ENGINEERING RESEARCH JOURNAL (ERJ)
Vol. 1, No. 46 October 2020, pp.141-146.
Journal Homepage: erj.bu.edu.eg

POST-OCCUPANCY PERFORMANCE OF (LEED) GREEN CERTIFIED BUILDINGS IN EGYPT

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Abstract

In the last few years there has been a growing interest in green buildings and there is a general movement towards a better sustainable built environment. Building owners, designers, and contractors always have to overcome a lot of challenges to fulfill building occupants 'needs and owner requirements while minimizing their harmful impacts on the environment, economy and society.

(LEED) Leadership in Energy and Environmental Design has typified the attempt of the (USGBC) U.S. Green Building Council to perceive structures intended to accomplish prevalent execution in a few regions including vitality & water utilization. Given the emanant enthusiasm for improving structures' vitality productivity, specialists have created prescient physical and information driven models for vitality and water utilization. Even though the physical methodologies expecting to compute the vitality utilization conduct at the structure level are precise, the need of persistently assessing and assembling information for all the information parameters frequently makes these methodologies unrealistic in certain applications [1].

Increasing Number of Commercial and office buildings in Egypt that seeks to be rated by international rating systems. More than 17 buildings in Egypt are LEED certified buildings. In order to assess if sustainable buildings are performing as expected, a post occupancy evaluation (POE) framework was developed and implemented on 4 fully occupied Buildings for more than 1 year all of them are office buildings.

POE Techniques were selected from literature review and international studies and was implemented on the selected case studies. The dataset includes water and energy consumption, feedback from building operation departments and Designers. The results showed different levels of variations in terms of energy and water consumption, LEED Certified Buildings have conjointly shown to be less Efficient over time in some cases. The findings indicate that LEED scoring system might generate skew savings expectations, as feedback is poorly taken into consideration.

The objective of this study is to introduce an assessment method that investigates the correlation between LEED certification and the actual energy & water consumption by investigating a case study of LEED-certified Buildings in Egypt.

Key words: Post Occupancy Evaluation (POE); LEED; Building Performance; Egypt.

1. Introduction

Increasing energy consumption in Egypt among the last few years due to the high population and raising people's life style led to the current crisis of energy also the crisis of Nahda Dam caused fears about water level reduction that requires sustainable solution to preserve the right of future generations.

United Nations Environment Program (UNEP) [2] stated that Building construction sector is responsible for 40% of global energy, 40% of global resources, 25% of global water, 40% of global resources, and the emissions of approximately 1/3 of Green House Gas (GHG).

Humans spend most of their time in buildings, therefore, the need for reducing Energy consumption and improve indoor environment quality is urgent.

According to the Annual Report of the Egyptian Electricity Holding Company Building construction sector consume more than 50% annually of the total electricity Demand in Egypt as shown in figure (1) [3].

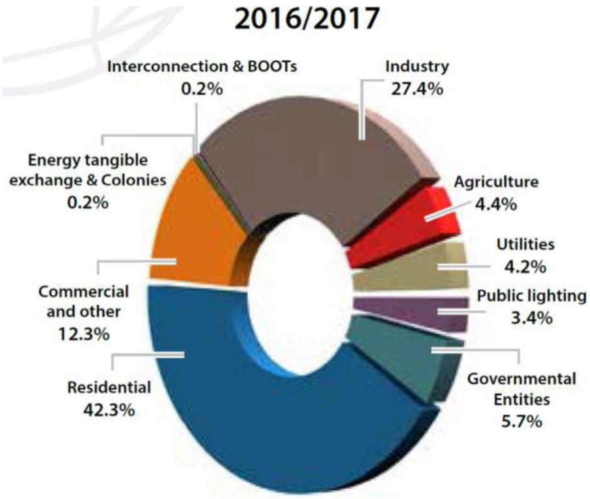

Figure 1: Energy Sold According to Purpose of Usage [3].

Building design, construction and operation have substantial impacts on the **Environment** specially the operation period which is almost the Hugest period of buildings' life cycle, **economy** and **society** which represent the three pillars of the triple bottom line That forms **sustainability**. A lot of resources are used during the life cycle of any building such as raw materials, energy, water and land. Buildings generate a lot of waste that goes to landfill and a lot of harmful emissions which affects occupants, water, land and atmosphere.

