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DEVELOPING ECOLOGIC HOUSING - CASE STUDIES IN CHINA

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ABSTRACT
Developing ecologic real estate has been promoted world-wide as an important mechanism for implementing the principles of sustainable development in construction activities. The housing industry is a major consumer of the environmental resources. This is even more obvious in developing countries such as China where the fast economic development is generating vast amount of housing activities but at the expense of environmental degradation. Construction activities particularly for housing in China will be the major economic sector for coming years, thus the implementation of environmental management in this field can contribute significantly to the mission of sustainable development. Existing research works have developed theoretical frameworks formulating the methodologies and principles of developing ecologic housing. By examining the practices of applying these methodologies in China, this paper identifies the key factors determining the application effectiveness of ecologic housing methodology. Benefits and existing problems in the application are investigated. The paper presents two case studies in applying the new methodology, and useful experience from the two cases is drawn accordingly. With the governmental determination, developing ecologic housing is the major direction of future Chinese housing industry. This presents good potential for overseas professionals who have good experience and techniques in developing ecologic housing to explore business opportunities.

KEYWORDS
Sustainable Development, Environmental Management, Ecologic Housing, China

1. INTRODUCTION

Ecology concerns the mutual relations between living things including human beings and their environment. Thus ecologic housing meets human needs whilst protecting the natural environment. The core characteristic of an ecologic housing is considered as 'green'. It emphasizes the connections between people and place, people and nature, and buildings and the nature. Court (1990) suggested that green development seeks for better energy consumption performance; restoration of prairie ecosystems; the fostering of community cohesion and reduced dependence on the automobile. A green development for housing has three typical features (Wilson et al, 1998), namely, environmental responsiveness, resource efficiency and community and cultural sensitivity. These three elements manifest themselves in many different ways and often reinforce each other.

Environmental responsiveness requesting for effectively using land by sitting buildings to blend in with the natural environment, by reusing the developed land, by restoring the degraded land, and by preserving as much virgin land as possible. On the other hand, environmental responsiveness promotes the mission of energy saving in operating a building across its life by using solar energy, wind, and natural vegetation to serve for heating, cooling, lighting, and ventilation in the operation of a building. Resource efficiency seeks better efficiency in land planning, building design, materials selection, waste reduction, water conservation, and energy use efficiency. In other words, resource efficiency is promoting the process of 'doing more with less' – using less resources particularly scarce resources to accomplish the same goals. Community sensitivity considers environmentally friendly and comfortable living surroundings. For example, it quests for proper planning of building's surrounding such as roads for pedestrians as well as cars; convenient access to the existing infrastructure of services, schools, work, and shopping; other public and quasi-public spaces such as squares, porches, and courtyard for accidental or planned gatherings. Community sensitivity also concerns the local history, the culture, and the existing built environment of a given location.

Crush (1995) suggested that the real challenge to environmentalists is not global warming, or toxic waste, or habitat loss, but to talk to people who are not environmentalists. Real estate developers, in particular, are caught in a controversory paradox of moral complexity, seeking for the balance between ecological sensitivity and economic sensibility. To mitigate the consequence of the extreme views from both developers and environmentalists, the mission of sustainable development has been globally launched. It is a mission which seeks as "to meet the needs of the present without compromising the ability of future generations to meet their own needs". Previous research suggests that considerable amount of environmental resources are used in buildings (the remainder is equally split between transport and industry). About 30% of the UK energy is used in houses and 20% in office (Hall & Warm, 1995). Considerable research efforts have been contributed to investigating the impacts of construction businesses on the environment (Bourdeau *et al*., 1998; Treloar, 1996; Ofori *et al*, 1998; Wu *et al*.,2000; Shen *et al.,* 2001; Wu e*t al.,* 2001; Shen *et al*, 1999). Their findings suggest that the major environmental impacts from construction include the loss of soil and agricultural land, the loss of forests and wild lands, air and water pollution, and the lost of non-renewable energy sources and materials, changing ecological characteristics due to land development; production of substantial volumes of waste; consumption of large amounts of energy during the processing of materials; and disruption of the lives of people living in the vicinity of a project through traffic diversions, noise pollution and others. Thus the study for effective solutions of reducing construction-related environmental impacts becomes a pressing issue. Construction activities particularly for housing in China will remain as the major economic sector for coming years, thus the implementation of environmental management in this field can contribute significantly to the mission of sustainable development of the country.

