Smart Readiness, a tool for Green Building Certification Schemes towards carbon neutrality in the built environment

Effrosyni Giama
Department of Mechanical Engineering
Aristotle University of Thessaloniki
Thessaloniki, Greece
fgiama@auth.gr

Konstantinos Chatzikonstantinidis
Department of Mechanical Engineering
Aristotle University of Thessaloniki
Thessaloniki, Greece
kchatziko@auth.gr

Georgios Chantzis
Department of Mechanical Engineering
Aristotle University of Thessaloniki
Thessaloniki, Greece
chantzis@auth.gr

Merope Manataki
Alma Sistemi
Rome, Italy
mma@alma-sistemi.com

Paris Fokaides
School of Engineering
Frederick University
Nicosia, Cyprus
eng.fp@frederick.ac.cy

Agis Papadopoulos
Department of Mechanical Engineering
Aristotle University of Thessaloniki
Thessaloniki, Greece
agis@auth.gr

***Abstract*— This paper introduces a methodology to correlate the environmental certification schemes such as Leadership in Energy and Environmental Design (LEED), Building Research Establishment Environmental Assessment Method (BREEAM) and the initiative from the German National Council for Sustainable Buildings, Deutsche Gesellschaft für Nachhaltiges Bauen (DGNB) with the Smart Readiness Indicator. The key performance indicators introduced by certification tools in line with Smart Readiness Indicator (SRI) provide a holistic approach in the evaluation of the built environment not only on the energy issue but also in water and waste management, transportation, construction materials, air quality and social parameters connected to users' health and well-being. The objective is to identify the synergy between green building certifications and SRI methodology in order to create a holistic methodological framework for evaluating buildings to reach the energy efficiency and decarbonization targets of European policy, focusing on how the SRI assesses energy efficicency. By promoting the integration of automation and control technologies, the SRI facilitates the adoption of energy-efficient practices and reduces the carbon footprint of buildings. This aspect is particularly significant given the imperative to mitigate the impacts of climate change and ensure the sustainability of our built environment. The methodology suggests a decision making tool promoting smart building technologies and advancing energy efficiency objectives. By offering a comprehensive framework for evaluation and improvement it empowers stakeholders to make decisions and spearhead meaningful changes, in particular in the refurbishment of the building stock, thus paving the way for a more sustainable future. The methodology is implemented in a typical office building located in Greece, belonging to the Mediterranean climate zone of southern Europe (Cfa on the Koeppen climate scale) and the findings of the analysis ensure the support of SRI to the overall environmental evaluation of building certification schemes concluding to an overall 65% performance index.**

Keywords— Smart Readiness Indicator (SRI), Environmental Rating Systems, Building Certification, energy efficiency, decarbonization

I. INTRODUCTION

The European policy for the energy and the climate sets a define framework with quantitative goals regarding all sectors and the building sector as well. Buildings as crucial parameter of cities are actually the cornerstone of energy consumption and CO2 emissions in urban centers, accounting for 36% of total CO2 emissions and 40% of total energy consumption [1]. Keeping this in mind and consider the European perspective for carbon neutral economy it is important to identify these parameters that can be upgraded in order to reach the goal of reduction of the greenhouse gas emissions by 80% compared to 1990 levels till the year 2050. In an effort to mitigate the increasing trend in the average global temperature as a result of climate change, which is expected to have dramatic consequences on human daily life [2]. Nevertheless, it is not only the energy and emissions issue. Buildings are related to users therefore the social parameter, the health and well being of users are targets that need to be accomplished when we evaluate building systems in a holistic approach. Another significant issue that should be considered in terms of the building management is resilience. The need to ensure security and well being of the users also under crises circumstances is another challenge that we need to achieve as a society. It is more than evident that building management is a complicated problem to solve [3]. The guide in order to upgrade the building stock is firstly to be in compliance with the European policy as well as with the national laws. In this line of approach there are several tools, methodological tools, strategies as well as technologies that support the vision of improving the building sector in terms of energy efficiency as well as carbon emissions. Smart buildings for example, the use of efficient sensors for monitoring the energy systems, energy flexibility, energy storage in cooperation to renewable energy systems play a vital role to efficient energy management. Building automation and control (BAC) and Technical Building Management (TBM) systems act as control centres in buildings. It is here that information for all of a building's technology is integrated, and it is from here that heating and cooling systems, ventilation and air conditioning plants, lighting, and sun- and fire protection systems are controlled, making them a key part of any drive for energy efficiency. However, existing buildings can also make great strides to decarbonize and it often makes more sense economically and environmentally to retrofit a building than demolishing it to make way for a new one. Installing thermal insulation and more efficient heating, ventilation and air-conditioning

