كلية الهندسة بشبرا
FACULTY OF ENGINEERING AT SHOUBRA
ERJ
PRINT ISSN 3009-6049
ONLINE ISSN 3009-6022

ENGINEERING RESEARCH JOURNAL (ERJ)
Volume (53),Issue (1)
January 2024, pp:170-180
https://erjsh.journals.ekb.eg

An Approach for Enhancing Architectural Performance-Based Design Assessment in Terms of Sustainability

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Abstract: This paper aims at adding a new dimension for green design assessment as a step forward towards better sustainable practice in architecture. The paper focuses on patterns of "architectural building performance-based design" as driver for sustainable practice. Although architectural design includes qualitative and quantitative dimensions, Current green rating systems are more oriented towards assessing quantitative results of performance measures in different means such as energy and water efficiency as well as optimised use of materials and resources, besides physical enhancement for indoor environmental qualities.
Through critical analysis for both performance design and green rating system, the research offers a development for the classical Ghielingh "Hamburger Model" of performance. The developed model adds an additional dimension of performance-based indices driven from Ghielingh model to the existing green rating systems model. The importance of this research is that it offers the theoretical bases for a new assessment paradigm for architectural performance in terms of sustainability. it combines two methods for assessments the first one is based on check points and the other is based on indicators. This re-imaging helps in combining additional dimensions of qualitative and quantitative design measures to current assessment method.

Keywords: Sustainable design, architectural performance, passive design.

1. Introduction

Generally, performance has multiple definitions and meanings. According to Cambridge dictionary the most related meaning to the research topic is how well a person, machine, etc. does a piece of work or an activity[1]. Also Oxford English dictionary defines performance as the quality of accomplishment of a certain task, action or operation when measured against a certain standard [2]. That means that performance of something is assessed with a reference to a certain quality of its functionality.

In architecture performance means to what level of quality the architectural building does its required functions against measurable standards. In order to properly understand architectural performance of a building; there should be a sort of classifications for different functions and variables that are required to be measured.

By tracking the research work that was held in relation to architecture and performance, it was found that the most common topics under the title "performance in building design" is known as performance based design PBD [3][4].It is an approach based on following standard codes that seeks high levels of functionality as a final output rather than following pre-required procedures ; so it is about ends rather than means. The first definition for performance-based design was by the CIB W60 Commission[5] where it stated :

"Foremost, the practice of thinking and working in terms of ends rather than means. …. It is concerned with what a building or building product is required to do, and not with prescribing how it is to be constructed".

The aim of this approach is to focus on innovative solutions which might not be easily achieved in case of having pre-required specifications or predefined acceptable solutions that by default creates barriers against innovation [6].

The first building code to be recognised dates back to king Hammurabi (1955 to 1913 B.C.) where it contained a performance- based rules for building structure safety .In article 229 he mentioned[6]*:*

"The builder has built a house for a man and his work is not strong and if the house he has built falls in and kills a householder, that builder shall be slain."

The most important part of this rule is that the statement didn't mention what type of material should be used or structural members' thickness or dimensions, but instead it assured clearly on avoiding building collapse and killing any one which is the end result.

Although the first building regulation was a performance-based design one, but historically design is based on the prescriptive design approach rather than performance-based design approach. Prescriptive approach previously determines rules, criteria and specifications that should be followed to assure that the building is doing its function properly .it minimizes the available solution for compliance through various building codes[7]. Such codes focus on the inputs rather than the out puts. The philosophy of this approach is that as much as the code puts factors of safety as much as the building will face lower possibilities of risks. On the opposite side Performance based design seeks to focus on the output and end results [4].The ICC PC defines performance-based design as:

"An engineering approach to design elements of a building based on agreed upon performance goals and objectives, engineering analysis and quantitative assessment of alternatives against the design goals and objectives using accepted engineering tools, methodologies and performance criteria." [8].

The concept of PBD is based on maintaining the design of a building that can protect functionality and the continued availability of services. There are various research works that are held on performance based design over the last 40 years. some of them were concerned with providing more clear description to the terminology of Performance based design either conceptual idea or practice process [6].The most significant discussion on PBD are easily traced though the US national bureau of standards reports ,and the series of joint CIB-ASTM-RILEM conference proceedings on The performance concept in buildings [9] as well as the CIB different publications starting 1998[10].some of them are related to performance evaluation[7],some others are related to some building features performance such as fire safety or structure performance.[4].

Since the emerging of sustainable design approaches in architecture by the second half of the twentieth century .many efforts are held to improve the architecture design and construction practice to be more sustainable[11].Rating systems evolved to assess the current practice and to push it forward. [12] .

In terms of sustainable design philosophy, this research focuses on the philosophical meaning of building performance as an approach achieved through sustainable design. The importance of this research work is that it links PBD to sustainable design principles. Also, it classifies patterns of performance in building design between technological fix and natural solutions.

