TITLE: ENVIRONMENTAL ASSESSMENT OF RESIDENTIAL BUILDINGS IN CHINA

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Keywords: residential development, green buildings, sustainability, environmental assessment methods

Summary

China is the fourth largest country and has the largest population in the world. With its economic growth since the economic reforms starting from 1978 the government has struggled to contain environmental damage and social strife related to the economy's rapid transformation. The environmental degradation in China has been accelerated with the rapid growth in population and urbanization and the foremost problem that has challenged the government is the insufficient supply of housings. The growth in residential development has increased the demand for energy and natural resources for the manufacturing of building materials. Any improvement in the sustainable performance of residential developments in China will have significant impacts on environmental deterioration on a global scale. The concept of sustainable residential development is adopted in many countries and rating tools have been developed to guide and assess environmental performance of buildings. The purpose of the paper is to analyze the tools that are available in China to assess the environmental performance of sustainable housings and to present the results of an on-line survey and interviews in Beijing.

1. Introduction

According to the Department of Communities and Local Government (CLG) in the UK in 2004, approximately a quarter of the CO^2 emissions came from the energy consumption of homes (CLG, 2006). Sustainable residential development is about considering possible design options and to evaluate their life cycle impact. The information available during the design stage is limited and requires tools that can guide designers with default data and intelligence. Environmental building performance assessment tools for residential developments are designed to improve the overall building performance, minimize environmental impacts and costs. Most of these tools have been developed to transform the design goal into specific performance objectives and to provide a framework to assess the overall design. However most of the tools are voluntary only and are undertaken at the discretion of developers.

The purposes of this paper are (1) to examine the main issues and problems in relation to sustainable residential development; (2) to analyze the methods/tools that are available in China in assessing environmental performance of residential developments; (3) to present results of an on-line survey and semi-structured interviews in Beijing to explore the impact of environmental performance assessment tools for residential development in China.

2. An overview of sustainability assessment of residential developments

In recent years, a growing number of sustainable housing projects have been completed and sustainable housing is increasingly becoming part of common building practice. Sustainable residential development was one of the issues addressed in the United Nations Conference on Environment and Development at the Earth Summit in Rio de Janeiro in 1992 (Bhatti, 2001; Li & Shen, 2002). Bhatti (2001) states that sustainable residential development can make major contribution towards an environmental future. The method by which residential development is produced, consumed and managed, and the way it contributes to social and cultural life has major impacts on the environment.

IEA (2006) suggests that sustainable residential development can be achieved through preservation of the global environment, harmony between house and environment, and promoting health and pleasant living. From this viewpoint, a sustainable residential development is characterized by futurity and equity issues which aim to ensure that everyone today and the generations to come have a decent place to live which uses less resources to run than most existing homes. In addition to considering land use, orientation, shadow and light, concerns need to focus on the long-term costs - social, environmental and economic. Sustainable housing will be a growing part of the housing industry, making it a business opportunity waiting to be explored.

The purpose of sustainable housing is to raise the standard of living and to offer an opportunity for people to have a decent house to enhance social unity, well-being, economic growth and social improvement. Sustainable housing concerns not only the fabric of buildings but also the social and environmental context of construction practices. In sustainable housing construction, the concept of eco-efficiency is important and implies that a reduction in the environmental impact of housing construction can be undone by trends such as an increase in the average size of houses, and a decrease in the average number of persons per house (Klunder 2004). Sustainability is not just about low energy; it also means that people are happy to live where they live and that they live in a healthy environment.

Conventional residential developments are designed and constructed in accordance with the building codes, whereas green residential developments are designed, constructed and operated to consider environmental performance and minimize environmental impact. Most of the assessment tools have been used for planning and design development with specific performance objectives and provide a framework to assess the overall design using either rating system or assessment criteria.

