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Social problems of green buildings: From the humanistic needs to social acceptance

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ABSTRACT

In the past few decades, scholars have conducted research and held discussions on green building to highlight their vital significance in addressing environmental, economic and social challenges. It is recognized that public attitudes and views towards green building may affect its application in daily lives, although studies on consumers' cognition are rarely carried out. The social problems related to green building such as consumers' basic understanding, purchase intention, social and humanistic needs, public attitudes and behaviors, rebound effects and furthermore social acceptance are therefore studied, based on three research methods including literature review, questionnaire and inductive analysis. Through the analysis, following results can be obtained: (i) green building's sustainable design has quite important influence over consumers' decision making process. The general public maintains a high regard for the advantages of green building, where better ventilation and lighting is a major benefit, saving energy and water are the second rated, and then land and construction material saving. (ii) Although the general public is not being familiar with the concept of green building, the majority of participants would pay more for green buildings over the standard building when they know the environmental impacts of them. (iii) Green building should not only be limited to energy performance-oriented, but also be user-oriented, the social and humanistic needs model is thus well established based on Maslow's Hierarchy of Needs. In the life cycle of green building, social and humanistic needs show a trend of dynamics, which means social processes with consumer engagement and participation needs to be considered in aspects of conceptual design, planning and design, operation and maintenance to improve users' happiness and productivity. (iv)Current user-oriented solutions to green building are always based on a hypothesis that consumers are readily motivated or prefer expensive goods for reducing energy use, to really reflect preference and influenced actions, social acceptance should be analyzed to fully gauge interest and perspective of the people. (v) Rebound effects of post-occupant building performance, including energy performance, human comfort, indoor environmental quality, greenhouse gas emission and workplace productivity can be divided into two stages. At present, it is necessary to establish appropriate samples, methods and parameters for an unbiased and valid post-occupant evaluation system. In addition, the social acceptance of green building framework is established based on Wüstenhagen et al. triangular model for renewable energy innovation. All the explorations to social problems of green building in this article are expected to provide a healthy social basis for the development of this green strategy.

Contents

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1. Introduction

Over the past few decades, the building energy consumption has surged with the improvement of living standards and growth of population. In developed countries, such as Britain, United States and Australia, it is estimated that the building sector accounts for 20% −40% of the total energy consumption [1,2]. Meanwhile, CO_2 produced by the building industry accounts for 40% of the total carbon emissions [3,4]. While in the peripheral countries, the growth rate of building energy is much higher than in developed countries, which correlates to more serious pollutant discharge [5,6]. The increasing environmental problems and energy depletion challenges are the driving force of the pursuit of energy efficiency, ecology and sustainability. Therefore, the important concept of green building, using these characteristics, was created for this rapid development. The idea of green building can be considered as a major reform in the history of the building industry. Goals in marketing residential and commercial spaces have changed from achieving occupancy rates to systematical controlling the construction to provide a healthy, and comfortable space for activities, as well as sustainability for the space [7,8].

The philosophy of green building is derived from Arcology, a combination of architecture and ecology put forward by Paolo Soleri in the 1960s. It aims to create a healthy and comfortable living space for humans, and also ensures energy efficiency and environmental protection [9–11]. The topic of “green building” was formally presented at the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992. Conceptually, green building is dedicated to provide users with healthy, comfortable and safe living, working and activity space. At the same time, it can achieve goals of implementing efficient use of resources (energy, land, water and materials), while minimally affecting the environment through the life cycle of the building (material production, planning and design, construction, operation maintenance, demolition and recycling process). Although many definitions of green building are given, a common theme is that the main scope of green building can be divided into three categories of environment, society and economy [12–14].

In the past 50 years, the concept of green building has gradually been established after much investigation [15–18]. In 1990, the first scientific rating system named Building Research Establishment Environmental Assessment Method (BREEAM) was established to make a comprehensive response to building and environment contradictions. The Leadership in Energy and Environmental Design (LEED) system in America activated a green building rating system with a global commercial operation for awareness. Many countries have so far issued complete rating systems with distinctive features to provide the basis for an orderly and sound development of green building [19–23]. However, this extensive research conducted mainly focuses on tackling the key technical problems and practical application. The preferences and behaviors of the public towards the green building still remain vague. Therefore, we argue that ensuring positive attitudes and perceptions of green building is significant to the implementation.

This article aims to analyze the social problems related to green building, from social and humanistic needs to public attitudes and behaviors, from consumers' purchase intentions to the rebound effects of post-occupant building performance, those may influence the development of this sustainable project. Research methods including literature review, questionnaire and inductive analysis are introduced to identify the public potentials and research the willingness to utilize green building methods in Section 2. A questionnaire with a sum of 116 fully answered respondents in Section 3 is rigorously studied to get a better understanding to public attitudes towards green building and their purchase intentions. Based on this, in Section 4 social factors in the life cycle of green building which have some potential influence to investments, environmental impacts and human satisfaction are analyzed in aspects of humanistic needs, public attitudes and rebound effects. And then, Section 5 presents the definition of social acceptance of green building in accordance to its basic structure in renewable energy innovation with three dimensions, social-political, community and market acceptance. The social problems research on green building is still in the early stage, so the discussions and conclusions in this article are expected to provide a healthy social basis for the development of green building.

2. Research methodology

In this article, there are three main research methods, including literature review, questionnaire and inductive analysis, which are used to study the social problems of green building. It is well known that research on green building has become a global problem after several decades of development and it has been extensively studied in many fields, such as sustainable technologies, social and economic demands and political aspects, etc. Based on the various steps of development, we have made a literature review on the development process of green building and explained the definitions and advantages of them in detail. Green building is currently regarded as one of most important means in construction industry to reduce the carbon dioxide emissions and to solve the energy crisis in both developing and developed countries, therefore, how to develop green building is an

important research theme. The achievements obtained and goals about developing green building could definitely cause certain effects on public living habits, attitudes, humanistic needs and social acceptance, and in general, social problems in the development of green building will be generated.

In order to survey public citizens' understanding of green residential building and their intentions of buying them, an academic questionnaire was conducted. In the process of questionnaire design, we carried out a literature review of green building at the very beginning, and then a list of people's possible recognitions to the advantages of green building was given. This questionnaire is conducted via a professional survey website and we could ensure it is scientific and open from the following three aspects: (i) Green building is for all individuals in the construction industry, which means everyone who has the intention to buy a house could be a potential owner. The questionnaire in this article is for the mass instead of engineers or designers who are only related to construction industry, these people generally have a better understanding of and recognition to the green building, thus the results of this questionnaire are more convincing than others who are only for professional in urban planning and architectural design. (ii) The process of this investigation is open. In the process of this investigation, the questions given are suggestive because participants might be confused when they are faced with an unfamiliar conception about green building, so that interviewees are able to get access to data in a timely manner to answer next question under the premise of ensuring impartiality of one question. (iii) At present, green building are mainly developed in urban areas in the forms of large-scale public buildings and residential buildings. Network survey can guarantee that the participants have some common sense about urban energy-saving building, therefore this could make sure that the interviewees in this questionnaire are consistent with the users of green building.

At the end, a total of 116 fully answered questionnaires were obtained, as shown in the Appendix. In general, three sections are included in this questionnaire. The first section is designed to obtain the basic information of interviewees, including gender, age, annual incomes per person, family size, occupations and education background. All these factors have certain social influence to people's buying intention of green building. The second section is conducted to investigate public basic knowledge about green building, including people's familiarity to, basic conception and evaluation criterion of green building, and all the understandings are prerequisites for the general public to purchase green building. Compared with conventional building, green building could achieve the goal of harmony between nature and human beings. In the lifecycle of green building, it could reduce the consumption of resources (including land, water, energy and construction materials), reduce the impact on environment and improve indoor environment. Therefore, the last section has directly inquired participants whether they are willing to purchase green building in three aspects. At the very beginning, the effects of advantages that may determine your purchase intentions of green building are investigated, so as to assess the importance of them. According to Ministry of Construction (MOC), green building can be labeled as three levels, one-star, two-star and three-star. This could influence people's choice to some extent, and then those influences of labels are surveyed. At the end, we investigate people's willingness to pay more for green building if other factors, such as location, traffic and environment, are same with conventional counterpart, namely, their price expectations to the environmental effects of green building.

