



## Developing a Green Building Standard in Lao PDR

Xayvatthana Chittaphong and Kumpon Subsomboon\*

**Abstract**— This research paper presents a green building standard development for building for the Lao People's Democratic Republic (Lao PDR) sustainable development. Three well-known green building standards which are: TREES-NC standard of Thailand, the LEED-NC standard of the United States, and the CASBEE-NC standard of Japan were reviewed, and used as a proposed Lao's green building framework because of their geographical similarity, universal acceptance, and contexts, respectively. All of the required indicators from the three standards were collected and used as a basis to design a questionnaire for interviewing and data collection. Forty related experts were carefully selected as purposive sampling for the interviewing process for their opinions regarding both the importance and possibility of each indicator. The collected data were analyzed using statistics. A matrix of the Important-Possibility Integration (IPI) factor was proposed to evaluate each of the 73 indicators. The results were rated and separated into three groups: low, medium, high according to the proposed IPI factor. The indicators with low IPI factors were eliminated from the Lao green building standard draft, whereas indicators with high IPI factors were published in the draft. The indicators with medium IPI factors were re-interviewed with the experts whether these indicators should be accepted in the draft. The results of the study concluded that the draft of green building standard for the Lao PDR consists of 10 categories: Sustainable Site (SS), Water Efficiency (WE), Energy and Atmosphere (EA), Material and Resource (MR), Indoor Environment Quality (IEQ), Innovation Design (ID), Regional Priority (RP), Building Management (BM), Environment Protection (EP), Quality Service (QS). There is a total of 71 indicators, with 110 points of the total score. The green building certification is certified into four levels that are similar to TREES-NC and LEED-NC, including certified, silver, gold, and platinum.

**Keywords**— Energy and Environmental Sustainability, Green Building, LEED, TREES.

### 1. INTRODUCTION

To comply with the policy of the Lao PDR Government [1] and the global trend to promote buildings that are environmentally friendly and reduce energy consumption in buildings, the concept of Green Building is proposed as a key to control and monitor energy-efficiency in the buildings, reduce environmental impacts, improve quality of occupants, and results in sustainable development. Green Building refers to a building that focuses on a minimal impact on the environment, efficiently using energy, water and eco-friendly building materials, reducing waste and toxins as well as using resources effectively and efficiently [2]–[5]. It is a combination of nature with the use of modern technology, relying on nature and making the most out of it by covering the entire lifecycle of a building [6]–[7]. Nowadays, the Green Building concept has been paid more attention by all over the world. Each country has developed its own Green Building standards to be used as its building rating system. For nearly two decades, numbers of standard have been set to certify the design and construction of Green Building [8] such as the

Leadership in Energy and Environment Design for Building Design and Construction (LEED) of the U.S., Building Research Establishment Environmental Assessment Method (BREEAM) of UK, Green Star of Australia, Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) of Japan, or Thai's Rating for Energy and Environmental Sustainability (TREES) and etc. Each standard is divided into categories but most are in common, for example, a category for sustainability, energy consumption, water consumption, materials and resources usage, indoor environmental quality and innovative designs. Most of the assessment methods are checklist and rating. Every standard aims to cover all aspects: quality of life, safety, environmental conditions both inside and outside the building as well as the development that will lead to a balance among economic, social, environmental, and sustainable development. Therefore, this research presents the framework and approach for developing of a Green Building standard in Lao PDR.

### 2. LITERATURE REVIEWS

#### *Green Building*

Ali and Al Nsairat studied and compared the green building standards of LEED, CASBEE, BREEAM, GBTool, consistent with the context of Jordan, then compiled the factors from the standards to create the interview evaluation forms for interviewing the relevant experts.

X. Chittaphong is a graduate student at the department of civil engineering, Faculty of Engineering, Naresuan University, 65000 Thailand.

K. Subsomboon is a director of the Water Resources Research Center, and a lecturer at the department of civil engineering, Faculty of Engineering, Naresuan University, 65000 Thailand.

\*Corresponding author: K. Subsomboon; Phone: +66-55-964084; Fax: +66-55-964000; E-mail: [kumpon@nu.ac.th](mailto:kumpon@nu.ac.th).

