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A Comparison of Plan and Facility Items in Green Building Certification Criteria - Focused on Energy-related Items in Schools -

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Abstract

Low-energy consumption and low-carbon emissions are global issues and a challenge for all countries. In this context, the green building certification criteria in the construction industry needs to be refined in order to focus on energy-related items in schools. In particular, energy-related plan items do not incur costs in terms of use and maintenance and their initial installation cost is usually less than that of facility items. Their installation should therefore proceed first in order to reduce the costs or building energy consumption for green growth. Consequently, this study provides basic data for improving the green building certification criteria based on findings from a survey on green certification criteria, energy-related items of 17 schools that possess the certification, and the plan items and facility items of those 17 schools. The findings of this study can be summarized in two key points. First, the energy-related items in the energy sector need to be professionally managed and evaluated. Second, plan evaluation items in the energy-related plan items need to be introduced and a minimum score criteria for plan items needs to be suggested to encourage the installation of plan items.

Keywords: green building certification criteria; school; plan item; facility item; EPI item

1. Introduction

1.1 Research Background and Objectives

To actively respond to global warming and abnormal climate, many countries have joined the Climate Change Convention. In January 2010, Korea began to enforce the Framework Act on low-carbon green growth to reduce greenhouse gas emissions to the appropriate level. Taking into account the need for a balance between the economy and the environment, the low-carbon green growth national strategy has been established to reduce the impact of climate change and environmental damage by saving and using energy and resources efficiently, and securing new growth engines by developing clean energy and green technology. In addition, to implement this strategy efficiently and systematically, a five-year plan has been put in place.

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The CO_2 emissions from buildings during their lifecycle account for 40% of global CO_2 emissions. Therefore an increase in green buildings can be expected to reduce greenhouse gas emissions significantly[5]. In March 2013, with the aim of reducing greenhouse gas emissions from buildings by 26.9% by 2020, the Korean government enforced the Act on Support for Green Buildings to build a comprehensive and systematic foundation to promote green buildings. This act specifies systematic tools to reduce greenhouse gas emissions from buildings and expand the construction and use of green buildings by establishing a basic plan and construction plan for green buildings, using information systems for evaluating energy consumed by buildings and their greenhouse gas emissions, enforcing green building certification, designating green building centers, evaluating total energy consumption, introducing energy consumption certifications, and training green building experts. Furthermore, there are various policies to conserve energy by providing incentives to those who achieve the greenhouse building certification and the energy saving grade.

Therefore, this study suggests certain measures to support the laws on energy conservation and greenhouse gas reduction, and encourage builders to comply with such laws.

In this study, first, a basic survey was conducted by categorizing energy-related items into plan items and facility items in order to suggest an increase of point distribution and the number of plan items and the minimum score. This approach was chosen because energy-related plan items cost less than facility items with respect to terms of use and maintenance and their initial installation cost was cheap enough to encourage building owners to use more energy-efficient technologies.

Second, this study was intended to increase EPI (Energy Performance Index) points -which pre-evaluate energy consumption during the building operation stage, in which the most energy is consumed during the building lifecycle within certification standards by comparing them with other energy-related items.

Third, this study tried to derive all the energy-related items within the green building certification criteria and integrate them into the energy sector and improve the items where evaluations overlap. This was done to improve the clarity and simplicity of the national energy management policy and provide an efficient installation environment for the integrated design process.

1.2 Study Scope and Methods

The scope of this study includes: deriving only the energy-related items from the green building certification criteria and the EPI items, categorizing them into plan items and facility items, surveying point distribution, and studying the plan and facility item scores of the 17 main schools in Daegu that possess green building certifications.

The study methodology can be summarized in three steps. First, we derived the energy-related items in the school certification criteria and compared the point distribution proportion in the entire certification criteria after categorizing them into plans and facilities, following which, we analyzed the problems.

Second, we compared and analyzed the scores of the EPI detail items and all the energy-related plan/facility items, targeting schools with green building certifications.

Third, we analyzed the energy-related items for improvement by analyzing the green building certification criteria and status, with an emphasis on suggesting basic data to introduce a wide range of plan items to adjust the point distribution and suggesting minimum points to encourage the installation of plan items.

2. Analysis of Energy-related Items in the Green Building Certification Criteria

2.1 Definition of a Green Building and Certification System

A green building refers to a building that is designed and built using eco-friendly techniques (energy saving, high-efficiency facility, recycling materials, and reducing environmental pollution) to minimize damage to the environment over the building's lifetime[11]. In a green building certification system, the environmental function of a building is accredited by evaluating environmental elements such as energy and resource savings, reduction in pollutant discharge, comfort property, and harmony with the surrounding environment throughout the entire process, selection of location and building materials, maintenance, and disposal.

