and thus will not be able to accurately measure the market risk, but only using contacts between the financial markets and real investment to adjust the project risks with the financial market data, this method will have an impact on the scientific of the calculation results. Secondly, since the long operating cycle of renewable energy power generation projects, when we use option valuation model to calculate the value of the project, the method of historical volatility may not accurately reflect the project's assets volatility of future changes in a longer period of time, so, how to better determine the volatility of project assets worth further investigation.

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