3. The green challenge of sustainable housing in China

China is the fourth largest country in the world and accommodates more than 20% of the world's population (CIA, 2006). With its economic growth since the economic reform in 1978 China's GDP has increased more than tenfold while the environment has been deteriorating at an alarming rate (Cai, 2004; Ho, 2006). In 2005 China stood as the second largest economy in the world after the United States (CIA, 2006) and the second largest greenhouse gas emitter in the world and will be the leading emitter within the next couple of decades (Rousseau & Chen, 2001; Cai, 2004, Ho, 2006).

With economic development the government has struggled to contain environmental damage and social strife related to the economy's rapid transformation. According to the United Nations seven of the ten most polluted cities in the world are in China (EIA, 2005, Glicksman & Lin, 2006). The ongoing environmental deterioration such as air pollution, soil erosion and loss of arable land poses serious threats to economic growth in the long term if the Chinese government fails to control the environmental problems as a matter of urgency.

The environmental degradation in China has been accelerated with the rapid growth in population and urbanization and the foremost problem that has challenged the government is the insufficient supply of housing. According to the United Nations (2004) China has 1.56 million households still in need of housing and 350,000 households are still living in situation where they have less than 8m^2 of gross floor area per capita and there is an increasing demand for residential housing needed to house the ever increasing population. As such any improvement in the design, construction and operation of residential housings will have significant impact on the rest of the world. The residential sector has already developed rapidly since the economic reform and is also the fastest growing sector in terms of energy and materials demands. Environmental pollution and insufficient housing are the two obstacles for achieving the goal of sustainable development in China (Ho, 2006).

Housing development in China is detrimental to the environment in many ways. Housing development is the main cause of loss of arable land for agriculture. The rapid growth in residential development has increased the demand for energy and natural resources for the manufacturing of building materials. In 2000 the total energy consumption in China had already exceeded total energy production by 17% of the same year (Ho, 2006).

In 1996 the Chinese government adopted housing reform to advance quality design standards and high quality construction methods and materials. However sustainability was not addressed to include energy conservation standards, healthy building features, durability and low maintenance features, water conservation standards, or recycling building materials (Rousseau & Chen, 2001). In 2006 the Central Committee of the Chinese Communist Party approved the 11th Five-Year Plan with the aim of reducing energy consumption by 20% per unit of GDP by 2010. The plan states that conserving resources and protecting the environment are basic goals, but it lacks details on the policies and reforms necessary to achieve these goals (CIA, 2006).

4. Toward sustainable housing

4.1 Laws and regulations

According to Rousseau and Chen (2001) China's rapid housing development was partly caused by the changes in the economic structure from a planned economy to market-driven economy which has led to the rapid expansion of the property market. The changes have led to the conversion of home ownership from government assigned to private ownership and the introduction of mortgage banking. The rapid economic development has stimulated serious migration of people from the rural areas to seek work and better living environment in the cities. The rapid modernization and industrialization in urban areas have escalated the demand for residential spaces.

Faced with the problems of insufficient housing especially for the low income people, affordable and appropriate housing has become a main focus of the Chinese government. In the series of Five-Year Plans for National Economic and Social Development, the government set goals to satisfy four key principles of housing development, namely affordability, livability, sustainability and adaptability. In recent years the government has established codes and standards to guide sustainable residential development. As Zhu and Lin (2004) state environmental building assessment systems developed by others will not be useful in China due to cultural and regional differences.

The Technical Assessment Handbook for Ecological Residence was introduced in 2001. This was the first rating assessment system for assessing sustainable housing which aims at improving environmental quality of residential buildings (Zhu and Lin, 2004). The handbook clarifies the concept of ecologically sustainable development as well as provides guidance in the planning, design, construction and management of residential buildings. It is constantly updated and the latest edition was published in 2006. The handbook is developed based on a list of performance standards and a set of design guidelines which are stringent requirements for pre-requisites. The handbook is only a simple rating system without explicit weighting. The usefulness of the handbook may be restricted as it only relates to residential projects and is voluntary only without clear consequences for non-compliance. The Technical Essential for Construction of Healthy Housing was introduced by the China National Engineering Research Centre for Human Settlement in 2004. It is very similar to the Technical Assessment Handbook for Ecological Residence. It also provides a standard for the design and construction of sustainable housing and emphases that green housing will need to concern environmental health as well as community welfare.