2.2 Korean Certification Criteria for Green Buildings

For sustainable implementation of the national certification for development of green buildings and to encourage resource-conservation and environment-friendly practices, the Ministry of Land, Transport and Maritime Affairs and the Ministry of Environment are jointly implementing this certification system. It was first implemented in Korea for apartment buildings in January 2002, for resident complex buildings and business purpose buildings in January 2003, for schools in March 2003, and for sales and accommodation facilities in September 2009. The certification system for all buildings was revised in July 2012 to offer 4 certification grades on a weighted-value grading system. Table 1. shows the evaluation criteria for school facilities.

Table 1. Score Standard by Certification Grade of School[8)]

Grade	Points	Remarks
A	80 or higher	Highest Points: 100
B	70 or higher	
C	60 or higher	
D	50 or higher	

Certification criteria for school facilities reviewed in this study are for 9 sectors, 24 categories, 39 evaluation items and their detailed evaluation criteria. Table 2. shows Korean green building certification criteria for school facilities and the energy-related items are highlighted in gray.

Table 2. Score Standard by Certification Grade of School[8)]

Sector Category		Evaluation Item	Point	Weighted Value
1. Land Use	1.1 Ecological value	1.1.1 Ecological value of the existing land	2	5
	1.2 Impact on surrounding land	1.2.1 Validity of protection of the right to have sunlight	2	
2. Transport	2.1 Traffic load reduction	2.1.1 Proximity to public transit	2	5
		2.1.2 Bicycle parking station	2	
3. Energy	3.1 Energy saving	3.1.1 Energy efficiency improvement	12	20
		3.1.2 Energy meter	2	
		3.1.3 Lighting energy saving	4	
	3.2 Sustainable energy source	3.2.1 New renewable energy	3	
4. Material and resource	4.1 Resource saving	4.1.1 Toilet expendables saving	1	15
	4.2 Sustainable resource use	4.2.1 Environment-friendliness certified product for recycling of valid materials	3	
		4.2.2 Separate collection of recyclable resources	2	
		4.2.3 Food waste reduction	2	
		4.2.4 Marking for carbon emissions of materials	2	
Evaluation only for remodeling		4.2.5 Reuse of existing building's main structure for material and resource saving	7	
		4.2.6 Reuse of existing building's non-bearing walls for material and resource saving	2	

5. Water resource	5.1 Water-circulation system	5.1.1 Validity of precipitation load reduction plan	3	10
	5.2 Water resource saving	5.2.1 Validity of daily water reduction plan	4	
		5.2.2 Precipitation use	3	
		5.2.3 Wastewater reuse system	3	
6. Prevention of environmental pollution	6.1 Prevention of global warming	6.1.1 CO2 reduction	3	5
		6.1.2 Ban on specific materials to protect the ozone layer	3	
	6.2 Air environment	6.2.1 Prevention of dust from the playground	3	
7. Maintenance	7.1 Systematic building management	7.1.1 Reasonability of the site management plan based on the environment	1	7
	7.2 Efficient building management	7.2.1 Validity of operation/maintenance documents and instructions	2	
		7.2.2 TAB and commissioning	2	
	7.3 Improved indoor environment and maintenance	7.3.1 Reduction of dust created by walkers	2	
8. Ecological environment	8.1 Green plot within the land	8.1.1 Linked green belt	2	15
		8.1.2 Green rate of natural ground	2	
	8.2 External space and ecological function of the building exterior	8.2.1 Ecological area rate	6	
	8.3 Habitat for plants and animals	8.3.1 Biotope	4	
		8.3.2 Ecological learning space	2	
	8.4 Use of natural resources	8.4.1 Reuse rate of surface soil	2	
9. Indoor environment	9.1 Air environment	9.1.1 Use of materials that emit less air pollutants	6	18
		9.1.2 Natural ventilation	3	
		9.1.3 Suppression of other harmful materials emitted from construction materials	1	
	9.2 Heating environment	9.2.1 Placement of appropriate heat source equipment and thermostat	2	
	9.3 Sound environment	9.3.1 Indoor noise caused by traffic noise (road, railroad)	2	
	9.4 Sunlight use and improved view	9.4.1 Plan to use sunlight and prevent glare (Shading device Installation)	2	
	9.5 Fresh indoor environment	9.5.1 Space for relaxation and refreshment	3	

Currently, the government offers incentives to building owners that are certified to encourage them to reduce energy use. For buildings that obtain both the building energy grade and green building certificate, local taxes (acquisition/registration tax) are reduced according to the grade as shown in Table 3. When investments and installation of energy-saving facilities are made to conserve energy, the building energy efficiency grade (grade 1–5) is given according to the energy saving rate[2] which is affected by energy items in the green building certification criteria and the EPI items.