(HVAC) systems and heat pumps, and sourcing a building's power from renewable energy, for example, can easily help decarbonize a building. All the above mentioned parameters are corellated and examined under the umbrella of Green Certifications Schemes and Key Performance Indicators such as Smart Readiness Indicator which is not just a monitoring indicator but a full methodology which evaluates buildings.

II. METHODOLOGICAL APPROACH

A. *The tools*

The study introduces a methodology to correlate the environmental certification schemes such as Leadership in Energy and Environmental Design (LEED), Building Research Establishment Environmental Assessment Method (BREEAM) and the initiative from the German National Council for Sustainable Buildings, Deutsche Gesellschaft für Nachhaltiges Bauen (DGNB) with the Smart Readiness Indicator. The key performance indicators introduced by certification tools in line with Smart Readiness Indicator (SRI) provide a holistic approach in the evaluation of the built environment not only on the energy issue but also in water and waste management, transportation, construction materials, air quality and social parameters connected to users' health and well-being [4]. The objective is to identify the synergy between green building certifications and SRI methodology in order to create a holistic methodological framework for evaluating buildings to reach the energy efficiency and decarbonization targets of European policy, focusing on how the SRI assesses energy efficiency. By promoting the integration of automation and control technologies, the SRI facilitates the adoption of energy-efficient practices and reduces the carbon footprint of buildings. This aspect is particularly significant given the imperative to mitigate the impacts of climate change and ensure the sustainability of our built environment [5].

B. *Certification Schemes and SRI*

It is important to offer a comprehensive framework for evaluation and improvement that empowers stakeholders to make decisions and spearhead meaningful changes, in particular in the refurbishment of the building stock, thus paving the way for a more sustainable future. This offer is given by the certification schemes which offer a detailed guidance in relation to existing buildings. The added value of certification schemes is that apart from the energy efficiency other significant parameters are evaluated and give an overall environmental rate for the building. In this session and based on the LEED, BREEAM and DGNB guides criteria analysis is implemented along with the available credits per category. For instance, BREEAM defines criteria based on major environmental categories that include the [6,]:

- Management (commissioning, monitoring, waste recycling, pollution, minimization, materials minimization)
- Health & Wellbeing (adequate ventilation, humidification, lighting, thermal comfort)
- Energy (sub-metering, efficiency and CO2 impact of systems)
- Transport (emissions, alternate transport facilities)
- Water (consumption reduction, metering, leak detection)
- Materials (asbestos mitigation, recycling facilities, reuse of structures, facade or materials, use of crushed aggregate and sustainable timber)
- Land Use (previously used land, use of remediated contaminated land)
- Ecology (land with low ecological value or minimal change in value, maintaining major ecological systems on the land, minimization of biodiversity).
- Pollution (leak detection systems, on-site treatment, local or renewable energy sources, light pollution design, avoid use of ozone depleting).

The possible credits available per environmental category are presented in table 1. It is noticed that each category has a representative weighting factor like the SRI methodology also. Based on the methodology and the guides the building is examined and evaluated [7]

Table 1. BREEAM in use environmental categories and credits

Environmental Category	Credits available	Category weighting
Health and Wellbeing	47	0,2
Energy	66	0,25
Transport	22	0,05
Water	38	0,11
Resources	23	0,13
Resilience	18	0,13
Land Use and Ecology	6	0,04
Pollution	18	0,09
Exemplary	12	0,1

The final scoring sets the building in a rate category based on the credits the building achieved during the evaluation process [8].