2. CHINA'S HOUSING DEVELOPMENT AND ITS IMPACTS TO ECOLOGIC ENVIRONMENT

In China, a large amount of investment has been annually put into housing projects. In 1998, the amount of housing investment (including private and public housing) in China was RMB211.79 billion (about US$27.15 billion)(CRESY, 1999). In 2000, the total investment on housing in China was RMB490.17 billion (about US$62.84), of which RMB331.87 billion (about US$42.55 billion) invested private housing. It gives 19.5% increase compared to the previous year and this investment took 20.2% of total national investment on fixed assets (CRED, 2001).

Whilst China has achieved fast growth in its economy, it has been to certain extent at the expense of environmental degradation. Considerable investment has been contributed to protecting the environment. According to a research report (Holley, 1999), the international environmental aid to China has been increasing over previous years. However, the effectiveness of controlling the environmental degradation is still limited, and this is due to the short-term economic growth being treated is the priority for both government & businesses (Whitcomb, 1992; Jacobson, 1994). Holley's report (1999) suggests that China's rapid economic growth over past two decades in urbanization and industrialization have been at the cost of steady deterioration of the environment. Ambient concentrations of particulates and sulfur dioxide as well as several water pollutants are among the highest in the world, causing damage to human health and lost agricultural productivity estimated at $54 billion a year, or about 8 percent of China's GDP in 1995. Air pollution alone contributes to the premature death of more than a quarter million people each year. This indicates that the achievement of China's economic objectives has been at the expense of its environmental degradation.

China's domain is similar to that of USA, but the population of China is 4 times more than America. The Chinese housing industry is just at developing stage and it is expected that the demand for real estate in China will soar. The average energy utilization efficiency rate in China is 30% to 40% and obsolete and inefficient technology in building material sector is a key factor contributing to low energy utilization and highly polluting emissions and effluents (ADB, 1998). The PRC's primary commercial energy consumption increased by 5.3% annually from 1980 to 1997, reaching 1.44 billion metric tons of coal equivalent (NEPA, 1997). This makes the PRC the third largest energy user after US and Japan. But per capita energy consumption in the PRC is low – about 700 kg oil equivalent, or 40% of world average.

LI's study (2000) suggests that the potential of energy saving through improving external wall in a typical Chinese housing building is about 4~5 times higher to that in developed countries, 2.5~5.5 times potential through improving roof-top, 1.5~2.2 times potential in improving external windows, 3~6 times potential in improving air infiltrate, about 3~4 times overall energy saving potential. Furthermore, housing construction activities also consume large amounts of water resources, whilst China has a serious shortage of water. Annually, the PRC faces a shortage of water resources that amounts to approximately 50 billion tons, but the amount of water used per unit of product ranges from 5 to 10 times the amount used to produce similar products in developed countries (ADB, 1998). Similarly, a large amount of woods and other environmental resources are consumed in engaging housing activities. The average forest area per person in China is about 1/6 of the World average standard, 1/8 wood of World average standards. It is reported that the materials consumed in the Chinese housing construction in 1995 were 10% of total materials production in the country, including 20% of total woods consumption, 47% of total cement consumption, 14% of total steel consumption and 40% of total glass consumption (LI, 2000).

In line with the fast development of housing industry in China, the damage to the ecologic and living environment is becoming increasingly serious. There is a strong appeal to protect the living environment whilst continuing to develop the housing industry. The Chinese government has recently launched a scheme called 21st Century Living Environment Construction (Aminul, 1999), which considers building environmental friendly living conditions as the major strategy of future housing activities. The balance between economic development and protecting environment is echoed by the people's demand for houses that not only shelters against wind and rain but durable, healthy, pollution-free, reliable and green. It seems that more attention has been given to these characteristics in the west where the research works looking for non-contaminated and non-toxics construction materials are among the key research fields.

Stepping into the 21st century, China is paying more attention to the improvement of human residences. Ecologic housing is promoted as the trend for future Chinese housing. The government department in charge has considered it as the primacy objective to develop high quality of ecology and the residences when housing district is planned (CCM, 2000). This driving force has caused good interests among both the developers and the researchers in exploring methodologies and techniques of developing housing projects that integrates sustainability, environmental friendly, traditional culture, and energy saving. In 2000, China's Ministry of Construction (MOC) issued a guideline of indicators for designing ecologic housing (CCM, 1999). In this guideline, all indicators are grouped under 9 systems including energy system, water environmental system, air environmental system, sound environmental system, light environmental system, heat environmental system, plant system, waste management and treatment system and green construction material system. The brief specifications of these nine systems are described in Table 1.

