

Study on Operation Mode of Anti-poverty Photovoltaic Project Based on Altruism Preference

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Abstract. The operation of anti-poverty Photovoltaic project puts forward higher requirements on multi-participates cooperation. The cooperative behavior among different subjects has altruistic motivation, so based on the stakeholder theory, this paper analyzed the stakeholders' rights and interests, establishes the operation mode of multi-participates collaborative optimization under the altruistic preference. This paper discusses and analyzes the influence of altruistic preference on project performance and project participants. Finally, the model is verified.

1. Introduction

With the increasing tension of traditional energy supply and the progress of industrial technology, countries in the world have increased efforts to research and develop sustainable energy such as solar energy, which has brought the vigorous development of photovoltaic market. The research of photovoltaic industry is emerging, such as technical issues, quality issues and management issues in the construction and operation [1], the organizational structure and risk problem of photovoltaic project construction and operation mode[2]. Through the analysis of the main operation mode of PV system at home and abroad, it is found that our country currently lack early financing and operation management.

Photovoltaic project has the characteristics of high economic benefits, good stability, energy saving and emission reduction effect, low cost of operation and maintenance, and has a great advantage in the poor areas[3]. At present, the research on anti-poverty Photovoltaic project in China is still lack. In order to study the collaborative optimization among different subjects, we must have a thorough understanding of the participants in the project. In 1984, freeman, an American economist, argued that stakeholders were broadly defined as "any individuals and groups that can influence the achievement of an enterprise, or that can be affected by the process of achieving its objectives"[4]. Using stakeholders to analyze the power and benefit of the project participants, build the power benefit matrix, can support the research of the operation model.

There are many participants in anti-poverty Photovoltaic project, how to improve the collaborative optimization of multi-agent project is an important problem that project managers need to solve urgently. Many experts work with the project team from the perspective of contract design. Holmstrom first proposed the issue of moral hazard in team cooperation through contract design [5].



Then many experts have further research on team cooperation on this basis, Yang [6,7] and others has been studied contract mechanism in the team cooperation, and proved the effectiveness of incentives. In recent years, behavioral economics and behavioral game theory developed rapidly, and the research found that the mutual preference between subjects can promote the cooperation of the team to some extent. Many scholars have also made research on the influence of altruism on team collaboration. For example, Mifune, through economic experiments, show that altruistic preferences have a positive impact on the reputation of the team [8]. Han Jiaojie [9] studied the cooperative behavior of multi-participates, and constructed the project decision model considering altruism preference. Altruistic preference is seldom used in the anti-poverty Photovoltaic project of multi-participates. Therefore, this paper combines the characteristics of photovoltaic power generation project and the related research results of altruism, constructs the team cooperation model of project owners and multiple participants, and analyzes the increased effort and the income of each subject under the altruism preference (including direct income and indirect benefit). It provides theoretical support and policy suggestions for how to improve the altruistic preference of the project participants and enhance the team cooperation.

2. Analysis of stakeholders in the construction and operation of anti-poverty Photovoltaic project

2.1. Stakeholder theory

The development of anti-poverty Photovoltaic project involves many stakeholders, and the stakeholders of the project participate in the project in the form of different roles. At the same time, there is a large number of network relationships among the stakeholders in the process of the distributed photovoltaic project construction, the action strategies of stakeholders influence other stakeholders, and the results are affected by other stakeholders. This network relationship and its structure affect the effectiveness of stakeholder management.

Based on stakeholder theory, stakeholders can be divided into four types by analyzing the rights and influence of each stakeholder in the project. according to the stakeholder matrix (figure 1), the key stakeholders of the project are located in the upper right corner of the matrix, it plays a key role in the success of the project. The upper left of the matrix has great power and small interests, they have great power in the decision of the project, but because of the small interests, there is a lack of interest in the development of the project; The stakeholders in the lower right side have large interests and small influence. The development of the project has great influence on their interests. they are also interested in the development of the project, but they do not have enough capacity and resources to promote the development of the project; The stakeholders in the lower left corner of the matrix have little power and interest, and in the process of the project, organizations often pay little attention to such groups, in contrast, their efforts are also the smallest. Due to the different resources of possession, the role of various stakeholders in the project can also be different. Correct understanding of the power and interests of various stakeholders in photovoltaic pro-poor projects is of great significance for the rapid and effective implementation of photovoltaic poverty alleviation projects.

