

## *Game Analysis on Promotion Stakeholders of Low-Carbon Building*

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The Asian Conference on Sustainability, Energy and the Environment 2015  
Official Conference Proceedings

### **Abstract**

Recently, the climate change has become a globe issue influencing human survival and development and all countries have taken steps to reduce carbon emissions to address climate change. Low carbon building is one of the effective methods to deal with climate change. However the low carbon building market is developing slowly. Thus, it is necessary to analyze the factors influencing the market promotion. Promotion of low carbon building market concerns about stakeholders including the government, developers and consumers. Considering their interest, a game analysis is done between the developer and consumer under the background of policy support. And the price of low carbon building is calculated which meets the interest of both sides. Results show that consumer dominates the promotion of low carbon building because the developer's decision relies on prediction about whether a consumer prefers to buy a low carbon or an ordinary building. Besides, higher government grants lead to more profits for developers and a lower incremental price for consumers.

Key words: low carbon building; promotion; stakeholders; game analysis

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## **Introduction**

Nowadays, climate change has imposed remarkable problems and significant risks worldwide. The climate change issue affects the basic elements of people's lives, such as water, health, and safety. The Kyoto Protocol 1995 sets a challenging target of reducing carbon emission by 60% by 2050 with real progress by 2020. While China has also set the goal to decrease carbon emission by 40%-45% by 2020<sup>[1]</sup>. According to the IPCC's report, building construction, operation and maintenance together account for 40 percent energy sources and lead to 36 percent of energy-related carbon emissions<sup>[2]</sup>. Thus, it is significant to promote the development of low carbon buildings, especially for its market promotion to control the overall carbon emission. Compared with green building, low carbon building emphasizes on reduction of carbon emission by using low carbon materials, renewable energy and operating efficiently<sup>[3]</sup>.

Low carbon building, as one of the effective methods of dealing with climate change, develops relatively slow. Thus, it is necessary to analyze the promotion factors of low carbon building. This issue involves many aspects, some scholars discuss the defects of the current policy<sup>[4]</sup>, some investigate the feasibility of low carbon building from the perspective of developers<sup>[2]</sup>, some analyze the promoting and restricting factors for low carbon buildings from designers' point of view<sup>[5]</sup> and some put forward the importance of consumer in low carbon building market and analyze the internal and external factors influencing consumers<sup>[6]-[8]</sup>.

However, these researches mainly consider one subject, which are not sufficient to analyze the comprehensive market. Promotion of low carbon building is a complicated target involving many stakeholders. Thus, it is essential to consider the relationship between different stakeholders.

Recently, the researches on multi-stakeholders have focused on government and developers<sup>[9]</sup> without considering the consumer. To make the market of low carbon building develop spontaneously instead of guided by the government, it must consider the benefits needed by stakeholders. At present, due to externalities, the low carbon building market promotion still needs the policy intervention. Thus, the paper establishes a game model considering the government, developer and consumer to explore the promotion of low carbon building.

### **1 Establish the game model**

The life cycle of low carbon buildings involves numerous stakeholders, such as government, designer, constructor, material suppliers, developers, operators and consumers, etc. They will cause certain effect for the promotion of low carbon buildings. However, when confining the stakeholders to the ones who have direct and great influence on promotion, it should only take the government, developer and

consumer into consideration.

### 1.1 The government

The government presents the interest of the public, thus will consider the environmental, economic and the social benefits. It cannot be considered as an entirely rational subject. Regarding the development of low carbon building, it has significant benefits. Thus, it assumes that the government supports the development of low carbon building and will provide an incentive policy environment.

### 1.2 The developer

The developer has two strategies: developing low carbon buildings or ordinary buildings. The influence of developers on low carbon buildings mainly effects by their development decisions. Only when the developers choose to develop low carbon building, can low carbon buildings be traded in the market. Because of the profit-driven, the developers will choose low carbon buildings only when the development of low carbon buildings will provide incremental benefits. Otherwise, they will develop ordinary buildings. The assumptions are as follows:

- 1) Developer is a completely rational economic party;
- 2) Developer will act after perceiving the strategies of the government;
- 3) Developer takes the risk that the consumers do not buy low carbon buildings

### 1.3 The consumer

The consumer is the subject who buy and use low carbon building. A large portion of the social and economic benefits of low carbon buildings emerge gradually in the operation process and the prerequisite is that customers are willing to buy low carbon buildings. Therefore, consumers also play an important role in low carbon building. The consumer has two strategies: buy low carbon buildings or buy ordinary buildings. The assumptions are as follows:

- 1) Consumer is a completely rational economic party;
- 2) Consumer can choose what kind of buildings to buy by them;
- 3) The incremental price of low carbon buildings charged by developers will affect consumers' decision.

