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Economic analysis of the distributed generation development in northern part of Hebei province

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Abstract: Northern part of Hebei province as an important resource area of solar energy and wind energy will promote distributed power development in the thirteenth Five-Year period vigorously. This paper took a distributed photovoltaic project as an example, and made an economic analysis for the distributed power in the north of Hebei province. The marginal sale price of distributed generation project was calculated on the basis of ensuring 8% internal rate of return. IRR of project is most sensitive to the change of photovoltaic distributed power sale price, followed by state financial subsidy, and the last is project initial investment.

Introduction

Wind, solar and biomass energy and other resource are rich in Northern part of Hebei province, which is particularly rich in solar resources.The thirteenth Five-Year Plan of Hebei province renewable energy development made it clear that Hebei province would vigorously develop distributed energy projects adaptation to local conditions, such as solar energy, wind energy, biomass power and natural gas cogeneration and other kinds of distributed generation [1, 2] . At the same time, the reasonable economic analysis for distributed energy has become one of the focuses of research [3, 4, 5, 6]. In addition, the research also evaluated the environmental benefits of distributed generation projects [7, 8].

Economic analysis model of distributed generation project

In this paper, the photovoltaic distributed generation project is taken as an example to carry on economic analysis on the base of life cycle theory in Northern part of Hebei province. The meaning of relevant parameters in model is shown in Table 1.

Table1 The remarks of parameters in following model

Parameters	Remarks	Parameters	Remarks
Q	Annual electric energy production	h	The efficiency of the PV system
C_{inv}	Project initial investment	M	Installed capacity of system
C_{ope}	Annual operation and maintenance cost	H	Annual utilization hours
C_{fin}	Annual financial expense	n	Project life cycle
C_{in}	Annual cash inflow	C_{out}	Annual cash outflow
P_0	Electricity sale price of photovoltaic distributed power	P_1	Feed-in Tariff
K	The rate of production back to utility grid	IRR	Internal rate of return of project
t_1	Added-value tax rate	C_{npv}	Net present value of project
t_2	Addition to the added-value tax rate	B	State financial subsidy
t_3	Income tax rate	T_{inc}	Income tax

The annual generation output of photovoltaic distributed generation system is related to the level of solar resource and the installed capacity of system.

$$Q = M \times H \times h \tag{1}$$

The annual income of photovoltaic distributed generation project is as follows.

$$C_{\text{in}} = Q \times B + P_0 \times Q \times (1-K) + P_1 \times Q \times K \tag{2}$$

The annual expenditure of photovoltaic distributed generation project includes operation and maintenance management fee, financial expense and taxes.

$$C_{\text{out}} = C_{fin} + C_{ope} + \frac{P_0 \times Q \times (1-K) + P_1 \times Q \times K}{1+t_1} \times t_1 \times (1+t_2) + T_{\text{inc}} \tag{3}$$

The annual net profit of photovoltaic distributed generation project is as follow.

$$P_{\text{net}} = C_{fin} + C_{ope} + \frac{P_0 \times Q \times (1-K) + P_1 \times Q \times K}{1+t_1} \times t_1 \times (1+t_2) - C_{in} \tag{4}$$

Therefore, the income tax is shown as follow.

$$T_{\text{inc}} = \begin{cases} P_{\text{net}} \times t_3 & P_{\text{net}} > 0 \\ 0 & P_{\text{net}} \le 0 \end{cases} \tag{5}$$

Assuming that the life cycle life of project is n, the formula for calculating the internal rate of return of photovoltaic distributed generation project in the whole life cycle is as follows:

$$C_{\text{npv}} = \sum_{t=1}^{n} [C_{\text{in}} - C_{\text{out}}](1+IRR)^{-t} - C_{\text{inv}} = 0 \tag{6}$$

Case analysis

The case study takes the installed capacity 50kW photovoltaic distributed generation project as an example, assumes that the proportion of loans for initial investment is 50%. The other data used in calculation are shown in Table 2.

Table2 The data of parameters in model

Parameters	Remarks	Units	Data
C_{inv}	Project initial investment	yuan	5130000
C_{ope}	Annual operation and maintenance cost	yuan	10260
C_{fin}	Annual financial expense	yuan	28215
K	The rate of production back to utility grid	%	25
P_1	Feed-in Tariff	yuan/kWh	0.3634
h	The efficiency of the PV system	%	75
M	Installed capacity of system	kW	50
H	Annual utilization hours	h	3200
n	Project life cycle	year	25
t_1	Added-value tax rate	%	17
t_2	Addition to the added-value tax rate	%	8
t_3	Income tax rate	%	25
i	discount rate	%	5%

The sales price of flat period in Hebei province is assumed to be sales price for photovoltaic distributed generation, and the price of resident users is 0.52 yuan /kWh, the commercial users is 0.6626 yuan /kWh, the large industrial users is 0.5476 yuan /kWh. Based on the above data, the internal rate of return (IRR)and dynamic recovery period of photovoltaic distributed generation project in in the northern part of Hebei province are shown in Table 3.