When it comes to the social factor that determines people's purchasing choices to green building, it not only includes some basic humanistic needs, but also includes views of people who are involved in the construction industry, economic efficiency and their performance in building life cycle, therefore, the methods of literature review and inductive analysis are adopted to analyze the factors mentioned above. Compared with the traditional counterpart, green building in addition to have some basic features of building energy efficiency and in harmony with nature and environment in its whole life cycle, it should meet some humanistic needs, including architectural styles, public facilities, cultural heritage and green living space. At present, the construction sector has become an important commercial market all over the world with a complete industrial chain. From the investment, research and development, construction, operation and maintenance of green building, a large number of participants are involved and their views or attitudes will affect the development of green building. In the green building life cycle, its economy including economic, environmental and social benefits also affects the promotion of green building. Hence it is necessary to carry out cost-benefit analysis to reduce the cost in the context of its full function. The research and development of green building is still in its infancy, many green buildings are just pilot projects with high-demanding building technologies. However, according to some research work, rebound effects exist in some green buildings. This phenomenon that might be detrimental to the promotion and application of green building in the whole society should be highlighted.

These above problems have jointly turned into a big issue, which might be a barrier in the development of green building, but has so far received little attention. Social acceptance is associated with two basic elements, namely, two words “social” and “acceptance”, which have their own extensive meanings, respectively, it is therefore hard

Table 1
Basic information of interviewees.

Item	Group	Proportion (%)	Item	Group	Proportion (%)
Gender	Male	47	Age	18–25	21
	Female	52		25–35	39
	NA	1		35–45	11
Annual incomes (10^4 RMB)	<1.8	6		45–55	10
	1.8–6	9		>55	18
	6–12	32		NA	1
	12–18	31	Family size	≤ 2	20
	18–36	9		3	61
	>36	9		4	17
	NA	3		≥ 5	2
Occupation	Senior management	2	Education	High school or below	10
	Middle management	8		Junior college	16
	General staff	36		Bachelor degree	45
	Self-employed	3		Master degree	21
	Student	29		Ph.D. or above	7
	Emeritus & retired	16		NA	2
	Others	6			

to give a clear definition of green building. Among the definitions provided by researchers, Wüstenhagen et al. [24] have studied the application of social acceptance in renewable energy innovation and put forward an exact definition from socio-political, community and market acceptance based on triangular model, so as to solve the conflict between public support and the implementation of real projects. This important concept then is introduced, meanwhile, to fully understand the meaning and research significance of social acceptance, questions related to the concept of green building are investigated via literature review. In the building industry, research on social acceptance is only focused on the development and utilization of green building, aiming to reveal public support and acceptance of sustainable and renewable energy technologies. Thus, we have made a literature review on the social acceptance in new energy sector, furthermore to summarize main problems existing in socio-political, community and market aspects. Based on the above analysis and three-dimension model given by Wüstenhagen et al., a triangle model about social acceptance is established in the green building contexts to improve public awareness and promote its development.

3. Questionnaire and its results

3.1. Basic information of interviewees

The sample, as shown in Table 1, included 60 women (52%) and 55 men (47%), which illustrates a balanced gender distribution, and the sample can be regarded as representative of the population (1% answered not applicable). The mean age of the interviewees was approximately 35. Among the participants, the majority was between 18 and 35 years old, about 60%, at which age range people are more likely to be potential consumers to buy houses in China. About 18% belonged to the age group of more than 55 years old, and the proportions of people who said they are 35–45 and 45–55 years old were both about 11%. From the age structure, the age groups of interviewees meet the request of both balance and continuity, which is in accordance with the age distribution of society as a whole.

This sample is made up of survey participants that include management (about 9%), general staff (about 36%), self-employed (less than 3%), student (about 29%) and retired (about 16%) positions. The respondents come from many fields. This means that the needs of the respondents' for social acceptance of green building are universal. The average income is about $24,900 per year (155,625 RMB according to the current exchange rate 1RMB=0.16 US dollar). The highest incomes among the sample (more than 31%) are $9600–$19,200 and $19,200–$28,800 per year. About 11% have an income between $2880 and $9600 per year. The people who indicate an income between $28,800 and $57,600 per year equate to about 9%, while about 6% have an income of less than $2880 and close to 9% have an income of more than $57,600.

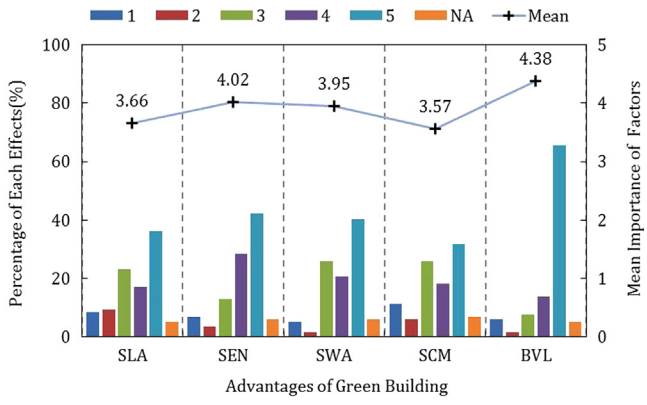

Fig. 1. The influence of the advantages of green buildings on people purchase intentions (Corresponding to the Question 10).

With respect to the family size, most of the respondents (about 61%) are living with a family of three people. About 17% of other responses show living in a family of four people and about 20% show having less than two people in a family. Less than 2% have a family of more than five people. Family population is an indirect factor for the needs of society that lie behind the social acceptance of green building. When referring to the education, bachelor degree and master degree are the mainly with the percentage of approximately 45% and 21%, while more than 15% are junior college with only about 10% have a high school or below educational level. And less than 7% are Ph.D. or above. People in different education will have different needs to social acceptance of green building.

3.2. Assessment of the effects of each advantage

In this assessment of the importance in green building advantages, we have not given any emphasis to particular variables or used normalize methods, because some methods used in other articles have misled the researchers and drawn distinctively different conclusions [25,26]. Fig. 1 provides the assessment of the importance of each advantage green building has over conventional building in the eyes of the general public. In evaluating the samples purchase intentions, each element was rates for the significance it would have over a purchase decision. The selection consisted of (i) no influence, (ii) very small influence, (iii) some influence, (iv) direct influence, (v) important influence. Respondents were to rate the categories of saving land (SLA), saving energy (SEN), saving water (SWA), saving construction materials (SCM), and better ventilation and lighting (BVL).

In general, a score of 1 or 2 accounts for less than 10% of the selections made. Few of the responses indicated that green building advantages had no influence to their purchase decision. This supports the conclusion that the public maintains a high regard for the advantages of green building that were mentioned. The sample acknowledged that green building's sustainable design has quite important influence over their decision making process. In addition, from the graph we can see score 3 and higher all generally account for more than 80%, and this can clearly be seen in Fig. 1.

The information provided also shows that the factor considered most important to respondents in green building was better ventilation and lighting. About 65% of responses rated better ventilation and lighting as 5 out of 5, which is the highest rating. This advantage had an overall mean of 4.38. Saving energy was recognized as the second most important advantage of green building, with a mean of 4.02. Indicated as the least important advantage factor, and 3.57 as the mean, was saving on construction materials. Saving land was a close second to last and saving on materials just above it with a mean of 3.66 and 3.97 respectively. This shows that the population sample has understanding of the important factors in sustainable development. Better ventilation and lighting is a major benefit of green building, where as saving on construction materials is not necessarily a noted advantage. Saving energy and water are the second rated, showing that the respondents feel that green building is enough effective in conserving natural resources that it would influence their purchase decision.