Table 3. Reduction and Exemption of Local Tax[8]

Environment-friendliness criteria Energy criteria	Excellent	Good
Building energy efficiency grade 1 or EPI 90 or higher	Acquisition/registration tax, 15% off	Acquisition/registration tax, 10% off
Building energy efficiency grade 2 or under EPI 80–90	Acquisition/registration tax, 10% off	Acquisition/registration tax, 5% off

In addition, as shown in Table 4., the local government's ordinance stipulates the floor space index, garden space, and maximum height of the building based on the environment-friendliness certification grade, energy efficiency grade, and EPI.

Table 4. Ease of Building Standards[8]

Classification	Energy efficiency grade 1 or EPI 90 or higher	Energy efficiency grade 2 or EPI 80–90
Environment-friendliness grade: Excellent	12% or less	8% or less
Environment-friendliness grade: Good	8% or less	4% or less

2.3 Analysis of Energy-related Items

(1) Plan and Facility Items

Methods to adjust the internal environment of a building with respect to the architectural environment can largely be divided into two categories: passive control through natural methods and active control through equipment. In the former, the indoor environment is controlled to suit the sensible needs of humans without using any equipment, by utilizing the shape, structure, and surface plan of the building. In the latter, the indoor environment (heat, light and sound) is controlled by using supplied energy without regard to the outdoor environment. However, the equipment necessary for heating, lighting, air conditioning and plumbing accounts for more than 30% of the total initial construction cost and is expensive to maintain and operate.[9]

(2) Energy Performance Indicator (EPI)

EPI is used to reduce energy consumption and greenhouse gas emission by pre-evaluating energy consumption in the operation stage which consumes the most energy during a building's lifecycle (Table 5.). Since December 2004, it has been revised four times and is now divided into four sectors: architecture, equipment, electricity, and new and renewable energy. In the certification criteria, the minimum grade is set at 65 points. Thus, this study included plan items in the architecture sector and included facility items in the equipment, electricity, and new and renewable sectors to fulfill the purpose of this study. The point distribution proportion accounted for 11.43%. In Table 5., items overlapping with those in the environment-friendliness certification criteria are highlighted in gray.

Table 5. Evaluation Items of EPI Examination for School Facilities[7)]