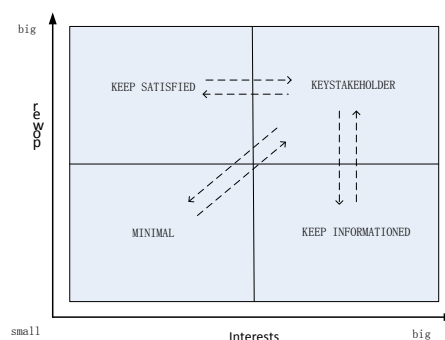


Figure 1. Power benefit matrix

2.2. Analysis of the rights and interests of stakeholders

The construction of anti-poverty Photovoltaic system needs the cooperation of all parties to complete. Speeding up the construction speed of photovoltaic power generation system needs to mobilize the enthusiasm of all parties to ensure the reasonable income of all parties. Professor Ding proposed the identification of project stakeholders through the construction of task dimension, process dimension and role dimension, and established a three-dimensional model. In this paper, through the three-dimensional model, identify the stakeholders. The main stakeholders of the anti-poverty Photovoltaic system are photovoltaic units, grid companies, government, bank lenders, photovoltaic component producers, third-party supervision, third-party certification, roof owners, etc. Each party has its own interests in the project implementation of photovoltaic power generation system, at the same time, the distributed photovoltaic project construction stakeholders also include the construction party, environmental organizations, the public and so on.

Table 1. power benefit analysis of stakeholders

stakeholders	NO	power	interests
project-owner	1	power generation capacity	sell electricity , get income
grid company	2	dispatch and distribution	get subsidies and good reputation
lenders	3	provide loans, supervise	Loan interest income
government	4	policy guarantee	adjust the energy structure, alleviate crisis, get good reputation
construction	5	engineering construction	get construction benefits
component producers	6	provide cells, components	increase sales and revenue
supervision	7	supervise construction	get profit from supervision
certification	8	assess quality of products	get profit
roof owners	9	have the roof, install the photovoltaic equipment	income from rent or electricity
the public	10	use of clean energy	a good living environment
Social group	11	promote use of clean energy	protect environment

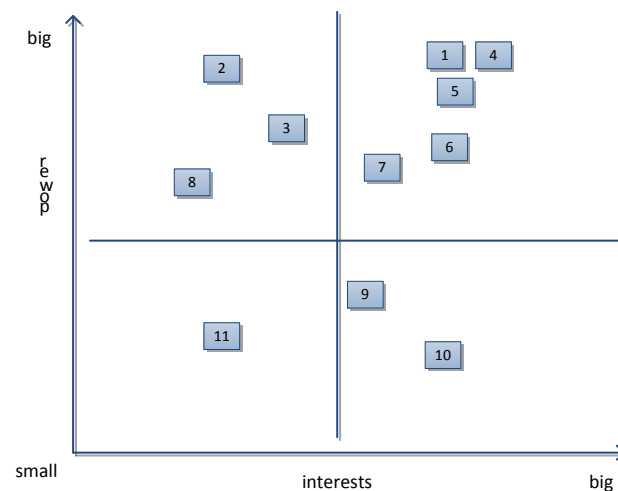


Figure 2. Power interest matrix of stakeholders

In the construction and operation of anti-poverty photovoltaic project, stakeholders want to take different measures to maintain their own interests due to their own resources and location, when these measures are inconsistent, to realize the cooperation optimization of stakeholders cooperation, we must clarify the position of the project stakeholders in the power benefit matrix, clarify roles and status, so as to establish the construction and operation mode of the project. As shown in figure 2 and table1, the main stakeholders of the anti-poverty photovoltaic project and their location in the power benefit matrix are analysed through an investigation of the relevant experts.

3. Multi-agent cooperation model of project based on altruism

3.1. Model hypothesis

Photovoltaic project is generally composed of a project owner and N independent organizations, such as the analysis of the stakeholders, they are independent stakeholders, their influence and interests in the project are different, to maximize their own interests as the goal. Suppose that the i body is called the body i , then $0 \leq i \leq 10$.

In the project, different subjects have different resources and advantages, the completion of the project needs the mutual cooperation among the various subjects, each subject needs to provide help to other stakeholders besides doing his own work.