Table 1: Indicators for Designing Ecologic Housing

System	Descriptions of Indicators	Criteria
Energy System	(1) The proportion of green energy (including solar energy, wind energy, earthly heat, waste heat, etc) in total district energy consumption shall reach the criteria	10%
	(2) Energy saving in the construction of building (in north heating region) shall reach the specified criterion	50%
	(3) Other energy saving in operating the building	5%
Water Environmental System	(1) Proportion of the coverage of the pipeline carrying drinking water	80%
	(2) Percentage of the draining sewage that have been treated to standard	100%
	(3) Percentage of recycling and reusing water in total water consumption	30%
	(4) Build up the system of collecting and utilizing raining water	√
	(5) Using mid-water or rain for planting, landscaping, washing cars, spraying roads, etc.	√

	(6) Percentage of using water-saving apparatuses.	100%
Air Environmental System	(1) Standard of air quality in the living environment	2nd level
	(2) Prohibit using productions (such as: CFC11) which can destroy Ozone Layer in the living district	√
	(3) Percentage of the rooms under natural draft among the total rooms	80%
Sound Environmental System	(1) Out-door Noise standard in the housing area (during the day)	≤45dB
	Out-door noise standard in the housing area (during the night)	≤40dB
	(2) Indoor noise standard (during the day)	<35dB
	Indoor noise standard (during the night)	<30dB
Light Environmental System	(1) The level of lighting in the housing district: road lighting	15~20LX
	Residence lighting in day time: executing criterion	GB50180-93
	(2) The level of indoor lighting:	
	1) Percentage of number of natural lighting rooms	80%
	2) Percentage of number of non-contaminated rooms	100%
	3) Percentage of using saving energy lamps	100%
Heat Environmental System	(1) Percentage of using green energy for cooling or heating	10%
	(2) Applying energy saving technique in providing heating and cooling.	√
Planting System	(1) Integrating the planting areas with the plan of residences, thus improving the ecological and environmental functions of the living areas.	√
	(2) Percentage of green land	≥35%
	Percentage of planting area in green land.	≥70%
	(3) Percentage of natural materials used in man-made landscapes.	20%
	(4) The live-die rate of the planting	≥98%
	The proportion of well grown plants	≥90%
	(5) Raining water is stored and utilized. Percentage of the rain stored should reach the defined criterion	√
	(6) Percentage of vertical planting area in total planting area.	20%
	(7) Density of planting in the housing estate	
	1) Number of arbors per $100m^2$ green land	3
	2) Proportion of special or multi-layer planting areas in total green area	≥20%
	3) Kinds of plant	
	Woody plants in northern China regions	≥40 kinds
	Wood plants in Central and East China	≥50 kinds
	Wood plants in South and South-West China	≥60 kinds
Waste Management and Treatment System	(1) Collection rate of domestic garbage	100%
	Sorting rate of domestic garbage	70%
	(2) Packaging rate of collected domestic garbage	100%
	(3) Treatment and disposition rate of domestic garbage	100%
	(4) Rate of recycling and reusing of domestic garbage	50%
Green Construction Material System	(1) Percentage of '3R' materials used for wall materials	30%
	(2) Prohibit using toxic construction materials and productions in the living district.	√
	(3) Rate of materials recycled in demolition constructions works.	40%

Remark: The symbol "√" means that this requirement shall be satisfied in the housing district concerned.

3. PRACTICING ECOLOGIC HOUSING – CASE STUDIES IN CHINA

This section presents two case studies concerning the development of ecologic housing in China, one in Chongqing, Southwest China, and one in Nanjing, East of China. The two cases have been constructively investigated and considered representative in demonstrating the practice of developing ecologic housing in the Chinese housing industry.

3.1 An Ecologic Residence District – A Nanjing Case Study

The project called "Yongmei Hill Housing District" is located in Nanjing City. The project has been promoted by the central government as the sample of developing ecologic residence district. The development of this project has applied new ecology techniques in improving the ecological performance of the surrounding area. The project is seated in the new urban area of Nanjing City, surrounded by mountain areas. The typical ecology techniques and ecologic criteria adopted in this development are summarized in Table 2 (LI, 2000), which are in line with the guideline set by MOC (CCM, 1999).