2. THE MEANING OF BUILDING PERFORMANCE

As mentioned above performance is related to both efficiency and functionality of the required purpose. In architecture performance would point at the quality and efficiency of the building different function against its requirements.it seeks how good a building has to be and not how it should be built. Engaging performance from the design early stages has been recognized early in the descriptions of Vitruvius in The Ten Books on Architecture which stated[13]:

"The three departments of architecture …, the art of building…, must be built with reference to durability, convenience, and beauty. Durability will be assured when foundations are carried down to the solid ground and materials wisely and liberally selected; convenience, when the arrangement of the apartments is faultless and presents no hindrance to use, and when each class of building is assigned to its suitable and appropriate exposure; and beauty, when the appearance of the work is pleasing and in good taste, and when its members are in due proportion according to correct principles of symmetry"

Performance has two basic characteristics. The first characteristic is a dialogue between two languages expressed within two targets; the User needs (UN) known as demand performance which seeks the user/client satisfaction and the supply performance which means available solution for demands. In 1986 Ghielingh offered the "Hamburger Model" (**see** Error! Reference source not found.) which explains the relation between Demand performance and supply performance as two half's of a hamburger bun, the first half is the functional concept which means requirements while the solution concept is technically how to fulfill that. What makes it two languages is that the functional concept in terms of the owner language is related to how important these requirements are for him ,while the solution concept is related to how the required performance can be technically realized [14]**.**

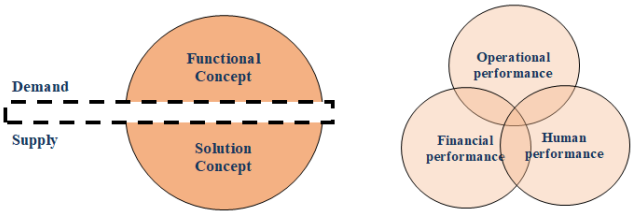


Figure 1: a) Hamburger Model **b)** Building performance Domains
Ref: (Gielingh, 1988)

The second characteristic is the need for being validated and verified through and assessment tool with reference to performance requirements (PR) [14].

Architectural building performance works with the integration of three main domains of performance which are the operational performance, the financial performance and the human (social and behavioral performance). Each domain has different structure than the other, the operational domain structure is based on system physical functionality, the financial domain is based on mathematics (income-expenses-profit) and the structure of social domain is based upon complex rules and theories that serves Human personal behavior and satisfaction[7].

As explained above the two characteristics defining performance are complex. The first complexity is related to demands satisfaction and solution delivery for such demands. Some demands have different limitation factors for example, unavailability of a required technology, design regulation limitations, financial expenses, conflict between two variables within the building design that requires optimization, in addition to many other limiting factors. For such reason performance is more to be measured in terms of performance indicator where indicator can reflect multiple

factors combined within one or set of indicators that can show insights about level of building performance.

The second complexity is a tripod one based on creating a balance between the required operation, the required finance to perform such operation, and the interaction with social and personal behavior towards such operation. This has been explained in (**see** Error! Reference source not found.)as a Venn diagram.

Building operation is regarded as a process-based problem where it deals with different building functionalities like MEP systems operation, energy management, daylight design, acoustics qualities, air ventilation, building circulation, space functionality; Such performance can be assessed though clear quantitative engineering measurements.

On the other hand, financial performance focuses on the economic value to achieve the operation required. Some solutions for performance might be better and more efficient but at the same time it requires higher economic values. The situation here might not be a technological limitation as expected. It's more toward affordability where the designer and client take a decision limited to the financial budget available. In such a situation high-performance won't be the choice as it may require low economic performance, which shows the first contradiction between operational and financial performance. The challenge is to reach a bottom line were acceptable performance means reasonable financial cost as seen in (s**ee** Error! Reference source not found.)

When dealing with Human personal behavior and satisfaction it is more complex as it deals with set of different variables especially in terms of architecture satisfaction impact. Human psychological attitude is affected by the architectural building design in terms of space and form through multiple aspects. The personal experience is related to many factors like culture age ,level of education which makes the social performance assessment a complex one [15].For that reason studying social behavior and its interaction with other performance domains represents a difficult challenge for a design to be achieved as it will be usually exposed to subjective judgment rather than objective one.