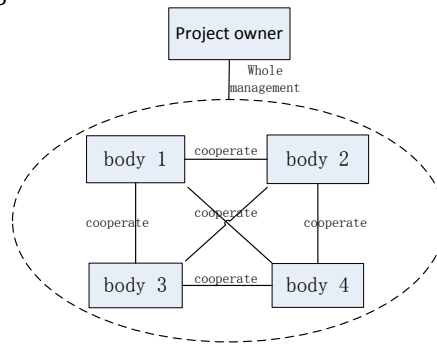


Figure 3. Multi-agent participation in photovoltaic project cooperation mode

Assuming that body i work in the project can be divided into production effort and cooperative effort, respectively by means a and b , a represents the production effort of body i , and $0 \leq a_i \leq 1$, b_{ij} represents the cooperation effort of body j , and $0 \leq b_{ij} \leq 1 (i \neq j)$, each subject also pays the cost, including the production effort cost and the cooperative cost. Suppose the cost function of body i is $C(a_i, b_j)$, and $C'(a_i, b_j) > 0$, $C''(a_i, b_j) > 0$, the cost function of the subject i can be expressed as:

$$C(a_i, b_j) = \frac{1}{2} c_i (a_i^2 + b_i^2) \quad (1)$$

Among them, c_i is the cooperative effort of the cost coefficient [10].

Referring to the collaborative output model [11] between subjects with different power and interests, the output function π of the body i can be expressed as:

$$\pi_i = \theta a_i + (1 - \theta) \sum_{j=1, j \neq i}^N b_{ji} + \gamma a_i \sum_{j=1, j \neq i}^N b_{ji} + \xi_i \quad (2)$$

Among them, θ and $1 - \theta$ are the influence factors of the main output efforts and other subjects' cooperation efforts on their output, and $0 < \theta \leq 1$, when $\theta = 1$, indicating that the subjects are independent, and the cooperation efforts of other subjects can not increase the output of the main body. conversely, when $\theta \rightarrow 0$, the influence of other subjects has great influence on the main output, and also indicates that the work of the main body has a higher demand for cooperation among other subjects. γ is potential impact of collaboration between subjects on output. ξ_i is a natural environment variable, showing the influence of external environment on the output of body i , $\xi_i \sim (0, \sigma^2)$.

As the contribution of each subject to the output of the project is different, such as the rights and interests of each subject on the project directly affects the contribution rate, the contribution degree of the main body i is k_i , $0 < k_i < 1$, and $\sum_{i=1}^N k_i = 1$, so the total output of the project is:

$$\pi = \sum_{i=1}^N k_i \pi_i. \quad (3)$$

3.2. Model building

1) the utility function of the project owner

This paper assumes that the project owner aims at maximizing the benefits of the project, and its income is affected by two factors: the project output and the main profit sharing. under the risk neutral condition, it can be expressed as

$$V_o = (1 - N\beta)\pi \quad (4)$$

Among them, β is the profit impact coefficient of the team output for body, that is, the profit sharing coefficient, $0 \leq \beta < 1$.

The expected utility is equal to the expected return, so the expected utility of the project owner is

$$EU(V_p) = (1 - N\beta)E(\pi) = (1 - N\beta) \sum_{i=1}^N k_i E(\pi_i) \quad (5)$$

2) the utility function of the other body

In this paper, the altruism - utility function has been studied by many scholars at home and abroad, and many scholars have expressed the utility of altruism as a combination of their direct utility and the utility of altruistic behavior, such as Levine[12]and yang chunxue[13], so the altruism can be divided into altruism to their own utility and altruistic behavior, and the latter can directly use altruistic behavior to contribute to the overall benefit of the project team. The direct utility of body i is expressed by μ_i and μ_j , and μ_i is the expected return of body i , it can be expressed as:

$$\mu_i = a_i + \beta E(\pi) - \frac{1}{2} c_i (a_i^2 + b_i^2) \quad (6)$$

μ_{ij} is the cooperative effort of the main body to bring the utility of the other subjects as well as the project team. Body does not know the action selection strategy of the other subjects when the body selects the action strategy, it assumes that the other subjects will pay a greater amount of production effort ($a_j=1$). thus the utility μ_{ij} produced by the main part I can be expressed as:

$$\mu_{ij} = (1 - \theta)b_i + \gamma b_i \quad (7)$$

Further, the expected utility function EU_i of the body i can be expressed as:

$$EU_i = (1 - \varepsilon_i)u_i + \varepsilon_i u_{ij} \quad (8)$$

For the altruism preference coefficient of the body i , satisfying $0 \leq \varepsilon_i \leq 1$. in particular, when $\varepsilon_i = 1$, body i is completely altruistic; When $\varepsilon_i = 0$, the agent i was completely selfish.

