Research on the Investment Valuation of the CCER Project for Waste-to-Power Based on the Real Option Model

Dai Chunyan, Wang Yixian, and Zhou Yanling

***Abstract*—The Chinese Certified Emission Reduction Waste-to-Power project has the characteristics of investment irreversibility, earnings uncertainty and investment growth. Due to those characteristics, the traditional discounted cash flow (DCF) method has not been suitable for the investment evaluation of such projects. This research fully measures the additional benefits that brought by the uncertainty of CCER transaction price, especially considers the impact of CCER transaction price volatility on the option value, and then by using the B-S pricing model theory, builds an investment value evaluation model of CCER Waste-to-Power projects which is based on real options. Turning a Waste-to-Power project into application, this paper tests the validity and rationality of the model, so as to provide a reference for enterprise investment decisions and promote the healthy and orderly development of the CCER mechanism.**

***Index Terms*—Real option model, waste-to-power, Chinese certified emission reductions, investment decisions.**

I. Introduction

How to seize the opportunities brought by the market is the key for enterprises to enhance competitiveness and sustainable development. Enterprise is the main body of project investment. It is important for enterprises to choose a project evaluation method carefully. With seven national carbon trading pilot projects opening in 2014 and with the plan to establish a national carbon market in 2017, China's voluntary emissions (Chinese Certified Emission Reduction hereafter referred to as the "CCER") will usher in new opportunities. Waste-to-Power is a special kind of renewable power generation. A new business model – the CCER Waste-to-Power project also arises at a historic moment. At the voluntary emissions trading platform in China, some of the record projects are Waste-to-Power projects. How can investment value evaluation be scientifically and rationally ensured to make the right investment decisions for Investors under the new business model? Scholars have begun to pay close attention to the study on this problem in the recent two years. Kang Zhentong used the cost-benefit method to analyse the life cycle of the Waste-to-Power BOT project economic evaluation for the costs, expenses and profits calculation process and pointed out problems it needs to be aware of [1]. Zhu Feng used the traditional cost-benefit method and sensitivity analysis to analyze Waste-to-Power projects' economic evaluation [2]. Zhang Yanchun summarizes six kinds of PPP project bidding objects by the means of inductive analysis, presents three kinds of bidding objects combination solutions aiming at PPP project of domestic waste incineration for power with BOT mode [3]. Yao adapts the method of system dynamics to establish the pricing model of the waste disposal fee of PPP WTE incineration projects with the help of Vensim software [4].These methods are using the traditional project evaluation model of the Waste-to-Power project economic evaluation. However it did not take into account the Waste-to-Power project as special new energy projects are faced with uncertainty. And it did not take into account that CCER new business model can give Waste-to-Power projects more future expectations of profit. This article will analyze the options and features of Waste-to-Power projects in the new commercial mode with CCER at first. Then measures the extra profit that comes with the CCER trading price uncertainty and the influence on investment income by the volatilities of the CCER market price. After that, using the theory of the B-S pricing model, it builds the value evaluation model of Waste-to-Power projects based on real option theory. This model can provide a method to evaluate and sustain economic growth for our country's CCER Waste-to-Power investment evaluation, and it allows investors to fully consider the various aspects of influence factors to make scientific and rational investment decisions.

II. Characteristics of the Options for CCER Waste-to-Power Projects

As a special renewable energy power generation project, the CCER Waste-to-Power project has the following option characteristics:

(1) Irreversible investment. The Waste-to-Power project's development and construction need professional equipment such as the burning furnace. They cost a huge amount of investment. Once the capital is invested, it is difficult to recover. The equipment is highly specific, if it is withdrawn from the project, the equipment almost cannot be transferred to other use, it can only be scrapped. Therefore, the initial investment will become a sunk cost that is non-reversible.