**Table 1. Description of TREES, LEED, and CASBEE**

	TREES	LEED	CASBEE
Country	Thailand	USA	Japan
Version	New Construction - 2013	New Construction - 2009	New Construction - 2014
Developer	(TGBI – Thai Green Building Institute)	1993 by the United States of America Green Building Council (USGBC)	2001 by Japan Sustainable Building Consortium (JSBC)
Criteria used in measuring	- Building Management - Site and Landscape - Water - Energy & Atmosphere - Materials & Resources - Indoor Environmental Quality - Innovation - Environmental Protection - Innovation	- Sustainable Site - Energy & Atmosphere - Water - Materials & Resources - Indoor Environmental Quality - Innovation - Regional Priority	- Indoor Environment - Outdoor Environment on Site - Quality of Service - Energy - Resources and Materials - Off-site Environment
Level	The Rating is divided into four level : 30 to 37 - Certified 38 to 45 - Silver 46 to 60 - Gold 61 to 85 - Platinum	The Rating is divided into four level : 40 to 49 - Certified 50 to 59 - Silver 60 to 79 - Gold 80 to 110 - Platinum	The Rating is divided into five level: Poor = C Rather Poor = B Good = B+ Very Good = A Excellent = S

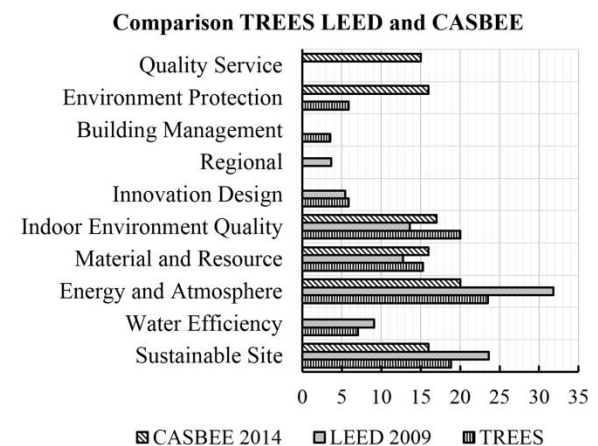
After taking the factors that have passed the expert opinion to determine the weight to find the proportion, the details and results have been drafted as standard in Jordan [9]. Adegbile studied and compared the 7 green building standards include BREEAM, CASBEE, GREEN GLOBES, GREEN STAR, HK-BEAM, IGBC Green Homes, and LEED, then surveying the opinions of Nigerian stakeholders in order to obtain a green building benchmark the environment of Nigeria. Based on the survey results, the LEED is well suited to Nigeria because of allowing building owners to easily monitor building performance [10]. Moussa and Farag used

LEED-NC as a tool to investigate and analyze construction projects in 25 different Middle East countries to determine if the standard will work. The results of the study showed that 5 countries (United Arab Emirates, Saudi Arabia, Israel, Egypt, and Oman) have scored well and are likely to pass the LEED-NC benchmark [11].

This paper summarizes the development of green building standards in Lao PDR, based on the context of Thai’s Rating for Energy and Environmental Sustainability (TREES) [12]. TREES is expected to be a benchmark for green building standards in Lao PDR since both countries share similar of geographical features: climate, society and culture. However, TREES has been influenced and under the context from the concept of green building standards LEED of the United States, which are universally accepted and widely accepted throughout the world, whereas many countries refer to LEED [13]–[15]. CASBEE of Japan has the right ideas in its own contexts, such as earthquakes and the building of structures that are resistant to lose, as Japan is often confronted with such problems [16]. Cultural distinctions have their own unique requirements, so the standard concepts of TREES, LEED and CASBEE are appropriate for drafting green building standards of Laos. Details of TREES, LEED, and CASBEE standard were summarized as shown in Table 1.

**Comparison TREES, LEED and CASEBEE**

The assessment and proportion of each of the standards contained in Fig.1 have similar requirements in many respects, in particular the similarly TREES and LEED green building standards covering sustainable site, water efficiency energy, materials and resources, indoor environmental quality, environment protection, and innovation design. CASBEE has similar categories of assessments, but has added some categories such as indoor environment, quality of service, outdoor environment on site, energy, resources and materials, and off-site environment.



**Fig.1. Comparison of TREES, LEED and CASBEE.**

**3. METHODOLOGY**

This section presents a qualitative survey in the area where the interviews of interested persons or those who

understand about green building in Lao PDR are clearly conducted and carefully selected as a purposive sampling for interviewing process.