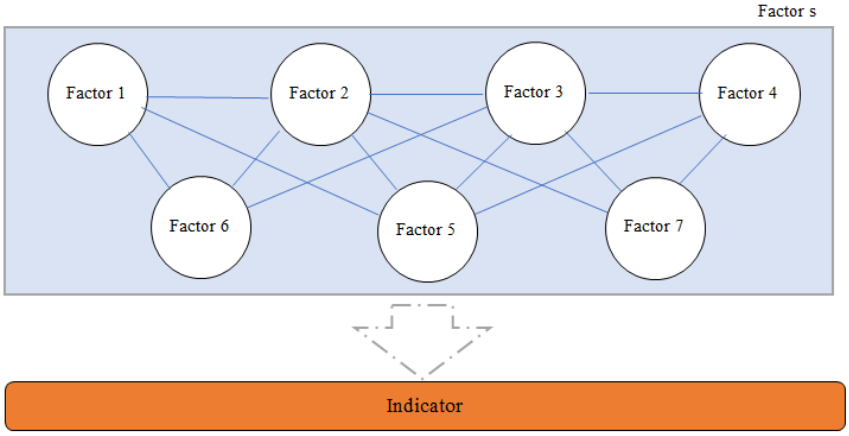


Figure 2: A diagram showing factors interactions reflected in terms of an indicator. **Ref:**(Author)

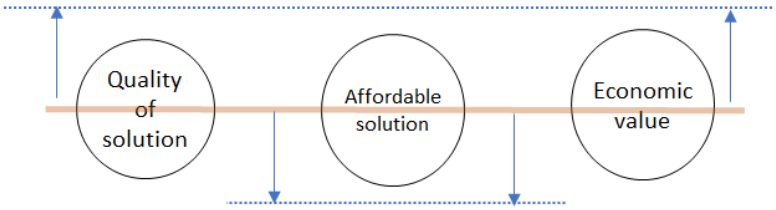


Figure 3: perfocmance versus solutions offered **Ref** :(autor)

3. THE TYPES OF BUILDING PERFORMANCE

To easily reflect the difference performance domains on an architectural building the research has divided the building components into four major components as follow[16]:

a. **The building site & location:** where the building site represents the external environment and Urban and context. building site plays an important role in building design in terms of orientation, positioning, contour, transportation and so on [17]. A lot of building performance elements can be easily achieved with carful study and understanding of the different site parameter. [11].

b. **The building indoor spaces:** Building space is the internal boundaries that creates the indoor environment, usually architectural spaces are divided into different typologies where a set of specific

characteristics identifies and categorize the indoor space properties [18].one of the major aspects of sustainability lies at the indoor environment quality at different levels. Building space performance reflects the level of personal wellbeing achieved. Some of the most recognized factors are the air quality, daylight, acoustic qualities, and quality views. space can be recognized as the building block of an architectural work. The smallest building can be formed only of one space; For that reason, a sustainable space can lead to a sustainable building.

c. **The building structure and material:** Building structure refers to the load resisting systems that ensures the building stability. The building structure is a critical and essential element of any architecture work as it is the way to represent form and create space external skeleton. Structure system and material has always played an important role in architecture across history starting the ancient Egyptian architecture till now. however building material can go further beyond only structure material it extends to internal and external finishing materials which had been classified in a complete section either on LEEd as “materials and resources” [19] or BREAAM as ”materials”. Such components play an important role across different stages of building life cycle starting the construction phase, operation phase and even demolition phase.

d. **The building operating systems:** another important and effective dimension in building design is the different building operational systems. Building systems provide all necessary services and infrastructures required to operate and maintain this space among internal spaces such as: water, drainage, plumbing...etc.

Building systems plays an important role in providing a successful building on the scale of green or sustainable design. Systems serves in proper achievement of either optimized operational and maintenance plan, energy saving building operation, efficient water use reduction, which all covers a wide range of different green rating systems checkpoints[19].

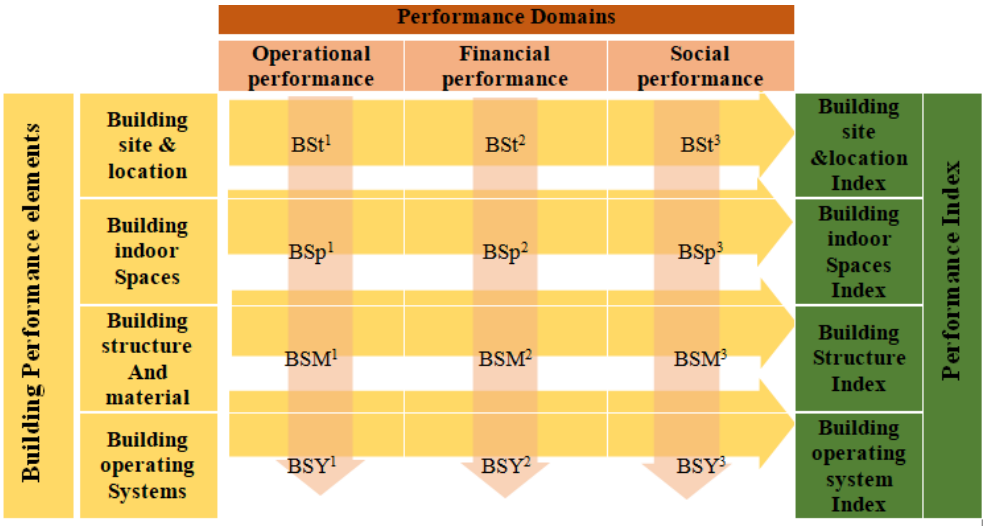
"building systems" can refers to all operating systems required for the building functionality like fire safety, electromechanical, building management systems and other subsystems.

