

# **An Evaluation of the Priority Order in Applying the Sustainable Office Building Design Focused On Ubiquitous Space**

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## **Abstract**

Recently, on account of increasing interest of sustainability, needs for sustainable building is growing more and more interested in construction industry. According to these concerns, it was introduced and in operation related systems, such as 'indoor air quality control', 'housing performance indicator system' and 'green building certification system' in Korea. Although practical affairs and researches are in progress to apply sustainable design in office buildings, there are still a lot of environmental criteria which could not be easily quantified in design phase and no information about the application priority order in office building design. Therefore, this research focuses on definition and quantifying the environmental criteria (factor) and finding application technology priority order in design phase for sustainable office building. To meet the needs of the research, firstly relatively representative sustainable design criteria were identified and prioritize the identified factors and ranking the importance level of each factor through a survey of the experts and office building architects.

## **Keywords**

Environment-friendly criteria, Sustainable building design, Application priority order, Ubiquitous space

## **1. Introduction**

Recently, on account of increasing interest of sustainability, needs for sustainable building is growing more and more interested in construction industry. According to these concerns, it was introduced and in operation related systems, such as 'indoor air quality control', 'housing performance indicator system' and 'green building certification system' in Korea. Although practical affairs and researches are in progress to apply sustainable design in office buildings, there are still a lot of environmental criteria which could not be easily quantified in design phase and no information about the application priority order in office buildings design. Especially, There are few information about 'the sustainable office building design technologies' in ubiquitous office space, that was presented as interaction of information (Blevis, 2007).

These sustainable design technologies should be considered not economical factors (Aaker *et al.*, 2007) such as 'market scale', 'Growth' and 'Profitability', but social demands such as 'public interest'. In addition, sustainable design technologies in ubiquitous space generally subsume increase of design and construction cost, and effect as a barriers to general purpose. Thus, It is very important that comprehends the related demand, investigates and analyze the market scale before development phase (Keenan and Georges, 2006).

The goal of this research is to 1) define and quantify the environment-friendly design evaluation criteria (incl. factors) through comparing and analyzing the ‘Green Building Rating Systems’ among Korea, United States, and UK and related researchs. And, 2) find the application priority order in sustainable office design phase through a questionnaire survey of design specialists.

## 2. Evaluation of Sustainable Design Factors

### 2.1 Categorization of Sustainable Design Factors

For draw out the application priority order for the sustainable office design, it should proceed that categorize the design technology adaptable to sustainable office buildings. However, the standard of these technologies is very various and it is hard to generalize because of regional characteristics. That is, there is no effective classification system about sustainable office design. Accordingly, this research suggest that sustainable office design factors based on LEED v2.1 in United States, BREEAM office 2005 in UK, and GBCC in Korea, with reference to related literatures and researches. In survey, pure research field’s technologies and items that have less relation with office design technologies were ruled out, sustainable office design technologies were classified into construction and equipment (Spiegel and Meadows, 2006). Finally, 25 design element technologies were found out, as shown in Table 1.

**Table 1: Classification of Sustainable Office Design Technologies**

	Field	Technologies
Construction	Shape of building	Variable level planning
		many faces open planning
		5-bay planning
	Skin system	balcony and indoor gardening
		Intelligent skin
		system windows and doors
	Material/Method of Construction	Low-E glass
		high insulation envelop system
		sustainable building materials
		sustainable adhesive
Equipment	Air –Conditioning /Lighting	Natural paint
		noise proof materials between floors
		Standardization of components
	Control System	prefabrication construction
		Built-in furniture
		natural ventilation
	Reuse heat source system	natural lighting
		HVAC
		Sun tracking awning system
		Automatic temperature& humidity control
		Human body sensing sensor
		Solar power generation
		Solar heating
		Wind power generation
		Geothermal power heating

## 2.2 Selection and Analysis of Evaluation Criteria

It should be preceded that selection of evaluation criteria for application priority order. In this research, based on three criteria, widely used in business administration, 1) market scale, 2) growth, and 3) profitability, add to 4) public interest, totally four evaluation criteria were selected. Each criteria's main evaluate details are shown in Table 2.

The survey was operated to persons who had an experience to join sustainable project or to do office building design. Also, as mentioned earlier, the question was limited in sustainable design phase focused on ubiquitous space. A survey period was performed during 4 days, from Feb. 24, 2008 to Feb. 27, 2008 and collected 52 copies among distributed 58 copies (Return rates are 89 percents). '5-Point Likert equal interval scale' was applied to evaluate 25 sustainable design technologies classified by 4 evaluation criteria, market scale, growth, profitability, and public interest. When results were analyzed, to remove the variation between respondents, score of responds were standardized. To standardize the scores, it has been revised so that the mean value is 3, standard deviation is 1.

