COMPARATIVE EVALUATION OF LEED AND QSAS CREDITS USING LIFE CYCLE ANALYSIS: CASE STUDY FROM QATAR

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Abstract: Implementation of sustainability rating systems for buildings had a recognized effect on the increased level of sustainability adoption in the construction industry. However, there is still a need for objective quantifiable evidence that the concepts adopted by the sustainability rating systems and implemented in projects lead to optimum positive impacts on resource consumption and the environment. The objective of this paper is to present research conducted to assess the actual environmental impact saved by implementing credits of both LEED (Leadership in Environmental and Energy Design) and QSAS (Qatar Sustainability Assessment System) using Life Cycle Analysis (LCA) approach. The impact of implementing LEED and QSAS credits under the categories of energy, water and urban connectivity on a selected project in Qatar was analyzed using LCA. The results of this analysis manifest the objective quantifiable benefits behind applying the respective sustainability credits and how the impact of an international rating system differs from that of a system developed for the specific region where the project is located. The relative weights allocated to these credits were also analyzed in light of the corresponding LCA results in order to evaluate the significance of such weights and how they can be reconsidered to achieve optimum reduction of impacts.

1 INTRODUCTION

The construction industry is distinguished, among other industries, by the large number of materials, processes and technologies that are incorporated within its activities. Warnock (2007) explained that the complexity of building construction is demonstrated by the various physical components used in projects, which significantly increases resource consumption and highly impacts the environment. The United Nations Environmental Program (2002) revealed that this industry consumes 40% of Europe’s energy in addition to its large contribution to the emission of greenhouse gases in the United States. Also, it is estimated that one-third of energy end-use is consumed for heating, cooling, lighting, appliances and general services in buildings whether residential, commercial or public (Ardenta 2008). Therefore, due to the referred incontestable significant impacts, achieving sustainability in construction projects has been the target for various initiatives, among which is development of sustainability rating systems.
Rating systems are used to evaluate construction projects through set of categories where each category encompasses a number of measurable targets that are evaluated under relevant credits. The objective of adopting these systems is to improve the performance of construction projects from sustainability perspective by appreciation of reducing resource consumption or harmful emission. Various rating systems have been developed in the last two decades in different countries. The use of some of these systems has gone beyond the boundaries of the countries where they were developed and are being applied internationally. Leadership Engineering and Environmental Design (LEED), for instance, was developed by the US Green Building Council (USGBC) and is currently implemented in many developed and developing countries (Kyrkou and Karthaus 2011). Building Research Establishment Environmental Assessment Method (BREEAM) has a long track record as the main rating system in UK (Fowler and Rouch 2006). In Australia, Green Star is implemented to assess environmental performance of construction projects (Lockwood 2006). Comprehensive Assessment System for Building Environmental Efficiency (CASEBEE) is the widely established as sustainability evaluation system used in Japan, (Reed et al. 2009).

2 BACKGROUND

The declaration of Qatar 2030 visionary plan endorsing environmental development as one of the four main pillars of Qatar’s National Vision (GSDP 2008) has led to various nation-wide initiatives and efforts to adopt sustainability in construction activities. One of these initiatives is the development of Qatar Sustainability Assessment System (QSAS) by the Gulf Organization for Research and Development (GORD) forming a tool to benchmark construction projects with respect to their environmental performance. However, similar to other rating systems being implemented all over the world, the current practices being adopted and supported by these rating systems do not provide sufficient quantifiable evidence that they lead to optimum saving to the environment. Rather, they have evolved from a consensus-based understanding of environmental issues. This understanding, in some cases, has been based on conventional environmental wisdom that does not always stand up to objective analysis (Trusty 2003).

One of the most powerful tools to address this issue is Life Cycle Analysis (LCA), which is a methodology used to analyze the “Cradle to Grave” impact of using a specific product or process on the environment. According to ISO standard 14040 issued by the International Standards Organizations (ISO 2006), the analysis takes into consideration the impact of all processes involved in the life cycle of such materials on the environment starting from extraction, through manufacturing, transportation, installation, operation till disposal. The Objective of this paper is to present utilization LCA as an objective assessment tool to hold a comparative evaluation between internationally recognized and locally developed rating systems with regard to their actual positive impact. The following sections of the paper demonstrate the methodology adopted to hold this comparative evaluation, the results of this application on a project in Qatar, comments on the results obtained leading to conclusion and finally, future suggested research work.