Table 2: Major Ecology Techniques Adopted In The Development Of Yongmei District

System	List of Ecology Techniques	Function of Ecology Technique
Energy System	Hot water system of solar energy	Supply hot water at 30~60℃ for every family throughout the year.
	Street lamp of solar energy	Supply lighting on main street in district during night.
Water Environmental System	Municipal water supply sub-system	Supply water for life and fire
	Pipeline drinking water sub-system	Supply water for drinking
	Drainage sub-system	Collect, treat and drain sewage
	Sewage treatment sub-system	Collect, purge the life sewage
	Mid-water sub-system	Treat the collective water and rain for reusing
	Rain collection sub-system	Collect rain
	Scenery water sub-system	Reuse the mid-water and rain collected.
Air Environmental System	Use green ornament materials	
	Design excellent ventilation system	
	Prohibit using materials which can destroy ozone layer such as: CFC11	
	Establish the monitoring station to monitor the district air quality.	
	Protect the land and vegetation and keep high coverage rate of trees.	
	Take effective usage of natural resources and maintain a healthy surrounding.	
	Protect the ecology system and ameliorate the poor quality district.	
	Design the district road according to the principle of transitability but un-smooth.	
	Plant trees that can absorb dusts along the roadsides.	
	Collocate the plants and choose the breed that can change the environment obviously.	
Sound Environmental System	Accord with the standard	
	Analyze the noise source in the phase of planning the district.	
	Don't disturb the sound environment when Assembling of public equipments and these equipments assembled in the insensitive noise place.	
	Arrange public buildings along the street and isolate residences from the noise.	
	Antidrumming treatment both in the external wall and the insulating layer.	
	Adopt the Celotex door, two layer glass window that are excellent in insulating sound.	
	Improve the effect of floor slab in insulating sound.	
	Take measures in indoor ornament and furniture arrangement for reducing the noise and shake.	
	Choose the ornament materials that have excellent effect in sound.	
	Install the interleaver or muffler in the indoor pipeline network system.	
Light Environmental System	Make the most use of natural light indoors. The scale of window to ground is larger than 1:7 and illumination is larger than 120LX.	
	Prohibit light pollution in all residences.	
	Use saving energy lamps wholly.	
	Adopt acoustic control switch in staircase.	
	Prohibit lighting the indoors from the car in designing the road and park.	
	Use green lighting outdoors.	
	Adopt the light reflecting nameplate, rail spike and doorplate and establish the road identification system.	

	Arrange the street lamp, yard lamp, grass lamp and ground lamp reasonably.
	Light over 97% of lamps in public places.
	Prohibit the use of neon lights, strong light and glass wall in district.
Heat Environmental System	Make the effective use of solar energy and terrestrial heat in residence heating, air-condition and hot water supply.
	Keep the temperature at 20~24℃ in winter heating and 22~27℃ in summer air-condition.
	The vertical temperature difference limits in 4 degree.
	Keep the ground temperature at 17~31℃
	The noise level of heating and air-condition equipments is lower 30dB(A).
Planting System	Keep accordance with standards.
	Advocate the concept of "open space first" in planning the roads, buildings and green lands.
	Build the pond in a lower place.
	The rate of green land in district is over 35%.
	The green land in public land is over 70%.
	The rate of causeway and road in green land is 15~30%.
	The material of causeway is infiltrative.
	Gardens building keep the same style with the main buildings and use 3R materials.
	Plant arbors, shrubs and grasses and shape the cubic planting and establish the planting community.
	Choose local trees and plant for landscaping.
	Choose fewer insects, non-hair pollution, non-thorn and non-toxicity plants.
	Choose flowerer and fruit plants to attract the butterflies and birds.
	Plant high arbors in the west of residences.
	Make use of roof, balcony, wall, carport and fence to plant.
Waste Management and Treatment System	Keep accordance with standards.
	Dustman collects rubbish in bags at doorway.
	Collect domestic garbage in sorts and in bags.
	Adopt incinerator to treat the domestic garbage and take use of the heat of incineration.
Green Construction Material System	Keep accordance with standards.
	Choose green construction materials.
	Choose recyclable construction materials.
	Choose reused construction materials.
	Choose non-toxin, non-harm, non-radioactivity, non-volatility products.
	Choose natural stone with the standard of radioactivity.
	Choose water paint with the standard of volatility
	Choose ceramic with the standard of stripping lead.
	Prohibit using asbestos products.
	Choose multi-film glue without benzene and halide.
	Choose bond without carbinol, halide or benzene and don't add compound of Hg, lead, cadmium, and chrome.
	Choose ardealite construction materials and fluorine in stripping liquid is less than 5mg/L.
	Formaldehyde stripping volume in man-made wood plate is less than 0.20mg/m^3; that in the wood floor is less than 0.12 mg/m^3. The paint of wood floor is ultraviolet light paint.