(2) Uncertainty of the return on of investment. Firstly, as a form of renewable energy generation, the investment return of the Waste-to-Power project includes electricity price sales revenue and government subsidies. Due to the impact of other factors such as fuel prices, market volatility,

Manuscript received May 19, 2018; revised August 9, 2018. This work was supported by Anthropological, Social and Scientific Research of the Ministry of Education on youth found in the western and border areas (Project No: 13XJC630003).

Chunyan Dai is with the National Research Center for Upper Yangtze Economy of Chongqing Technology and Business University, National Research Base of Intelligent Manufacturing Service of Chongqing Technology and Business University, China (e-mail: 1212971@qq.com).

Yixian Wang is with the Engineering Center of Chongqing Technology and Business University, China (e-mail: 705593420@qq.com).

Zhou Yanling is with the Energy Management and Low Carbon Development Research Center of Chongqing Technology and Business University, China (e-mail: 1060616528@qq.com).

doi:10.18178/joebm.2018.6.3.556

technological innovation and analogous competitors in the future, the Waste-to-Power project faces a high risk and uncertainty. Secondly, China's voluntary emission reduction transactions are in the initial stage currently, although society's development is very rapid, the life cycle of CCER projects from the initial development to putting it on file and to get the certification issued finally is very long. From the status of China's carbon trading market, the uncertainty of the future cost of CCER, demand and price are very high.

(3) Growth of investment. CCER Waste-to-Power projects have strategic value for enterprises. With the intensification of global climate issues, China will shoulder the responsibility for emissions reductions in the future. Once carbon emissions become the industry's resource, developing the CCER project will have strategic significance for the industry. It will have a certain impact on the industry's main business and strategic direction.

In summary, CCER Waste-to-Power projects have a character of irreversible investment and investment growth uncertainty, that make the project’s future cash flow face a great uncertainty. The real option evaluation method is used by financial option thinking to solve the problems existing in real investment. And it will make the investing problems conceptualization more flexible. Therefore, this study will measure the additional revenue that is brought by the uncertainty of the transaction price from CCER projects, and build an investment valuation model of CCER Waste-to-Power projects based on option analysis.

III. Investment Value Evaluation Model of CCER Waste-to-Power Projects Based on Real Options

A. *Model Construction*

Considering extra income brought by the trading of emission reductions in China’s voluntary emission reduction program, the income of the CCER Waste-to-Power project mainly consists of three parts: the income from the sale of electricity, government subsidies, and the certified reduction displacement by CCER revenue. In addition, due to the uncertainty of the trading price of emission reductions, the income of the CCER project may be considered the option premium based on the perspective of real options.

(1) Income of the sale of electricity: 《the National Development and Reform Commission for improving the Waste-to-Power price policy》 noticed that the provisions of one ton of solid waste conversion grid electricity is tentatively scheduled for 280 kW, and the implementation of the national unified Waste-to-Power benchmark price is 0.65 RMB per kilowatt hour (kWh) [5]. The Waste-to-Power network electricity prices all over the country also had different regulations before 2012, but the overall change is not great. Therefore, this paper considers that the price of electricity is a certain value in the evaluation. At the same time, in order to take into account the rationality of the model and the availability of data, the project's annual electricity is fixed.

(2) Subsidy income of government: The government subsidy income of waste-to-power projects mainly refers to the waste disposal fee subsidies. The subsidy standards throughout are different, but the range of change is very small within a certain period. Therefore, it can be assumed each ton of garbage processing fee subsidies is a fixed value when evaluating a CCER Waste-to-Power project investment value.

(3) CCER income: The carbon emission trading price of each period estimated is P_n. The annual reduction of displacement is Q_n assuming that the investors predict it according to the same datum line and boundaries of the project. Then each carbon emission reduction benefit will be P_n*Q_n if we do not consider the option value carbon reduction displacement earnings instability brings to the enterprise.