Table 3 The internal rate of return and dynamic recovery period of project

Index/The types of user	Resident users	Commercial users	Industry users
The internal rate of return	7.98%	10.47%	8.47%
Dynamic recovery period(year)	14.21	10.97	13.46

Through the above calculation results, the internal rate of return reaches 8% when the sales targets are commercial users and industry users, slightly less than 8% for residential users. In order to ensure the profit of investors, the sale price should reach 0.5215yuan/kWh in the northern part of Hebei province. When the sale price exceeds the marginal price, the internal rate of return meets the requirement 8%. As shown in Fig.1, when the electricity price is higher than Feed-in Tariff, the lower rate is, the higher internal rate of return is.

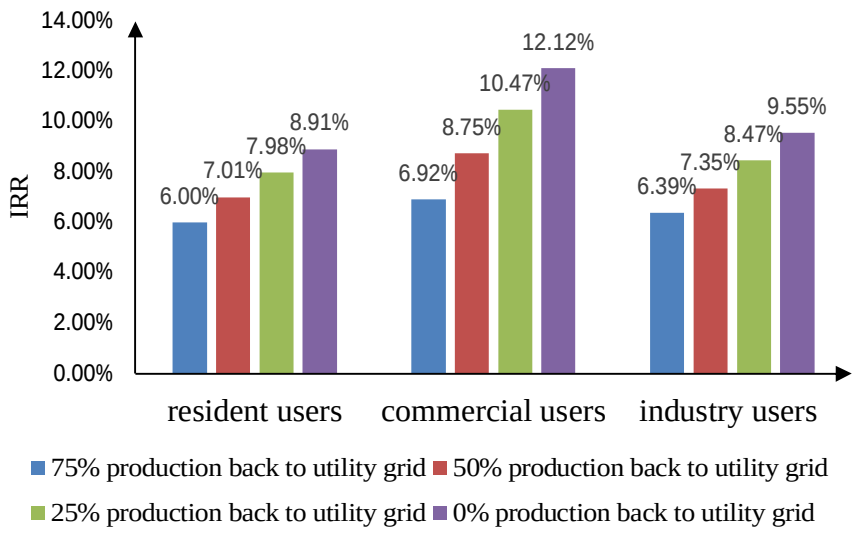

Fig.1 The IRR in different rate of production back to utility grid

The following sensitivity analysis mainly selects the main influencing factors of electricity sale price, state financial subsidy and project initial investment to anaylsis.

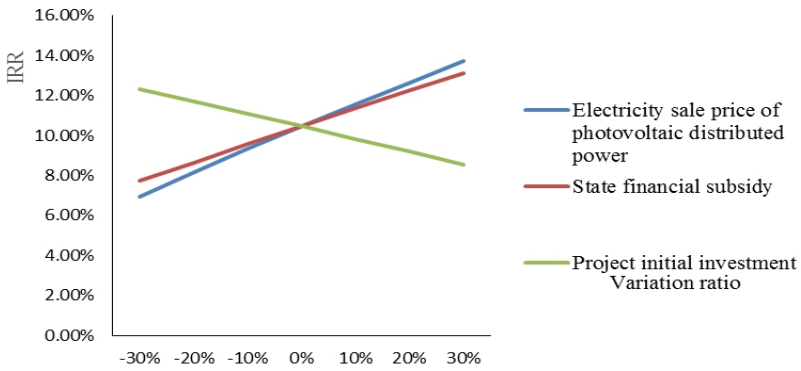

Fig.2 The sensitivity analysis of different influencing factors

Conclusions

(1)Northern part of Hebei province as a rich solar resource region, it is very suitable for the development of photovoltaic distributed generation. Taking local electricity price as sale price of photovoltaic distributed generation, the internal rate of return is the largest when customer is commercial users, followed by large industrial users, the smallest is resident users. In order to ensure the profit of investors, the sale price of photovoltaic distributed generation project should be more than 0.5215yuan/kWh in the northern part of Hebei province.

(2) The rate of production back to utility grid of photovoltaic distributed generation system has a huge impact on investment income. When the electricity price is higher than Feed-in Tariff, the lower rate is, the higher internal rate of return is, it can be more conducive to recover the investment for investors. IRR of project is most sensitive to the change of photovoltaic distributed power sale price, followed by state financial subsidy, and the last is project initial investment.

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