Item				Point (School)
Building	1. Average heat transmission coefficient of the outer wall, Ue ($W/m^2 \cdot K$) (including windows and doors)			27
	2. Average heat transmission coefficient of the roof, Ur ($W/m^2 \cdot K$) (average heat transmission coefficient for other parts except for the roof or transparent exteriors)			7
	3. Average hat transmission coefficient of the living room floor on the lowest floor, Uf ($W/m^2 \cdot K$)			7
	4. Exterior insulation technique (installation ratio against the entire outer space, only for where the ratio between window area and the entire outer space is less than 50 %.)			6
	5. Installation of air-tight windows (air-tightness grade based on KS F2292, unit: m^3/hm^2)			6
	6. Opening for natural lighting (swimming pool), operable window installed in the wall in the living room which is facing the outer atmosphere (other buildings)			1
	7. Insulated window			-
	8. Shading device installation (installed more than 80 percent of the window area to the southwest)			3
	9. Rooftop landscaping (according to Paragraph 3 of Article 27, Enforcement Act of Construction. This does not apply where the rooftop landscaping substitutes the landscaping area within the site.)			1
Machinery/ facility	1. Heating equipment (Efficiency %)	Oil boiler		8
		Gas boiler	Centralized heating	
			Individual heating	
		Other heating equipment		
	2. Cooling equipment	Centrifugal type (Energy efficiency, kW)		3
		Absorbing type (Grade coefficient, COP)	① 1 effect	
			② 2 effect ③ 3 effect ④ Cold/hot water supplier	
		Other heating/cooling equipment		
	3. Efficiency of the heat source equipment and a ventilator (%)			3
	4. Average efficiency of cold/hot water circulation, water supply and hot water pump (%)			2
	5. Economizer system and other outer air cooling system			1
	6. Waste heat recycling ventilator or ventilator using floor heat			1
	7. Insulated equipment, pipe and duct			2
	8. Multiple units application for partial load of heat source equipment proportional control or multistage control operation			2
	9. Acceleration control for the air-conditioning fan and other energy saving control			1
	10. Installation of waste heat from the boiler or air-conditioner			1
	11. Installation of waste heat from domestic waste water			-
	12. Cool storage electric cooling, gas-based centralized cooling, local cooling, small heat-combined cooling (maximum load ratio during daytime, %)			1
	13. Night electricity-based heat storage facility (20% or more of heating load)			1
	14. Heating boiler			2
	15. Operating number control of heating or cooling/heating circulation pump, acceleration control or other energy-saving controls			2
	16. Water supply pump, pressurized water supply pump, acceleration control or other energy-saving controls			1
	17. Energy-saving control for the ventilation fan at the underground parking lot			-
	18. Computer automatic control system or site control system capable of networking			1
	19. Indoor thermostat for each room or zone (only for apartment buildings)			-
	20.	- Compensation point when items 1, 8 and 10 cannot be satisfied as local heating or small gas heat-combined system is selected		11
		- Compensation point when items 8, 10 and 15 cannot be satisfied as individual system is selected		5
Electric facility	1. Highly-efficient induction motor (ratio for electric facilities, %)			1
	2. Line voltage drop (%)			2
	3. Bank configuration transformer for operating number control			2
	4. Direct step-down for 25kW or less passive equipment			2
	5. Maximum electricity demand control facility			2
	6. Automatic control according to group or line for indoor lighting facilities			1
	7. Automatic control for passive equipment			1
	8. HID lamp for outdoor lamps, lamp reduction, automatic lighting control			1
	9. Energy-saving motor for elevators			1
	10. Electricity meter for each floor or lease zone			-
	11. Automatic power factor controller when automatic power factor condensers are installed in group			1
	12. The open communication system is selected for each facility energy control system as a distributed control system to enable energy management data sharing among control systems, and centralized control.			1
	13. Ratio of LED lighting consumption against total lighting consumption (%)			1
	14. Power outlet with low standby power consumption			2
New rene-wable energy	1. Ratio of new renewable energy capacity against total heating capacity			3
	2. Ratio of new renewable energy capacity against total cooling capacity			3
	3. Ratio of new renewable energy capacity against total hot water capacity			2
	4. Ratio of new renewable energy capacity against total electricity capacity			2

(3) Non-EPI Energy-related Items

The green building certification criteria includes energy-related items in the non-energy and energy sectors, including EPI items, and some EPI detail items overlap in the evaluation criteria. This study includes energy sector items besides EPI items and all energy-related items in the non-energy sector. Energy sector non-EPI items include new and renewable energy used for facilities, lighting energy saving and the installation of meters, and the point distribution proportion is 8.57%. The non-energy sector includes direct sunlight use, rooftop greening, right to sunlight, maintenance document filing (plan) in the plan item, and includes CO_2 emission reduction, performing TAB (Testing Adjusting and Balancing) or commissioning, adopting thermostats, and maintenance document filing (facility) - a total of 7 items (3 plan items, 3 facility items, and one maintenance and filing item which is a common item).

2.4 Comparative Analysis of Energy-related Items overlapping with EPI Items

Among the detail items within EPI and non-EPI items, the items with overlapping evaluation criteria include direct sunlight use facility installation in plan items, CO_2 emission reduction items, and new and renewable energy use items in rooftop greening and installation items.

Therefore, the evaluation criteria, point distribution, and the proportion of point distribution in the entire certification criteria were compared, as shown in Table 6. When comparing EPI detail items with non-EPI items for the overlapping items, most of the evaluation criteria were high, yet their point distributions were

Table 6. Comparison of Overlapping Item Point Distribution Proportion between EPI Items and Non-EPI Energy-related Items

Classification / Items		EPI items (Revised in Dec. 2012)			Non-EPI energy-related items			
		Evaluation criteria	Point distribution (converted as certification criteria total score)	Compare point distribution with non-EPI items	Before revision	Point distri-bution	Point distribution after the revision (the weighted value by sector is applied)	
Plan	Direct sunlight use (Shading device Installation)	External shading device only, when automatic control is connected, internal is admitted (installed more than 80 percent of the window area to the southwest)	0.3	Low	Installed above 30% of general classrooms	2	Installed above 30% of general classrooms	1.89
	Rooftop greening	Installed above 30%	0.1	Low	Installed above 10% of rooftop area	2	Optional item	0.83
	Total		0.4	Low	4		2.72	
Facility	CO2 Emission reduction	District cooling, small cogeneration, cool storage system, gas use centralized air-conditioning (above 90%)	0.1	Low	Supplement 20% of cooling and heating load with cogeneration. Use LNG and LPG for district cooling	2	Cover 20% of the heating and cooling loads, cogeneration, district cooling, renewable energy grade 5 application	1.67
		District cooling, small cogeneration (above 60%)	1.1					
	New and renewable energy use	Cooling, heating, and electric load (2%)/hot water supply load (above 10%)	1	Low	Share cooling, heating and hot water supply load (above 2%)	2	Share cooling, heating and hot water supply load (above 5%)	2.86
	Total		2.6	Low	4		4.53	