(4) Option premium: China's unified carbon trading market has not been established. The market is facing instability factors such as the situation of supply and demand of the carbon emission reduction market, policy adjustment and the global economic environment. The CCER Waste-to-Power projects will face some uncertainty because of future carbon emission reduction trading prices by the carbon trading market, the quota market reduction of the supply and demand situation and other factors. The uncertainty can present investors with an option premium, because there is presently a certain price (project) of the amount of investment to buy certain standards of assets, and due to the uncertainty of value of the asset the future price may change favorably or unfavorably (the key factor is the uncertainty of carbon emission trading prices). The investors may get more or less favorable income from the project. That is the option premium. This article selected the B-S pricing model for the calculation of the option premium items of the project, and assumes that changes in carbon emission trading price are compounded by a geometric Brownian motion, and the fluctuation of the standard Wiener process. In addition, under the voluntary emission reduction trading mechanism in China, the project of carbon emission reduction requires a certain period of time to gain revenue, and there always is uncertainty between putting the project on file and its execution. Therefore, CCER Waste-to-Power projects introduce an expected probability parameter named μ, that is to say, when an enterprise is making investment decisions on Waste-to-Power projects, the project comes with the issuance and transaction probability forecast probability μ. Its size depends on the investment decision maker's risk preference and expectations for the future of the carbon trading market. Based on the above analysis and assumptions, the investment value of Waste-to-Power CCER projects based on real options ENPV is determined by the net present value method.

$$\text{ENPV}=\text{NPV}+\text{OP} \tag{1}$$

Among them, the ENPV is the investment value of the project which is the extended project net present value; NPV is the net present value of projects which is used in the discounted cash flow method to calculate; OP is the option premium of the project.

Assuming the project investment cost is I. The project revenue, which is depending on electricity sale and government subsidy is A. The (CCER) price expected is P_n, emissions reductions are Q_n, and the probability attached to the emissions issued to CCER is μ, therefore:

$$\text{NPV}=\sum_{n=1}^{n}\frac{A}{(1+r)^n}+\mu\sum_{n=1}^{n}P_n\cdot\frac{Q_n}{(1+r)^n}-I \tag{2}$$

$$\mathrm{OP} = \sum_{n=1}^{10} C_n . Q_n \quad (3)$$

$$C_n = \mathrm{S} * \mathrm{N}(d_1) - \mathrm{X}\mathrm{e}^{-\mathrm{r}(T_n - \mathrm{t})} * \mathrm{N}(d_2) \quad (4)$$

$$d_1 = \frac{\ln s}{\mathrm{X}} + (r + \frac{\sigma^2}{2}) * (T\text{-}t) \quad (5)$$

$$d_2 = \frac{\frac{\ln s}{\mathrm{X}} + \left(r - \frac{\sigma^2}{2}\right) * (T-t)}{\sigma\sqrt{T-t}} = d_q - \sigma\sqrt{T-t} \quad (6)$$

C_n is the option value that the project emission reductions include in each unit emission reduction in the period. S is the present price of the underlying assets, namely the present value of the emissions trading prices. X is the execution price of the underlying asset. P_n is the expected market price of emissions reductions in each period. $T_{n\text{-}t}$ is the option expiration. σ is the underlying asset volatility, namely the CCER market price volatility.

B. The Determination of Model Parameters

(1) A: A equals the yearly income of selling electricity plus the government subsidies, minus the annual operating costs of the cash outflow, namely:

$$\mathrm{A} = \mathrm{C}I_t - \mathrm{C}O_t = \mathrm{AE}P_t \times \mathrm{P} + \mathrm{GS}I_t - \mathrm{O}C_t \quad (7)$$

Among them, the AEP (annual energy production) is the project's generating capacity. GSI (Government subsidy income) is the Government subsidies income of garbage disposal. OC (Operating costs) is the yearly operation cost of the project.

(2) The determination of the discount rate r. The Risk-free interest rate can be chosen by the project starting date, and the bonds' basic yield, which duration is the same or similar with the operating life of the project, can be used as the discount rate of the model.