**Collection of Indicator and Regulation**

This research applies the regulation of three standards - LEED, TREES, and CASBEE as the major concepts which collectors gradually collect indicators and information details, evaluation and certification criterion, and analyze the differences in each regulation standard in order to design the structured interview. If there is any identical regulation, it will be chosen only one indicator. Moreover, there are some considerable literature reviews and relevant laws in order to add more regulation for the proper country condition besides the regulation of three standards above.

**Interview Designing and data collection**

The questionnaire is divided into two parts including 1) basic information of respondent - original divisions and working experiences and 2) opinions on level of importance and level of possibility for each indicator or regulation divided as 3 rating scale (high:3, moderate:2, and low:1). Data collection and interviewing process were distributed and collected during October – December 2017. Forty related experts were carefully selected as a purposive sampling for interviewing process comprising government officers, lecturers from the National University of Laos, and architects and engineers from private sectors.

**Analysis Method**

The Important-Possibility Integration (IPI) factor is proposed by using a matrix diagram adopt from the risk matrix analysis approach, to analyze the level of important and possibility integration factors for each indicator. Each indicator was measured by using statistical mean in two factors: level of importance and level of possibility. These two factors were combined or integrated by using the proposed 3x3 “IPI factor” matrix as shown in Fig.2. The IPI factors were categorized into three levels: high, medium, low. The high IPI factor showed that most experts agreed that it is very important and very possible for that indicator. The medium IPI factor showed that most experts feel that it is moderately important and possible. The low IPI factor showed that most experts agreed that it is less important and less possible for that indicator. IPI factor can be calculated from the equation (1) as shown

$$IPI\ factor = (\bar{X}_{Importance}) \cdot (\bar{X}_{Possibility}) \tag{1}$$

where:

$\bar{X}_{IPI\ factor}$ : Importance-Possibility Integration factor

$\bar{X}_{Importance}$ : Statistical mean of important level for each indicator

$\bar{X}_{Possibility}$ : Statistical mean of possibility level for each indicator.

		Importance ( $\bar{X}$ )			
		Low	Medium	High	
Possibility ( $\bar{X}$ )	Low	1	1	2	3
	Medium	2	2	4	6
	High	3	3	6	9

Score	$\leq 2.99$	3.00 - 5.99	$\geq 6.00$
IPI Factor	Low	Medium	High

**Fig.2. Importance-Possibility Integration (IPI) Factor.**

The level of acceptance of the IPI factor were rated, and categorized into three levels: green, yellow, and red zone as shown in Table 2. All 73 indicators were rated by IPI factor whether each indicator should be included in the standard.

**Table 2. Level of Acceptance of the IPI Factor**

Level	Zone	Meaning
$\geq 6.00$	Green Zone	Experts considered that indicator was very important and very possible. It should be included in the standard.
3.00-5.99	Yellow Zone	Experts considered that indicator was moderately important and possible. It should be evaluated by the expert again.
$\leq 2.99$	Red Zone	Experts considered that indicator was less important and less possible. It should not be included in the standard.

**Re-interviewing Process for Indicator with Medium IPI Factor**

Since, the medium IPI factor showed that most experts feel that it is moderately important and possible. Therefore, all indicators with medium IPI factor were re-interviewed by the experts whether or not the indicator should be accepted. If more than 50 percent of respondents agreed to accept, that indicator would be considered as accepted. If less than 50 percent of respondents accepted, that indicator would be considered as rejected.

**4. RESULTS AND DISCUSSION**

**Results**

According to the statistical mean from the overall 73 indicators as shown Table 3, Fifty-five indicators were considered as regulation with high IPI factor inwhich experts considered that indicators are very important and possible. These 55 indicators should be included as regulations in the Lao PDR Green Building Standard. Eighteen indicators were considered as regulation with medium IPI factors inwhich experts considered that

indicators are moderately important and possible. These 18 indicators were re-interviewed with the same 40 experts whether or not these indicators should be considered and accepted as regulations in the standard. After re-interviewing process, sixteen indicators were accepted and considered as regulations but two indicators which are: SS(8) and BM(1) were rejected and cut-off.