Based on the classification of for architectural buildings components mentioned above the research has investigated how can such components affects the different domains of performance in architecture design as in **Table 1**.

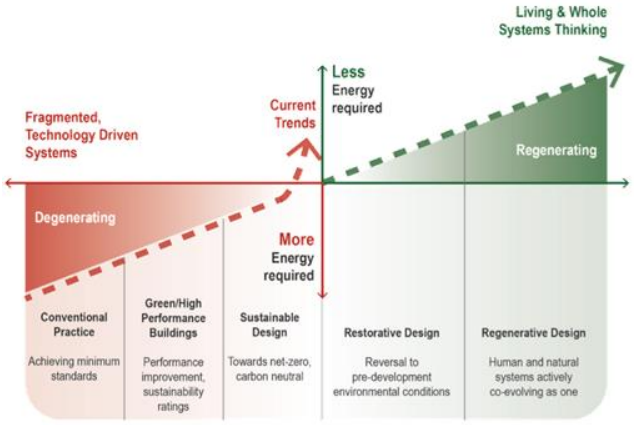
Referring to building performance domains the research proposes to provide a breakdown to each of the three performance domains in two subcategories based on the four components proposed above. That means, for each building element/components there are three domains of performance assessment: the operational, financial, and social ones.

Each of the building components will challenge three performance demands to fulfill. The complicity of fulfilling such demands if referring to **Error! Reference source not found.** & **Error! Reference source not found.** is that each component witnesses a multiple variable and demands. For such dialectic relationship, the research has proposed to deal with performance indicator as a reference point for building performance assessment. This may vary from what takes place in green rating systems like in case of LEED assessment which also focus on building performance but through fulfilling prescriptive checklist with predefined checkpoints.

Table 1: Building performance classification.



4. MODES OF SUSTAINABLE DESIGN



Sustainable design falls withing two main streams the first one is classified under engineering domain while the other is under the ecological domain; for that reason, the sustainable design and development in the built environment is assessed from both an engineering perspective as well as an ecological one [20] [21]. design refers to the design that has no net impact on the environment. This is slightly different from green design that tackles lowering the negative impact on the environment as in **Error! Reference source not found.**. Different research work since 1990 nominated regenerative design as an ecological approach for sustainable design development enhancement. Bill Reed argued this issue in his essay "Shifting our Mental Model – 'Sustainability' to Regeneration," he stated [22] [23]:

"Sustainability, as currently practiced, is primarily an exercise in efficiency. In other words, through the use of BREEAM, LEED, and other rating systems we are attempting to slow down the damage caused by excessive resource use. We must do better...Our role, as designers and stakeholders is to shift our relationship to one that creates a whole system of mutually beneficial relationships. By doing so, the potential for green design moves us beyond sustaining the environment to one that can regenerate its health – as well as our own."

-Architect Bill Reed

As seen in **Figure5**, the curve known as a model for "Trajectory of ecological design" or "Trajectory of Environmentally Responsible Design" showed five modes of transformation towards sustainability. Two are classified as degenerative, one is classified as a neutral one while two others are classified as regenerative. the starting point was conventional practice which has less concerns about sustainability, then comes the green practice, which focus on minimizing the negative impact on the environment till it reaches regenerative practice [24]. , The research argued that the degenerative and regenerative modes of design differs because of the full understanding of Performance role and domains. Performative design which operates locally on components without a comprehensive vision of the pillars of sustainable design (social- economic- environment) resulted in an imbalance between elements of sustainability pillars Error! Reference source not found. .Measuring performance on local components for example energy efficiency resulted in good significant in this domain still other components might not be affected or even affected negatively. On the other hand, implementing some strategies for energy efficiency and performance could lead to high economic impact on initial cost of the building. For that reason, reassessing the dominant current practice for sustainable design approaches helps in reorienting performance base design towards better results and practices.

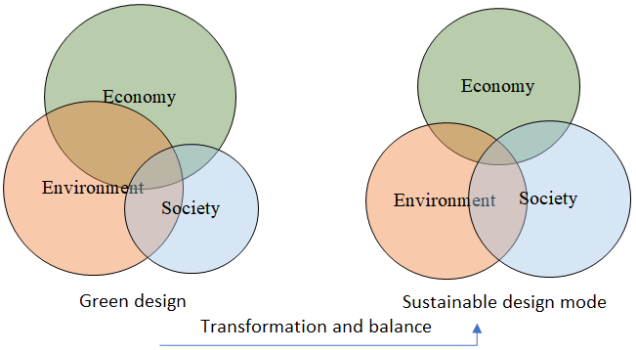


Figure 5: sustainable development design pillars between green and sustainable modes (Author)

5. CURRENT SUSTAINABLE PRACTICE

Green design approaches are still the most dominant practical mode of design and construction dominating the movement towards sustainability knowing that green design seeks minimizing of negative impact on the environment as being a degenerative mode; still there are lots of different approaches towards regenerative practices taking place side by side [12]. To assure that the building's design and construction would meet the minimum requirements for being more sustainable and less harmful to the environment, green rating systems were established. BREEAM in 1990 followed by LEED were formalized as the two green leading rating systems[25],[26].