3 METHODOLOGY

As introduced in the previous sections, this paper presents research carried to utilize LCA to evaluate the efficiency of international versus local rating systems in the state of Qatar. The international rating system selected for this study is LEED and the local one is QSAS. To enable comparative evaluation of the two rating systems, the methodology proposed by Attallah et al. (2013) is implemented on a commercial center at Alshamal City, which is a project currently under construction in Qatar using the comparable credits under the two rating systems. Implementation of the methodology is described under this section and briefly illustrated in Figure 1.
3.1 Step 1: Selection of comparable credits under LEED & QSAS

Since the rating systems are developed in different countries and under by different organizations, they tend to be dissimilar in terms of their development of the evaluation procedures and the prioritization of credit, which is reflected in the relative weights assigned to each credit. However, since the most significant elements of the construction projects affecting the environment are basically the same anywhere in the world, we can still claim that similar language can be detected under different rating systems. For example, the water and energy consumption credits are typically of the highest relative weights under any rating systems. This is due to the established consensus among practitioners and experts that water and energy consumption are of high significance due to the processes involved in securing both, which are characterized by high resource consumption and heavy emissions.

The target here is to compare the impact of implementing two different rating systems. Therefore, we have selected the credits under LEED and QSAS that are of comparable nature and identified their relative weights in order to understand the relative contribution and consequently the relative efficiency. Table 1 shows sample of selected comparable credits under the two systems and their relative weights towards certification.

<table>
<thead>
<tr>
<th>Credit Objective</th>
<th>QSAS Credit</th>
<th>Weight (%)</th>
<th>LEED Credit</th>
<th>Weight (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimization of Energy Consumption</td>
<td>E1</td>
<td>5.2</td>
<td>EA1</td>
<td>17.3</td>
</tr>
<tr>
<td>Use of renewable energy sources</td>
<td>E3</td>
<td>3.64</td>
<td>EA2</td>
<td>6.4</td>
</tr>
<tr>
<td>Rationalization of Water Consumption</td>
<td>W1</td>
<td>16</td>
<td>WE1</td>
<td>3.6</td>
</tr>
<tr>
<td>Decrease traffic load by improving access to public transportation</td>
<td>UC6</td>
<td>1.3</td>
<td>S4.1</td>
<td>5.5</td>
</tr>
</tbody>
</table>
3.2 Step 2: Content analysis of rating system documentation

The second step in the methodology is to analyze the contents of the respective working documents forming the basis of implementing credits and achieving the targeted certifications. The first set of documents is commonly the design guides or manuals created to provide the project participants with various ideas or approaches to improve the building performance in respect to the environmental issues addressed under each credit. These documents typically refer to relevant sections of standards or codes which are used in assessing the savings achieved. In the case of QSAS, design manuals are available for those who procure license from GORD or companies applying for project certification. For LEED, the reference for our research here is the document titles “LEED 2009 for New Construction and Major Renovation”, which is open to public. The later document was used as one single source of reference since it included the information required to carry out the analysis in the case of LEED.

The second set of documents typically refers to how the score for each credit is calculated using the relevant calculation sheets or toolkits. Designers or concerned stakeholder change parameters under each credit to come as close as possible to the reference target figures in the design manuals. The score is typically calculated by comparing the project parameter planned for the project with the set standard or reference. Assessment manuals for QSAS were obtained to complete this task. The third set of documents is the calculation tools, the form of which can be extensively different from one rating system to another as they are very specific to the nature and scope of credits under each system. The calculation tools assist the users or applicants to feed the relevant project input and perform computations for self-evaluation before submission for certification. For QSAS, set of calculation excel sheets and tool kits were obtained along with the design and assessment manuals to complete this task. As explained, the objective of this research step of the presented methodology is to establish a thorough understanding of the adopted sustainability approach, the assessment criteria, and the build-up of scores for each credit.

3.3 Step 3: Defining project parameters for achieving sustainability credits

A very critical step in the adopted methodology, linking the conceptual phase of evaluation with the quantification phase, is to determine the critical project parameters that have to be appropriately addressed and changed in order to reach the target score. Extensive analysis for each credit, which is carried out through exploring the design and assessment manuals, reveals what are the options the designer has in order to achieve the target points. The holistic approach followed under some credits, which leads to unclear intangible parameters, forms the biggest challenge for implementing this methodology on all credits. The parameters identified for each comparable credit under QSAS and LEED are shown in Table 2.
Table 2: Sample of identified parameters under QSAS & LEED credits

<table>
<thead>
<tr>
<th>QSAS Credit</th>
<th>Parameters</th>
<th>LEED Credit</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>Planned (design) building energy demand versus reference figures</td>
<td>EA1</td>
<td>Saved energy versus base line design</td>
</tr>
<tr>
<td>E3</td>
<td>Percentage of energy produced by alternative renewable sources</td>
<td>EA2</td>
<td>Percentage of energy produced by alternative renewable sources</td>
</tr>
<tr>
<td>W1</td>
<td>Planned annual water consumption</td>
<td>WE1</td>
<td>Reduced percentage of potable water consumption</td>
</tr>
<tr>
<td>UC6</td>
<td>Project layout Public transportation locations Estimated traffic to project</td>
<td>S4.1</td>
<td>Public transportation locations Estimated traffic to project</td>
</tr>
</tbody>
</table>