In the last few years there has been a growing interest in green buildings and there is a general movement towards a more sustainable built environment. Property owners, designers, and contractors always have to overcome a lot of challenges to fulfill building occupants 'needs and owner requirements while keeping their Negative impacts on the environment, economy and society to the minimum.

Green Building practices can generously decrease or wipe out negative ecological effects through high-Efficiency in all building life cycle stages design, construction and operation, thus with the rising trends and needs to be sustainable, and the remarkable growth of sustainability in the construction market, a lot of sustainable building rating systems have merged, including the LEED framework.

2. An Overview of Green Buildings Performance

Cicelsky et al [4] noted demand to lower energy consumption and simultaneously improve occupant comfort can be conflicting requirements. This requires a delicate balance, only attainable through POEs involving occupants and facilities personnel.

Stevenson and Leaman [5] discussed various studies showing a lowering of occupant energy consumption with feedback mechanisms. They note taking control away from occupants may result in adverse behaviors, such as increased energy consumption. It's emphasized that the human element is the biggest variable in energy use predictions. Cultural and normative behavior must be accounted for in relation to thermal comfort and energy consumption. Researchers indicate POEs are necessary to inform the design process and identify course correction measures. Only then can energy consumption and occupant behavior be altered. POEs should also focus on 'interactive adaptivity' as to why occupants consume and behave the way they do. Behavioral consumption differential is also documented in a study [6].

A study by Gram -Hanssen [6] showed that occupants of similar household often consumed more than three times Energy Specially for heating or cooling as compared to their neighbors.

Streimikiene and Volochovic[7] emphasized t he significance of the use of occupant behaviour. They show in a review of different research the difference in consumption can
be explained in part by climate, wealth, culture, and be havior.

A few salient consumption examples showed t hat 21 percent of residential energy
sage in UK houses in 1998 and 51 percent in Sweden w as linked to dishwasher usage.
Cultural preferences have shown low use of water for washing clothes in Taiwan, whereas warm water is typi cally used in Europe.

Astudy showed that there are significant variat ions between nations in how lightingsystems are used, and which room temperatures are deemed comfortable for the occupant. Occupant education is also supported by many arguments in the Sustainable University [7].

Although their review was geared towards household applications, the need for consumption awareness and occupant education is applicable in numerous contexts. Zalejska-Jonsson [8] highlights occupants of sustainable houses are more aware of their energy and water consumption. Occupants are more eager to behave in an environmentally friendly manner. In a survey of occupants in a sustainable apartment building 50% of occupants believed they spent less on energy and water. Occupants believed it was due to increased awareness highlighted by individual metering. The major behavioral changes of occupants in sustainable buildings were: (1) change of clothing habits and (2) increased awareness of energy and water consumption [8].

Sustainable building assessment systems resul ted to the creation of a fresh paradigm for the design of environmental buildings [9].

Turner [10] studied 11 sustainable rated buildings, examining energy consumption and indoor water. In terms of energy consumption results were favorable, however only half the buildings did well in terms of indoor water use (compared to LEED Sustainable Design Case). Turner notes baseline cases are based on possibly inaccurate assumptions therefore a need exists to verify models. Turner also indicates further studies to establish benchmarks is direly required. These findings and suggestions echo researchers, magnifying the need to close existing performance gaps through POE implementation.

Energy consumption was studied by Masoso during non-occupied periods of six buildings. The study highlights the importance of tracking, measurement and ongoing building performance awareness; as they are responsible for reducing energy consumption and promoting sustainability. This study provided examples of occupant impact on reducing energy consumption. In the study performed the energy used during off hours was 56% more than when the building was being used 44% [11].

3. Research Methodology

A POE Framework was used to assess the physical qualities and to capture the general efficiency of each building with two categories of LEED certified buildings:

1- energy consumption.
2- water consumption.

