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Assessment of green building policies – A fuzzy impact matrix approach

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ABSTRACT

Green building has achieved a rapid growth as a result of growing public awareness of environmental impacts of the building stock. It is not unusual that governments use policies as a driving force for green building developments. It is well recognized that effective public policies help to overcome barriers to sustainable development. This study proposed a novel approach to evaluate the effectiveness of policies related to green buildings based on the fuzzy impact matrix. This approach was then tested in the Chinese context to assess how effective are those green building policies implemented during the "Eleventh-Five-Year" period. It is found that these green building related policies are heavily environmental sustainability oriented such as building energy efficiency, emission reduction and pollution control. The results showed that some of these policies are effective for promoting green building development in China. However more efforts are required to improve the policy effectiveness on a range of issues such as the fiscal incentive mechanisms; the transformation to integration design model; the development of energy management contracting market; the enhancement of regulatory control during the demolition stage; and increasing the service life of buildings. These findings provide a useful reference to the future policy making process.

Contents

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1. Introduction

It is well recognized that buildings have significant impacts on the environment. These impacts reflected in consumption of natural resources (e.g. water, energy and materials), production of greenhouse gas emissions, and pollutions (e.g. construction and demolition waste; wast water) [1–4]. For instance, the existing building stock accounts for 30% of total energy consumption [5] and contributes towards 25% of greenhouse gas emission of China [6]. The annual production of waste from construction activities reached 300 million tonnes in China, which accounts for 40% of the total amount of waste volume across the country [7]. The International Energy Agency predicted that the volume of the residential and commercial sector will increase 67% and 195% respectively by 2050 [8]. This makes the environmental impacts of the building stock even more significant. Indeed, the building sector plays a crucial role in achieving sustainable future as documented in the *Vision 2050*, the strategic document of the World Business Council for Sustainable Development [9]. Furthermore, these environmental impacts exist not only during the construction phase, but also the operation phase therefore a life cycle perspective is required to deal with cost and benefit analysis of incorporating sustainability principles into building developments [10–14]. These include the emerging concept of embodied energy of building materials compared to operational energy [15–18].

As a result, the concept of green building was put forward to mitigate these environmental issues. Green building is defined by the US Green Building Council as: "…(buildings that) are designed, constructed, and operated to boost environmental, economic, health, and productivity performance over that of conventional building" [19] (p.4). Kibert further defined green buildings as "… healthy facilities designed and built in a resource-efficient manner, using ecologically based principles" [20] (p.9). Since then the green building has achieved rapid development, as evidenced by the steady growing number of buildings that have been certified by various assessment tools. For instance, more than 13,000 buildings have achieved Leadership in Energy and Environmental Design (LEED) certification from the US Green Building Council by the end of 2012 globally with a total floor area of 709.6 million m^2 [21]. The main benefits associated with green buildings include: long term savings from energy efficiency; reducing resource consumption and waste generation; and health and productivity of tenants due to improved indoor environmental quality [22–24].

Public policy plays a paramount role in facilitating sustainable development, e.g. the structure of power generation; performance of wind turbine manufacturers; air quality issues associated with rapid urbanization; the implementation of corporate social responsibility; and development of sustainable community [25–31]. Similarly, the effective endorsement of public policy plays a crucial role for successful green building developments [32].

The aim of this research is to develop a novel method to evaluate the effectiveness of public policies related to green buildings. This method is then tested in the Chinese context to evaluate how effective are those green building policies released during the 11th Five-Year Plan (2006–2010). The contributions of this study are: (1) serving as the key inputs for authorities for the future policy making related to green buildings and (2) providing a useful reference to the assessment of public policy related to green buildings that may be applicable in other contexts.

2. Research methodology

2.1. Conceptual framework

The policy formulation for green building is also a process of goal management. Therefore it is necessary to clearly define the goals of policy, and then to set the corresponding measures against these goals. Based on this logic, this paper provides a methodology of a conversion matrix through the establishment of the goals–measures conversion matrix in order to define the green building policy system (see Fig. 1). The row vector represents policy goals and the column vector represents policy measures against these goals. The elements in the matrix represent the relationship between the goals and policies. This correlation reflects the effectiveness of policies for the realization of goals. Another key issue is to determine the weight and order of policy measures based on the weight of policy goals. This order reflects the priorities of policies for realizing the specific goals.

Therefore, the steps of the policy system based on the goals–measures matrix are:

1. Identifying the policy goals.
2. Formulating corresponding policies.
3. Determining the order for the formulated policies according to the objectives–measures matrix (i.e. the policy with the higher order is more significant for the realization of the specific goal).

As shown in Fig. 2, the first stage of this research involves critical review of relevant literature on green building in China, particularly barriers and policies. A policy assessment framework will be developed based on fuzzy impact matrix. Consequently, relative importance and priority of policy measures will be identified. This is followed by the evaluation of green building related pubic policies in China that were released during the 11th Five Year Plan period (2006–2010). The results aim at providing a useful reference to the future policy making.

2.2. Policy assessment method based on the fuzzy conversion matrix

2.2.1. Methodology selection

Policy evaluation needs a combination of the value analysis and empirical analysis. The fuzzy evaluation method is adopted in this study to establish the green building policy evaluation model. The fuzzy set theory is an effective method for multi-objective optimization problems with a consideration of some degree of subjective imprecision of decision makers [33,34]. In other words, fuzzy theory provides a connection between the subjective judgment and objective analysis. On one hand, the value judgment of policy measures is conducted the fuzzy scoring process. On the other hand, the mathematical analysis is presented via establishing a fuzzy evaluation model.

A triangular fuzzy number is adopted to establish the policy evaluation model. Triangular fuzzy number has been widely used

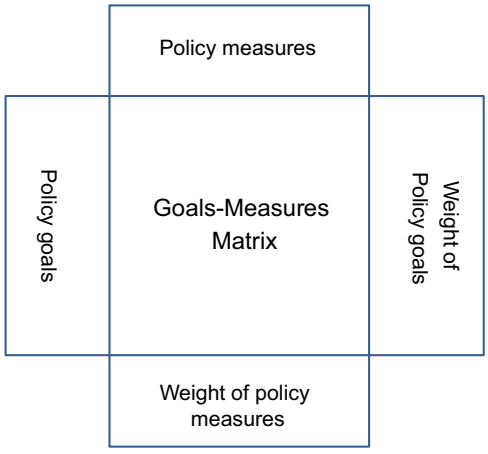

Fig. 1. Goals-measures matrix.