3.4 Step 4: Analysis of project data

Upon identifying the critical parameters for each credit, these parameters are then converted into LCA inventory data in order to quantify the associated LC impacts. To do this, we have selected a project currently under construction in Qatar to apply the concept with actual quantities derived from available drawings, specifications and other project information. The project is targeting 3 stars on the QSAS scale, which is at 50% of the maximum certification. For the comparison purpose, the LEED certification targeted is taken as 55 points corresponding to 50% on of the maximum achievement (silver level). According to this presumption, the obtained project data were explored in order to translate the change in the identified parameter (i.e. saved impact) to inventory. The following two sections provide more details on the inventory analysis and impact calculation steps.

3.5 Step 5: Project inventory assessment

The changed parameters result in saved impact on the environment and/or saved resources. In order to quantify this saved impact, we first calculate the amount of resources saved or emissions reduced due to implementing the considered credit. In some cases, the parameter is itself a quantity that can be traced through the LCA database to calculate the associated saved environmental impact. Water consumption credits in any rating system is an example, where the score is based on the amount of savings in consumed water annually due to the implementation of some strategies and the use of economical fittings or systems that reduce consumption. Nevertheless, in other cases like vegetation credits under the QSAS, the parameter identified is the area planted in relation to the project overall area. In this case, project drawings and specifications are used to identify the type of plants used and calculate the approximate annual saved CO2 due to this planting scheme. Deriving the inventory saved based on the changed parameters is the most critical step in this methodology as it requires careful reading and interpretation of the project technical data. The changed parameters to achieve certain scores can usually be measured from the project drawings. Specifications are usually required to determine the technical features of the identified parameters. Table 3 shows the calculated inventory for some QSAS and LEED credits based on the selected commercial building project.
Table 3: Calculated inventory for the selected project

<table>
<thead>
<tr>
<th>QSAS Credit</th>
<th>Saved Inventory (Annual)</th>
<th>LEED Credit</th>
<th>Saved Inventory (Annual)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>1,080 MWH of electricity</td>
<td>EA1</td>
<td>954 MWH of electricity</td>
</tr>
<tr>
<td>E3</td>
<td>1,477 MWH of electricity</td>
<td>EA2</td>
<td>223 MWH of electricity</td>
</tr>
<tr>
<td>W1</td>
<td>3,713 m3 of potable water</td>
<td>WE1</td>
<td>1,685 m3 of potable water</td>
</tr>
<tr>
<td>UC6</td>
<td>2 tons of fuel</td>
<td>S4.1</td>
<td>2 tons of fuel</td>
</tr>
</tbody>
</table>

3.6 Step 6: Calculation of LCA impact using Simapro

The LCA impact involves lengthy calculations of all processes involved in throughout the whole life cycle of the project components. It is well established among LCA practitioners that while the products under study are used in certain countries, portion of the life cycle impacts could be generated in other countries. For construction products like wall cladding systems, ironmongery, and carpentry, there are usually imported components from industrial countries that are not themselves the origin of the raw materials. This leads to having several locations worldwide where the traceable environmental impact could be recorded. For this reason, the LCA approach has a cross-borders nature, which justifies why an international database can be used for LCA studies even in countries different from the one where data for this database was collected. One of the available LCA databases was targeted to identify the LC impact for each saved inventory. The last step is to perform weighting of the LCA impact in order to reach a single score representing the total impact and to enable comparison of results. Weighting is done here based on the built-in figures in Simapro.

4 RESULTS

We chose the SimaPro software with application of eco-indicator 99 database built-in the software to calculate the impacts. Table 4 in the results section shows an example of the impacts as an outcome of the Simapro software after weighting. The unit Pt used in this table represents the unit adopted in the database of eco-indicator 99, which is a dimensionless unit that reflects the single-score environmental impact after applying weighting as an interpretation technique. The comparison graphs, sample of which is presented in Figure 2 highlight the relative contribution of comparable credits for the certification and as per LCA calculation as well.
Table 4: Sample of impact as calculated through Simapro for the QSAS credits