**Table 2: Main Evaluation Details of Criteria**

Criteria	Main Evaluate details
Market Scale	How big is the relative domestic market size? How big is the relative international market size? How it is possible entry to the new expansion? How much is the recent rate of growth?
Growth	In there a possibility that increase the demand constantly? How about the requirement in the market?
Profitability	How many rival companies are there? Is this a higher value-added technology? How tall is the entry barrier of market?
Public interest	Does it have a public benefit? Does the government encourage technology development? Does it agree with government policy?

Also, the degree of importance of 4 criteria was calculated in order to overall evaluation about application priority order. And, deriving weights with a pair wise comparison using AHP (Analytic Hierarchy Process) was produced; the result is shown in Table 3.

**Table 3: Weights of Evaluation Criteria**

	Market Scale	Growth	Profitability	Public interest
Weight (%)	30.3	18.5	31.8	19.4

## 2.3 Result of Survey (Table 4)

**Table 4: Result of Survey**

Field	Technologies	Market Scale		Growth		Profitability		Public interest		
		Score	S.D	Score	S.D	Score	S.D	Score	S.D	
Construction	Shape of building	Variable level planning	3.02	0.91	3.29	1.27	3.06	1.10	3.12	0.84
		Many faces open planning	2.74	0.99	3.08	1.05	3.14	0.85	3.02	0.92
		5-bay planning	3.07	0.84	3.12	0.87	2.90	0.90	2.85	0.79
		Balcony and indoor gardening	3.27	0.92	3.02	0.90	3.61	0.91	3.29	1.01
	Skin system	Intelligent skin	3.13	0.92	3.30	0.78	3.41	0.60	2.75	0.88
		System windows and doors	3.25	0.73	3.02	0.90	3.30	0.78	2.95	0.73
		Low-E glass	3.15	0.72	2.70	0.90	3.11	0.92	2.88	0.76
		High insulation envelop system	3.30	1.20	2.73	0.88	2.87	1.21	2.82	0.80
	Material/Method of Construction	Sustainable building materials	4.14	0.47	4.19	0.51	3.89	0.49	2.74	0.97
		Sustainable adhesive	3.62	0.63	3.78	0.90	3.75	0.53	2.60	0.81
		Natural paint	4.01	0.52	4.00	0.74	3.59	0.47	2.80	0.74
		Noise proof materials between floors	3.76	0.63	3.62	0.60	3.30	0.97	3.03	0.93
		Standardization of components	3.24	0.60	2.63	1.28	3.49	0.83	3.42	1.15
		Prefabrication construction	3.26	0.90	2.57	0.82	3.62	0.85	3.40	0.62
	Built-in furniture	3.39	0.74	2.32	1.02	2.68	0.80	2.86	0.94	
Equipment	Air – Conditioning /Lighting	Natural ventilation	2.37	1.20	2.95	0.88	3.01	0.75	3.23	0.48
		Natural lighting	2.79	1.06	2.89	0.79	3.10	0.72	3.15	0.65
	Control System	HVAC	3.12	0.87	2.99	0.77	3.24	0.69	2.70	0.66
		Sun tracking awning system	2.13	2.11	2.29	0.71	2.30	0.77	2.69	0.83
		Automatic temperature& humidity control	2.45	1.50	2.75	0.84	2.63	0.68	2.46	0.75
		Human body sensing sensor	2.59	1.20	2.96	0.92	2.44	1.01	2.38	0.82
	Reuse heat source system	Solar power generation	2.58	0.63	3.24	0.76	2.09	0.72	3.97	0.51
		Solar heating	2.30	0.90	2.50	0.98	2.10	0.77	3.39	0.77
		Wind power generation	2.35	0.81	2.85	0.93	2.30	0.98	3.18	1.05
		Geothermal power heating	2.15	0.90	2.21	0.89	2.27	0.77	3.32	1.11
		Average	3.00	-	3.00	-	3.00	-	3.00	-

### **2.3.1 Market Scale**

Among the office design technology, the factor that has largest market scale is sustainable building materials (4.14). That refers to growing interest to indoor's toxic materials, such as Formaldehyde and VOC (Volatile Organic Compounds), and is analyzed that increasing the demands according to operation of related laws, for example 'indoor air quality control'. Natural paints (4.01) and noise proof materials between floors (3.76) also have a big market scales. Natural paints have a trend to grow increase because of same reason with sustainable building materials. Noise proof materials between floors of apartment building recently were strengthened. However, in spite of there are no special rules in office building design, possibility of market is deemed high.

### **2.3.2 Growth**

As well as market scale, sustainable building materials (4.19) also scored highest in growth criteria. Natural paints (4.00) and Sustainable adhesive (3.78) scored related high growth, too. It indicates that consumers' demands with government policies influence sudden increase of demands. The reason that sustainable materials and construction methods have high Growth than energy reuse and equipment criteria, is so far lack of recognition about energy saving.