3.3. Basic understanding of green building and purchase intention

In the survey of green building some of the public indicated not being familiar with the concept of green building, which is shown in Fig. 2. About 30% of participants selected that the concept of green building refers to the color green, or the color of outdoor or indoor plants. About 40% of respondents were somewhat or very

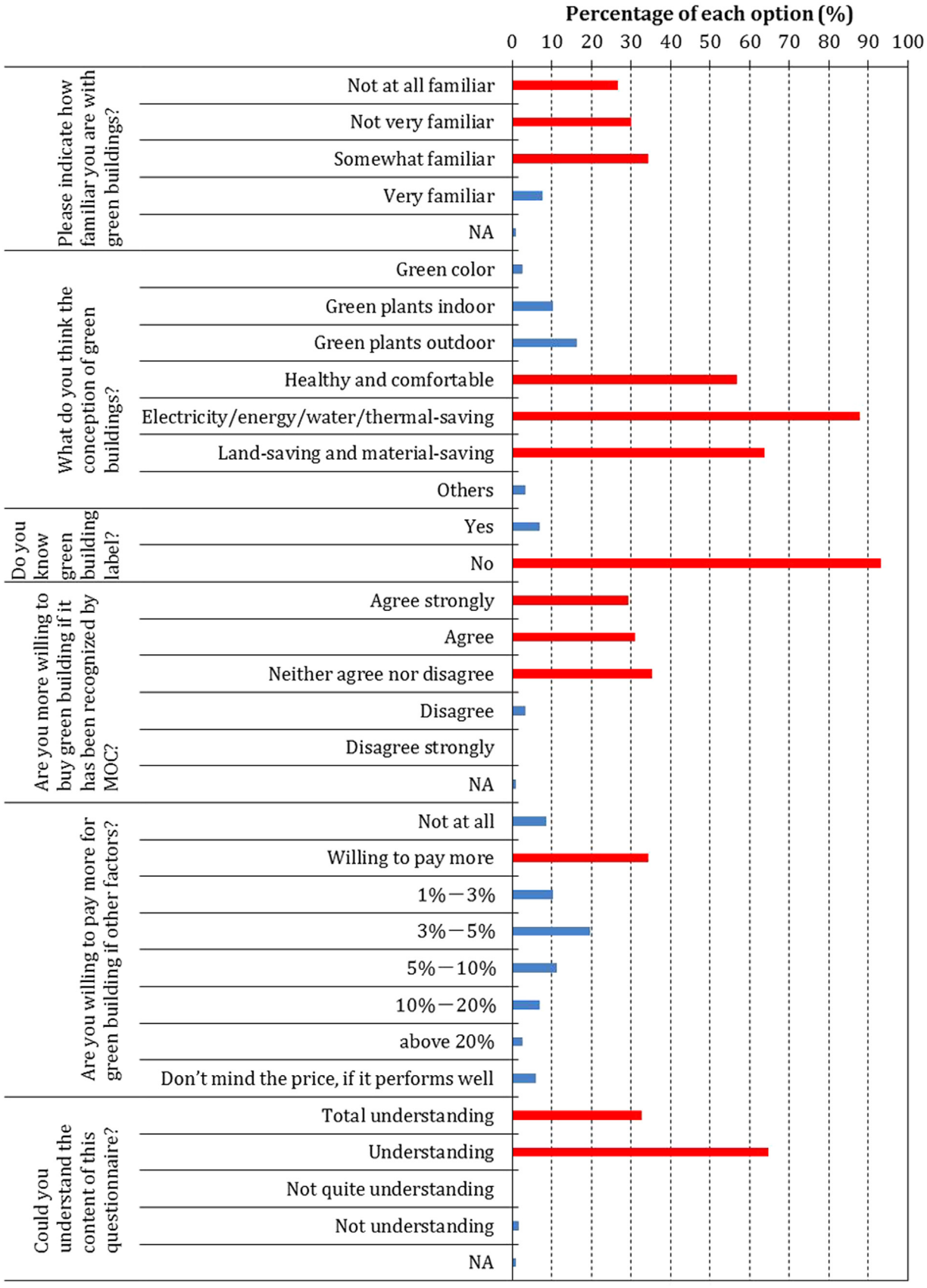

Fig. 2. Citizens' basic understanding of green building and purchase intentions.

familiar with green building. Only 10% indicated being very familiar with the green building concept. Therefore, about 60% of the sample was unfamiliar with this type of building. Over 90% of participants were also unaware of green building labels. This result offers evidence that shows the social understanding of green building is still in the early stage. The social familiarity with the

concept of green building is essential for the success of future sustainable building. Without the knowledge of green building, the public and consumers are not able to make informed decisions. Green building is more expensive and challenging for investors and designers, therefore the greatest incentive for companies to pursue this sustainable method is social advocacy to create motivation to pay more.

About 40% of responses also disagreed or were indifferent about being more inclined to purchase a recognized MOC building. At present, many advanced, innovative building technologies are generally being used in green buildings, pushing the cost of green buildings to be much higher than the conventional alternatives. However, about 30% agreed and strongly agreed respectively, to being more willing to purchase a recognized MOC building. A positive assessment from the survey indicates that less than 10% would not pay a premium for the features of a green building despite its ability to be sustainable and beneficial for the environment, providing balance in the urban economies. This means 90% of the sample would pay more for a green building over the standard building, though 35% are unsure of exactly how much more. In this category there are just fewer than 10% of responses that would not consider paying more just for green building certifications. It is promising that the responses showed many would consider paying more for the MOC recognition. It can be said that although the sample states not being too familiar with the concepts of green building, the public does understand its value. The general public appears to give more significance to the innovative ideas of green building though it is in the very beginning stage of social acceptance development.

Overall the survey indicates that 100% of the sample understood the questionnaire, just over 30% stating total understanding and just fewer than 70% selecting basic understanding. The population selection understood the important aspects of green building but there is still improvement for complete understanding of the concept. Educating society on these important factors of green building can help improve the public desire to live in and pay for a more sustainable living environment. Most of the responses indicate some awareness of the value and benefits of green building, but continuing to inform society can further enhance comprehension of the benefits in green building.

When looking at the demographics of the sample some conclusions can be drawn as well. A little over 70% of the sample has completed a Bachelor's degree or above. This may indicate why the responses showed knowledge of green building despite the populations overall lack of awareness. Students made up about 30% of the sample. Sustainable approaches and new technologies are typically taught in college and would also explain the understanding of green building shown in the questionnaire. Additionally, the largest age range of the sample was 25–35 years old. This age range accounts for about 39% of the sample. The individuals in the 25–35 age range are typically the young professionals. With green building being a newer trend in our society it seems logical that the young professionals would be familiar with the concept. This awareness is beneficial for the success of green building in the future. If the young professionals are more aware of green building it can mean that they may also be more likely to understand the benefits of it as well. This age range would then prefer more sustainable housing when they are ready to purchase a home.

4. Social problems related to green building

Although the concept of green building has been established for several decades, citizens' basic understanding of green building is still weak. Nevertheless, green building should be basically imparted with many advantages, such as energy saving, resource saving, water saving and healthy living and workplace. According to Rick Fedrizzi [27], Chairman of World Green Building Council, in the whole life, green building should meet requirements of sustainable site, optimal energy efficiency, sustainable materials, indoor environment quality and independent monitoring and certification party. Meanwhile, the potential huge economic benefits that could be main power of green building promotion should be envisaged. Therefore, in this era of construction industry, the development of green building should take human health and comfort, economic return, environmental impact into account. In general, these factors are reflected in the aspects of humanistic needs, public attitudes, economy and its life cycle respectively. When it comes to the environmental impact, it is not only related to a special walk of life, but a complex challenge that needs to be faced up by the society as a whole. Based on the gathered information, consumers will establish basic rating standards, which direct the work of comparing, evaluating and even forming a purchase decision on some potential products. In the process of publicity, performances of green building concerning energy intensity, cost-effectiveness and environmental comfort, have a huge impact on the decision-making [28,29]. In order to convince the better performance of green building, it is necessary to obtain field test data, and then make a comparative evaluation based on green buildings and conventional ones.

4.1. Social and humanistic needs

When it comes to green building, its environmental impacts rather than user's options and choices obtain great attention. For

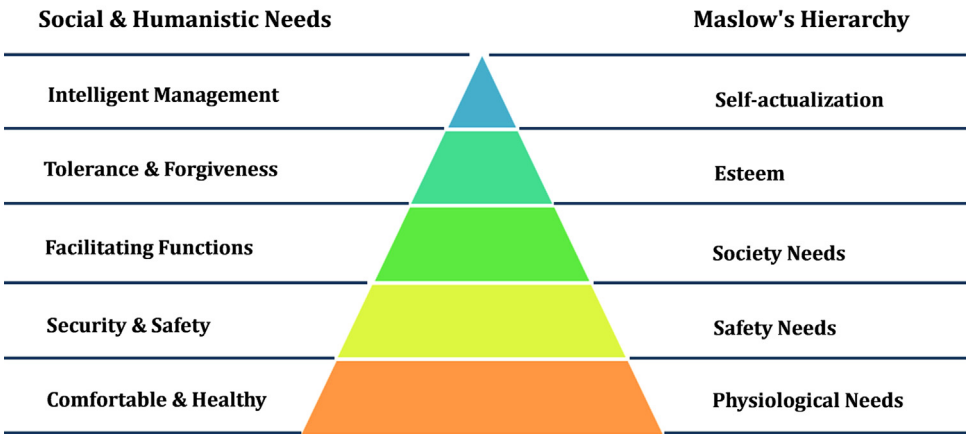

Fig. 3. Maslow's hierarchy needs for green building.

some researchers however argue that design cannot exist without the use of consumers, we come to realize that research on green building should not be limited to energy performance-oriented, but also be user-oriented [30]. The user-related green building research that includes individual options and choices might be deemed just to bring benefits to consumers, by means of gathering their individual feelings and then maximizing their satisfaction and productivity. As for designers and investors, on the other hand, they could indirectly collect the data and form a media catalog about the bidding and the buying model, which reflected by individual consciousness and behaviors.