Green rating systems philosophy have common origins known as green rating strategies. These strategies are as follow[27]:

a. Optimize Site Potential: this includes different factors for best use and choice of site location, transportation and efficient design driven from site parameters optimization.

b. Optimize energy use: this includes carful optimized design and management for energy usage and consumption with more rely on renewable clean energy production resources.

c. Protect and conserve water: this includes different strategies for optimizing water usage and protecting it as unique resource.

d. Optimize building space and material use: this includes a design philosophy based on proper choice of material with disclosure. material selection is based on optimized selection for recyclables and ecofriendly materials during all phases of material lifecycle (production -operation- demolition).

e. Enhance indoor environmental quality (IEQ): this includes a responsible design that provides a suitable and healthy indoor quality for users. The design strategy focuses on the enhancement of quality of spaces for users; this may include air, sound, thermal and visual qualities.

f. Optimize potential and maintenance practices: this includes comprehensive vision for operation and maintenance strategies that ensure continual proper operation for the design work.

Through critical analysis, the research can summarize green rating strategies into three green design demands for six built environment design categories. The three green design demands are the optimization, protection and enhancement for the building and the built environment. The following diagram (**see** Error! Reference source not found.**Error! Reference source not found.**) explains the three demands and its relation to the six built environment design categories.

The following demands are expressed similarly in different rating systems and are broken down into a set of checklist categories and subcategories where each has a credit value. Although Check points of rating systems benchmarks are designed to address measurement of performance but still Rating systems stand like sustainable design codes which seeks quantitative results for each check point. Achieving the required points in each benchmark would result in certifying the building as green building. This design of the Rating systems, even if it measures modes of performance it seems to be closer to a prescriptive rather than performance based.

6. SUSTAINABILITY AND BUILDING PERFORMANCE

The research offers an approach for developing Ghielingh's model "Hamburger Model" to response to performance base design. Similar to the classical model the developed model provides "functional concept" and "solution concept"; in between sustainable design performance framework is located; an intelligent framework that links sustainability strategies" Green rating systems strategic demands" to performance domains. This framework was built on the careful analysis and understanding of performance-based design and green strategic principles. This framework is composed of three groups as follow:

a. **Group 1'' Performance required action domains'':** this group represents the connection between the three green design demands and the three Performance Domains where each green design demand should perform properly on the scale of operation, financial and social domains.

b. **Group 2'' Green rating systems strategic demands categories''**: These are the six common built environment design categories that most rating systems are based on.

c. **Group 3'' Building performance element''**: These are the four buildings performance basic elements that are mentioned above."(**see** Error! Reference source not found.**)**

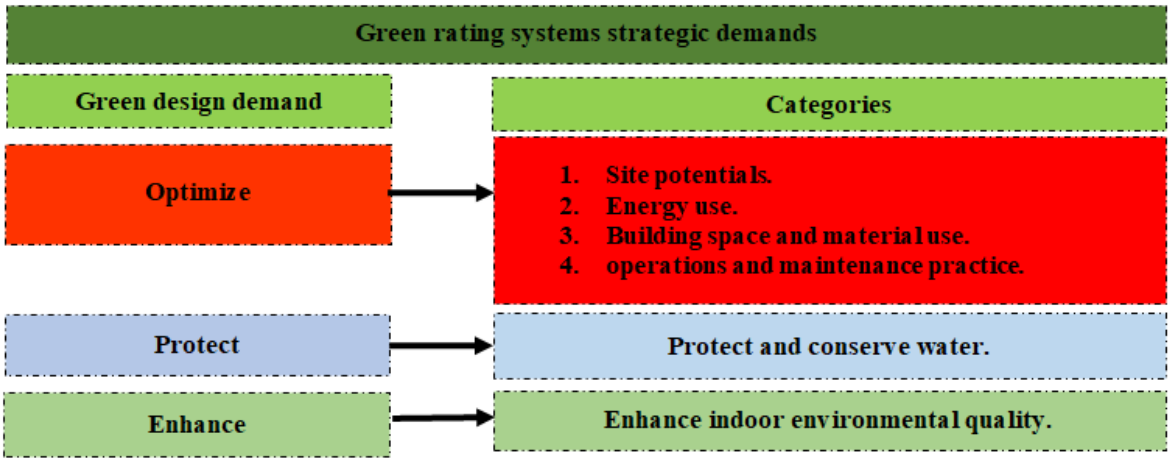


Figure 6 : Green rating systems strategic demands **Ref:** (Author)