### **2.3.3 Profitability**

Sustainable building materials (3.89), sustainable adhesive (3.75), prefabrication construction (3.62), balcony and indoor gardening (3.61) have high score in profitable criteria. It was comprehended by reason of big market scale and recently demands increase. Solar power generation (2.09), solar heating (2.10), geothermal power heating (2.27), and wind power generation (2.30) were realized as poor profitable criteria, because they can't easily adapt to the fields and the efficiency is low compared with development cost.

### **2.3.4 Public interest**

In public criteria, solar power generation (3.97) has the high score in public interest criteria. Standardization of components (3.42) and prefabrication construction (3.40) are relatively ranked high. This means that according to increase of recognition about environmental pollution, new office design technologies which considerate public interest is need. Even if the market scale and profitability not big yet, It means that has possibility according to government policy or needs in future. And, technologies included to 'Reuse heat source system' such as solar heating, wind power generation, and geothermal power heating have high score. This means that, in public sector's technology development, inflecting reuse energy and natural energy is very important.

## **3. Overall Review of Result**

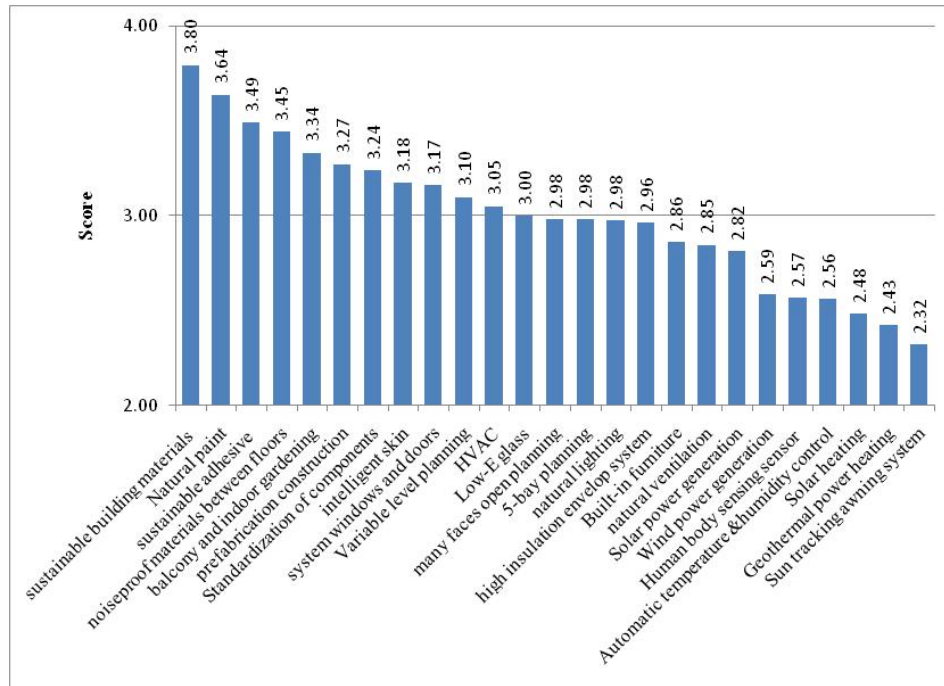
After drawing out 25 sustainable office design technologies, and categories into 4 criteria, such as 1) market scale, 2) growth, 3) profitability, and 4) public interest. And then overall evaluation was conducted about application priority order. As noted earlier, weights are derived applying the degree of importance to criteria. The result that consider 4 criteria is pictured in Figure 1. The figure is ranked in descending order. sustainable building materials (3.80), natural paint (3.64), sustainable adhesive (3.49), noiseproof materials between floors (3.45), balcony and indoor gardening (3.34) have high score. Consequently, In Korea sustainable office design market, demands for sustainable materials and construction methods are more larger than saving energy and reuse energy.

## **4. Conclusions**

Application priority order of sustainable office building was evaluated using design experts' survey. In market scale, growth, and profitability criteria, sustainable building materials, natural paint, sustainable

adhesive, noise proof materials between floors were comprehended as important design factors. Only in public interes, it was concluded that design technology using natural energy, such as solar, wind, and geothermal energy is more important. That is, immediate practical use is impossible, over the long term, it is has a good possibility to settle institutionally. Accordingly, in design company, to establish superiority, it is concluded that investment should be strengthen technical development inflecting natural energies.

The result of this research, also could be utilized to plan a sustainable ubiquitous building. In next research, it should be continued not only architect’s needs but also the other participants’ (such as owners, engineers, and users) demand analysis.



**Figure 1: Overall Result of Sustainable Design Priority Order**

## 5. Acknowledgements

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