The user-oriented research, namely, the social process of green building includes its sales volume as well as many indispensable human needs, whose ignorance will greatly degrade the achievements of green building achieved so far, according to explanation of social process of sustainable consumption [31]. From the perspective of living demand, different levels of social and humanistic needs should be satisfied. According to Maslow's Hierarchy of Needs, it is easy to know living space should perform requirement of physiological, safety, society, esteem and self-actualization. Based on that, Zhang and Ke [32] have preliminary explained the humanistic needs in four aspects, including comfort and health, security and safety, facilitating functions and intelligent management. As shown in Fig. 3, the most basic part is to provide a comfortable and healthy living environment for human beings in terms of physical environment (including noise, light, heat, air quality and environmental quality) and psychological environment (including humanities, public order and living entertainment). While the needs of security and safety can be divided into physical and psychological parts, facilitating functions contain public hardware services, creating good prerequisites for building construction and operation. Intelligent management, an important part of green operation, has adapted needs of residential functions, but also has reflected the consumers' improving demands of living environment and quality. In reference [32], Esteem is thought as a part of intelligent management, but we argue that the tolerance and forgiveness received by green building are more appropriate to reflect the quest of esteem. A higher tolerance and forgiveness to deficiencies existing green buildings happens to be users' recognition and respects to these buildings.

Along with the life cycle of green building, social and humanistic needs show a trend of dynamics. In this part in order to improve users' happiness and productivity, the social processes with consumer engagement and participation are explained in four sections, such as conceptual design, planning and design, operation and maintenance. Conceptual design is the process that predefines performance and contents of green building. In tradition, the philosophy of sustainable environment was highlighted, however, humanistic concerns, also a part of architectural design, cannot be ignored in the earliest design stage. Design intention, for design researchers, is the key thing to be considered, that is to say “how humanistic concerns of buildings work to maximize users' subjective feelings”. In planning and design stage, utility has been mentioned as an essential question by means of how buildings work well to serve their real purposes and afford their capabilities [33]. At present, very few researchers have studied the social and humanistic needs on green building, Li et al. have analyzed the demands of social problems in terms of architectural style, residential space and public service facilitates [8]. Apart from these factors mentioned, architectural context and regional characteristics and natural landscape that may have large subjective, cultural and ideological meanings should also be focused. Next stage comes to operation of green buildings, in which phase effect should be thought as the main element, namely, “how green buildings perform to improve the level of humanistic needs”. It is in this stage that Maslow's hierarchy needs for green building are realized from the physiological needs to mental experiences.

Many researchers have mentioned that building should be a concept of four dimensions, including the eyed 3D space and existing time dimension. In the life cycle of buildings, maintenance stage involved in operation stage accounts a large proportion of building life, showing an increasing importance with the increase of building service. Furthermore, it is necessary to highlight that user's social requests for architectural design is not invariable. The life of a building can be extended to more than 100 years, which means at least three to four generations will use it. This could be imaginable that large numbers of daily requirements will change to support life styles. Therefore, the maintenance stage needs to focus on how to make buildings reach humanistic needs at different levels. However, there will always be limitations because it will be very difficult to make the assessment of real needs over 100 years that can be incorporated in design or made provisions that will be added later. To address this issue, one must design buildings to be flexible and adaptable at minimal effort, giving preferences and priorities to occupants and future house owners.

4.2. Public attitudes and behaviors

Under the influences of the incentive based market economy, green building, as a commodity, is becoming the focus of global attention. From its production to the operation, green building requires mutual support of different groups, which also constitutes a complete industrial chain. As the distinctive parts of this industry chain, administration, real estate institutions, research and design institutions, construction organization, product supplier, consumers, financial institutions and media are all a driving force and influential factor in the development of green building [34]. However, consumers and real estate investors are the main participants from the perspective of buying and selling, as well as other institutions and agents involved in motivating the rapid and healthy development of green building [35,36]. At present, the existing policies and measures issued by administration, and others, aim to promote consumer adoption of green building. Therefore, consumers are becoming the potential recipient, which is not conducive to form a good cycle mechanism [37–39]. Thus, it is essential to analyze the consumers' attitudes and demand requirements for high participation in green building.

It is well known that the social perception and public behavior of human beings are influenced by attitude. Furthermore, people's work and life are both largely affected their attitudes regardless of right and wrong [40]. However there is no general conclusion of what is attitude and how to define it. Considering the theory of consumer's behavior, Baron [41] noted that the consumer's attitude is an individual psychological tendency for a particular thing, including cognitive, affective and behavior. Ajzen [42] and Hagger [43] put forward the theory of planned behavior and influence factors, and concluded that affective attitude is more predictable. Huang's literature review contained the definition of consumer's attitude and defined the attitude with the three dimensional variables of instrumental composition, affective attitudes and behavior tendency. In addition, some potential factors that may influence attitudes are as follows: social class, social community, buying conditions, information transmission, regional culture, family life cycle and commodity cognition, instrumental composition, emotive attitudes and behavior tendency [44].

Based on the above analysis, Huang [40] conducted an investigation about the public attitudes towards the green building in Changsha City, China. The results, to some extent, show that people have formulated ideas on the green building, and they definitely consider green building as beneficial to the ecological environment. Nevertheless, there are some misunderstandings of green building and real estate due to misleading investors and insufficient publicity. Most people hold conservative and doubtful

attitudes because business operation and profitability of green building are not transparent. That indicates people who are and are not willing to buy this new type building both make up a large proportion when asked whether they are ready to pay for green building. Although public green building is a good prospect, society's attitude towards the development of residential buildings should be researched, just as the utilization of renewable energy and green electricity [45,46]. The role of developers and investors has always been emphasized, while no feedback mechanism for consumers' attitudes has been formed. This gap in analysis can largely restrict the development of green building [47–49].

In addition, researchers and policy-makers attempt to put forward some relevant, people-oriented solutions after their full analysis of building energy efficiency. However, those given suggestions and recommendations are always based on a hypothesis that consumers are readily motivated or prefer expensive goods for reducing energy use [50–52]. Mithra and Kathryn [53] pointed out, the consumptions of: (i) If only they knew; (ii) If only they could do and care and; (iii) If only they stayed home have omitted the social background, and therefore these limitations should be expanded. To really reflect preference and influenced actions, even the potential effects, social acceptance of green building should be analyzed to fully gauge interest and perspective of the people.

4.3. Rebound effects

In the development of green building, it is always described as a kind of high performance building with several characteristics of sustainability, environmentally responsibility, resource efficiency, good comfort and high productivity. Meanwhile, according to a report from the United States Green Building Council (USGBC) [54], green buildings do exhibit positive environmental impact, occupants comfort, productivity and health at the cost of higher investments in construction, operation and maintenance. Thus, occupants would have a vision that this kind of buildings outperforms conventional counterparts in many fields, such as indoor environment quality (IEQ), energy saving and occupant comfort and satisfaction. For example, in a green office building, workers should enjoy a more comfortable and healthy workplace with better IEQ and this could definitely result in a higher productivity.

Due to the feature of expensive commodity, green building not only has important real-estate values, but also exhibits environmental effects. In the marketplace, following the gradually mature green building rating systems, green building has already taken a large proportion. As for environmental effects, it is critical for green building to show great advantages of minimizing energy consumption but still supplying good indoor environment [55]. Therefore, only by verifying their anticipated environmental benefits can green building improve continuously in the long term. In order to promote green building projects, solid evidence of their lower environmental impacts should be provided. Since the construction of high performance buildings, it has been more than ten years for their operation and maintenance and it is time to evaluate whether they have reached original requirements.