(3) The carbon emissions for each transaction price's expected value determination is P_n. It is necessary to issue carbon emissions trading price forecasts for the future project investment value evaluation. When the investors decide to invest in the project, a carbon emissions trading price expectation is necessary and used as a future cash flow of the discount. Assuming that after China's market unification, the carbon market prices' volatility of CCER is in line with the general Wiener process, the drift rate for a volatility of fluctuations in the price of the Wiener process for the formula is:

$$\mathrm{dp} = \mathrm{adt} + \sigma \mathrm{dz}$$

In project investment decision-making, it is necessary to make a prediction of the trading price of the carbon emissions in the future, this article assumes that the price of CCER is P_0, the future expected price is P:

$$\Delta P = \alpha P \Delta t$$

When $\Delta t \to 0, \mathrm{d}P = \alpha P \mathrm{d}t$, Then , $\frac{dP}{P} = \alpha dt$

Then, integral within 0 ~ T_0, are:

$$P = P_0 \mathrm{e}^{\alpha T} \quad (8)$$

Among them, a growth rate of emissions trading price for investors' expectations is assumed; T is the time for distance from the P_0 moment.

(4) The present value of the asset is S_0. The net present value of the project option premium uses the discount rate method to determine.

(5) The determination of executive price X. The option premium of the strike price is the cost of consumption in order to obtain the option value, that is, the project's investment cost.

(6) The volatility of the asset σ. Evaluation model of this paper is only considering the uncertainty of carbon reduction benefits, and at the same time, assumes that the annual emissions fixed value is Q. As a result, the underlying asset volatility is the volatility of the carbon emissions trading price. Because the underlying asset volatility in real options is the most important parameter in the model, it directly affects the evaluation results of the option premium, which is a more accurate assessment of the fluctuations. China's carbon emissions trading is still in its infancy, future development will face more uncertainty, therefore, the historical volatility method is not suitable for current and future periods of time to calculate the carbon trading price volatility. The set-valued iteration method is used to determine the price of the asset volatility possible value and weight index in the paper, according to m investors or related domain experts about the future of carbon emissions trading price volatility forecasts, the subjective importance of index weights are given, the CCER market price volatility is calculated by the interval and the corresponding weights, finally.

Taking the volatility index set $X=\{\delta_1,\delta_2,\delta_3,\delta_4......\delta_n\}$, n's volatility may be the number of parameter values, select by m investors or related industry experts, the indicators selected from the set X are what they think is most likely the volatility of the delta value, so k investors or experts are a selection index set, so the result should be a subset of $X(k)=\{\delta_{k1},\delta_{k2},\delta_{k3},\delta_{k4}......\delta_{ks}\}$. k is the value from 1 to m, m will be a similar subset.

Next, create the index weight in a function

$$\mathrm{A}_k(\delta_j) = \begin{cases} 1, & \delta_j \in \mathrm{X}(k) \\ 0, & \delta_j \notin \mathrm{X}(k) \end{cases}$$

Finally remember $\mathrm{g}(\delta_j) = \sum_{k=1}^{m} \mathrm{A}_k(\delta_j)$ (j=1,2......n) , , according to the result of the choice of m investors or experts, $\mathrm{g}(\delta_j)/\sum \mathrm{g}(\delta_j)$ as volatility may acquire the δ_j and the weight coefficient of W_j, namely:

$$\mathrm{W}_j = \mathrm{g}(\delta_j) / \sum_{j=1}^{n} \mathrm{g}(\delta_j) \quad (9)$$

Calculated according to the most likely possible values and their corresponding weights to the reduction of market price volatility of delta.

(7) T-t is the expiration time. It is the project emissions trading time. t is the project start time 0, T is the issuing time

of the project emission reduction.

IV. Case Application

A waste incineration project [6] uses one mechanical grate garbage incinerator which capacity is 300 tons/day and one turbo-generator power generator which produces 6 mW. The power generating capacity is 38520 mWh, including 31586.4 mWh online power. Before this project, municipal solid waste was collected and directly shipped to the project's local downtown landfill for treatment, but not for landfill gas recovery and disposition. The CCER's adopted methodology of this project is CM-072-V01 which is defined by the national development and reform commission issued voluntary greenhouse gas emission reduction methodology. See as Table I.

