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Integrating Sustainability Parameters at the American University of Sharjah

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ABSTRACT

The movement towards high performance buildings has been strong in the recent years. This can be also noticed in the Middle East, especially United Arab Emirates (UAE). Recently, UAE's energy council approved the idea to retrofit old buildings toward green buildings. The major component of it is the reduction in energy consumption. Similarly, leading education institutes in the Middle East such American University of Sharjah (AUS) is also taking steps towards sustainable construction. Recently, one of the buildings at AUS was awarded with the green building certification. This study compares the recently awarded building with a non-green building at AUS. Comparison is held in terms of energy consumption and carbon footprint of both the buildings. The results showed that green buildings have significant lower energy consumption than existing building. The carbon footprint savings per m^2 for a green building are shown to be 42 kg CO_{2e}/m^2. In addition to this, U-value of non-green building also exceeds the limit defined by Estidama (UAE's green building rating system) that reflects on the poor insulating techniques. The calculated U-value of the wall in Engineering building is 4 W/m^2K compared with 0.32 W/m^2K specified by Estidama rating. Finally, recommendations are provided that could help in minimizing the energy consumption of the non-green buildings.

INTRODUCTION

Sustainability is well adopted and thoroughly practiced in the western part of the globe where many countries have incorporated green building regulations in the society. For instance, USA, Germany, Australia, and Japan have green building councils in their respective countries. This encourages using energy efficient and cost effective materials and in return having a better society. However, the idea of sustainability is relatively new in the Middle East region, and significant steps are being taken to incorporate them into society. Emirates Green Building Council (2006), and Estidama(2008) were formed in the cities of Dubai and Abu Dhabi respectively to adhere the need of sustainability especially in the construction sector. Dubai and Abu Dhabi are cities of United Arab Emirates (UAE). In fact, recently, government made it mandatory to retrofit existing inefficient buildings, and there are 120,000 buildings that need retrofitting (Fahy 2015; Leon 2014).

This awareness is not limited to commercial and residential buildings. Leading educational institutions in UAE, Masdar Institute of Science and Technology (i.e. part of sustainable city), and American University of Sharjah (AUS) are also taking positive steps towards sustainability to ensure they are not left behind. Even more, in 2015, AUS was awarded by the EGBC in the green school category for one of their buildings i.e. campus service center (AUS wins green school 2015). This awarded building was recently constructed in comparison to the rest of the campus. However, turning existing buildings into sustainable buildings will not be easy for AUS. This is because integrating energy efficient ideas might increase expenses of AUS. Furthermore, other prime concern for AUS is the housing facility for faculty. The residential housing is having high energy consumption which in return increases the expenses of AUS. Even though, several initiatives were taken such as raising awareness in conserving energy, AUS was still not able to control energy consumption. Hence, the purpose of the study is to look at the energy consumption parameters of green and conventional buildings at AUS, calculate the carbon footprint of these buildings, and discuss about integrating factors that could help in meeting the criteria for green building certifications.

LITERATURE REVIEW

Several green solutions, and cost effective ideas are proposed for green buildings. But, the literature discusses them for several other purposes as well. This literature review will primarily focus on two aspects of sustainable buildings that are thoroughly discussed. These aspects are: upgrading existing buildings, and energy efficiency of buildings. Although, literature presents these aspects for various fields, this paper will focus on the potential benefits of integrating them.