**Table 3: Assessment Categories and Indicators**

Assessment Categories and Indicators	
<b>Sustainable Site (SS) 15</b>	
SS (1)-construction Activity Pollution Prevention	SS (9)-Site Development, Protect or Restore Habitat
SS (2)-Site Selection	SS (10)-Maximize Open Space
SS (3)- Development Density and Community Connectivity	SS (11)-Storm water Design, Quantity Control
SS (4)-Brownfield Redevelopment	SS (12)-Storm water Design, Quality Control
SS (5)-Public Transportation Access	SS (13)-Heat Island Effect ,Non-Roof
SS (6)-Bicycle Storage and Changing Rooms	SS (14)-Heat Island Effect ,Roof
SS (7)-Low-Emitting and Fuel-Efficient Vehicles	SS (15)-Light Pollution Reduction
SS (8)- Parking Capacity	
<b>Water Efficiency (WE) 4</b>	
WE (1)-Water Use Reduction,20% Reduction	WE (3)-Innovative Wastewater Technologies
WE (2)-Water Efficient Landscaping	WE (4)-Water Reduction
<b>Energy and Atmosphere (EA) 7</b>	
EA (1)-Minimum energy efficiency	EA (5)-Enhanced Refrigerant Management
EA (2)-Optimize Energy Performance	EA (6)-Measurement and Verification
EA (3)-On-Site Renewable Energy	EA (7)- Green Energy
EA (4)-Enhanced Commissioning	
<b>Material and Resource (MR) 9</b>	
MR (1)-Storage and Collection of Recyclables	MR (6)-Recycled Content
MR (2)-Building Reuse	MR (7)-Regional Materials
MR (3)-Building Reuse, Maintain 50% of Interior Non-Structural Element	MR (8)-Rapidly Renewable Material
MR (4)-Construction Waste Manage , Divert 50% form Disposal	MR (9)-Certified Wood
MR (5)-Material Reuse	

Throughout the research process, it can be concluded that the Lao PDR Green Building Standard comprises of

71 indicators.

Indoor Environment Quality (IEQ) 18	
IEQ (1)-Minimum IAQ Performance	IEQ (10)-Low-Emitting Material, Composite Wood and Agrifiber
IEQ (2)-Tobacco Smoke Control	IEQ (11)-Pollutant Source Control
IEQ (3)-Outdoor Air Delivery Monitoring	IEQ (12)-Comfort- Indoor lighting
IEQ (4)-Increased Ventilation	IEQ (13)-Thermal Comfort , Design
IEQ (5)-Construction IAQ Management Plan ,During Construction	IEQ (14)-Thermal Comfort , Verification
IEQ (6)-Construction IAQ Management Plan ,Before Occupancy	IEQ (15)--Daylight
IEQ (7)-Low-Emitting Material, Adhesives, and sealants	IEQ (16)- view
IEQ (8)-Low-Emitting Material, Paint and Coating	IEQ (17)-Thermal Comfort , Control of Systems
IEQ (9)-Low-Emitting Material, Carpet Systems	IEQ (18)-Control of Systems, Lighting
<b>Innovation Design (ID) 1</b>	
ID (1)- Innovation Design	
<b>Regional Priority (RP) 2</b>	
RP (1)-Regional Priority	RP (2)-Local characteristics and appearance
<b>Building Management (BM) 3</b>	
BM (1)-Public relations	BM (3)-Monitoring and Evaluation
BM (2)-Manuals and Training	
<b>Environment Protection (EP) 4</b>	
EP (1)-less environmentally-friendly chemicals in the fire system	EP (3)-glass outside the building
EP (2)-Placing position air cooling	EP (4)-.Install electric gauges for wastewater treatment
<b>Quality Service (QS) 10</b>	
QS (1)-Allocation	QS (6)-Decoration
QS (2)-Information and Systems	QS (7)-Design Considerations Maintenance
QS (3)-Barrier-free Design	QS (8)-Maintenance
QS (4)-Width and good view	QS (9)-Earthquake resistance
QS (5)-Comfortable corner and refreshing space	QS (10)-Earthquake Relief and Vibration

**Overview of Laos Green Building Standard**

The Lao PDR Green Building Standard assessment categories are shown in Figure 3 comprising of 10 categories with respected to their proportion including Energy and Atmosphere (EA), Sustainable Site (SS), and Indoor Environment Quality (IEQ), Material and

Resource (MR), Quality Service (QS), Water Efficiency (WE), Environment Protection (EP), Building Management (BM), Innovation Design (ID), and Regional Priority (RP), respectively. There are total of 71 indicators, with 110 points of total score.