The development of the Green Olympic Building Assessment System (GOBAS) has impact on the development of environmental assessment tools in China. In order to integrate the goal of ESD into the development of Beijing Olympic 2008, the GOBAS was developed in 2002 and launched in 2003 supported by the Ministry of Science and Technology. The GOBAS gives a clear introduction on the design, assessment criteria and methodology of green building for the Olympic buildings. It lays down guidelines and principles for improving quality of buildings as well as reducing resource consumption and impact on the environment. It is Olympic buildings only. The assessment system was developed based on the concept of building environmental efficiency as in the CASBEE and LEED on a whole of life approach (Lin et al., 2005). Beijing Municipal Construction Committee has issued official document to adopt GOBAS as the Beijing local green building standard.

Following the launch of GOBAS, the Evaluation System for Green Buildings in China was developed as one of the 10^{th} five-year national research plan. This system is an extension of GOBAS to be more regional specific and overcome the weakness of GOBAS to be a national standard for the evaluation of green buildings. It can be used to assess different types of construction in different climate zones (Qin & Lin, 2005).

In addition to sustainable housing assessment tools there are codes and standards issued by the government as a mean to improve building performance and to promote green buildings construction. The Outlines and Technical Principles for Green Ecological Residential Quarter Construction was introduced in May 2001 and it outlines the principles and targets on saving water and energy, ecological land use and pollution abatement. The Assessment Criteria for Green Building was issued in June of 2006 and it was the first nation-wide criteria on project construction in China to assess the green building from multiple objectives and criteria based on the whole of life approach for residential buildings. The assessment criteria clarifies the concept of green building and set up a legitimate assessment approach to assess housing performance. According to the assessment criteria, a green building should save resources (energy, land, water and materials), protect the environment and reduce pollution maximally, provide healthy, applicable and high-efficient space, and harmonize with nature during its life cycle.

Laws and regulations on energy conservation in China can be dated back as early as 1998 and the Design Standard for Energy Efficiency Building was issued in July 2005 as the first national wide criteria in China for energy saving design of public buildings. It is applicable to the design for energy efficiency of new and existing buildings. With improvement to the building structure and insulation, the standard aims at reducing the total energy consumption to 50% of that in 1980s. In 2006 the Regulations for the Administration of Energy Conservation in Civil Buildings came into force with the aim to develop household-based heat metering technique and equipments. It aims at enforcing the administration of energy conservation to improve the efficiency of energy use, and promote indoor environmental quality. It was applicable to residential but not applicable to low-rise residences built by peasants.

4.2 Research method

The introduction of the Technical Assessment Handbook for Ecological Residence in 2001 has marked an important era of sustainable housing in China. The Handbook has no doubt raised environmental awareness among construction professionals and guidelines that they can follow in the design and construction of sustainable housing. In order to examine the extent of impact an on-line survey was designed and conducted among construction professional in Beijing in December/January 2008. The questionnaire survey was designed and distributed online for a wider coverage and provided a quick and easy platform to return the completed survey. The purposes of the survey were to examine construction professional perception on green buildings and to explore the role of these assessment systems in the construction industry in enhancing sustainability in residential developments. Following the survey two semi-structured interviews

were undertaken with representatives from the Beijing Institute of Architectural Design and Beijing Urban Engineering Design & Research Institute Co. Ltd. in January 2008.

The questionnaire was divided into three parts. The first part was intended to obtain general details of the respondents. Part two was intended to obtain the views of respondents in respect to their understanding and acceptance of green buildings in construction. It contains twelve questions. Part three was designed to identify the level of expertise the respondents have on the criteria for assessing sustainable housing and how familiar were they in using the Assessment Handbook for Ecological Residence for sustainable housing in China. This part contains eight questions. In addition to choice-based questions the questionnaire also contained several open ended questions whereby the respondents were asked to provide written opinions and have received tremendous replies.