## 2 Game analyses

Regarding the benefits of low carbon building and the current situation, it can be assumed that the government will support the market promotion and provide subsidy (N) to low carbon building developers. On the premise of government support, the complete information dynamic game model between developer and consumer is as shown in figure 1.

$\pi_{C1}$  is the benefits for consumer buying low carbon building under the premise when developer builds low carbon buildings.

$$\pi_{C1} = n\Delta S - P - \Delta P \quad (1)$$

$\square S$ ——annual incremental economic benefit compared with ordinary buildings

in operation period

$n$ ——design working life

$P$ ——the price for ordinary buildings

$\Delta P$ ——incremental price for low carbon buildings

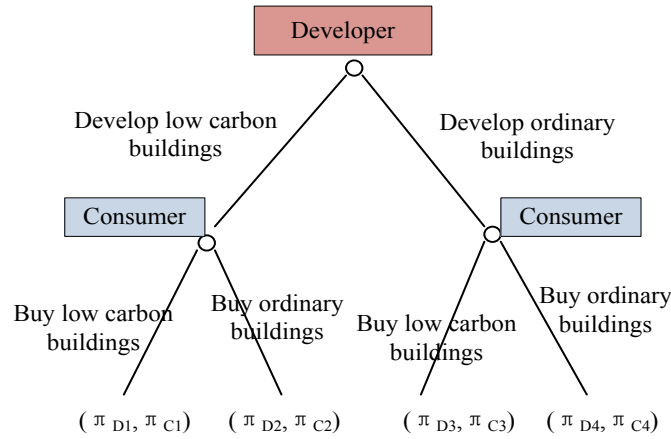


Fig.1 Game model between stakeholders of low carbon building

$\pi_{C2}$  is the benefit for consumer buying ordinary building under the premise when developer builds low carbon buildings. Considering the large amount of ordinary buildings in the market, the cost the consumer pays to find ordinary ones can be simplified into 0. Thus:

$$\pi_{C2} = -P \quad (2)$$

$\pi_{C3}$  is the benefits for consumer buying low carbon building under the premise when developer builds ordinary ones. Because that there are a few low carbon buildings in the market, consumer has to pay to find low carbon building and the price is  $\Delta F$ .

$$\pi_{C3} = n\Delta S - P - \Delta P - \Delta F \quad (3)$$

$\pi_{C4}$  is the benefits for consumer buying ordinary building under the premise when developer builds ordinary ones.

$$\pi_{C4} = -P \quad (4)$$

As to the developer, the benefits it can get when it builds low carbon building and consumer chooses to buy it is:

$$\pi_{D1} = P + \Delta P + N - C - \Delta C \quad (5)$$

$N$ ——subsidies for low carbon building developers

$C$ ——construction cost for ordinary buildings

$\Delta C$ ——incremental construction cost for low carbon buildings

The benefit the developer can get when it builds low carbon building while the consumer chooses to buy ordinary ones is:

$$\pi_{D2}=N \quad (6)$$

The benefit of the developer when it builds ordinary building while the consumer chooses to low carbon ones is:

$$\pi_{D3}=0 \quad (7)$$

When the developer builds ordinary building and the consumer wants to buy it, the benefit of the developer is:

$$\pi_{D4}=P-C \quad (8)$$

### 3 Model Solutions

#### 3.1 Simplification

In the actual analysis, searching cost ( $\Delta F$ ) of low carbon buildings is relatively smaller than other indicators ( $\Delta S, P, \Delta P$ ). It also has relatively less impact on the game result. To simplify the calculation,  $\Delta F$  can be ignored and then  $\pi_{C1}=\pi_{C3}=n\Delta S-P-\Delta P$ ; Developers are profit-seeking, they can passed on the incremental constructing cost  $\Delta C$  to consumers by incremental price ( $\Delta P$ ). So the developer will decide to build low carbon building only when they can earn money, which means that  $\pi_{D1} > \pi_{D3}=0$

#### 3.2 Calculation

Using backward induction, the sub game refining Nash equilibrium solutions are as follows.