To encourage interaction amongst locals, the developer built the community hall, cultural center, tennis courts, swimming pools, ping pang rooms, poolrooms and other physical facilities. Various cultural and sporting activities are held at ad hoc basis, such as: painting and calligraphy shows, ball matches, chess matches and entertainment parties. Major newspapers and popular magazines are also available in the hall. The management of the estate also organizes tours for the dwellers over holidays and festivals periods. The developer harmonizes the district with the nearby educational institutions for sharing the cultural and physical facilities. The elders living in the estate established an "elderly center" and they often arrange various social events which enhances the communications among themselves. Nursery school with well-designed playground is available with high quality staff. All these facilities and events raise the merits of community and cultural sensitivity of the district. After assessing the project in line with the guideline issued by MOC, the central government development endorsed the project as the sample of developing ecologic residence in China.

3.2 Energy-Saving Residence– Case Studies in Chongqing

Chongqing, Southwest China, is the largest municipal of the country. Developing housing is one of the major economic activities of the city whilst the environmental pollution remains at extremely high level. The Municipal Government has promoted the application of ecology development techniques by setting up guidelines in developing future houses (CCTDC, 2001a). It nominated that the project titled "Tianqi Garden" as a sample for future housing projects, as it falls in line with environmental requirements.

Tianqi Garden is considered a typical housing project in energy saving. The central governmental department MOC endorsed the project as the sample of energy saving housing estate in 1999 (CCTDC, 2001b). The level of energy saving for daily operation of the project was tested during the design process. Two tests were carried out, namely, summer thermal performance test and winter thermal performance test. A working group including academics from Chongqing University, consultants and professionals recommended by the project developer conducted these two tests. The test results indicated that overall 50% energy saving can be achieved with additional 5% investment by applying advanced technologies such as energy-saving window/door made of plastic-steel, KP1-cork-brick and heat-preservation mortar, roof covered with soil and water, energy-saving air-condition equipment. The employment of these technologies focuses on preventing heat in external wall through specific techniques including solar energy technology applied to window areas new energy-saving materials for walls such as light-weight aggregate concrete block and gypsum wall (CCTDC, 2001c).

Another typical housing project developed with energy-saving orientation is Longhu Garden. The project developer established the environmental management system for the whole project development process from design to operation in line with the principles and standards set in ISO14000. In the early planning and design stages, trees and shrubs were planted for reducing the noise, lowering the temperature in the summer time and adjusting the level of air humidity when necessary. Special considerations were given to different kinds of trees in order to kill the bacilli and mosquitoes by taking advantages different trees or plants have different embodied chemicals. Compared to normal housing building, 30% energy-saving has been achieved in Longhu Garden by adopting the following specific energy-saving methods:

a. Choosing the shale-agglomerated cork brick in laying the wall of buildings by replacing the normal red clay brick;

b. Choosing the polyphenylene board for the heat preservation layer. The 200mm-wide wall covered with the 20mm polyphenylene board has the same thermal performance as the 370mm wide wall;

c. Choosing double-layer and hollow plastic-steel window;

d. Choosing the air-conditioning system that can change air flows frequently;

e. Choosing PP-R pipeline for water in-flows;

f. The outdoor lighting system is controlled with both optical controlling system and time controlling system;

g. Cesspool is treated with deep-burying technology, which carries no energy consumption.

4. CONCLUSION

Developing ecologic housing has been promoted as the direction of future real estate. It aims to protect the environment by effectively using environmental resources whilst building comfortable and environmental friendly living surrounding. This development has been well received in both developed and developing countries as an important mechanism in implementing sustainable development. The promotion of this mechanism is even more important in China where a huge amount of housing works are predicted for coming years. This paper identifies the growing problems with environmental pollution in China as its housing industry is consuming environmental resources at high speeds. On the other hand, the study demonstrates the progressing move in developing ecologic housing with the driving force from central government departments. With governmental determination, developing ecologic housing is the major direction of the future Chinese housing industry. This presents good potential for overseas professionals who have good experience and techniques in developing ecologic housing to explore business opportunities.