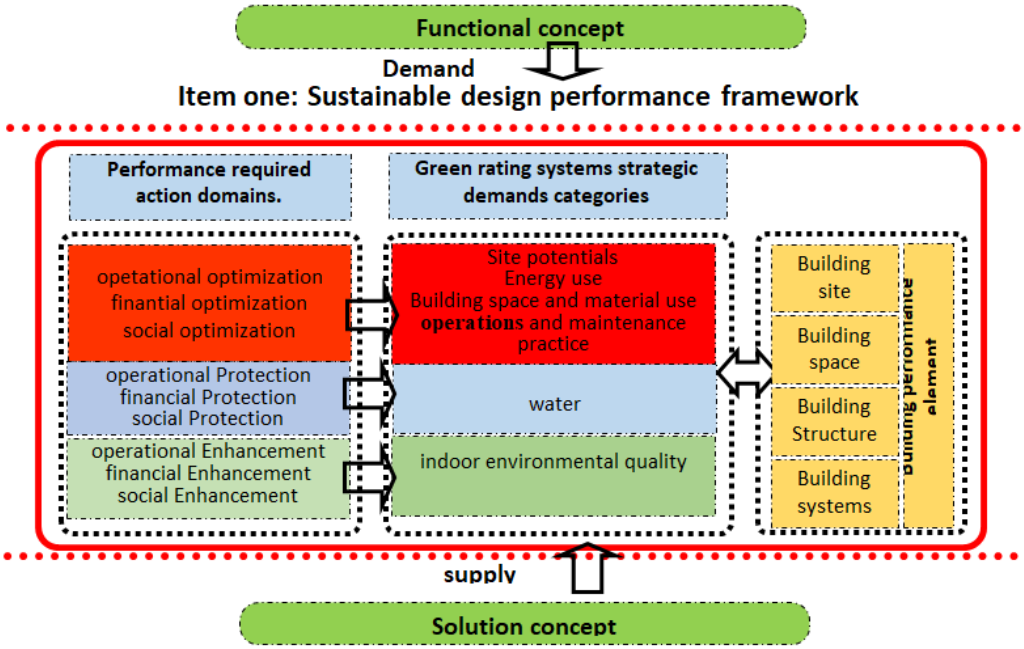


Figure 7: Sustainable performance based design Model **Ref:** (Author)

7. DEVELOPING GREEN RATING SYSTEM ASSESSMENT BASED ON SUSTAINABLE PERFORMANCE-BASED DESIGN MODE

The current green rating system model works on measuring sustainable performance through credit check list and scores. the model is offering rating schemes for different building types to insure covering diverse construction themes, knowing that these schemes are being developed each version; also, for each rating system model there are certification levels based on the score achieved in each of its categories see Error! Reference source not found..

In the case of BREAAM, there are maximum available credits and a relative weight for each category/section. The final score credit is calculated through the summation of total credits obtained in each section taking in consideration its relative weight. Similarly in LEED, the assessment is based on score card built from categories and subcategories credits.

Currently the green rating systems has some mandatory credits that should be achieved at each category, in addition there are some credits that are action-based credits like water reduction, heat island reduction while others are for measurement and assessment of these action based like water metering and energy metering. These credits are quantitative measures for performance assessment of green design. This research works on improving the current score cards by adding qualitative and quantitative dimensions reflected in the form of performance indices. The rationale behind developing the current model is that some architecture work can give high level of performance quantitatively according to the current checklist although it has less qualities in terms of user experience and satisfaction, for that reason the research tries to combine double methods of check to green rating assessment to ensure that quantitative results are aligned with another reference point as double-check as in **Table 3&4**.

Table 3: BREEAM rating system model and score card.

Environmental section		**Weighting**	
Fully fitted out		**Shell only**	**Shell and core only**
1. Management	12%	12.50%	11%
2. Health and Wellbeing	15%	10%	10.50%
3. Energy	15%	14.50%	15%
4. Transport	9%	11.50%	10%
5. Water	7%	4%	7.50%
6. Materials	13.5%	17.50%	14.50%
7. Waste	8.5%	11%	9.50%
8. Land Use and Ecology	10%	13%	11%
9. Pollution	10%	6%	11%
Total	100%	100%	100%
Innovation (additional)	10%	10%	10%

BREEAM Section	Credits Achieved	Credits Available	% of Credits Achieved	Section Weighting (fully fitted)	Section Score
1. Management	11	22	50%	0.12	6.00%
2. Health and Wellbeing	9	10	90.00%	0.15	13.50%
3. Energy	16	30	53.33%	0.15	7.99%
4. Transport	5	9	55.56%	0.09	5.00%
5. Water	5	9	55.56%	0.07	3.89%
6. Materials	6	12	50.00%	0.135	6.75%
7. Waste	4	7	57.14%	0.085	3.64%
8. Land Use and Ecology	5	10	50.00%	0.10	5 %
9. Pollution	7	13	53.84%	0.10	5.38%
10. Innovation	2	10	20.00%	0.10	2%
Final BREEAM score			59.15%		
BREEAM Rating			VERY GOOD		

Table 4: LEED rating system model and score card.