1)When  $\pi_{C1} > \pi_{C2}, \pi_{C3} > \pi_{C4}$ , which means that the benefit for consumer to buy low carbon building is greater than ordinary one, the refining Nash equilibrium is (develop low carbon building, {buy low carbon building, buy low carbon building}). The result is:  $n\Delta S > \Delta P; P + \Delta P + N - C - \Delta C > 0$ .

2)When  $\pi_{C1} < \pi_{C2}, \pi_{C3} < \pi_{C4}$ , which means that the benefit for consumer to buy low carbon building is less than ordinary one, if  $\pi_{D2} > \pi_{D4}$ , the refining Nash equilibrium is (develop low carbon building, {buy ordinary building, buy ordinary building}). The result is:  $N > P - C$ .

3)When  $\pi_{C1} < \pi_{C2}, \pi_{C3} < \pi_{C4}$ , if  $\pi_{D2} < \pi_{D4}$ , the refining Nash equilibrium is (develop ordinary building, {buy ordinary building, buy ordinary building}). The result is:  $P - C > N$ .

## Conclusion and suggestions

### Conclusion

1) Whether consumers choose low carbon buildings depends on incremental costs ( $\Delta P$ ) and the expected value of low carbon buildings ( $n\Delta S$ ). Only when  $n\Delta S > \Delta P$ , will they choose to buy low carbon buildings. Whether developers build low carbon buildings or ordinary ones depends on incremental benefit of low carbon building ( $\Delta P - \Delta C$ ), benefit of ordinary building ( $P - C$ ) and the subsidies ( $N$ ). Because that  $P + \Delta P + N - C - \Delta C > 0$ , when the developer predicts that the consumers will buy low carbon buildings, they will build low carbon one. While the consumers are predicted to buy ordinary buildings, only when  $N > P - C$ , will the developer build low carbon building. This means that the government will take the risk that the developer cannot sell out low carbon buildings, which is doubtless a huge burden.

Thus, the consumer dominates the low carbon building market which is in conformity with the market law. The choice of developer depends largely on the consumer. Developers will pass on the incremental building cost ( $\Delta P$ ) to the consumer. When consumers expect the benefit of low carbon building in operation period can offset the incremental cost of buying ( $\pi_{C1} > \pi_{C2}$ ), they will choose low carbon building and drive developers to build low carbon building.

2) In the equilibrium of (Develop low carbon building, {buy low carbon building, buy low carbon building}), the developer and customer both want the maximum benefit which are  $\pi_{D1} = P + \Delta P + N - C - \Delta C$ ;  $\pi_{C1} = n\Delta S - P - \Delta P$ . However the developer wants the price to be higher while the consumer wants it to be lower. So when  $\pi_{D1} = \pi_{C1}$ , the price gets to an agreement, which is  $P + \Delta P = (n\Delta S - N + C + \Delta C) / 2$ .

3) The government hopes that the equilibrium to be developed into (Develop low carbon building, {buy low carbon building, buy low carbon building}). It requires that  $n\Delta S > P$ ;  $\pi_{D1} > 0$ , thus increasing  $N$  can promote the developer and decreasing  $\Delta P$  can promote the customer

### Suggestions

1) Educate the consumer

Low carbon building is dominated by consumers. However, as the difference of education and culture background, consumers have various understanding and expected benefit of low carbon buildings. Consumer's decision largely depends on their expectations on low carbon building ( $n\Delta S$ ). The government should enhance the publicity of low carbon buildings by network transmission, community lectures, advertising and other ways to show the consumer advantages of low carbon building and its benefits in operating period.

## 2) Economic incentive on consumer

Consumers' purchase decisions are determined by the incremental cost of the low carbon buildings  $\Delta P$ . The government can share the incremental cost paid by consumers in purchase phase. The government can also provide certain economic rewards and other preferential policies to encourage consumers to buy low carbon buildings.

## 3) The extension of developers functions

The government can extend the functions of developers to operation stage. The developer is responsible for both the building and operating of low carbon buildings and the operation and be realized by proprietary or outsourcing. In this way, the developer only charge consumer the price of ordinary building (P) and the incremental cost ( $\Delta C$ ) of low carbon building will be charged in operating period by energy saving. It can stimulate the developer and consumer to save energy in operating period and share the consumer's purchase cost to avoid the short-sighted behavior of consumers.

## 4) Policy incentives on developer

Recently, the market of low carbon has not been matured enough. So it still needs the government provide policy intervention, such as the reduction or exemption of tax, economic incentives or low carbon building label.

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