<table>
<thead>
<tr>
<th>Impact category</th>
<th>Unit</th>
<th>E1</th>
<th>E3</th>
<th>W1</th>
<th>UC6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>Pt</td>
<td>66.595</td>
<td>91.075</td>
<td>435.075</td>
<td>1.031</td>
</tr>
<tr>
<td>Carcinogens</td>
<td>Pt</td>
<td>1.026</td>
<td>1.403</td>
<td>6.687</td>
<td>0.066</td>
</tr>
<tr>
<td>Non-carcinogens</td>
<td>Pt</td>
<td>0.046</td>
<td>0.062</td>
<td>12.046</td>
<td>0.006</td>
</tr>
<tr>
<td>Respiratory inorganics</td>
<td>Pt</td>
<td>8.424</td>
<td>11.521</td>
<td>87.044</td>
<td>0.118</td>
</tr>
<tr>
<td>Ionizing radiation</td>
<td>Pt</td>
<td>0.002</td>
<td>0.002</td>
<td>2.275</td>
<td>0.000</td>
</tr>
<tr>
<td>Ozone layer depletion</td>
<td>Pt</td>
<td>0.005</td>
<td>0.007</td>
<td>0.009</td>
<td>0.001</td>
</tr>
<tr>
<td>Respiratory organics</td>
<td>Pt</td>
<td>0.015</td>
<td>0.021</td>
<td>0.068</td>
<td>0.003</td>
</tr>
<tr>
<td>Aquatic ecotoxicity</td>
<td>Pt</td>
<td>0.007</td>
<td>0.010</td>
<td>63.570</td>
<td>0.001</td>
</tr>
<tr>
<td>Terrestrial ecotoxicity</td>
<td>Pt</td>
<td>0.275</td>
<td>0.376</td>
<td>7.578</td>
<td>0.002</td>
</tr>
<tr>
<td>Land occupation</td>
<td>Pt</td>
<td>0.003</td>
<td>0.004</td>
<td>3.834</td>
<td>0.000</td>
</tr>
<tr>
<td>Global warming</td>
<td>Pt</td>
<td>25.010</td>
<td>34.203</td>
<td>114.296</td>
<td>0.088</td>
</tr>
<tr>
<td>Non-renewable energy</td>
<td>Pt</td>
<td>31.527</td>
<td>43.117</td>
<td>136.311</td>
<td>0.741</td>
</tr>
<tr>
<td>Mineral extraction</td>
<td>Pt</td>
<td>0.000</td>
<td>0.001</td>
<td>0.118</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Using results as presented in the sample comparison graph in Fig 2, the contribution of each of the QSAS towards certification by 3 stars along with its associated LCA single score can be compared to the contribution of corresponding comparable LEED credits towards silver certification and their associated LCA results. The LCA score for each credit under study was calculated by multiplying the score achieved to target the required certification level (2 for QSAS and 0.5 for LEED) by the assigned weights for each credit. The product was then multiplied by a ratio of 1000 for the purpose of graph presentation (to have the same primary scale). These values are referred to as the certification score in Figure 2. The objective here is to check the performance of comparable credits to reach optimum potential saved impact on the environment under different rating systems, in this case a locally developed versus international one. To illustrate the results presented in Fig. 2, the blue column represent the certification score achieved for each of the subject credits while the blue columns represent the scores recorded through LCA calculations.
5 DISCUSSION & CONCLUSION

Comparison of the E1 (QSAS) and EA1 (LEED) shows consistent trend in terms of the LCA results as opposed to the certification scores. Both contributions to certification and LCA score of E1 are higher than those of its comparable LEED credit EA1. On the other hand, while the LCA score for QSAS E3 credit is higher than the LCA score of its comparable credit EA2 under LEED with a huge difference (more than 6 times), the contribution of E3 towards certification exceeds that of EA2 with much less difference than the one noticed for LCA. Taking into consideration that these two comparable credits are essentially addressing the same environmental issue, both contribution to certification and LCA score were expected to be comparable. Since this is not the case, it can be deduced that either QSAS is underestimating the percentage allocated to E3 or LEED is overestimating the score assigned to EA1. In other words, if we assume, for the sake of clarification, that LEED’s distribution of weights assigned to credits are reflecting actual benefits to the environment as it’s a more developed rating system being internationally used by professionals around the globe, then QSAS developers should be considering assigning higher percentage to E3 to reflect the impact in light of the discussed LCA study. It’s also noticed also that, comparing E1 and E3 under QSAS, shows that the LCA score of E3 is higher than that of E1 while its contribution for certification is less than that of E1. That could also be considered a basis to reconsider the weights assigned to both credits. Higher weight should be assigned to E3 in order to reflect more realistic saved impact on the environment.

According to the above sample analysis of the results, it is perceived that although implementation of sustainability rating systems on construction projects has clear positive effect on reducing burdens on the environment, rationalization of these rating systems using fair quantifiable measures is still required. This paper presented application of a quantification methodology on two rating systems, QSAS and LEED, to explore their relative efficiency through comparing similar credits using LCA approach. As discussed, results show possible superiority of some credits over others although the relative contribution towards similar certification levels is not indicating this. Future works on this research is envisaged to be addressing all credits of these two systems whenever quantification is feasible in addition to credits of other systems especially those which tend to be used on an international scale.
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References