3) multi - agent cooperation model

In the multi - agent project team cooperation, the goal of the project owner is to maximize the individual income, maximize the output efforts and cooperative efforts. The owner and the individual entities in different decision-making levels, have their respective objective function and decision variables, and the project owner decision will directly affect other subjects' behavior selection, so the cooperation model is a double-level programming model. The multi - agent cooperation model of the project team under altruistic conditions can be expressed as:

$$\max_{a,b,\beta} (1 - N\beta)E(\pi) \quad (9)$$

$$(IC)_1 \quad a_i \in \arg \max_{a_i} EU_i \quad (10)$$

$$(IC)_2 \quad b_i \in \arg \max_{b_i} EU_i \quad (11)$$

when other relevant conditions such as profit sharing are not changed, the performance of the project team under the altruistic preference conditions is significantly higher than the project team performance under pure selfishness[9].

Therefore, from the above altruistic preference model, we can know that: (1) The increase of altruistic preference increased the cooperative effort of the participants, which increased the input of the project team. (2) The cooperation effort of each subject consumes itself cost, but it also increases the output of other main body, so the output of subject I is related to the assistance and cooperation of other subjects in the project besides the production effort. (3) The increase of the performance output of the participants is greater than the cost of the project team, and then the total output of the project is increased. This shows that the increase of altruistic preference will increase the performance output of

the project team. Therefore, for the project owner, incentive and carry forward the altruism behavior of the project participants will benefit to improve the project performance and increase the project output.

3.3. Analysis of an example

In this paper, the various variables of altruism preference are more abstract, and in many cases it is difficult to measure, so the empirical test method chosen in this paper is not to calculate directly the variables involved in 3.2. But taking a small photovoltaic power station as the research object, in a certain period of time, the independent mode, cooperation mode, and cooperation mode with altruistic preference are simulated, and the income of each participant and the project owner are compared in three cases.

Assuming that in the independent operation mode, the small photovoltaic power station, in addition to the project owner of the main involved in the main photovoltaic operators and users, cooperative mode of participation will increase the energy storage operators. The capacity of photovoltaic power station is 200 kw, and the energy storage system is 50KW.h, and the inverter is 65kw.

The load and photovoltaic output of the typical day are shown in fig. 4, the daytime is in the trough, at night is in the peak of electricity, and the photovoltaic output is greater than the load at 9: 00 - 17: 00., there will be a small peak. In the model, the electricity price of power grid is 0.6 yuan/(KW.h), the photovoltaic price is 0.85 yuan/(KW.h), and the photovoltaic subsidy is 0.42 yuan/(KW.h).

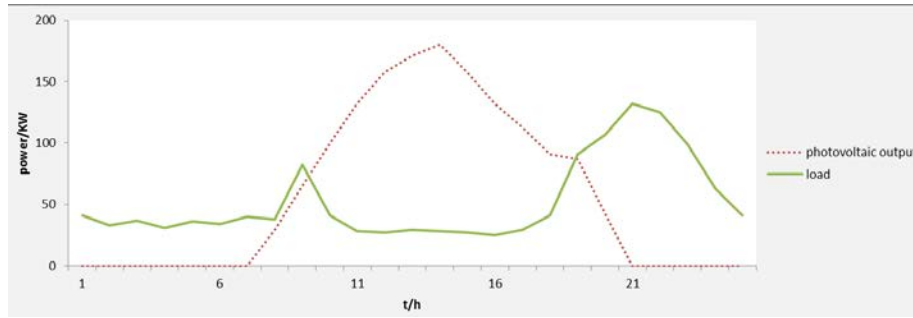


Figure 4. Power curve of photovoltaic output and load

In the independent mode, photovoltaic operators' output is all connected to the net, users directly buy electricity from the grid, energy storage operators used to ensure the reliability of the grid, without direct economic benefits. In the mode of cooperation, photovoltaic output first supply customers, the surplus photovoltaic energy storage equipment connect to the net after the charge; Energy storage operators use off-peak power, send out electricity peak power, energy storage surplus photovoltaic supply users; Users will give priority to photovoltaic output, followed by the energy storage system. In the altruistic cooperative mode, photovoltaic operators and energy storage operators have altruistic preference.

The proceeds of the three subjects in the independent model are[14]:

$$C_{PV,0} = \sum_{t=1}^T ((V_e P_{PV}(t) + V_{PV} P_{PV}(t))) \quad (12)$$

$$C_{BS,0} = \sum_{t=1}^T ((V_{i,p}(t) P_{b,f}(t) + V_{i,o}(t) P_{b,c}(t))) \quad (13)$$

$$C_{U,0} = \sum_{t=1}^T (-V_i(t) P_d(t)) \quad (14)$$

$C_{PV,0}, C_{BS,0}, C_{U,0}$ are the typical daily benefits of photovoltaic operators, energy storage operators and users under the independent mode; $P_{PV}(t), P_d(t)$ are photovoltaic output and load power, respectively. $P_{b,f}(t), P_{b,c}$ are energy storage charging and discharge power, respectively. $V_{PV}, V_e, V_i(t)$ are photovoltaic power tariff, grid power price.