Research Approach

The research was available to all 17 Egyptian L EED structures occupied by February 2019 for at least 1 year.
Results included the four buildings which the owners could Provide the necessary data during the limited timeframe of study as well as the study limitation for office buildings only as shown in table 1:

Table 1: List of Participating Buildings

Case studies	Building Name	Type	City	Conditioned Square Meter	Occupied Stories	LEED Certification Level	LEED Score
Case 1	Credit Agricole	Office	Cairo	20000 Sqm	2basements, garden level, ground floor& 3typical floors	Platinum	81
Case 2	EMEC	Office	Cairo	2880Sqm	2 Basements, ground floor & 5 Typical floors	Gold	66
Case 3	Dar Alhandasa	Office	Cairo	30000 sqm	2 basements, Ground floor& 5 typical floors	Gold	62
Case 4	MB4	Office	Cairo	15000 Sqm	basement, ground floor & 4 typical floors.	Silver	50

For each construction, LEED Documents wer e used to determine the original design purpose and sus tainable objectives.All structures also required to be abl e to supply
their real meters of energy and water.Finally, the chose n buildings should be situated within a single climate z one to eliminate any variation in building performance that may have happened due to temperature, moisture and rainfall modifications in the climate.Only four buil dings skilled from the original list of accredited structu res based on the criteria
described above. These are the following buildings:

1- Case 1: Credit Agricole.
2- Case 2: EMEC.
3- Case 3: Dar-Alhandasa.
4- Case 4: MB4.

Data Sources

The information was acquired with the permission of th e owners from building ownersand facility managers or from sources such as architects or utilities. (No extra measurements or confirmations were performed on site).

Definitions

The following terminology is used throughout this paper:

Actual refers to the building's metered energy or water usage. Actual data was compiled directly from BMS log System & utility bills.

Baseline refers to modeled usage from the LEED Energy Cost Budget or Water Use Baseline Case designed based on **ASHRAE Standard 90.1, 2007**Baseline calculations are typically.

Design refers to the modeled usage from the LEED Design Energy Cost or Water Use Design Case uploaded regarding energy& water saving procedures.

Energy Use Intensity *(EUI)* refers to MJ / square Meter / year.

Conditioned square Meter of the building was provided by the building operation and maintenance teams and sometimes was calculated from original as built drawings, without verification.

Actual consumption was obtained from at least 12 months of BMS System or utility billing records.

- **<u>POE Techniques Used:</u>**

There are four main groups of techniques were used in this study as following:

1- **Observation.** A lot was noticed and learnt from just walking through the case studies buildings, either alone or with Facility Teams. Observation was an Effective tool during data gathering& analysis time.

2- **Questionnaires and interviews.** Validated, adapted surveys of Nasa Model were used to gather data from Facility management team, Operation & maintenance team, design and commissioning teams in Each Building, Data collected is analyzed and used in preparing final findings for each building. All responses given should remain anonymous. The survey and final report are not to undermine or disparage the facility or anyone who participate on the survey, but simply to obtain and accumulate data to assist future Design. The following POE Surveys have been developed and conducted to Each Building except Building occupant survey due to study Limitation and data availability:
a. Process Evaluation Survey.
b. Facility Manager Survey.
c. Operations and Maintenance Personnel Survey.
d. Building Occupant Survey (wasn't implemented due to study limitation).

Also, several interviews were conducted to the stakeholders of the buildings

3- **Facilitated discussions.** Several technical Discussions were held with operation & maintenance teams, Facility management teams and consultants' teams.

4- **Physical monitoring**, measurement and analysis of performance statistics. By BMS and data loggers in the Buildings No additional or confirming site measurements were made.

Water Consumption Analysis

Overall, in terms of design calculations and th eir baseline instances, all structures were discovered to be under construction. Initial findin gs showed that *Case 1* was about 11% below the basel ine and 141% below the design case.
Similarly, original results in *Case 2* stated that output was 390% above baseline and 690% above designed estimate. In addition, original re sults in Case 3 stated that output was 170% above basel ine and 250% above designed estimateFinally, the origi nal results of Case 4 stated that the output was 120% above the baseline and 185% above the estimate.

Current LEED documents show that all cases received two points for WE credit 3 Water Use Reduction and *case 2* received an additional bonus point for exemplary water reduction performan ce under the ID category. However, if these points wer e to be reassessed by all structures as shown in Table & figure (2).