TABLE I: Project Investment Valuation Economic Parameter List

Name	Value	Unit
Garbage disposal ability	122000	ton/year
Installation capacity	6	Mw
Net electricity online	31586.4	MWh
The project total investment	14968.08	Ten thousand RMB
Annual operating costs (estimated)	1201	Ten thousand RMB
Electricity price (including taxes)	0.66	RMB/kWh
Project construction	2	Years
Running life of project activities	22	Years
income tax	25	%
Residual rate	5	%
Domestic waste incineration	68	RMB/ton

The Project was signed on a turbine purchase contract in January 26, 2015, the project requires two years of construction, and it is expected to begin in early 2017. The project's intended active running time is 22 years, including ten years of emissions reductions, the scheduled start time is on January 1, 2017. It's estimated that the average annual emissions reduction is 54942 tCO_2e. According to the IPCC International Greenhouse Gas (GHG) emissions profile, the project owner estimates in advance emission reductions (on January 1, 2017-December 31, 2026), see as Table II:

TABLE II: The Project Activities of the Project Activities in the Period of the Annual Reduction

Year	**baseline emissions (tCO2e)**	**project emissions (tCO2e)**	**Leakage (tCO2e)**	**emission reduction (tCO2e)**
2017.1.1-2017.12.31	39522	27806	0	11715
2018.1.1-2018.12.31	53176	27806	0	25370
2019.1.1-2019.12.31	64861	27806	0	37054
2020.1.1-2020.12.31	74887	27806	0	47080
2021.1.1-2021.12.31	83515	27806	0	55709
2022.1.1-2022.12.31	90965	27806	0	63158
2023.1.1-2023.12.31	97417	27806	0	69611
2024.1.1-2024.12.31	103025	27806	0	75219
2025.1.1-2025.12.31	107918	27806	0	80111
2026.1.1-2026.12.31	112201	27806	0	84395
Annual mean in the period	827487	27806	0	549422
Total period time	10 years			

The project was approved by Hubei Provincial Development and Reform Commission in December 17, 2014. Thus, the time for investment decisions is January 1, 2015. The investment valuation model shows that the expected net present value of the project can be deduced by formula(2) when the price of the deal is not considering CCER instability. Then according to the formula (7),

$A = CI_t - CO_t = AEP_t \times P + GSI_t - OC_t$, then the annual cash flow of the project A = 1713.3024 million RMB;

According to the formula (8) $P = P_0 e^{\alpha T}$, can caculate the price P_n for the carbon dioxide emission reductions transaction in each period of the project. Given the unified national carbon market has not been established, China CCER trading is mostly undertaken by non-compliance, non-publicly traded companies with greater price fluctuations in the current quota system. Thus, according to the performance of the CCER pilot in 2014, we select the current trading price of P_0 is 20 RMB/tCO_2e, a transaction for investors with CCER price expectations of growth by 4%.

Reductions included in the emissions trading price during each phase of the predicted values are in the following Table III:

TABLE III: Each Lasting Emissions Trading Price Forecast Unit: RMB

P1	**P2**	**P3**	**P4**	**P5**
21.6658	23.4702	25.4250	27.5426	29.8365
P6	**P7**	**P8**	**P9**	**P10**
32.3215	35.0135	37.9296	41.0887	44.5108

Q_n is the average period for the project included in the annual emission reductions, detailed in Table II.

I is the total investment into projects, in this case, I = 14968.0800 million.

r represents the 20-year bond yields of 3.76% issued in 2015 (note: Treasury code 019521).