low. With respect to the shading device installation and direct sunlight use items, the evaluation criteria of EPI items were more than 80% higher than all windows in the installation, yet their point distribution was 0.3, which is significantly lower than the value of 1.89 for non-EPI items. With respect to rooftop greening, the point distribution of EPI items was 0.1, and that of non-EPI items was within the ecological area rate and had no minimum area criteria. The evaluation criteria were higher than 0.83, the weighted value, yet their point distribution was low. With respect to the CO_2 emission reduction items, the evaluation of EPI items was high, yet their point distribution was low. Evaluation criteria of EPI items in the new and renewable energy use items were 10% higher than those of non-EPI items in the hot water supply load only. This reveals the need to integrate overlapping evaluation items into one category or to modify the evaluation system in order to improve management convenience, such as the control of the weighted value of the energy sector or the rationality and expertise of energy evaluation.

3. Analysis of the Point Distribution Proportion on Energy-related Items in the Green Building Certification Criteria

3.1 Comparative Analysis of the Point Distribution Proportion of Energy-related Items before and after the Revision

With respect to the point distribution proportion of all the energy evaluation items, LEED 2009[12] accounts for 30%, BREEAM 2008[1] accounts for 18.3% and CASBEE[4] varies from the other three certification tools in the evaluation methods. Thus, it is impossible to compare them by using the same method, even though it accounts for 40% of LR (Load Reduction). However, with respect to the green apartment certification system in Korea, the energy evaluation items account for 11.0%, which is less than that of the other three tools[6]. This study derived all non-energy items and examined the point distribution by assuming that the weighted value of each sector is applied after the revision. The total point distribution is 35, which accounts for 33.2% of the point distribution proportion and which is higher than the 20% proportion of the energy sector point distribution. This is an increase of 6.4% in energy-related items before the revision, which is similar to the 6.26% increase in the energy sector.

3.2 Comparative Analysis of Point Distribution before and after the Revision of Plan and Facility Items

Point increase or decrease rate before and after the Revision of Energy-related Plan and Facility Items is shown in Table 7. EPI plan items increased by 0.94%, the non-EPI facility energy sector increased by 4.54%, and the non-EPI facility energy sector decreased by 0.19%, indicating that the point distribution of the non-EPI facility energy sector was the greatest. The energy-related items point distribution in plan items is 11.56%, which is significantly lower than the total of 21.46% (facility items). This significant reduction arises because there are three more items (8.57%) in the energy sector within non-EPI facility items and because the facility point distribution proportion is higher by 1.07% in the non-energy sector. This reveals that there is a need to increase the point distribution by introducing a wide range of plan items to non-EPI design items and encourage the installation of energy-related plan items.

Among energy-related items, the point distribution of EPI plan and facility items was the highest. However, the point distribution of the detail plan and facility items in EPI items had a significantly lower

Table 7. Variation of Point Distribution before and after the Revision of Plan and Facility Items

Items \ Certification criteria			Certification criteria point distribution before the revision	Certification criteria point distribution after the revision (total score: 105)	Variation (%)
Plan	EPI		(As of Nov. 2008) 5.74 (4.63%)	(Since Jun. 2010) 5.85 (5.57%)	+0.94
	Non-energy sector	Direct sunlight use (shading device installation)	2 (1.61%)	2 (1.91%)	+0.3
		Rooftop greening (within ecological area items)	2 (1.61%)	1 (1.08%)	-0.53
		Prohibiting the interruption to the right of sunshine	2 (1.61%)	2 (2.5%)	+0.89
		Maintenance document filing	1(0.81%)	0.5(0.5%)	-0.31
	Total (non-EPI)		7 (5.65%)	5.5 (5.99%)	+0.34
Planned point distribution			12.74 (10.28%)	11.35 (11.56%)	+1.28
Facility	EPI		(As of Nov. 2008. 11) 6.26 (5.05%)	(Since Jun. 2010. 6) 6.12 (5.83%)	+0.78
	Energy sector	New and renewable energy use	2 (1.61%)	3 (2.86%)	+1.25
		Lighting energy saving	3 (2.42%)	4 (3.81%)	+1.39
		Installation of meters	-	2 (1.9%)	+1.9
		Total	5 (4.03%)	9 (8.57%)	+4.54
	Non-energy sector	CO2 emission reduction	2 (1.61%)	3 (1.67%)	+0.06
		Performing TAB or commissioning	2 (1.61%)	2 (1.99%)	+0.38
		Adopting thermostats	2 (1.61%)	2 (1.91%)	+0.3
		Maintenance document filing	3 (2.42%)	1.5 (1.49%)	-0.93
		Total	9 (7.25%)	8.5 (7.06%)	-0.19
	Total (non-EPI)		14 (11.29%)	17.5 (15.63%)	+4.34
Facility total score			20.26 (16.34%)	23.59 (21.46%)	+5.12
EPI total score			12(9.68%)	12(11.4%)	+1.72
Non-EPI energy item total score			21(16.94%)	23(21.62%)	+4.68
Energy-related item Total Score			33(26.62%)	35(33.02%)	+6.4
Energy sector Total Score			17(13.71)	20.97(19.97%)	+6.26