5. REFERENCES

ADB (Asian Development Bank). (1998). Proposed Technical Assistance Cluster to the People's Republic of China for the Promotion of CP (September).

Aminul Huq, et al. (1999). 'The Asian Development Bank's Role in Promoting Clear Production in the People's Republic of China', *Environ Impact Assess Rev* 1999; 19:541-552.

Bourdeau, L., Huovila, P., Lanting, R., and Gilham, A. (1998). *Sustainable Development and the Future of Construction: A Comparison of Visions from Various Countries,* CIB Report 225, Rotterdam, The Netherlands.

CCM (China Construction Ministry). (1999). 'The Key Points and Technologies Guidance for City Ecology Housing Construction' (discussed).

CCTDC (Chongqing Construction Techniques Development Center). (2001a). *Chongqing Construction Saving Energy*, pp4-7.

CCTDC (Chongqing Construction Techniques Development Center). (2001b). *Chongqing Construction Saving Energy*, pp9-11

CCTDC (Chongqing Construction Techniques Development Center). (2001c). *Chongqing Construction Saving Energy*, pp13-14.

China Real Estate Statistical Yearbook 1999, China City Publication, pp4-5.

Cole, R. (1998). Emerging trends in building environmental assessment methods, *Building Research and Information*, Vol.26, No.1, pp.3-16.

Court, Thi js de la. (1990). *Beyond Brundtland: Green development in the 1990s*, New York: New Horizons Press; pp45-89.

CRED (China Real Estate Dynamic). (2001). *China Real Estate Dynamic*, published by National Information Centre, p7.

CRESY (China Real Estate Statistics Yearbook). (1999). *China Real Estate Statistics Yearbook*, published by China City Publications, pp8-9.

Crush, J. S. (1995). *Power of development*, New York: Routledge, pp87-100.

Hall, K. & Warm, P. (1995). *Greener Building*, AECA Publication, Section2, p3, p7, p32.

Holly Sims. (1999). *'One-fifth of the Sky: China's Environmental Stewardship'* World Development Vol.27, No.7, pp.1227-1245, 1999.

Jacobson, Michael. (1994). Beware of the tiger: The hidden agenda of China's environmental foreign policy, *Journal of Pacific and International Affairs* 5, 190-217.

LI Qiming *et al.,* (2000). *The Feasibility Study Report on Nanjing Yongmei Garden,* pp10-11.

NEPA (National Environment Protection Authourity) (1997), *China Environment Year Book*. Beijing.

Ofori, G. and Chan P. (1998). Procurement Methods and Contractual Provisions for Sustainability in Construction, *Construction and the Environment, CIB World Building Congress*, Gavle, Sweden, June 7th – 12th, C296.

SHEN Liyin and WU Dehua (2001), *"Structured analysis to environmental impacts of Construction",* 2001 International Conference on Project Cost Management Beijing, P.R.China

Shen, L. Y., Zhang, Z. H. (1999). 'Sustainable development challenges to urbanization in China', *Proceedings of COBRA 1999, The Challenge of Change: Construction and Building for the New Millennium*, 1-2 Sept. 1999, University of Salford, UK.

Treloar, G. (1996). *The Environmental Impact of Construction - a Case Study*, Australia and New Zealand Architectural Science Association (ANZAScA), Sydney, Australia, pp. 1-95.

Whitcomb, Vanessa. (1992). An environmental SOS. *China Business Review* pp.9-10, 30-34.

Wilson Alex, Jenifer L.Uncapher, *et al.* (1998). *Green Development – Integrating Ecology and Real Estate*, John Wiley & Sons, Inc,pp.4-9.

WU Dehua, Edwin H W CHAN and Liyin SHEN. (2001). Scoring System for Measuring Contractor's Environmental Performance, *Journal of International Construction Management, (Accepted).*

WU Dehua, SHEN Liyin and TAM W Y Vivian. (2000).*"Investigation to An Alternative for Measuring Contractor's Environmental Performance",* presented on Proceedings of the International Symposium on Construction Management and Economic Development, Tianjin, P.R.China.