μ is probability of the carbon reductions projects can get put on record and certification and issuance for the project investors. The value is based on the risk appetite of investors and other subjective factors. Thus,

(1)When earnings do not consider reductions to the Waste-to-Power project, the project's net present value: $NPV1 = \sum_{n=1}^{n} \frac{A}{(1+r)^n} - I$=-899.2973 (Ten thousand RMB)<0, Investors will choose to abandon investment in the project.

(2)When considering the earnings reductions of Waste-to-Power projects, ignoring the impact of carbon emissions trading price uncertainty on the investment value of the project, the net present value of the project becomes:

$$NPV2 = \sum_{n=1}^{n} \frac{A}{(1+r)^n} + \mu \sum_{n=1}^{n} P_n \cdot \frac{Q_n}{(1+r)^n} - I$$

=1474.1724μ-899.2973(Ten thousand RMB), where μ is the probability of emission reductions issued, which depends on the degree of risk appetite, investment decision-makers and expectations of the future carbon trading market. In this case, only economic considerations, will determine the size of μ NPV projects, thereby affecting the investment decisions of investors.

When μ=61%, NPV=0; the project breaks even.

When μ>61%, ENPV>0, investors should choose to proceed with the investment.

When μ< 61%, ENPV<0, investors should abandon the investment.

(3) When considering the benefits of emission reductions in Waste-to-Power projects, and considering the carbon emissions trading price uncertainty, the project gains option premiums, according to formula (1) the net present value of the project expansion is:

ENPV=NPV+OP=14507378.84μ-2686764.638+OP, then using formula (3) to calculate the CCER price uncertainty, the value of the project's the option overflow OP becomes apparent, according to the formula.

In the case, the volatility of the carbon emissions trading price is determined using the third part set value iteration method for calculation. First the volatility of the possible indicators set is selected, and then the weights are assigned according to the selected industry-related experts.

TABLE IV: POSSIBLE VOLATILITY VALUES OF THE PROJECT'S WEIGHT DISTRIBUTION UNIT: %

σ	2	3	4	6	8	9
Weight	8	10	12	14	10	12
	9	10	11	12	15	16
	12	8	9	7	6	4

Through using the iterative method on the set, the value = 7.83% can be calculated. By formula (4) it can be calculated, that each project unit's lasting reductions overflow option value is as shown in Table V.

TABLE V: EACH PHASE OF THE PROJECT'S UNITS OF EMISSION REDUCTIONS OPTION PREMIUM TABLE

C1	**C2**	**C3**	**C4**	**C5**
0.4551	0.7533	1.0506	1.1882	1.3266
C6	**C7**	**C8**	**C9**	**C10**
1.3845	1.4428	1.6629	1.8446	1.7814

Formula (3) returns the project option OP overflow value of 80.4298 million RMB expansion project NPV thus:

$$\text{ENPV}=\text{NPV}+\text{OP}=1474.1724\mu-899.2973+80.4298 \\ =1474.1724\mu-818.8675$$

As in the case of formula (2), if only economic considerations are taken into account, the size of μ NPV projects can be determined, thereby affecting the investment decisions of investors.

When μ=55.55%, ENPV=0;

μ>55.55%, ENPV>0, investors should choose to proceed with the investment.

μ<55.55%, ENPV<0, investors should abandon the investment.

Based on this case, the project may be obtained if investors believe that the probability of issuing and trading is more than 55.55%, then considering the economic benefits, it should be selected for investment. Otherwise, it may be discarded.