point distribution than the energy items with similar non-EPI evaluation criteria, which reveals the need to adjust and increase the point distribution for an accurate evaluation of energy conservation.

4. Analysis of Score Ratio of Energy-related Items in Schools

4.1 Outline of Study Subject Buildings

Study subjects were limited to the facilities of 17 schools in Daegu that had acquired green building certifications between 2008 and 2012. These buildings were built as BTL (Build-Transfer-Lease) projects, yet their grade was, in general, mere "excellence." The outline of the certification is shown in Table 8. Since 2006, the construction, reconstruction, and extension of schools have been performed based mostly on BTL and the educational office and ordering organization mandated green building certification for BTL bidding. Furthermore, schools in Daegu have been required to obtain green building certifications since 2010. Since 2005, the BTL system has been applied to school facilities on the basis of return on investment in which the civil sector leases the public facilities built with civil funds to the government and receives a lease fee in return for the use of the facilities for a certain period rather than transferring ownership of the school facilities to the government after a certain period of time[3]. Since 2007, green building certification has been required for BTL projects and thus most new schools have obtained green building certifications since then. However, no school has received "the best" grade according to the statistics, which indicates that it is merely a quantitative need for certification in order to satisfy the obligation of green building certifications, and that a matching quality improvement has not yet been achieved[10].

This study investigated the installation status and score ratio of the green energy-related items, plan, and facility items and discovered avenues for improving the energy-related items.

4.2 Energy-related Plan and Facility Item Score Ratio

The findings from the analysis of the score ratio show that the score of the energy sector and energy-related items is higher than that of the non-energy

Table 8. Outline of Certifications of Buildings in the Study

School / Classification	A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R
Certification	Main certification	Main certification	Main certification	Main certification	Main certification	Main certification	Main certification	Main certification	Main certification	Main certification	Main certification	Main certification	Main certification	Main certification	Main certification	Main certification	Main certification
Certification grade	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Total score (Points)	68.257	66.342	70.281	66.603	71.856	68.965	69.58	75.854	70.67	68.99	68.934	70.58	65.437	66.802	68.964	68.405	66.716
Date of certification	2008.3.20	2008.3.20	2008.3.20	2008.3.20	2008.3.20	2008.9.30	2008.9.30	2009.4.1	2009.2.24	2009.2.24	2009.2.24	2009.4.1	2009.6.15	2010.11.2	2011.3.10	2011.7.29	2012.7.6
Certification criteria Before/after the Revision	Before revision	Before revision	Before revision	Before revision	Before revision	Before revision	Before revision	Before revision	Before revision	Before revision	Before revision	Before revision	Before revision	Before revision	Before revision	Before revision	Before revision
EPI item revision year	2004.12	2004.12	2004.12	2004.12	2004.12	2004.12	2004.12	2004.12	2008.1	2008.1	2008.11	2008.11	2008.11	2008.11	2008.11	2008.11	2008.11

sector and non-energy-related items, thereby revealing an absence of problems such as cost, for both, in scoring. The results of the comparison of the score ratio between energy-related plan and facility items in EPI and non-EPI categories are as follows. In plan items, EPI items accounted for 80.07%, and the non-energy sector accounted for 52.1%. In facility items, EPI items accounted for 52.7%, the energy sector accounted for 65.42%, and the non-energy sector accounted for 73.22%. The score ratio of the entire energy-related plan was lower than that of the entire facility because the score ratio of EPI plan items was greater than that of EPI facility items, whereas in non-EPI items, the facility was greater than the plan with respect to items and point distribution. Therefore, the score standards in the items were rather low except for CO_2 reduction items and new and renewable energy use items. This reveals the need to increase the point distribution by introducing a wide range of energy-related plan items and by suggesting minimum score standards for the energy sector and EPI plan items to encourage scoring of points for energy-related items and their installation. The score ratio of each plan and facility item is shown in Table 9., which suggests avenues for improving the items.