The survey was undertaken in conjunction with Tianjin University of Technology (TJUT) and assisted by the China Engineering Cost Association (CECA) in distributing the online survey as well as organizing personal interviews for the research. The anonymous questionnaire was sent to practitioners in the construction industry in Beijing via email with a URL containing the online survey in December/January 2008. Many of the participants also forwarded the URL to other practitioners in the industry. Therefore it was difficult to determine the exact response rate. At mid February, 59 completed questionnaires had been received via online.

4.3 General information

Of the 59 returned survey 66% were from male respondents whilst 34% were from female respondents. Respondents came from a variety of background. The cost engineers and engineers have contributed the majority of the returned survey of 39% and 34% respectively. Architects and contractors have only contributed 10% and 9% respectively whilst the remaining 8% of the respondents were developers, project managers and academics.

Approximately 91% of the participants have less than 16 years of work experience and 65% were 26 to 35 years of age. The survey result reflects the keenness of younger professionals to take part in the survey and to provide personal opinions. Of the 59 returned survey 78% have provided written responses on the government regulations on environmental issues and their opinions on what the government could do to protect the environment. The responses will be summarized and reported later.

The respondents were asked to express their concern about the environment, 32% claimed that they were concerned about the environment a great deal, 59% were only concern a fair amount whereas 9% responded only little concern. The feedback indicated that they are quite skeptical about environmental protection and this may reflect the level of environmental awareness among the professionals. It is further reflected through their experience in working with environmentally related projects. About 23%% have less than 1 year work experience on environmentally related project whilst 69% have between 1 to 5 years and 8% have between 16 to 20 years working experience with environmental design, construction, maintenance and assessment. However with the respondents having work experience in environmental projects about 78% have done less than 5 projects whilst only 22% have done from 5 and up to 16 projects so far. The outcomes indicate that the respondents have insufficient exposure for dealing with environmental issues in construction and experience in relation to environmental projects. However considering that the first environmental assessment handbook was published in 2001 the result is quite encouraging.

In addition to the limited years of work experience in environmentally related project, based on the survey returns work experience of practitioners in construction industry in environmental project had been immature and at an early stage. Overall the respondents were rather young and inexperience. The outcome may be due to the majority of respondents (approximately 91%) having less than 15 years of work experience. It demonstrated that practitioners in the construction industry have very limited experience in environmentally related construction projects.

The survey also discovered that only 10% of the respondents with work experience in environmentally related project have received training in order to perform the work such as post-graduate studies, energy saving courses, clean technology courses or attended environmental CPD seminaries. Environmental training should be an area that the construction industry supports in order to equip professionals to improve their competence in environmental projects.

4.4 Observations and discussions

Part II was designed to obtain opinions and feedback on greening the construction industry. The questions were designed as a standard Likert scale where respondents were asked to rate each question from strongly disagree to strongly agree. The results are summarized in Table 1. Based on the returned survey the majority of the professionals agree that environmental issues are important for the construction industry and should be incorporated in construction projects. Approximately 95% agree that the demand for green buildings will increase and 90% believe that green buildings will increase in importance and increase in workload in the next few years.

About 84% believe that adherence to environmental practices can help the industry to grow further. This indicates that people are gradually realizing the benefits of green buildings to the well-being of humankind. This result was in line with the opinions from the two semi-structured interviews as they experience an increase in demand for sustainable housing in Beijing and people tend to prefer staying in green buildings as

opposed to conventional buildings. The table also indicates the opinion from the survey respondents that laws and regulations will become more demanding and it was also confirmed in the semi-structured interviews. This is particularly serious for the energy conservation laws passed in October 2007 and in place in April 2008. In addition in December 2007 the government issued the Government Procurement List of Energy Saving Products which was the first mandatory energy law to enforce the use of energy saving products to reduce impact on the environment.