From the analysis of this case, the paper argues that under the new business model, investors making investment decisions should mainly consider three points in such projects, it is necessary to measure the Waste-to-Power projects' revenue reductions, the new business model of the Waste-to-Power projects has brought a new revenue structure, investors in the investment value of the project should make a comprehensive assessment when assessing the income; the second is to consider the carbon trading price uncertainty that brings an option premium to the project. China's unified carbon market has not been established yet, CCER transactions are fully disclosed in compliant non-state companies. The future trading price of CCER is faced with uncertainty, and then what kind of impact the project may have needs assessment; thirdly China's voluntary emission reduction mechanism in its infancy, according to ICIS statistics on China's carbon trading market CCER projects may be implemented with a record speed of about 270 days, then fully established in about 193 days. The project's probable emission reductions also depend on the future supply and demand situation in China's CCER carbon market, the proportion of carbon quotas, government policies on a variety of projects to make judgments, etc. To obtain a prediction of trading of emission reductions, this study is based on a real option CCER Waste-to-Power project investment valuation model. Resolved in the new business model, the relevant investors now require careful scientific evaluation methods to make the right investment decisions. This paper may provide potential investors with theoretical support and new investment decisions ideas for Waste-to-Power projects and promote the healthy development of China's voluntary emissions reduction mechanisms.

V. SUMMARY

In summary, special Waste-to-Power and renewable energy projects in China under the voluntary emissions trading mechanism are facing opportunities and challenges, China's unified carbon market has currently not been established, the CCER Waste-to-Power projects' carbon emissions have an earnings uncertainty. On the basis of analysis of Waste-to-Power project option characteristics possessed, combined with real options theory, and through introduction of the emission reductions' expected probability μ, integrated projects affected by the market supply and demand situation, quotas and trends, objective factors and subjective factors are presented to investors. Constructed under the new business model, the investment valuation model of the project is established, a method of determining the parameters is found, and applied to a specific case, in a scientific and effective model on the basis of verification, to give investors clear Investment decisions ideas for reference. Of course, this paper only establishes the perspective of economic research to assess whether the project should be invested into and does not yet fully take into account environmental and social benefits of such projects. How to assess integrated waste incineration's economic, environmental and social benefits for electricity generation through CCER projects requires further study of the issue.

ACKNOWLEDGMENT

This work was supported by the found of the Anthropological, Social and Scientific Research of the Ministry of Education on Youth in the Western and Border Areas (Project No: 13XJC630003), and by the found of National Research Center for Upper Yangtze Economy of Chongqing Technology and Business University (Project No:950617005).

REFERENCE

[1] Z. Kang, "With garbage incineration power generation economic evaluation of BOT projects deal with some problems," *Construction Industry*, 2013.

[2] F. Zhu, "Waste-to-power project technical and economic analysis," *Technical Economics*, 2015.

[3] Y. Zhang, "Study on bidding object designing of PPP project of domestic waste incineration for power," *Journal of Railway Science and Engineering*, vol. 14, no. 2, pp. 408-414, 2017.

[4] Z. F. Yao, *et al*., "Research on PPP project concession pricing based on system dynamics for waste- to- energy incineration projects in China," *Price: Theory & Practice*, vol. 4, pp. 131-135, 2017.

[5] National development and reform commission. The national development and reform commission on improving waste incineration power price policy. [Online]. Available: http://www.sdpc.gov.cn/zcfb/zcfbtz/201204/t20120410_472395.html

[6] China voluntary greenhouse gas emission reduction project design document. (2014). *China Resources Trading platform*. [Online]. Available: http://cdm.ccchina.gov.cn/archiver/cdmcn/UpFile/Files/Default/20150602164450219445.pdf

Chunyan Dai was born in Chongqing, China in Feb. 1975. She has got the post-doctoral of management science and engineering in Tsinghua University from 2010 to 2012, the PHD of management in the Department of Business and Management of Chongqing University, Chongqing, China at 2010. Her research field contains low carbon and development, energy management.

Chunyan has been a visiting scholarship at the Wuerzburg University of Germany from 2015 to 2016. And she is a professor at the Chongqing Technology and Business University, Chongqing, China now. She has presided over 6 provincial projects, took parts in 5 international cooperated projects, more than 10 national and provincial research projects, and published more than 30 papers. She has completed the "Multi-criteria renewable energy planning decision-making model based on VIKOR", "Multi-attribute approach based VIKOR renewable energy technology assessment research", "New energy based on risk-adjusted investment decision model", "China's renewable energy information collection and statistical problems and countermeasures" and other papers.