The income of the three subjects in the cooperation mode is:

$$C_{PV,1} = \sum_{t=1}^T ((V_d P_d(t) + V_i P_{d,PV}(t) + V_e P_{b,c,PV}(t) + V_{PV} P_{PV}(t))) \quad (15)$$

$$C_{BS,1} = \sum_{t=1}^T ((V_i P_{b,dc}(t) - V_e P_{b,c,PV}(t) - V_i P_{b,c,C}(t))) \quad (16)$$

$$C_{U,1} = \sum_{t=1}^T (-V_i(t) P_d(t)) \quad (17)$$

$C_{PV,1}$, $C_{BS,1}$, $C_{U,1}$ are the proceeds of the three main bodies of the mode of cooperation. $P_{b,c,PV}(t)$, $P_{b,c,C}(t)$, $P_{b,dc}(t)$ are the charge power of photovoltaic and grid to energy storage equipment. $P_{d,PV}(t)$ is the power of the photovoltaic and energy storage equipment to the load; $P_d(t)$ is the photovoltaic power.

In the model of altruistic cooperation, the three participants of the project are not all altruistic preferences, this paper assumes that the photovoltaic operators and energy storage operators have altruistic preference, the contribution of photovoltaic operators is higher than the energy storage operators, the optimal production efforts and cooperative efforts are: $a^1 = 0.7$, $b^1 = 0.2$, $a^2 = 0.8$, $b^2 = 0.3$, and the contribution of the photovoltaic operators, energy storage operators, users are $k_1=0.6$, $k_2=0.3$, $k_3=0.1$. $\theta = 0.5$, $\gamma = 0$.

The results of the profit comparison of the independent model and the altruistic cooperation model are shown in table 4.

Table 2. Income comparison of various models

independent mode	cooperation mode	altruistic cooperative mode
297.35	349.36	379.23

As can be seen from table 4, the total income of the three participants in the altruistic cooperative mode is higher than the total income under the independent mode, which is higher than the total income in the cooperative mode.

4. Conclusion

First of all, this paper have the stakeholders analysis of the anti-poverty photovoltaic project and build the stakeholder matrix. Next, this paper introduces the altruism preference to the multi - agent participation in the anti-poverty photovoltaic project, constructs the multi - agent cooperation model of the project owner and other relevant subjects, and analyzes the production effort, cooperative effort, the main output of the altruistic preference team and the output of the whole project. The analysis of the altruism behavior of the participants will improve the project performance and increase the project output. The results are tested by an example. The results show that the increase of altruistic preference will increase the cooperation efforts of the main body and promote the cooperation among team members. The total income of the project under the altruistic cooperation mode is obviously higher than the total project income under the independent model.

Based on the above conclusions, this paper puts forward the following suggestions for the multi - agent cooperation of anti-poverty photovoltaic project:

1) The project owner shall identify and select the main body with altruistic preference to form the team. Because altruistic people will improve their own efforts to improve the output of the project.

2) The spirit of collectivism and team cohesion are the key factors affecting cooperation. Project owners can enhance team cohesion by organizing competitions, competitions and so on, enhance the collective sense of honor of the project team, and improve the social relations among the teams by organizing various amateur activities, enhancing the altruistic preference of team members, enhancing team cooperation and enhancing team performance.

3) In order to promote cooperation better among team members, in addition to material incentive, staff training can reduce the cost of team cooperation, improve the quality of team members, so as to improve the enthusiasm of team members.

4) Altruistic preference may reduce the production efforts of team members, so the client encourages team members to help and cooperate with each other, and to ensure the production level of team members too.

5) Increase the transparency between the main bodies, arrange the action sequence of each subject, and ensure that the latter is mutually beneficial when the main body is not acting simultaneously, so that the efficiency of team production can be improved.

This paper analyzes the impact of the stakeholders and the altruism preferences on the project multi - agent cooperation, and provides theoretical support and suggestions for the project team cooperation.

However, there are a series of deficiencies: how to quantify the theoretical model parameters is still a question, it is difficult to test the model, so the test of the model results only involves three participants, the case study only from the macroscopic angle and not in-depth, so it need follow-up study to further improve.

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