Table 2. BREEAM rating

BREEAM In-Use International Rating	%score
Outstanding	≥85
Excellent	≥70 to <85
Very good	≥55 to <70
Good	≥40 to <55
Pass	≥25 to <40
Acceptable	≥10 to <25
Unclassified	<10

In correspondence to BREEAM the basic environmental aspects included in LEED evaluation process are presented at the figure following. LEED rating system examines the following environmental aspects during the evaluation process [9,]:

- Sustainable sites, the intent is to reduce pollution from construction activities by controlling soil erosion, waterway sedimentation and airborne dust generation.
- Water efficiency, the intent is to limit or eliminate the use of potable water, or other natural surface or subsurface water resources available on or near the project site, for landscape irrigation.
- Energy and atmosphere, the intent is to verify that the building's energy related systems are installed, calibrated and perform according to the owner's project requirements, basis of design, and construction documents.
- Materials and resources, the intent is to facilitate the reduction of waste generated by building occupants that is hauled to and disposed of in landfills.
- Indoor air quality, the intent is to establish minimum indoor air quality (IAQ) performance to enhance indoor air quality in buildings, thus contributing to the comfort and well-being of the occupants.
- Innovation and design process, the intent is to provide design teams and projects the opportunity to be awarded points for exceptional performance above the requirements set by the LEED.

As far as the basic structure of the DGNB system for buildings in use, is based on the well-known three-pillar sustainability model [10,11]. For this reason, it divides the key aspects of sustainable building operations into three quality sections, environmental quality, economic quality and sociocultural and functional quality [12]. Each quality section participates in the overall performance of a project, to a different extent as expressed by the weighting factor of each one. Environmental quality accounts for 40%, economic quality for 30%, as well as sociocultural and functional quality. Terms like functional quality are defined in the DGNB guidance and focuses mainly on technical monitoring of the systems included in the building, building operation system, responsibilities shared to the users, management schemes implemented. In addition, each quality section consists of a set of criteria. Specifically, the system focuses on all issues related to the sustainable operation of the building in nine criteria.

Table 3. Awards of the DGNB system for Buildings In Use and the total performance index defined by each.

Level of certification	Points awarded
Certified	40-49
Silver	50-59
Gold	60-79

The assessment of smart ready services is based on their impact on occupants, the building and the grid, according to some distinct criteria defined by the SRI calculation methodology. Based on the study of Chatzikonstantinidis [13], the returns resulting from the services of each technical domain are classified into impact criteria. These criteria are 7 in total and are presented [14]:

- Energy savings,
- Maintenance and fault prediction
- Comfort,
- Convenience,
- Information to occupants,
- Health and well-being,
- Information to occupants,
- Energy flexibility and storage.

These impact criteria are further clustered under three key-functionalities which carry equal weights (1/3) in the overall SRI score and reflect the main goals of SRI. In line with the requirements of the revised Directive (EPBD), these three key-functionalities have been considered when defining the services for the SRI:

- Energy performance and operation,
- Response to the needs of the occupants,
- Energy flexibility.

According to the procedure of developing an effective and sustainable decision-making framework related to interventions for buildings refurbishment the following categories are taken into consideration. More detailed, criteria for selecting a refurbishment strategy and the appropriate interventions for each case should be summarized to the following general categories: technical, energy efficiency and environmental impact assessment [15,]. Based on recent reviews there are several schemes and certifications for evaluating buildings [16]. All of them share common features and methodological framework and differ to the criteria classification, the weighting factors and the final rate characterization [17].

From the methodologies presentation is evident that there are a lot of similarities in the way the evaluation is implemented. All the relevant environmental impacts are examined along with issues that are related to health and well being and cost effectiveness. In this line of approach, a renovated office building located in Greece that was first constructed in 1960s is evaluated both in SRI methodology as well as the DGNB rating scheme.

III. BUILDING PERFORMANCE INDEX

The total heated area of the office building is 2730 m2 (Length: 20,40m, Width: 12,50m, Height: 27,60m) and the heated and cooled volume is 7038 m3, while a typical floor plan is shown in Figure 1. The renovated design of the building will have a glazed formed envelope, with movable blinds for shading as required for a typical Meditteranean climate and its construction is based on the principles of bioclimatic architecture. As far as the energy systems and based on the ongoing renovation of the building, it is assumed that the building will have advanced monitoring and control systems, especially for the heating, cooling, and lighting systems, which will operate with presence control and based on the actual needs.