LEED v4 for BD+C: New Construction and Major Renovation

Project Checklist

Project Name:

Date:

Y	?	N				
			Credit	Integrative Process		1
0	0	0	**Location and Transportation**			16
			Credit	LEED for Neighbourhood Development Location		16
			Credit	Sensitive Land Protection		2
			Credit	High Priority Site		3
			Credit	Surrounding Density and Diverse Uses		6
			Credit	Access to Quality Transit		6
			Credit	Bicycle Facilities		1
			Credit	Reduced Parking Footprint		1
			Credit	Green Vehicles		1
0	0	0	**Sustainable Sites**			10
Y			Prereq	Construction Activity Pollution Prevention		Required
			Credit	Site Assessment		1
			Credit	Site Development - Protect or Restore Habitat		2
			Credit	Open Space		1
			Credit	Rainwater Management		3
			Credit	Heat Island Reduction		2
			Credit	Light Pollution Reduction		1
0	0	0	**Water Efficiency**			11
Y			Prereq	Outdoor Water Use Reduction		Required
Y			Prereq	Indoor Water Use Reduction		Required
Y			Prereq	Building-Level Water Metering		Required
			Credit	Outdoor Water Use Reduction		2
			Credit	Indoor Water Use Reduction		6
			Credit	Cooling Tower Water Use		2
			Credit	Water Metering		1
0	0	0	**Energy and Atmosphere**			33
Y			Prereq	Fundamental Commissioning and Verification		Required
Y			Prereq	Minimum Energy Performance		Required
Y			Prereq	Building-Level Energy Metering		Required
Y			Prereq	Fundamental Refrigerant Management		Required
			Credit	Enhanced Commissioning		6

			Credit	Optimize Energy Performance	18
			Credit	Advanced Energy Metering	1
			Credit	Demand Response	2
			Credit	Renewable Energy Production	3
			Credit	Enhanced Refrigerant Management	1
			Credit	Green Power and Carbon Offsets	2
0	0	0	**Materials and Resources**		**14**
Y			Prereq	Storage and Collection of Recyclables	Required
Y			Prereq	Construction and Demolition Waste Management Planning	Required
			Credit	Building Life-Cycle Impact Reduction	5
			Credit	Building Product Disclosure and Optimization - Environmental Product Declarations	2
			Credit	Building Product Disclosure and Optimization - Sourcing of Raw Materials	2
			Credit	Building Product Disclosure and Optimization - Material Ingredients	2
			Credit	Construction and Demolition Waste Management	2
0	**0**	**0**	**Indoor Environmental Quality**		**16**
Y			Prereq	Minimum Indoor Air Quality Performance	Required
Y			Prereq	Environmental Tobacco Smoke Control	Required
			Credit	Enhanced Indoor Air Quality Strategies	2
			Credit	Low-Emitting Materials	3
			Credit	Construction Indoor Air Quality Management Plan	1
			Credit	Indoor Air Quality Assessment	2
			Credit	Thermal Comfort	1
			Credit	Interior Lighting	2
			Credit	Daylight	3
			Credit	Quality Views	1
			Credit	Acoustic Performance	1
0	**0**	**0**	**Innovation**		**6**
			Credit	Innovation	5
			Credit	LEED Accredited Professional	1
0	**0**	**0**	**Regional Priority**		**4**
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
0	**0**	**0**			
	Certified: 40 to 49 points, **Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110				

Adding performance indices to the current green rating score card helps in offering the double methods of check to green rating assessment. The performance indices will target sustainable performance in terms of building elements (**see** Error! Reference source not found.) while the current scorecard will target sustainable performance through the strategic demands categories (**see** Error! Reference source not found.).