Upgrading Existing Buildings

Retrofitting existing building is a necessity to realize the targeted emissions goals for the future. With a ratio of 1-3% of old building replacement per year, retrofitting existing buildings seems to have a significant weight on annual energy efficiency and carbon emissions (Ma et al., 2012). However, refurbishment of existing building proves to be an optimization problem between energy related and non-energy related factors compounded by the complexity of effects of retrofitted sub-systems on each other (Ma et al., 2012). In addition, there is a level of uncertainty is associated with retrofitting due to the small amount of research and work done in that field as well as human factor uncertainty. Therefore, to minimize uncertainty, an “appropriate selection criteria and weighting factor assignments are essential in the formulation of multi-objective optimization problems” and research on risk assessment of buildings’ retrofits (Ma et al., 2012). In newly developed buildings architects and engineers have the leeway of a larger scope addressing sustainability, which is not the case for existing buildings where the main areas of improvements are energy efficiency and reduced emissions of building operation (Cetiner and Edis 2014). Various methods to reduce emissions and upgrade the buildings’ energy efficiency were the topic of research in different countries however environmental conditions vary from one to the other and the best sustainable technology is the one best suited for its particular area. One method used in Turkey was based on building a comparative database was built that can be used as a reference for engineers in that city – Istanbul-as a reference. In their database researchers used life cycle assessment method to evaluate air-conditioning space as a comparative measure for detached buildings located in Istanbul with a natural gas-fired central heating system (Cetiner and Edis 2014). This can be a simplified method to approach sustainable alternatives in areas with similar environmental conditions and human behavior. A research paper written by(Hestnes and Kofoed 2002), studies a set of retrofitting strategies designed for ten existing office buildings situated in Denmark, England, France, Germany, Greece, Italy, Norway, Sweden, and Switzerland. The objective of this project was to encourage the office buildings to use passive solar and energy efficient retrofitting measures. This objective was achieved by examining different low energy retrofitting measures in terms of energy, indoor environment, and economy. The results of this research showed that the consumption of purchased energy by the existing office buildings in all countries participating in this project can be significantly reduced at acceptable costs by implementing passive and low-energy technologies.

Energy Consumption & Evaluation

In a research article by (Menassa et al. 2012), 11 LEED Certified United States Navy (USN) buildings with a minimum of Silver rating have been analyzed and were compared with other USN Buildings that were not certified. These buildings were required to have at least a LEED silver certification as an executive order which was done to reduce energy consumption by 30% by 2015. Results have shown that only 2 out of the 11 buildings have achieved the expected energy consumption reduction, even worse, the majority of the buildings showed relatively higher energy consumption than the national averages. Menassa, et al. (2012) suggest that users and occupants actions and behaviors may have affected the results, which means LEED's rating is not enough to achieve the required energy savings. Further researches on these buildings need to be done to show which points of the LEED certification have the largest impact on energy savings.

METHODOLOGY

Two buildings have been selected to evaluate the differences in energy consumption of the green and conventional buildings at AUS. These are Campus Service Center (CSC), and Engineering Building (EB). CSC is the green building, and EB is the non-green building. Energy consumption values are collected for the period Oct, 2014- Sep, 2015. The energy consumption charts for both the buildings were supplied by the Sustainability Department of AUS. These values were used to calculate the annual equivalent carbon emissions of the buildings. The carbon footprint has been calculated for the two buildings to determine the significance of integrating green buildings standards. IR camera model Cantronic IR860 was used to capture the heat transfer inside the College of Engineering building and gain some insight on how insulation may help in making the building green. Cantronic IR 860 camera captures images using the interval of wavelength between 8-14 µm which is less likely to introduce errors due to energy losses (Cantronic Inc. cited in Khan 2008). The camera has a thermal sensitivity of 0.08 ºC at 30 ºC with an accuracy of ± 2 ºC under normal temperature and pressure" (Khan 2008). Pictures were captured for the external walls in the College of Engineering to study heat transfer mechanism, and to know which places have significant heat loss in this building. Based on the results the savings of insulating the engineering buildings can be estimated. Finally, recommendations are given that could help in achieving green building certification using either Estidama or LEED ratings.

RESULTS AND ANALYSIS

Energy comparison of green and non-green buildings

Table 1 shows the summary of the carbon footprint for the two buildings; the CSC and EB buildings. In general, summer time experiences a peak in energy consumption. This is primarily because of extreme weather conditions that requires higher energy maintain temperature inside building premises. Additionally, the values calculated suggest that CSC has significantly lower carbon footprint values in comparison to EB building.