With respect to plan items, the direct sunlight use item has higher score standards and score ratio, indicating a need to encourage lighting energy conservation through planning by distributing higher points for installation of light shelves rather than blocking of sunlight. With respect to the maintenance document-filing item, the schools built as BTL projects, in general, had facility maintenance documents but not the green zone maintenance document because they were able to obtain full marks without the green zone maintenance document according to the current criteria. This reveals the need to evaluate after separating the rooftop green maintenance document-filing item, evaluate the completion of the relevant training programs, or suggest maintenance guidelines. The rooftop greening item had a high point distribution and was installed in more than 10% of sites, which is the minimum standard. In contrast, the item in the EPI was not installed at 30% of the sites, which is the minimum standard. Therefore, this indicates that most of the schools had installed rooftop green areas to satisfy the ecological area requirement rather than to consider energy load reduction. This result reveals the need to revise the evaluation of rooftop greening to avoid overlapping evaluation of EPI items with respect to the ecological area evaluation items in the ecological sector. Furthermore, the area standards should be raised beyond the current standards and the point distribution increased in order to secure clear heating and cooling energy reduction functions with regard to EPI items.

Table 9. Comparison of Individual Score (Ratio) between Energy-related Plan and Facility Items

Revision \ Certification criteria before			Energy-related item point distribution (Total score: 33)	Score (Points)	Score ratio (%)
Plan	EPI		5.74 (4.63%)	43.56	80.07
	Non-energy sector	Direct sunlight use (shading device installation)	2 (1.61%)	1.529	76.47
		Rooftop greening (within ecological area items)	2 (1.61%)	1.059	52.94
		Inhibiting interruption of the right to sunlight	2 (1.61%)	1.059	52.94
		Maintenance document filing	1 (0.81%)	0	0
	Total (non-EPI)		7 (5.65%)	3.65	52.1
Plan score ratio (%)			12.74 (10.28%)	8.52	64.95
Facility	EPI		6.26 (5.05%)	27.43	52.57
	Energy sector	New and renewable energy use	2 (1.61%)	0.8	40
		Lighting energy saving	3 (2.42%)	2.47	82.35
		Installation of meters	-	-	-
		Total	5	3.27	65.42
	Non-energy sector	CO2 Emission	2 (1.61%)	0	0
		Performing TAB or Commissioning	2 (1.61%)	1.77	88.24
		Adopting thermostats	2 (1.61%)	2	100
		Maintenance document filing	3 (2.42%)	2.82	94.12
		Total	9	6.59	73.22
	Total (non-EPI)		14 (11.29%)	9.86	70.43
Facility score ratio (%)			20.26 (16.34%)	13.11	65.98

With respect to facility items, adopting thermostats, lighting energy saving, performing TAB and commissioning and maintenance document filing items had a high score ratio compared to cost except for those items with high initial installation cost such as new and renewable use items and CO_2 emission reduction in non-EPI facility items. This reveals the need to increase the score standards and adjust the point distribution. As a result, new and renewable energy use and CO_2 emission reduction items had a low installation rate, which suggests there is a need to encourage installation by providing information on costs, benefits, references, and cases as installation guidelines.

5. Conclusions

In this study, energy-related items in the environment-friendly building certification criteria were researched in order to support the Korean national policy and act for energy and greenhouse gas reduction for green buildings. Suggestions to improve the environment-friendly building certification criteria for schools in Korea and encourage the installation of energy-related items are as follows.

First, energy-related items should be classified into plan and facility for focused management. In particular, the installation of plan items should be encouraged. The plan point distribution of all energy-related items was 11.56%, which is significantly lower than the 21.46% value for facility point distribution. This is because the non-EPI item's point distribution in facility items was 8.57% and 1.07% higher in the energy sector and the non-energy

sector, respectively, indicating that the point distribution proportion was higher than plan items. After revision, the grade rate increase of the EPI plan items is higher than facility items. However, the grade is low. For all items grade and grade increase rate, plan is less than or equal to facility except for the maintenance document storage item. Therefore, to comply with energy and greenhouse gas reduction policies and laws and encourage the installation of cost-effective plan items, points for plan items should be increased in the certification criteria and a minimum point criterion should be suggested. However, to keep a balance between energy-related items and other items, the minimum point for indoor environment quality and other critical items should be included to maintain environmental performance.