At present, several institutions and researcher have conducted research on the performance of green building. According to 2014 statistics from USGBC [56], green buildings generally exhibit obvious environmental effects. LEED-certified green buildings consume 25% less energy, 11% less water and emit 34% lower greenhouse gas (GHG) than average commercial buildings. Meanwhile, they spend 19% less maintenance investments but result in 27% higher occupant satisfaction. Of course, these effects have brought great benefits to American society. In general, LEED green buildings have reduced the CO_2 emission by 0.35% in 2011 and it is predicted that LEED will contribute to 4.92% CO_2 reduction in 2030. However, all data the general public can obtain are shown in the way of overall results, data of separated LEED-certified buildings submitted to USGBC are not open to researchers. It is hard for them to know the sample of green building set and the comprehensive performance of particular green building. Later, based on limited sample provided by New Buildings Institute, some groups have studied the energy use of green building. In terms of site energy saving, the conclusion drawn by USGBC is confirmed, but LEED certification does not exhibit any influence on energy consumption reduction and GHG emissions when it comes to source energy. Compared to conventional buildings or design goals, the phenomenon that green building shows inconspicuous or lower expected performance (such as energy saving, resource efficiency, higher indoor comfort, less GHG emission etc.) can be deemed as rebound effects, which originally referred negative relationships between energy efficiency and energy consumption in relation to economic growth [57,58]. In energy economics, several scholars later evidenced the empirical existence of energy rebound effect and studied its magnitude as well as influencing factor based on empirical methods [59,60,61,62]. Likewise, energy rebound effect had also been advocated and studied in both fields of heavy industry and residential buildings based on different mathematical models [63,64].

The rebound effects of green building have been verified by many researchers, as shown in Table 2. Before 2006, actual performance of green buildings were mainly compared with their design goals, modeled energy consumption or energy baseline given by codes. In general, green buildings seem to consume less energy, but a wide range of buildings measured do not exhibit as expected. This trend was confirmed by studies from Torcellini [65], net energy consumption of green buildings was far less than that of code-based buildings, but this was still much more than their expected values. At the same time, studies from Diamond [66] revealed the same effects, although billing data was lower than value of code compliant buildings, green buildings did not witness energy reduction than modeled buildings in USGBC. In addition, occupant satisfaction also seems to be improved, but it fails in many aspects.

Apart from the potential problems in green technics and applications, reasons for rebound effects before 2006 can be summarized as follows. (i) At the very beginning, designers had good intentions to greatly alleviate environmental impacts led by buildings when they got the knowledge that building represented a large proportion of primary energy use and GHG emissions. Ambitious goals including multi-dimensions of sustainability, such as energy efficiency, resource management and human comfort, were therefore established, but at last it turned to be negative results. (ii) Numerical simulation methods were gradually used in the building design process, analyst attempted modestly to achieve the consistency of modeled and actual energy use, but materials and energy performance in real operation were quite relaxed, compared with accurate data and information input computers. Although an integrated group of high-performance materials or elements in numerical simulation could achieve higher energy scores, but in real buildings, these might be just a set of symbols of green buildings with low functions. (iii) At present, rating systems are well developed and they play beneficial roles in lifecycle of green buildings, but ten years ago these frameworks were not available. It should also be observed that no experience or lesson could be mirrored from preceding buildings.

After 2006, energy use and satisfaction of green buildings were compared with conventional buildings. However, the results showed a trend that green buildings, on average, cannot outperform common buildings. Newsham et al. [25] has re-analyzed the post-occupancy energy use of 100 LEED-labeled green buildings, the results showed that there is little correlation between the energy intensity and certification level. A positive might lie in the fact that LEED buildings present green

Table 2
Research on the performance of green buildings.

Reference	Research scope	Analysis & results
[65]	Six buildings with initial interests of lower energy consumption were field measured for more than one year. Their actual energy performance was respectively compared with their design goal and the performance of code compliant, base-case buildings.	Compared with code compliant, base case buildings, the six high-performance designed buildings showed a great advantage over net source energy saving, with the range of 22–79% less than the value set in code, but did no buildings realize their anticipated value in design process. A wide range of problems existed in the creating process of high-performance buildings, such as design and construction process, operating process (lighting and HVAC systems), construction and commissioning process, monitoring and evaluation process, etc.
[66]	Modeled and actual energy performances of a sample with 21 LEED-certified green buildings were compared, where the modeled energy performance was got via utility billing data and modeled energy data was determined by the data submitted to USGBC.	Actual energy use of 18 green buildings was 1% lower than their simulated energy amounts, which were modeled as 27% below the baseline. A large variability about 50% showed that some green buildings performed worse that modeled ones. The level of LEED energy credits were irrelevant to actual energy used on every floor area in green buildings.
[67]	Post-occupancy evaluation was made in terms of physical features (including temperature, ventilation, lighting and noise) and soft features (including design, image, needs, health, and perceived productivity) based on Building Use Studies of 22 green buildings and 23 conventional buildings.	For physical features excluding lighting, green buildings generally underperformed their conventional counterparts. Although thermal comfort performance in the best green buildings was better than that in conventional buildings, it was still too cold in winter and too hot in summer, respectively. With regards to soft features, green buildings outperformed or at least were the same as conventional buildings, but perceived productivity was slightly lower with a greater variation.
[68]	A green building and a conventional building on two separate university campuses in Southeast Australia with a typical Mediterranean climate are studied to test their occupant comfort and satisfaction based on a x^2-test questionnaire in the aspect of esthetics, serenity, lighting, acoustics, ventilation, temperature, humidity, and overall satisfaction.	Subjectively, interviewed individuals were more likely to think green building are more comfortable, especially work space in green building were only perceived to be warm but that in conventional parts to be poor. In fact, green building had not offered any evidence to verify the hypothesis that it could outperform in terms of esthetics, serenity, lighting, ventilation, acoustics, or humidity. In addition, the higher anticipated thermal comfort with unobvious true results had reduced the general satisfaction of green building.
[25]	A comparison of energy consumption in terms of Mean Energy Intensity was made between the energy use of 5000+ general US commercial buildings and 100 LEED-certified commercial and institutional buildings based on multiple *t*-tests.	In general, LEED-certified green buildings consumed 18–39% less energy per floor area than general commercial buildings, but this did not mean all green buildings perform well for 28–35% of LEED buildings used more energy. Meanwhile, there was no obvious relationship between the level of LEED certification and Mean Energy Use Intensity.
[26]	A re-examination of energy use data of 121 LEED buildings provided by New Buildings Institute and USGBC was made based on gsf-weighted model (which considered the influence of building size) rather than building-weighted model.	There was no connection between building-weighted model and total energy consumption of 121 LEED buildings, but the gsf-weighted method could exactly evaluate the total energy. Over the 121 commercial buildings, no evidence showed that green buildings consumed lower energy than conventional buildings because 10 large office buildings contributed more than 50% total energy consumption and 58 smallest buildings only consumed 10% total site energy.
[69]	45 factors related to operation, environment, personal control and satisfaction among 31 sustainable buildings and 109 conventional buildings were compared to get the difference of users' views on the performance of sustainable buildings and conventional buildings.	In terms of mean user's perception scores, sustainable buildings overall obtained higher scores than conventional buildings. For operational and satisfaction aspects, sustainable buildings obviously outperformed conventional buildings, but thermal conditions and lighting were modest enhanced when it comes to environmental effects. No obvious evidence showed that sustainable buildings were better than conventional parts in noise and personal control. But the standard deviations for sustainable buildings were generally higher than that for conventional buildings, so the advantages of sustainable buildings showed a lower consistency.
[70]	The sustainable performance of 953 office buildings in New York City (NYC), including 21 LEED buildings, was evaluated based on 2011 energy benchmark data, in terms of the source energy consumption, GHG emission and energy performance rating (EPR).	These 21 LEED buildings generally had the same performance as the rest 932 NYC large office buildings when it comes to source energy and GHG emissions. The fact that only Golden buildings did show a 20% reduction meant LEED-certified and LEED-silver buildings 20% underperformed than NYC conventional buildings. The reason for the same performance might be the “higher productivity”, such as longer building hours, higher occupancy density, or housing larger numbers of personal computers. Due to the lack of measured performance data of commercial buildings, at present, it is hard to verify the interpretation and validity of EPR model.
[71]	A comparative occupant satisfaction evaluation to indoor environmental quality was undertaken in office buildings based on a large building use database of 144 buildings and 21477 occupants' responses, with 65 green buildings and 10129 responses for them.	Overall, the satisfaction of occupants had no obvious association with the rating of buildings and workplace. While LEED-certified green buildings got marginally more satisfaction in the aspects of air quality, building maintenance, colors and textures and cleanliness, they obtained lower scores in the amount of light, ease of interaction, visual privacy, visual comfort and space. In addition, LEED buildings could not show any advantage in furniture adjustability, temperature, and comfort of furnishing.
[72]	A comparative post occupant satisfaction and comfort evaluation, based on 14 office buildings (including 9 green buildings and 5 non-green buildings) in China, was conducted with the approaches of Building Use Studies (BUS) Occupant Survey and Reporting Method.	Green buildings obtained higher scores in terms of satisfaction factor, such as design, needs, productivity and health, but they were lower evaluated at two comfort factors, including temperature, air in winter and noise environment. However, the satisfaction and comfort over green buildings did not show any consistency, for the best and the worst satisfactions were both achieved by two green-certified buildings. In addition, occupants were more tolerant of outdoor environment in green buildings than that in non-green buildings.
[73]	Based on a field survey of subjective perception, on-site environmental measurements and questionnaires, post-occupant performance and	Occupants were more satisfied with the acoustics, lighting, thermal conditions and IAQ, but the lighting performance in green office buildings. According to on-site environmental measurements, green buildings