With regards to whether the construction industry has done enough to protect the environment the respondents had diverse opinions and only 28% agree, 34% disagree and 38% are not sure. About 70% disagree that research and development of green building is sufficient and further development is crucial in this area. However about 55% believe that the construction professionals are well aware of the importance of green buildings to the environment as opposed to the 21% that disagree. In relation to the level of expertise of construction professional in the design and construction of green buildings only 47% agree but 36% disagree that professionals have the expertise in the design and construction of green buildings.

Table 1 - Summary of opinions on greening the construction industry in China

Proposition	Responses (%)				
	Strongly Disagree	Disagree	No Opinion	Agree	Strongly Agree
Environmental issues are important for the construction industry	2	0	5	55	38
Environmental issues should be incorporated in construction projects	2	2	3	59	34
The demand for green buildings will increase	2	0	3	54	41
Green buildings will increase in importance in the construction industry	2	0	8	53	37
The workload in the design and construction of green buildings will increase in the next few years	2	0	8	63	27
Adherence to environmental practices helps the industry to grow	2	2	12	71	13
The law and regulations on green buildings will become tougher	2	0	25	49	24
The construction industry has done enough to protect the environment	5	29	38	23	5
Research and development of green buildings is sufficient	24	46	12	13	5
Construction professional are well aware of the importance of green buildings to the environment	2	19	24	50	5
Construction professionals have the expertise in the design and construction of green building	2	34	17	30	17

The survey results only provide a rough indication of the current situation of environmental awareness among construction professionals. However the survey results provide insight into the areas that may require attention. The overall result indicates that the construction professional's environmental commitment in Beijing is immature and lacks exposure. The situation will change dramatically when government environmental protection rules and regulations will be more and tougher.

Table 2 - Impact of Technical Assessment Handbook for Ecological Residence in the construction industry

Proposition	Responses (%)				
	Strongly Disagree	Disagree	No Opinion	Agree	Strongly Agree
The handbook is user friendly	6	6	35	53	0
The handbook is useful in assessing environmental performance of residential developments	0	6	35	59	0
The handbook is a useful guide in the design of green residential developments	0	6	53	41	0
The criteria set in the handbook are achievable	6	6	59	29	0
The handbook will help to provide better sustainability outcomes in residential developments	0	12	35	53	0
The assessment criteria are sufficient to cover the environmental aspects of promoting green residential developments	6	18	29	47	0
The cost of building green residential developments will be more expensive than traditional developments	6	6	35	47	6
Green residential building will take longer to complete	6	12	23	47	12
The handbook should be improved and applied to other types of construction	0	6	23	65	6

Part III of the survey was designed to examine the impact of the environmental assessment tools for residential building performance. The survey chose particularly the Technical Assessment Handbook for Ecological Residence as an example as this was the first assessment tool introduced in China. These

questions were also designed as a standard Likert scale and questions were rated from strongly disagree through to strongly agree. Based on the returned surveys about 8% have used the assessment handbook before whilst about 20% only knew about it but had not actually uses it. This indicates that environmental assessment tools for sustainable housing in China were not very well accepted as compared with other countries. The use of the Handbook is voluntary and it is up to the developers to decide whether to adopt the guidelines set in the Handbook or not. For the performance tools to be more effective in enhancing housing sustainability they may need to be mandatory such as BASIX in Australia. Summary of survey results are included in Table 2 above.

As summarized in Table 2 about 53% agreed that the Handbook is user friendly. About 59% agree that the handbook is useful in assessing sustainable housing performance and 53% believe that the use of the handbook will help to enhance housing sustainability. However only 41% believe that the handbook is useful in guiding design and construction for residential projects. With regards to the assessment criteria set in the Handbook only 29% agree that the criteria set in the handbook are achievable whilst a majority (59%) is not sure. This indicates insufficient exposure to the Handbook and lack of environmentally related work experience of respondents. There are also not enough details about the area that they believe to be unachievable.