Table 1. Carbon Footprint Results

Date	Electricity Consumption of CSC (KWh)	Electricity Consumption of EB (KWh)	Carbon footprint of CSC ($KgCO_{2e}$)	Carbon footprint of EB ($KgCO_{2e}$)
Oct. 2014	50,500	191,695	34,845	132,269.55
Nov. 2014	36,000	108,640	24,840	74,961.6
Dec. 2014	39,000	101,105	26,910	69,762.45
Jan. 2015	41,500	100,050	28,635	50,025
Feb. 2015	43,000	102,190	29,670	70,511.1
Mar. 2015	39,000	124,270	26,910	85,746.3
Apr. 2015	46,000	169,470	31,740	116,934.3
May 2015	44,500	208,320	30,705	143,740.8
June 2015	43,000	214,990	29,670	148,343.1
July 2015	46,000	234,250	31,740	161,632.5
Aug. 2015	45,500	235,490	31,395	162,488.1
Sept. 2015	45,000	225,130	31,050	155,339.7
Total	519,000	2,015,600	358,110	1,231,957.5

Table 2. Carbon Footprint and Energy Consumption per m^2

	Area (m^2)	Annual Energy Consumption	Energy Consumption per m^2 (KWh/m^2)	Carbon Footprint per m^2 ($Kg\ CO_{2e}/m^2$)
CSC	4400	519,000	118	81
EB	10,000	2,015,600	`202	123

Based on the data, CSC has less energy consumption per m^2 when compared with EB, and carbon footprint savings per m^2 are around 42 kg CO_{2e}/m^2. There are several factors contributed to this reduction such as the use of LEDs, control sensors that maintain air conditioning temperature, triple-glazed windows, and energy efficient chillers that rely on recycled water. All these solutions contribute to more sustainable design and lower operation energy. Furthermore high energy consumption of EB building could be attributed to the poor insulation technique i.e. thermal bridges. Typical thermal conductivity of a concrete block is 0.8W/m.K; whereas, a typical thickness of an external wall is 0.2m. Therefore, the U-value would be 4 W/m^{2}K. As per Estidama, U-value of an external wall should not exceed 0.32 W/m^{2}K. This means EB buildings exceed the permitted limit. The following section discusses it explicitly. Furthermore, high carbon footprint is mainly due to high energy consumption, lack of use of natural ventilation, and the lack of passive design consideration.

Thermal Imaging using IR Camera. These images were taken of the south-west facing wall in a classroom in the EB at around 4 pm when the temperature outside is starting to cool down in the month of November, a relatively cooler month in UAE.

Figure 1 shows the colder element is a structural column and is it colder than the surrounding; it is acted as thermal bridge. The temperature where the cursor is read to be 24.7^o C while the surrounding ambience it 28.9 ^{o} C. This can be interpreted by the high heat mass of the well compacted concrete. The surrounding walls seem to have less capacity and thus it is emitting more infrared waves.