Table 2 (*continued*)

Reference	Research scope	Analysis & results
	satisfaction of indoor environmental quality (IEQ) were compared between EEWH-certified green office buildings and conventional buildings.	outperformed conventional ones in terms of temperature, illumination, CO_2 concentration, VOC concentration and air speed except for relative humidity and sound. From the questionnaire survey, green buildings got more satisfaction than the conventional parts in overall IEQ, but high temperature in both types of buildings should be the top reason for the uncomfortable IEQ.

buildings consume 28–35% less energy than the conventional buildings. But the same data analyzed by Scofield in gsf-weighted model shows totally different results, namely, LEED buildings are not really better than non-LEED buildings [26]. Reason for the conflict result can be easily found when making a comparison between the samples used in both analysis procedures. As analyzed by Newsham et al. [25], the sample includes 100 LEED buildings that just consume about 30% of the total site energy but the rest 21 LEED buildings consuming about 70% of the total site energy. By this we can conclude that it is necessary to select an appropriate sample to be compared with non-LEED buildings. In addition, Scofield pointed out that building-weighted model ignores the size effect of green buildings, based on the fact that large buildings consume most of the total energy [26]. However, due to the lack of credible validation, the gsf-weighted method put forward by Scofield has not been confirmed and accepted.

When considering the cost-effectiveness of green building, the upfront cost is higher than its counterpart, but this kind of new building is imparted higher environmental benefits. This is reflected by the fact that buyers are pleased to prefer the green buildings [67,74–76]. The buying intention will reduce if those performances cannot be achieved. Kim et al. [77] has evaluated required performance based on the user experience, and the results indicate that the green building can meet the requirements of the desired, function-oriented, satisfaction-oriented, and average categories, but human satisfactory is in the medium level and no evidence about the satisfactory level of non-green building is provided. There is little theoretical research about building satisfaction and comfort. Gou et al. [72] studied the satisfaction and comfort of some green buildings through mathematical equations and index "forgiveness" is used to quantify overlooking inadequacies in the ambient circumstance. They pointed out that many green buildings have not allowed for user comfort, but forgiveness of green building is higher than non-green one.

According to the analysis in Table 2, the energy performance, human comfort, IEQ, GHG emission and workplace productivity have not been improved, compared with conventional buildings. In conclusion, the research hypothesis that green buildings are much better is invalid. But if green buildings are still thought as a progressive process and still share higher forgiveness scores before a set of issues that "green buildings are too hot in summer and too cold in winter", the reasons for rebound effects in this stage can be summarized as the following aspects. (i) An appropriate sample of green buildings has not been established, which means it is difficult to exhibit their unbiased energy performance. (ii) The methods used to evaluate post-occupant energy performance have not been verified and accepted, it is necessary to develop valid frameworks to rate these methods. (iii) Evaluation parameters used should be unified, because energy use intensity, energy performance rating, net source energy, site energy etc. are adopted in current research work.

5. Social acceptance of green building

5.1. The introduction to social acceptance

Social acceptance was originally used to survey the general public attitudes rather than a special community's opinion towards renewable energy, such as wind energy, bio fuel and solar energy, to reveal the social support or acceptance of new energy product [78–80]. So far, the definition of social acceptance remains unconfirmed due to its combination of two unrelated words, "social" and "acceptance", which both depend on the uncertainty of the public's subjective attitudes. In the context of renewable energy, the acceptance turns to being more complex when other factors are involved [81–83]. The acceptance can be subdivided into the "active" and "passive" social acceptance, where the "passive" refers to purchase decision that is encouraged and stimulated by the government incentives. But the "active" one means occupants' subjective higher satisfaction and productivity, although this is adverse to actual results at some times.

In the process of promotion, renewable energy resources are widely accepted by the public. However, local residents oppose the infrastructure facilities. That phenomenon is defined as "Not in My Backyard" (NIMBY), which is used to reveal the discrepancy in social acceptance [84–86]. Many researchers have mentioned influential factors of NIMBY phenomena, such as citizen participation, perceived fairness and media effects, which should be explored for its adverse effects [87–89]. Therefore, based on the energy research of the large and small scale, some scholars have found that many are willing to support renewable energy projects, but they are unwilling to be involved when the community-based projects are implemented. Thus, Wustenhagen et al. [24] has put forward a three-dimensional model, including socio-political acceptance, community acceptance and market acceptance, to solve the tough drawbacks of renewable energy innovation. Herein this three-dimensional model is introduced to explain social acceptance of green building.

5.2. Socio-political acceptance

As for green building, socio-political acceptance is derived from three parts; policy-makers, investors and public. Furthermore, public opinion determines whether the information policy-makers obtained is the accurate or not [24]. At present, most of the green labeled buildings exist in the form of individual buildings, not large-scale communities, and therefore this determines that general public plays an absolute role in providing feedback [90]. It is well acknowledged that green building throughout the world only account for a small proportion of the total built environment, and therefore governments have begun many green pilot projects to promote their development. Currently, policy-makers universally suggest the government to supply funding and subsidies, but the result is basically the same. This is an unfavorable method in establishing systematic green building policies. Meanwhile, a comprehensive problem remains that minimal data can be found to reveal the post-occupancy performance of green building, and therefore, it is difficult to provide positive, useful comments and evaluations for the public [91,92]. However, in the long run, green building should be preferred method in the building industry and gradually extended to residential buildings. This would provide the necessary precedent to investigate the attitudes and opinions of the public in the implementation of green building.

Stakeholders, including investors and producers, not only care about pollution emissions and energy solutions, but also attach