The new combined model coined as “Performance Index assessment tool offers” two languages for performance assessment. The first one is credit point achievement for each green demand categories- which is applied in LEED, BREEAM- and the other is the performance index value. This assessment tool offers more flexible assessment method compared to traditional rating systems because it offers the possibility for each building element to play a role on the three green rating demands. For example, in the site potential optimisation demand is expressed in two categories which are Sustainable Sites and Location and Transportation (**see Table 3)**. The credit check point are single oriented category where all sub category are derived from the main category .on the opposite side, in Performance Index assessment tool building element is exposed to green design domains where building site assessment is affected not only by site potential but also by how much it has an effect on optimising energy and how much building materials are related to the site and to how much extent the building site design plays a role in water protection and so on. The concept of double assessment offers possibilities for double check. In mathematical expression two chances for success compared to one chance. The model shows the relative index value,

this relative index value would refer to the relationship between index value results and credit scores, Moreover, it provides across reference check to validity of credits as there would be three cases as follow:

a. **A performance index value is relatively high as well as the score credit chieved:** in such case that would represent that the design quantitative measures of performance meet design qualitative values of performance.

b. **A performance index value is relatively low while the score credit chieved is relatively high:** in such case that would represent that the numerical assessment of the building is considered as green although qualitative dimensions of design are not sufficient. That would point at importance reassessment of the building design before giving certificates.

c. **A performance index value is relatively high while the score credit chieved is relatively low:** in such case that would represent an error in assessment or design, this would help in further research developing the model of evolution from one point and building assessment from another.

The model in Error! Reference source not found. represents the combined model driven from Building performance classification and green rating systems strategic demands categories. The model shows in rows green rating systems strategic demands categories while in columns it shows Building performance classifications and domains. Some assessment points may not be available due to its duality or inapplicability; for example, site potential and building site location would be duplicated in dual assessment. For that reason, the model is dynamic and flexible to deal with non-present factors in checklist score card assessment and to eliminate common factors that already exists within the current score card. As seen in **Error! Reference source not found.** a snap capture of LEED V4 location and transportation category score card. The new model has developed this score card as seen in **Error! Reference source not found.** as a direct application for Sustainable Performance Index assessment tool. The credit column summation is the current credit point that exists within the scorecard at LEED evaluation system. Adding the horizontal row dimension which represents domains of performance of the building with relation to the site operational financially and socially.

Table 6: A capture from Lead V4 checklist.

0	0	0	Location and Transportation		20
			Credit	LEED for Neighbourhood Development Location	20
			Credit	Sensitive Land Protection	2
			Credit	High Priority Site	3
			Credit	Surrounding Density and Diverse Uses	6
			Credit	Access to Quality Transit	6
			Credit	Bicycle Facilities	1
			Credit	Reduced Parking Footprint	1
			Credit	Green Vehicles	1

0	0	0	Sustainable Sites		11
			Credit	Construction Activity Pollution Prevention	Required
			Credit	Site Assessment	1
			Credit	Site Development - Protect or Restore Habitat	2
			Credit	Open Space	1
			Credit	Rainwater Management	3
			Credit	Heat Island Reduction	2
			Credit	Light Pollution Reduction	1
			Credit	Tenant Design and Construction Guidelines	1

Table 7: Sustainable Performance Index assessment tool.

Sustainable Performance Index assessment tool			Building performance classifications and domains												**performance Index value**
			Building site & location			**Building indoor Spaces**			**Building structure And material**			**Building operating Systems**			
Green rating systems strategic demands categories		credit	**O**	**F**	**S**	**O**	**F**	**S**	**O**	**F**	**S**	**O**	**F**	**S**	
Optimise	**Site potentials**		**N/A**	**N/A**	**N/A**										
	Energy use														
	Building space and material use								**N/A**	**N/A**	**N/A**				
	operations and maintenance practice											**N/A**	**N/A**	**N/A**	
Protect	**Water**														
Enhance	**Indoor environmental quality**					**N/A**	**N/A**	**N/A**							
Credit point achievement		**Credit score**	**Index value**			**Index value**			**Index value**			**Index value**			**Relative index value**

8. RESULTS AND RECOMMENDATIONS

The research shows possible development of current green rating score card through the integration of performances-based design indices. The research shows classification for building performance-based design based on both performance domains and building element from which the research has derived building performance index as a concept for assessment. On the other hand, the research worked on finding green design assessment strategies common roots. The research simplified these strategies into 3 demands which are the optimisation, the protection, and the enhancement for the different elements of the built environment.

In order to shift the sustainable practice toward more sustainable performance-based practice the research has worked on developing the classic hamburger model of performance to a more detailed model to be coined as Sustainable performance-based design Model. The research added Sustainable design performance framework to the classical model. this framework combines performance domains to green deign demands, categories and building performance elements.

And to cover both green rating systems and performance evaluation the research offered a developed assessment tool that combine the concept of index evaluation to credit evaluation. This tool can help in transferring the green design method from the prescriptive approach to the performance based approach

a. It is recommended that the further research should work on Building performance classification and indices. They should be studied in more details, enhanced, and developed from its conceptual approach to a solid evaluation tool that shows significant.
b. More detailed studies should be done on Sustainable Performance Index assessment tool to make a detailed breakdown to its categories and give more detailed description for methods of evaluations and subcategories.
c. The new introduced tool with a help of multidisciplinary team should work on case studies on the comparative method to measure the difference between the results obtain through traditional method of assessment and the new one.

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