Second, EPI points within the certification criteria should be increased reasonably. Some of the EPI items evaluation overlapped with the energy and non-energy sectors, which reveals the need to increase the point distribution proportion of EPI items in order to encourage energy saving. Our results show that EPI items had higher score standards, but low point distribution. The overlapping items corresponded to direct sunlight use and rooftop green areas in the plan item, and to CO_2 emission reduction and new and renewable energy use in facility items.

Third, the non-energy items should be integrated into the energy sector in the certification criteria so that weight values in the energy sector can be adjusted. The aim of this is to clearly and conveniently control energy-saving efforts in buildings at the national policy level. With respect to the non-energy sector items, the plan item had three (5.49%), the facility item had three (5.57%), and there was one common item (1.99%).

Next, a survey on energy-related items was conducted to suggest rational improvement measures and encourage the installation of plan items. The findings are as follows.

First, with respect to EPI items, plan items had a higher score ratio than facility items because of the fewer plan items compared to the facility items and because the plan items are uniform and the items, except for sealed window installation and rooftop gardening, had a higher score ratio. This reveals the need to introduce a wide range of plan items to EPI and increase the point distribution to reduce the costs related to facility items and energy consumption for government projects.

Second, energy conservation needs to be encouraged by separating the point distribution from the lighting energy savings through the use of sunlight such as the installation of light shelves in the non-EPI direct sunlight use item from the direct sunlight use facility.

Third, there was no score for the rooftop green maintenance document in the non-EPI maintenance step, an energy-related plan item, because none of the schools had this document. Most of the schools had a facility maintenance document due to the nature of the BTL project with its strong focus on energy maintenance cost. The schools did not file the rooftop green management document item due to the difficulty in maintaining green areas on rooftops. This reveals the need to evaluate the rooftop green maintenance item alone and to encourage on-going maintenance through the suggestion of guidelines or through the completion of training courses.

Fourth, with respect to the rooftop greening item whose evaluation overlapped in the EPI and non-EPI, most of the schools that received marks based on the certification criteria before the revision achieved only 10%, which is the minimum standard of the score. As for the rooftop greening item, a detail EPI item, full marks were given when 30% was achieved and as for non-EPI items in the revised certification criteria, the ecological area was an optional element for the evaluation item and its point distribution was lower than that of the EPI items. This reveals the need to exclude rooftop green areas from the ecological area evaluation item in order to avoid overlapping evaluation with EPI, to suggest high area criteria, and to increase the point distribution in order to reduce cooling and heating energy use with respect to rooftop green areas in EPI items.

Fifth, among facility items, non-EPI lighting energy saving, performing TAB or commissioning, adopting thermostats and facility maintenance document filing items achieved a higher score ratio vs. cost than that of other energy items, which reveals the need to adjust the point distribution and score standards.

Acknowledgement

This study provides basic data for improving the energy-related items and plan items within the green building certification criteria for energy saving and greenhouse gas reduction. Further studies need to be conducted on the effect of design and facility items on energy saving and greenhouse gas reduction.

References

1) BRE Global. [internet]. Available from http://www.breeam.org/
2) Cho, H. K. *et al*. (2013) A Study on the Policy Analysis and Improvement on Self-governing body for the Spread of Eco-friendly Architecture, the Architectural Institute of Korea Paper Collection, 15(2), pp.57-64.
3) Ha, I. C. *et al*. (2009) An analysis of the new schools on BTL, Korea Institute of Ecological Architecture and Environment Conference Papers, pp.213-217.
4) JaGBC/JSBC. [internet]. Available from http://www.ibec.or.jp/CASBEE/
5) Jeong, J. N. *et al*. (2011) A comparison of the standards between before and after the revision of business purpose green building certification criteria, Architectural Institute of Korea, 27(2), pp.235-243.
6) Kang, B. H. (2010) A study on the evaluation system of green building certification criteria for the energy saving of apartment: Doctoral dissertation, Gyeongsang National University.
7) Korea Energy Management Corporation. [internet]. Available from http://www.kemco.or.kr/
8) Korea Green Building Council. [internet]. Available from http://www.greenbuilding.or.kr/
9) Lee, G. H. (2009) Architectural Environmental Science. 3rd ed. Seoul: Moonwoondang
10) Lee, T. M. *et al*. (2010) An analysis of the application of green building certification evaluation items to school facilities, The Architecture Institute of Korea Paper Collection, 12(2), pp.119-129.
11) Park, S. D. *et al*. (2002) A study on the introduction of a green building certification system to Daejeon city, Deajeon City Report, p.1.
12) USGBC. [internet]. Available from http://www.usgbc.org/leed