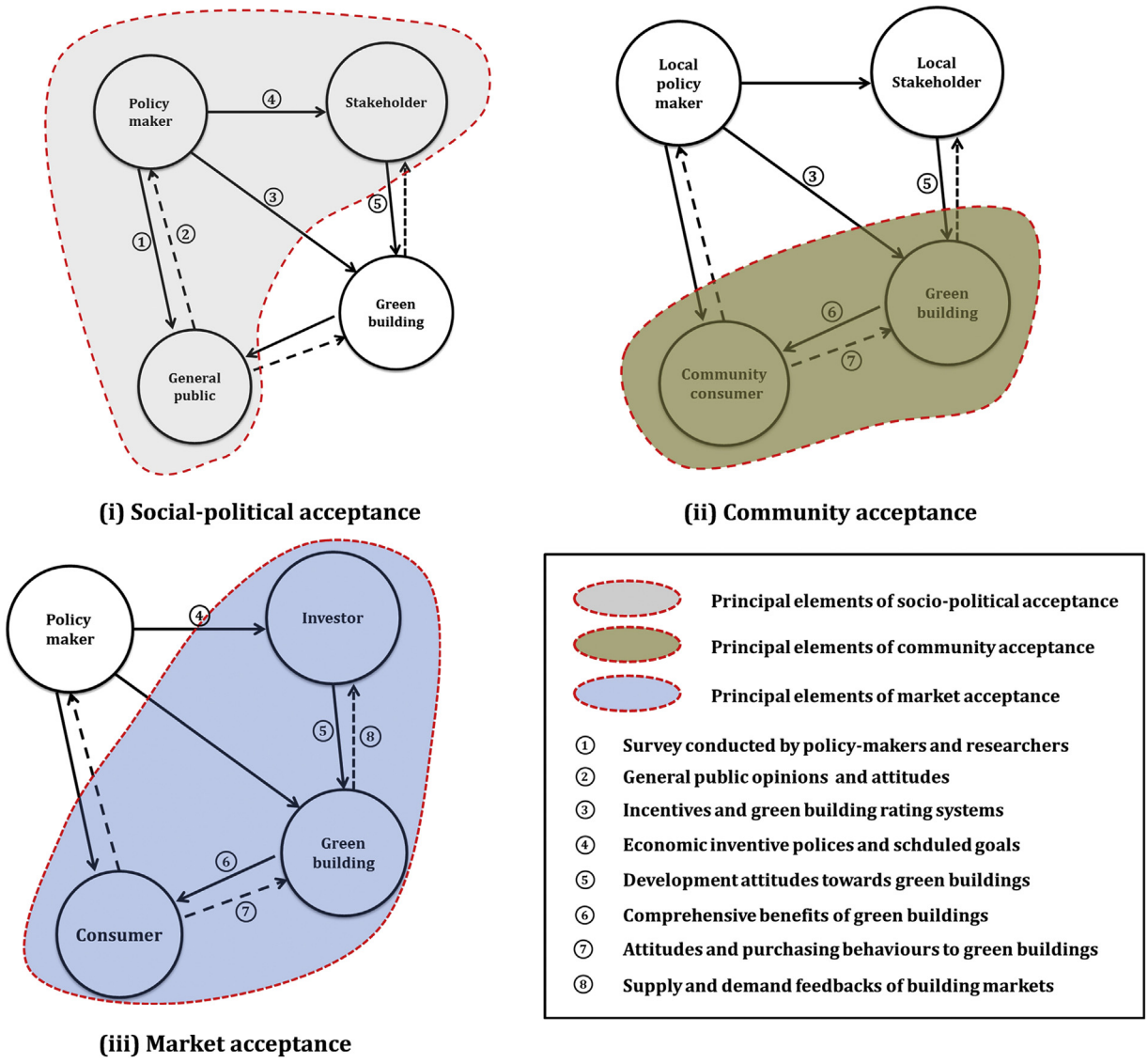

Fig. 4. The model of social acceptance of green building.

importance to economic benefits created by green building. At present, sustainable development is encouraged and stimulated by the government and could obtain more ways to increase the acceptance of the green building development is high. The roles of policy-makers include: (i) Understanding the demand and promotion in the general public. (ii) Green building stimulation for investors. (iii) Rating system establishments for green building, shown in Fig. 4 (i). They undertake the responsibility of revising the existing projects and policies. Currently, a lot of economic incentive systems and management models are currently established based on a questionnaire survey rather than practical data [53]. Furthermore, the development of green building is still in a relatively narrow range with a voluntary way. Nevertheless, the improvement of green building technology continues and many scholars have put forward sustainable buildings that should be constructed in a community area [75,93,94]. This has enabled guidance and encouraged community and investor acceptance.

To realize the user-related functions of green building, three effective paths, including scientific technologies, environmental benefits and public policies should be highlighted, in which as argued the green technologies are the fundamental element [95]. However, after decades of development, architectural scientific systems, including active and passive building energy-saving technologies have been well established [96,97]. The technological factors are no longer the primary matter, instead, barriers to hinder the implementation of green building lie in non-technical causes. As the environmental benefits are the goals of green building project, public policies in the social-political acceptance should be highlighted. Concerning potential environmental benefits, it is argued that general public is willing to accept this green project, based on a large amount of questionnaires and polls [83,98,99]. This kind of favorable opinion has misled the policy-makers to believe that green buildings will be easily to be promoted by the implementation of public policies. If general public's feelings are not considered in implementation stage, those policies could be then thought as stakeholders' and policy-makers' willingness [100–102]. Under the complex context of green building promotion, the simplistic hypothesis of policy-makers is now a real bottleneck of how to develop green buildings.

5.3. *Community acceptance*

Community acceptance is recognized as the second aspect of social acceptance. Debates of “NIMBY” towards green building are a major

possibility [103]. The critical solution of this question cannot only narrow the gap between the general public's resistances but also enhance people's acceptance and the development speed of new projects. The local policy-makers have been working on how to formulate feasible economic stimulus methods based on regional economic level, living habits and geographical characteristics. The local developers, accordingly, also need to control building cost to realize its dual role of benefits in energy savings and the economy. As for the local residents, factors related to social problems are mainly reflected in citizen participation and media publicity.

Nevertheless, compared with general public, consumers in the community are more concerned about overall excellent performance, including economic, ecological and social benefits [104]. As a kind of commodity, green building often cost more and therefore, they have to perform better in reducing environmental impact, building comfort and creating a sustainable society [24,105,106]. Through media publicity, green building are usually expressed as reducing energy and resources' consumption, however, the goal of energy efficiency and good comfort have not been well proved according to the current investigation. As shown in Fig. 4 (ii), the community consumers play a vital role in the development of green building. In community acceptance, people may want to question the government decision-makers and real estate developers. First of all, they are concerned about the shared benefits (how can we share the economic and environmental benefits of green buildings?), and then the operation of green building project (operational means of green building: for the government and investors, how do they profit from green building and how much profit can they earn?). In addition, community is just a part of the society, and local citizens may doubt the information and intentions of other participants (Is it advisable for local government to develop green building and is the information credible and feasible expressed by the public media?).

5.4. Market acceptance

The third dimension of social acceptance is market acceptance, mainly involving the consumers and investors. As shown in Fig. 4 (iii), the economic subsidies and tax preferential policies adopted by policy-makers are considered as the external influencing factors, which make consumers' purchasing decision more complex [24]. In the context of construction industry, based on the traditional non-green building, consumers can shift attention to green building for benefits in sustainability [107]. For consumers purchasing behaviors, the voluntary principle is adopted. If these buildings maintain good performance, the green building market will expand to influence the balance of supply and demand. In general, market acceptance is dominated by social acceptance, but the level of market acceptance will differ due to regional economic levels and green building awareness [108]. To some extent, therefore, the market acceptance will in turn affect the socio-political and community acceptance.

In addition, the investor is another important participant in the market acceptance. They attach great importance to the economic benefits brought by green building. According to the change of consumers' demand for green building, investors will adjust the supply and management methods [109]. Similarly, they are concerned about the balance between research and development for projects in the early stage, as well as investment recovery and profitability in the building life cycle. This is reflected by the cost of green building and the amount of green building developed, which may lead to differences between consumers and investors. Meanwhile, it will also increase the contradiction between consumers and investors if the green building fails to achieve their basic functions. At present, the green building market is in its early stage. To realize the ambitious goals of green building, the developers are consistently encouraged by governments through incentives to continue to develop. This may lead to certain negative effects, causing an opposition to the investors [35]. Therefore, market acceptance is influenced by a variety of factors, and further research would be of great significance. There is a certain correlation between market acceptance and socio-political acceptance, and therefore, their interaction should be studied to reconcile the development of policies and markets.

6. Discussions and conclusions

Green building is thought as a kind of structure using sustainable technologies to achieve the goal of environmental responsibility, resource efficiency and human satisfaction in buildings' life cycle. Since the establishment of the concept of green building, however, research on green buildings has been always conducted in terms of environmental impacts. Studies in the aspect of social challenges are rarely carried out, although some scholars gradually realize that public attitudes and views towards green building may affect its application and promotion. Based on research methods of literature review, questionnaire and inductive analysis, this article has analyzed complex social problems of green building, aiming at supplying a healthy social environment for the development of green buildings. Although the research on social aspects is in the early stage, we still obtain several achievements through rigorous study in this article.

Based on 116 fully answered questionnaires, we have investigated citizens' understanding of and attitudes to green building. In general, the general public shows little awareness to green buildings projects, but they positively accept and support green building when they get the knowledge of less environmental impact. The majority of respondents express higher requests to physical advantages of green buildings, especially in terms of better ventilation and lighting. At the same time, only has less than 10% interviewees indicated that they know green label system, but this has not influenced their original pre-environmental intentions, as more than 90% participants are likely to pay more money for green buildings than conventional ones. Therefore, the relatively higher price of green building could be balanced to some extent. Without appropriate knowledge of green building, users and consumers are not able to make valid decisions. In green building promotion, the general public should be imparted with more information and knowledge about the ambitious strategy. Furthermore, the current priorities of green building are given to its environmental effects, but the potential economic and humanistic benefits cannot be ignored in the next stage, this will be one of the key points for the success of green building in the future.