Table 2: water consumption deviation Actual, Baseline & Design

	Actual/Baseline deviation	Actual/Design deviation
Case 1	11%	141%
Case 2	390%	690%
Case 3	170%	250%
Case 4	120%	185%

Water Use intensity

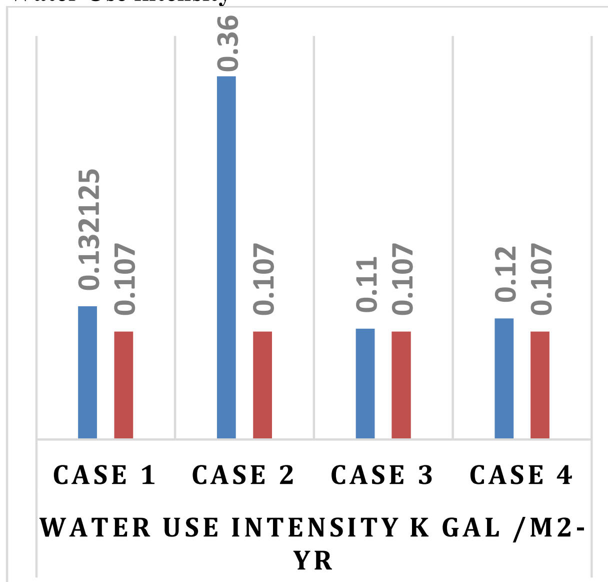

Figure 2: Water Use intensity Benchmarking

Energy Consumption Analysis

Overall, all Cases perform below their baselin e instances, but only *Case 4* conducted Over i ts baseline and design calculations it was 110% above t he baseline and 137% above the design case.Results f or this category showed that *Case 1* was about 81% bel ow the baseline and 53% below the design case. Conve rsely, the results of *Case 2* showed that the output was 10% below the baseline and 28% below the estima te intended.

Current LEED records show that 19 points we re obtained for EA loan 1Optimized Energy Performan ce *Case 1*, 5 points *Case 3* earned 3 points and *Case 4* earned 3 points.
If, however, the points earlier granted by the USGBC f or all structures were reevaluated and their energy output evaluated on consumption, *Cas e 2* would lose points under the EA Credit 1Optimized Energy Performance and *Case 3* would receive two points under the same credit.In ad dition, the extra purchase connected with the Renewabl e Energy generation Credits would not have been needed by *Cas es 1&4* as shown in Table & figure (3).

Table 3: Energy consumption deviation Actual, Baseline & Design

	Actual/Baseline deviation	Actual/Design deviation
Case 1	81%	53%
Case 2	10%	28%
Case 3	47%	59%
Case 4	111%	137%

Energy Use intensity

Actual Energy Use Intensity Benchmarking

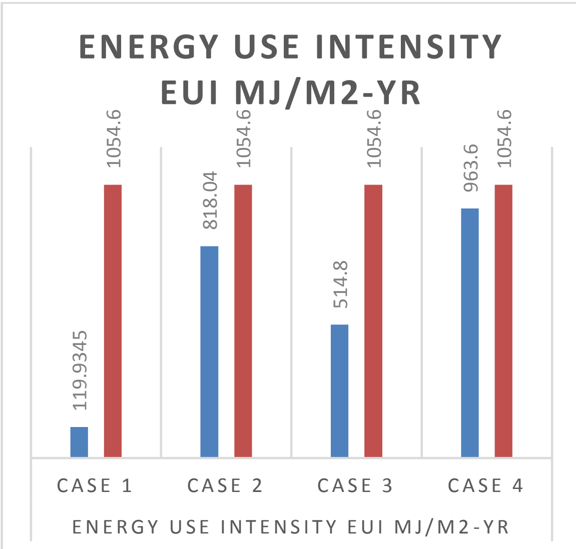

Figure 3: Energy Use intensity Benchmarking

4. Results, Analysis and Recommendation

As discussed in literature and case studies analysis the following findings are noticed:

1. actual water consumption data for all buildings is extremely high
2. The findings from the water and energy consumption analysis indicated that all buildings demonstrated varying levels of deviation from their design calculations during the LEED application process.
3. All case studies depend on energy efficiency strategies more than energy generation in site.
4. Energy Use Intensity Benchmarking indicates that overall Case studies are over Performance.
5. Water Use Intensity Benchmarking indicates that Case studies consumption is critical.
6. It is clear from the findings that performance of some strategies can positively impact behavior in one condition yet have negative impacts on others.
7. Most of case studies depend on properties of materials and building physics instead of Environmental design principles.
8. Users were generally not provided instruction on how to use the green features of their buildings.
9. As discussed in literature review and case studies analysis it was noticed that the gap between energy simulation and actual energy performance is inevitable. There are diverse factors which because that gap the most significant factors are:

<u>Building occupancy:</u>

building occupants. The desktop computers that get left on during lunch hour, the lineup of power-hogging photocopiers, and the space heaters under every other desk are all noted examples of the fallible human behaviors affecting efficiency. All too often, it seems that building occupants are unaware of their own energy use, and without the committed participation of everyone such actions can negate the benefits of sustainable design elements

<u>Building occupancy schedule:</u>

some months like July showed exaggerated energy use, as it experienced extended working hours, along with repeated peak temperature ranges.
Actual working hours for each facility need to be taken into consideration during design phase as it's found that most of buildings were designed to be operating from 8 AM to 4 PM five days a week but in actual case building was operating all week which caused deviation in consumption.