Figure 1. Exterior façade of the examined building.

It is also assumed that they will be able to monitor and store data. The building will have class A BMS (Building Management Systems) optimizing the control and performance of the building's indoor conditions . Furthermore, regarding air conditioning, this will consist of a VRF (Variable Refrigerant Flow) system with thermostatic control in all zones. A total of 5 kW of PV panels will be installed on the roof of the building, while the facades will have external vertical sun protection fins, their orientation being optimized based on incident radiation. In that case the SRI was calculated at about 60-65% depending on the renovated scenarios while in the existing situation the building had a performance index not bigger than 10%. The same renovated scenario was evaluated with DGNB which has a similar structure to SRI methodology and gives an overall evaluation of the renovated case at about 65% almost the same result with the SRI.

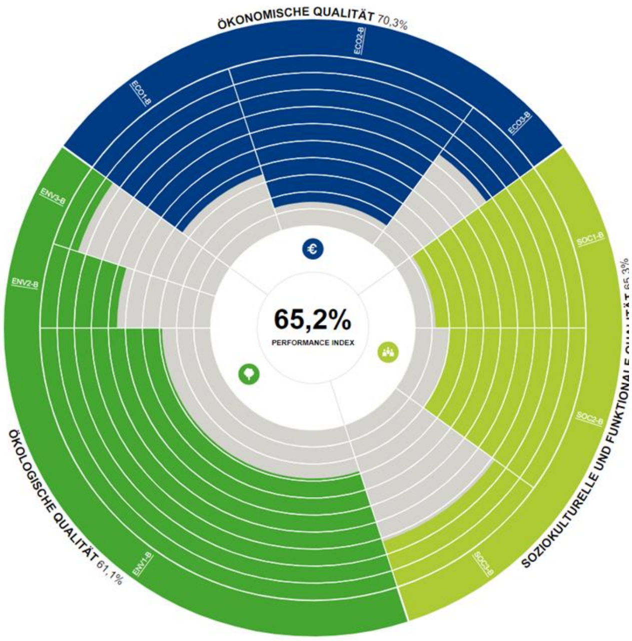

Figure 2. Total performance index of the case study office building/ Performance per quality section.

The classification of the building's rating meets the requirements for a holistic approach to sustainability in its office building. This fact is confirmed by the performance it presents in each quality section (over 60%), which are directly related to the three aspects of sustainability. Specifically, in environmental quality it has a rate of return equal to 61%, in economic quality 70% and in sociocultural and functional quality 65%. Regarding the sociocultural parameters criteria like indoor air quality, thermal comfort, accessibility as well as facilities for the user are examined [18].

IV. CONCLUSIONS

Considering the certification schemes discussed, the differences amongst them mainly focus on the importance each method is giving to selective evaluation criteria, on the evaluation procedure as such, on the available points given for each criterion, on the weighting factors and on benchmarking ratings. The comparison pointed out that the majority of the assessment methods have a common structure, include in essence the same evaluation criteria and only differ with respect to the rating procedure and the certification benchmarking. Still, the goals of all the schemes remain common and concern the compliance with environmental and energy policies and legislation, the achievement of economic and financial benefits, the achievement of competitive advantages in the construction market and the establishment of indoor environmental comfort and quality conditions for the occupants. BREEAM and LEED are clearly the leading green building rating systems, while it is only reasonable that preference is given to the national certification system, or at least to those approximating more the regionally prevailing building patterns. The fact is that building assessment tools keep constantly evolving, in order to overcome their shortcomings and provide comparable results for the environmental and sustainability assessments of buildings.

It is essential to achieve greater compatibility, transparency, coordination and consistency between the different certification schemes and to utilize harmonized standards, be it EN or ISO, in order to achieve a broader market penetration. Nevertheless, addressing sustainability in the building sector is expected to remain in the core of developments over the foreseeable future, making the establishment of efficient and effective tools a prerequisite. Evaluation on the case of total building's upgrade proved to rate almost the same in the case of DGNB and SRI methodology and giving an overall evaluation at about 65% performance index.

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