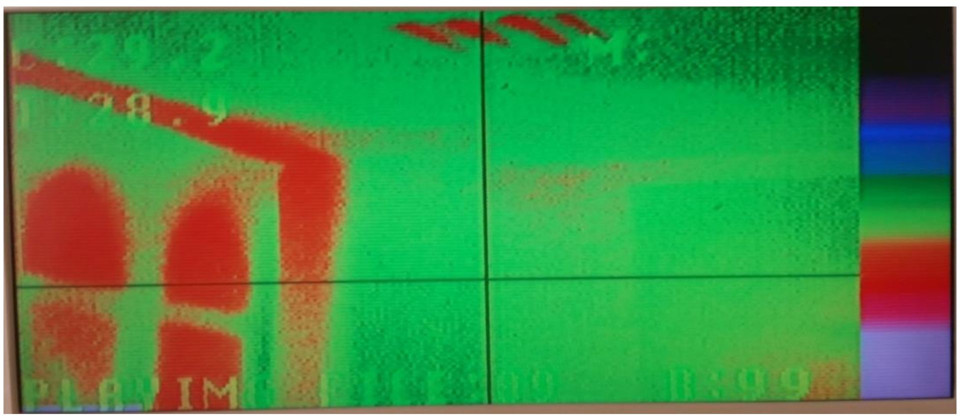

Figure 1. IR Picture of Structural Column

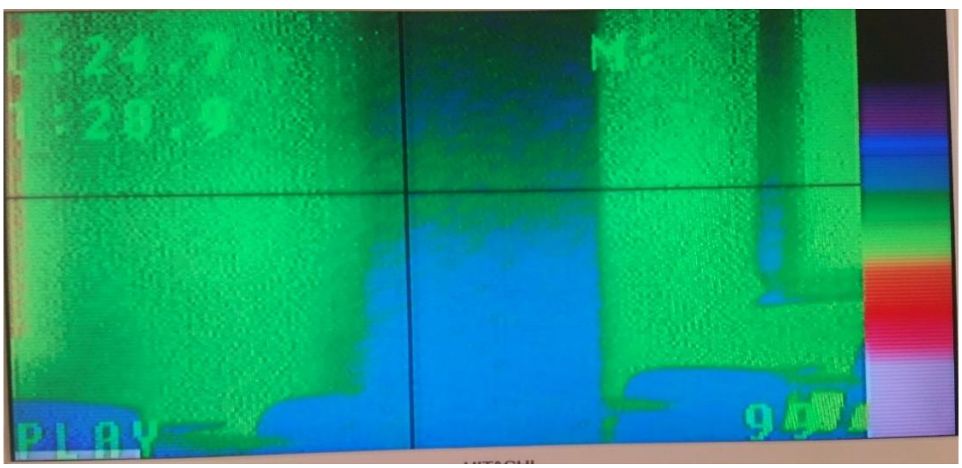

Figure 2. IR Images of the Wall

Figure 2 shows the cursor reading the temperature of the wall to be 29.2 ^{o}C and ambience temperature to be 28.9 ^{o}C. There is clear heat transfer from the wall to the surrounding atmosphere inside the room. The image also shows high contrast of temperature around the window area where is thermal bridging is bound to take place.

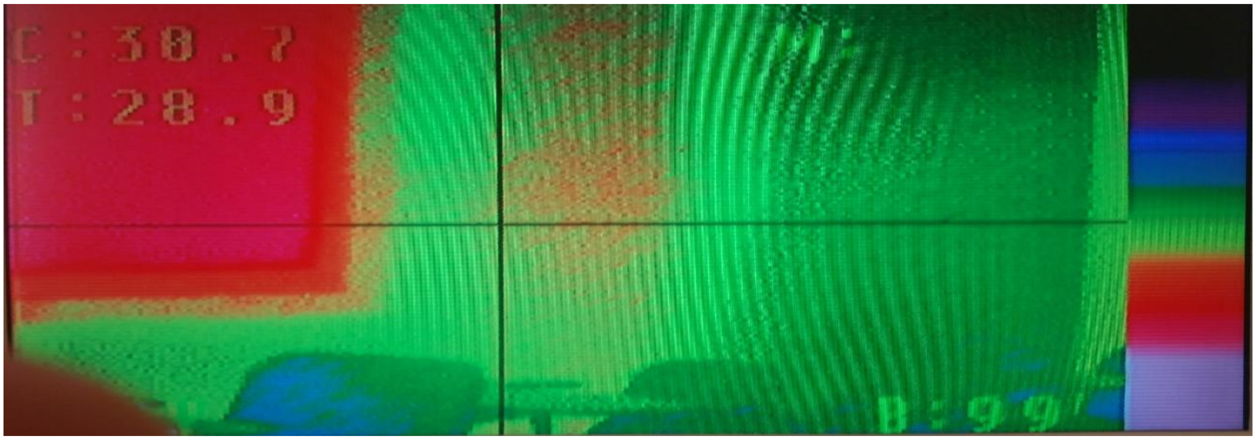

Figure 3. IR Images close to the Window

Figure 3 shows wall temperature near the window, the temperature of the wall is 30.7^{o} C while the ambient temperature is almost constant with 28.9 ^{o}C.