<u>The change in weather conditions:</u>

The energy modeling process normally simulates the outdoor weather conditions based on standard historical weather data for each climate zone, while actual weather conditions do vary. In Egypt the ambient temperatures recorded higher peak and average temperatures during summer, and higher average but lower peak temperatures during winter, which caused more cooling energy use during summer and less heating energy use during winter.

Recommendations:

<u>1- Recommendations for Case Studies</u>

- Replace old lights with LEDs
- Adapt Building operation Schedules.
- get periodical feedback from Occupants.
- Periodical Benchmarking with international similar buildings.
- Enhance Awareness sessions for occupants to deal with sustainability features in their buildings.
- Establish a building Manual for operation and facility management.
- periodical cleaning (self-Cleaning System) and adding ventilation system for Solar panels to increase Efficiency.
- Motion sensors in meeting room are not Efficient and it's better to replace to Occupants Sensors (for Case 1&4).
- taking periodical feedback to enhance Building Efficiency.
- Conduct public sessions to Increase Public awareness about green building Experience.

<u>2- Recommendations for Future Building Design and Maintenance</u>

- Involve Operation and maintenance team from early stage is essential.
- Involve building occupants from Early stage.
- Taking into consideration the efficiency of Solar Photovoltaic Panels regarding dusty and hot days.
- Generate Maximum Energy in site.
- Grey water station is highly recommended as it saves more than 40% of fresh water used in buildings.
- provided users with instruction on how to use the green features of their buildings.

- Training sessions for facility staff and building owners is required.
- By educating occupants on the available sustainable features to be more aware of their consumption of resources and help to identify equipment that is malfunctioning.
- It would be useful to inform Occupants of the energy saving features of the building as well.

3-Recommendations for LEED system

According to literature review and applied study the research recommends some points for LEED system as following:

- A minimum number of **Long-Term Impact Criteria points** should be required to apply for Silver, Gold, and Platinum certification.
- Make Renewable energy Generation in site prerequisites.
- Water Credits weighting needs to be increased.
- As previously described, the EA Credit 1 Optimized Energy Performance is accessed on **the reduction of energy costs, not energy consumption**.
- the USGBC allows applicants to purchase REC's in order to offset their projects energy costs on the submitted LEED template. However, this essentially allows designers to create a building without the use of energy saving features.
- Actual performance tracking is important as several assumptions regarding Energy calculations, Water Calculations and building Occupancy are not Accurate in most cases.
- It's recommended that projects receive anticipated points **for the first 2 years of operation and only be awarded points and certification after efficient energy performance has been confirmed**.
- The USGBC has taken a preliminary step in addressing this issue. All projects registered under LEED version 3.0 are now required to report 5 years of energy **and water use data to the USGBC for analysis only**.

5. Conclusions

Based on the review of literature and the analysis of data collected from the case studies the following conclusions have been drawn

- The main conclusion in this study is that green buildings can't work probably without green occupants.

- Based on the applied research Actual building performance is related to the level of building certificate as shown building credit Agricole (platinum) was over performance, also case 2&3(Gold) looks to be over performance on the other side building MB4 (silver) seems to be under performance.

- Although LEED buildings do not consistently perform as predicted or meet the standards set by both the USGBC, they do appear to maintain their sustainable integrities over time and in some instances, exceed the expectations of their design teams.

- Building occupants have indicated they are satisfied with the design and operation of their building (Operation and Maintenance Team).

- Research findings support the need for a variety of procedural and operational improvements including the installation of independent meters, better communication of sustainable goals, and more frequent assessments of building occupants' satisfaction with indoor environmental factors.

- Improvements to the LEED system itself would include the use of more accurate prediction tools during the application process and to require that Optimized Energy Performance points be awarded based on the savings of energy consumption and not utility costs.

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