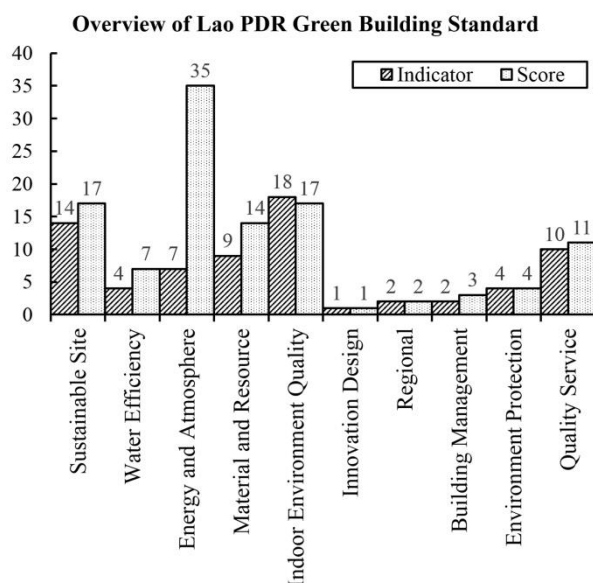


Figure 3. Overview of Lao PDR Green Building Standard.

Table 4: Proposed Lao PDR Green Building Rating System

Lao PDR Green Building Rating System		
Category	Score	level
Sustainable Site	17 Point	Platinum 80 above
Water Efficiency	7 Point	Gold 60 - 79 point
Energy	35 Point	Silver 50 - 59 point
Material and Resource	14 Point	Certified 40 - 49 point
Indoor Environment Quality	17 Point	
Innovation Design	1 Point	
Regional priority	2 Point	
Building Management	2 Point	
Environment Protection	4 Point	
Quality Service	11Point	

Details of indicators for each assessment categories are shown in Table 3. It was summarized in Figure 3. Sustainable Site (SS) consists of 14 indicators, with 17 points (15.45%). Water Efficiency (WE) consists of 4 indicators, with 7 points (6.36%). Energy and Atmosphere (EA) consists of 7 indicators, with 35 points (31.82%). Material and Resource (MR) consists of 9

indicators, with 14 points (12.73%). Indoor Environment Quality (IEQ) consists of 18 indicators, with 17 points (15.45%). Innovation Design (ID) consists of 1 indicators, with 1 points (0.91%). Regional Priority (RP) consists of 2 indicators, with 1 points (0.91%). Building Management (BM) consists of 2 indicators, with 3 points (2.73%). Environment Protection (EP) consists of 4 indicators, with 4 points (3.64%). Quality Service (QS) consists of 10 indicators, with 11 points (10%).

### Level of Assessment

The checklist was used as a tool similarly to TREES and LEED standards. Some indicators were required as prerequisites and mandatory. All of prerequisites were required to pass before the following indicators can be rated as credits. Rating system for each indicator for their credits equals to 1 point.

The green building certification is certified into 4 levels that are similar to TREES-NC and LEED-NC, including certified, silver, gold, and platinum as shown in Table 4.

## 5. CONCLUSIONS

This research developed the Lao PDR Green Building Standard for building. Three well-known green building standards which are: TREES-NC standard of Thailand, the LEED-NC standard of the United States, and the CASBEE-NC standard of Japan were reviewed, and used as a framework. Seventy-Three indicators were collected and used as a basis to design a questionnaire for interviewing and data collection. Forty related experts were carefully selected as purposive sampling for the interviewing process. The level of importance and possibility for each indicator were surveyed and analyzed by using statistical mean. A matrix of IPI factor was proposed to evaluate indicators. The results were rated and separated into three groups: low, medium, high according to their IPI factors. The indicators with low IPI factors were eliminated from the draft, whereas indicators with high IPI factors were published. The indicators with medium IPI factors were re-interviewed with the same experts whether these indicators should be accepted in the draft. The results of the study concluded that the draft of Lao PDR Green Building Standard consists of 10 categories: Energy and Atmosphere (EA), Sustainable Site (SS), and Indoor Environment Quality (IEQ), Material and Resource (MR), Quality Service (QS), Water Efficiency (WE), Environment Protection (EP), Building Management (BM), Innovation Design (ID), and Regional Priority (RP). There are a total of 71 indicators, with 110 points of the total score. The green building certification is certified into four levels including certified, silver, gold, and platinum.

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