In general the respondents agree green buildings will cost more and will take longer to complete as compare to the traditional approach. Finally about 71% agree that the Handbook should be applied to other types of construction. However some respondents believe that the handbook is only a concept and lacks practical structure for implementation. With regards to improvement that can be made to the handbook, some respondents suggest to comprise statistical data to exhibit the usefulness and potential of the tool in promoting housing sustainability in addition to use case studies for demonstration. Some recommend a more detailed investigation to ascertain the usage and impact of the tool. Others suggest that an environmental assessment tool cannot be single dimensional and environmental aspects should be taken into account at the same time with economic considerations. On the other hand both environmental and economic appraisals need to be considered in the assessment framework on a whole-of-life approach. Due to lack of experience from the respondents in the tool the survey can only provide a superficial reflection on the impact of the tool and further research will be required.

Two semi-structured interviews were undertaken in January in Beijing. Representatives from Beijing Institute of Architectural Design and the Beijing Urban Engineering Design & Research Institute have experiences in both design and construction of green buildings in Beijing. At the interview they stated that green residential development is still at an early stage in China. Firstly, most developers still place financial return at high priority because green designs generally cost more. They prefer the traditional construction in the design and construction of residential buildings. They believe sustainability can only be put into practice if it becomes mandatory. Secondly, the existing sustainability assessment systems need further development. The existing system is either insufficient or incomplete in guiding design and construction. In addition the system is not appropriately known or understood by most professional in the construction industry. Thirdly, there is a lack of financial incentives by the government to encourage green development. This is particularly important as green construction is generally costly. Unless green construction cost is reduced, developers will not have the motivation to build green. Fourthly, the general public is commonly fond of living in green residential buildings as they all accept that these buildings can provide with healthier and better living environment. However since the supply of these building is generally insufficient and expensive they are inclined to stick to traditional residential buildings.

5. Conclusion

Sustainable housing has profound effects on human beings' daily lives and well-being. In China with a huge population and rapid urbanization, housing shortages has become an important task confronting the government. More effort needs to be made to provide sufficient accommodations to the people as well as minimizing load to the environment. The task needs a more systematic and holistic approach to assess and promote housing sustainability. There is no doubt that environmental assessment tools contribute significantly to achieve the goal of sustainable development within construction. On one hand, it provides a methodological framework to measure and monitor environmental performance of residential development, whilst on the other it alerts the building profession to the importance of sustainable development.

Sustainable housing is multidimensional and the evaluation of sustainable housing cannot be achieved using a single criterion and single objective function. The decision-making process for sustainable housing uses multiple criteria and objectives and needs to be considered on a whole-of-life approach as it is not just considering economic and environmental problems. It also needs to include social and economic evaluations during the service life of the building. Therefore a set of multiple goals and criteria needs to be considered simultaneously. The sustainable housing industry needs to appreciate the affordability for home buyers especially those issues relating to design and cost. The reality is that home buyers will respond to environmental issues providing it is affordable and does not come at a cost penalty. Professional designers should maximize the environmental performance and concentrate more on achieving lower costs. If additional cost items are to be included, developers, builders and governments will need to consider introducing innovative financial incentives.

The questionnaire survey and interviews have provided a preliminary insight into the current situation of sustainable assessment of housing development in Beijing. Beijing is the capital of the country and any

conclusions drawn will provide an indication of the condition of environmental awareness among construction professionals in the country. However China is a huge country with regional variations, therefore further research may be required in other regions of China in order to obtain a better understanding of the situation. In order for housing sustainability to be made more important, environmental awareness should be made in a more radical way to promote sustainable housing for the sake of creating market demand and stimulating business interest in developing sustainable housing. The government by developing and coordinating sustainable housing polices in a more systematic way as well as providing financial incentives to encourage more sustainable housing. On the other hand supporting and providing further education and training to construction professionals, researchers and academia will contribute to the design and technology advancement of sustainable housing.

Acknowledgement

This paper is supported by the Early Career Research Grants funded by the University of Technology Sydney and in collaboration with Tianjin University of Technology.

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