Structural elements with denser material and thicker cross-sections seem to buffer the variation of temperatures and dampen the spikes in temperature. In the column-wall connection, columns act like earth rod dissipating the heat as they have higher capacity to store heat. On the other hand, big sized windows are considered to be the biggest weakness in terms of heat gain as they allow unfiltered radiation into the room and introduce discontinuity in the wall. Thus, windows not only allow radiation but also can be considered as loss in the bulk of the wall that might protect against the solar gain by reflection and buffering the heat gained. Windows can be protected by reflective layer lowering direct radiation into the room. Shade devices can also be used like louvers and overhangs. Lastly, walls role can be enhanced if they were insulted from the outside so it can mitigate possible thermal bridges. The result will be less energy required for the air-conditioning in hot months.

CONCLUSION

Social responsibility and public awareness of the environmental effects and climate change have been increased world-wide including the UAE. LEED rating in the USA and Estidama rating in UAE have been implemented in many buildings to provide indoor and outdoor environmental comfort as well as lowering carbon dioxide emissions. AUS, being one of the leading fronts of the educational institutes in the country, would take the lead towards greener and more sustainable future. This research is an assessment of the current energy consumption trends in one building –Engineering Building "EB"- compared to a newly certified building on campus – Campus Service Center "CSC" according to the local rating system (Estidama). In this paper, thermal imaging was used to capture heat escape indoors to find weakness point in the building's enveloping where maximum radiation occur. As expected, window, and window frames and solid concrete columns are hotspot for heat escape. It was found that walls contribute to the heat escape especially since they constitute the majority of the building's shell. Shading devices and solar films are possible solutions that may cut the electricity bills with low investments value. Also, study on the implementation of solar panels can also be carried out, and determine if solar panels can meet the demandof the buildings. The calculated U-value of the wall in EB is 4 W/m^{2}K. This is much higher than what is specified by Estidama regulation which is 0.32 W/m^{2}K. The present calculations and approaches in this study provided good approximations of the possible retrofitting possibilities that can be reiterated. The use of LEDs, control sensors that maintain air conditioning temperature, lower U-value, triple-glazed windows, and energy efficient chillers contributed to reduce the energy and carbon footprint in the CSC building.

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REFERENCES

AUS “Green School” category at Emirates Green Building Council 2015 Awards - American University of Sharjah. [online] Available at: http://www.aus.edu/news/article/927/aus_wins_green_school_category_at_emirates_green_building_council_2015_awards [Accessed 2 Nov. 2015].

Cetiner, I. and Edis, E. (2014).An environmental and economic sustainability assessment method for the retrofitting of residential buildings.*Energy and Buildings*, 74, pp.132-140.

Estidama.upc.gov.ae, (n.d.).*Estidama - Estidama Villa Products Database - Insulation Products and Systems*. [online] Available at: http://estidama.upc.gov.ae/estidama-villa-products-database/insulation-products-and-systems.aspx [Accessed 14 Dec. 2015].

Fahy, M. (2015).Dubai to introduce energy efficiency rankings for buildings.*The National*. [online] Available at: http://www.thenational.ae/business/property/dubai-to-introduce-energy-efficiency-rankings-for-buildings [Accessed 2 Nov. 2015].

Hestnes, A. and Kofoed, N. (2002). Effective retrofitting scenarios for energy efficiency and comfort: results of the design and evaluation activities within the OFFICE project. *Building and Environment*, 37(6), pp.569-574.

Hyperphysics.phy-astr.gsu.edu, (n.d.).*Thermal Conductivity*. [online] Available at: http://hyperphysics.phy-astr.gsu.edu/hbase/tables/thrcn.html [Accessed 14 Dec. 2015].

Leon, J. (2014). Green building practices get a boost. *Gulf News*. [online] Available at: http://gulfnews.com/news/uae/environment/green-building-practices-get-a-boost-1.1401482 [Accessed 2 Nov. 2015].

Ma, Z., Cooper, P., Daly, D. and Ledo, L. (2012). Existing building retrofits: Methodology and state-of-the-art. *Energy and Buildings*, 55, pp.889-902.

Menassa, C., Mangasarian, S., El Asmar, M. and Kirar, C. (2012).Energy Consumption Evaluation of U.S. Navy LEED-Certified Buildings.*J. Perform. Constr. Facil.*, 26(1), pp.46-53.