Green building project cannot exist without the consideration of users. Research on green building should not be restricted to energy-performance oriented, but also user-oriented. Studies on individual options and choices towards green building could not only improve users' satisfaction and productivity, but also provide scientific bidding and the buying model for investors to enlarge their construction industry. Based on Maslow's Hierarchy of Needs, social and humanistic needs could be divided into five levels, including comfort and health, security and safety, facilitating functions, tolerance and forgiveness, intelligent management, where the comfort and health factors provide the physical and psychological basis for occupants, security and safety factors and facilitating functions create good prerequisites for building construction and operation, higher tolerance and forgiveness mean green building receives better users' recognition and respects and intelligent management factors reflect green building's adaption to humanistic needs. In terms of life cycle, social processes of green building are explained in four stages, including conceptual design,

planning and design, operation and maintenance. The main purposes and their responding implementers vary greatly with different stages. Conceptual design, for designers, concerns the question "how humanistic concerns of buildings work to maximize users' subjective feelings", planning and design refers to how buildings work well to serve their real purposes and afford their capabilities, operation highlights "how green buildings perform to improve the level of humanistic needs" and maintenance considers how to continuously keep buildings reaching humanistic needs. In the operation of green building systems, these two methods above could provide a basis for social and humanistic needs design or be adopted to evaluate their realization degrees.

Green building, as a commodity, requires mutual support of different groups under the background of construction market. At present, influenced by buildings (developed by real estate investors) and existing policies and measures (issued by administration), consumers are gradually turning to be recipients in the complex industrial chain. There is no general conclusion showing the relationships between consumer's behavior and social construction. It is necessary to investigate the complex question over social structure and public cognation and behavior tendency. At present, the development of green building is generally based on the simplistic ideal hypothesis that (i) if only they knew; (ii) if only they could do and care and; (iii) if only they stayed home have omitted the social background. In terms of participants, consumer' attitudes and behavior evaluation mechanism thus should be established to improve the building market.

Although participants in the building industry, from investors to consumers and to decision-makers, expect green buildings can perform better in terms of IEQ, energy saving, less GHG emission and occupant comfort than conventional buildings. Unfortunately, little energy consumption data can be found to validate this, let alone the comprehensive performance. The authoritative conclusions presented by USGBC have evidenced that green buildings generally exhibit obvious environmental effects, but one thing has to be highlighted is that building performance data of each building are not open to the public, therefore it is difficult to evaluate the appropriation of USGBC building use database and selected sample. Rebound effects in green building performance have been widely confirmed. Before 2006, designers have ambitious goals of environmental responsibility, but these were proved to be negative results. In practice, due to lack of experience and lessons, numerical simulation and rating systems are real reasons for rebound effects. As the good development of green buildings, these barriers and challenges have been overcome, but the current work is to establish scientific evaluating system according to situations of different countries and regions. After 2006, compared with conventional buildings, green ones failed to overall outperform in energy performance, human comfort, IEQ, GHG emission and workplace productivity. Through literature review, reasons for rebound effects can be summarized in biased sample, inappropriate method and evaluation parameters, therefore, these points should be one of the key points in the future post-occupant building performance research.

The concept of social acceptance, originally used in the field of renewable energy innovation, is introduced into the topic of green building to analyze the related social relationships. The public opinion research is just in the beginning stage, many studies have to be conducted in the following aspects. Social-political acceptance concerns the technologies and public policies between the general public, investors and policy-makers. The questions mainly exist in the following aspects: (i) it is necessary to establish an adequate policy-making system. At present, the policies made are just based on the simplistic ideal hypothesis that citizens are willing to accept green building project, in the future work, policy-makers are thus requested to create effective policies supported by scientific institutions. In the US, green building policies vary with the distribution of every state; likewise policies in each province are different in China, but the US mode cannot be imitated. (ii) The key point should be highlighted is that how to implement these policies. First of all, medium-term and long-term plans for green building project should be subdivided into short-term planning and the central policies should be transferred into local policies according to the local situations, such as the degree of green building development, economic levels and geographical factors. (iii) More specifically, green building has a long service life. In the local implementation process how to make green building be voluntarily rather than compulsively accepted in the long run is another challenge. (iv)The social acceptance of green building contains three sections, only combine all the parts in the implementation can green building develop well.

Community acceptance reflects the relationship between local projects and implementation decisions. (i) The biggest challenge should give priority to trust. It is essential to investigate whether local citizens accept green buildings when they know rebound effects, because people may question how we can share the economic and environmental benefits of green buildings. (ii) Another key challenge is how to deal with the differences between different countries. As in America, many people argue that high investments in green building are not deserved for it might be a barrier to national economy. On the contrary, citizens are gradually envisaging its economic benefits. (iii) In the implantation process, local citizens are not quite familiar with green building, they may doubt "Is it advisable for local government to develop green building and is the information credible and feasible expressed by the public media?" In the future work, the public attitude and adoption should be investigated. (iv)As for social and humanistic needs, how to reach the overall requirements in the life cycle is another important question.

At present, since green building is a kind of new commodity, we have a superficial understanding over its market. In market acceptance, many issues should be tackled, including (i) As a kind commodity, green building should be sold to consumers, the top matter is thus to know the factors affecting their buying intentions and get a better understanding of the relationships between these factors and buying intentions. (ii) For the investors, they afford the responsibility to develop new techniques, as a means of reducing the cost of green building. Therefore, the question will be how many investments they would like to pay for the purpose of technology and construction industry improvement. (iii) As the development of green building is still in the early stage, the policy-makers have set up a series of economic subsidies and tax preferential policies. Thus, research on the influence of these policies on market behaviors should be also conducted.

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Appendix.A. Questionnaire about acceptance of green residential building

To whom it may concern,

This is an academic questionnaire about the acceptance of green residential building. Because of your participation that determines the success of this study, so I hope you can participate in this survey. Please fill in this questionnaire in according to actual condition, and we confirm that the results will be only used for academic statistical research rather than other use in any form.

Thanks again for your kind help to fill in questionnaire.

Section I Your basic information

1. What is you sex?
   □ Male □ Female
2. What is your age?
   □ 18-25yr □ 25-35yr □ 35-45yr □ 45-55yr □ above 55yr
3. What is your educational level?
   □ High school or below □ Junior college □ Bachelor degree □ Master degree □ PhD or above
4. How many people are there in your family?
   □ Two or below □ Three □ Four □ Five or above
5. How much is your household income of one month (RMB)?
   □ Below 1,500 □ 1,500-5,000 □ 5,000-10,000 □ 10,000-15,000 □ 15,000-30,000 □ Above 30,000
6. What is your current occupation?
   □ Senior Management □ Middle Management □ General Staff □ Self-employed
   □ Student □ Emeritus & Retired □ Others

Section II Your Basic understanding about green building

7. Please indicate how familiar you are with green buildings ?
   □ Not at all familiar □ Not very familiar □ Somewhat familiar □ Very familiar
8. What do you think are green buildings ?
   □ Buildings in green color
   □ Buildings with full of green plants indoor
   □ Buildings with full of green plants outdoor
   □ Buildings which are more healthy and comfortable
   □ Buildings with Electricity -saving, energy -saving, water -saving, and therm al-saving techniques
   □ Buildings that are land saving and material saving
   □ Buildings that are land saving and material saving
   □ Other
9. Have you ever heard of green building label?
   □ Yes □ No

Section III Your purchase intentions of green building

Compared with conventional building, green building could achieve the goal of harmony between nature and human beings. In the lifecycle of green building, it could reduce the consumption of resources (including land, water, energy and construction material s), reduce the impact on environment and improve indoor environment.

10. Compared with conventional buildings, green building has the following advantages that may determine your purchase intentions. Please select and assess the effects of these factors. (The effects increase as the number increases, 1 means no influence, 5 means quite important)

	1	2	3	4	5
Green buildings help to save land, protect environment, reduce pollution	□	□	□	□	□
Green buildings help to save energy (electricity, gas et al.)	□	□	□	□	□
Green buildings help to save water	□	□	□	□	□
Green buildings help to save construction material	□	□	□	□	□
Green buildings have better ventilation and lighting conditions, which help to improve indoor environment	□	□	□	□	□

11. According to Ministry of Construction (MOC), green building can be labelled as three levels, one -star, two-star and three -star. Are you more willing to buy green building if it has been recognized by MOC?
    □ Strongly agree □ Agree □ Neither agree nor disagree □ Disagree □ Strongly disagree
12. Compared with conventional building, the cost of green building is much higher but it can bring about a large amount of environmental benefits. Are you willing to pay more for green building if other factors, such as lo cation, traffic and environment, are same with conventional counterpart?
    □ Not at all
    □ I am willing to pay more, but I don't know pay how much
    □ 1%－3%
    □ 3%－5%
    □ 5%－10%
    □ 10%－20%
    □ above 20%
    □ I don't mind the price if the green building performed well
13. Could you understand the content of this questionnaire?
    □ Total ly understand □ Understand □ Not quite understand □ Totally cannot understand

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