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Improvement of efficiency through an energy management program as a sustainable practice in schools

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ABSTRACT

Educational sector is growing drastically as a result of upward trend of population. These schools require tremendous quantities of energy units to be generated and consumed. As a result, this will impact negatively on the environment by increasing the carbon emissions and depletion of non-renewable energy resources. Moreover, the harsh climate condition contributes substantially to increase the energy consumption in various weather zones in the world. Therefore, several energy efficiency plans have been developed to improve the energy performance of the schools facilities globally. Hence, this paper discusses the energy management program as a sustainable strategy that applicable on the schools. This program is designed for the schools to improve the energy efficiency, indoor environmental quality and adopting the best management practices during the operating stages. This research has developed a customized energy management program for one of the schools in UAE. It has concluded the findings by using computerized hourly thermal modeling. The energy model has evaluated the proposed energy conservation measures and the best practices that were generated by the energy management program steps. This case shows that the energy performance could be improved substantially by 35%. Thus, the energy use index of the audited school that adopted the energy management program has reduced from 438 kWh/m^2/year to 285 kWh/m^2/year. The proposed energy management program has been articulated in this study as a consecutive and linear progression. This methodology presents several steps to mitigate the carbon emission by addressing the sustainability dimensions; economic, environment and social aspects. This study discusses the steps and the work flow of developing the energy management program and the anticipated outcomes for the school's buildings. The program considers practical ECMs along with the students and teachers participation and interaction. Furthermore, it highlights the success criteria that assure the sustainability of the energy efficiency at the operating life cycle of school's facilities.

1. Introduction

Climate change and energy sources future are major challenges facing the human race (Zhao et al., 2015). However, mankind's use of fossil fuels not only has a warming effect on the weather, but also leads to energy shortfall (Zhao et al., 2015). Current environmental issues are rooted in the lack of proper awareness and cultural weakness regarding the relationship between human and nature (Meiboudi et al., 2016).

A sustainable society can only commence with knowledge and understanding, where a transformation in the educational sector is needed in order to practice the sustainability and interact with the eco-systems (Ferrer-Balas et al., 2010), (Jabbour et al., 2013).

Several higher education institutions have recently recognized the importance of integrating sustainability issues into educational system to make this impact focused and explicit (Zsóka et al., 2013). Understanding the interaction of users/buildings is therefore relevant to promoting better design strategies to

List of abbreviations: AHU, Fresh Air Handling Unit; ASHRAE, American Society of Heating, Refrigerating, and Air-Conditioning Engineers; ECMs, Energy Conservation Measures; EUI, Energy Use Index; GHG, GreenHouse Gases; IPCC, Intergovernmental Panel on Climate Change; IPMVP, International Performance Measurement and Verification Protocol; LED, Light Emitting Diode; HVAC, Heating, Ventilation & Air conditioning; LEED, Leadership in Energy and Environmental Design; M&V, Measurement and Verification; CASBEE, Comprehensive Assessment System for Built Environment Efficiency; BREEAM, Building Research Establishment Environmental Assessment Methodology; K-12, The Grades from Kindergarten (K) to 12th Grade; ESCO, Energy Services Company.

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enhance buildings' sustainability (De Santoli et al., 2014), (Wei et al., 2014).

Among all public buildings, on account of their educational purpose, school buildings have a major social responsibility. Therefore energy performance in these types of buildings has a great importance (Pereira et al., 2014). In the USA, the schools in general, have major consumers such as lighting, ventilation, heating, and cooling contribute more than 80% of energy consumption (Department of Energy US, 2013). Besides, considering the energy efficiency and high quality of indoor environment increase of complexity in school buildings, which may change the energy consumption patterns (Lourenço et al., 2014). This approach will push to adopt the sustainable buildings for schools. These sustainable buildings have a holistic approach of integrated systems including design, construction, and operation (Ramli et al., 2012). Sustainable buildings are also referred to as green or high performance buildings designed. These buildings are developed to provide optimal environmental and economic performance by increasing efficiencies, productivities and satisfaction. Thus, the green buildings adopt energy and water savings strategies, improve the indoor environment quality, use environmentally preferable materials; and educate building occupants about the sustainable practices (Olson and Kellum, 2003). Therefore, these approaches push the society to accept interacting positively with the efforts of the sustainable development to spread this concept (Almeida et al., 2015).

Educational facilities are a vital field to implement the sustainability practices and energy efficiency programs. The environmental air quality is an essential part that should be considered during the design and operation stages (Pereira et al., 2014), (Burman et al., 2014). Also, the classes and the common indoor spaces in such buildings should be maintained in a high level of thermal and visual comfort and ventilation (Jovanović et al., 2014), (Wang et al., 2014). Therefore, the energy management and sustainability strategies of this cluster shall be taken into the account of designer, operator and management. Furthermore, as the energy cost is one of the highest operating costs of the buildings, the systems efficiency and sustainability play a key role to develop the economy, social life and improvement of the quality of life in the educational cluster (Bulut, 2004). Especially, the world population is in a continuous growth that influence on the number of students and the schools (Fernández-García et al., 2015). Many countries are developing sustainable regulations and policies for schools building. In order to achieve several national energy efficiency targets, the local governments support all possible and effective initiatives to augment the benefits and the sustainable practices (Berg, 2011), (Cincera and Krajhanzl, 2013). In USA alone, the students and teachers are nearly 73 million in 117,007 schools' facilities (Alshamrani et al., 2014) (EPA, 2004). Thus, as a response of this growth and to conserve the energy and water resources, many of initiatives and policies have been set globally. For instance, in Europe, buildings contribute approximately 40% of the energy consumption. Various best management practices and initiatives are in place to reduce energy consumption in Spanish schools (Spanish NREAP, 2010). In addition (Gaitani et al., 2015), presented that Greece currently has 15,446 schools of which 4500 are over 45 years old. The total energy consumption of school buildings is around 270,000 MWh. As of 2011, in order to get a new building permit it is necessary to achieve an annual solar fraction of 60% for sanitary hot water production from solar thermal systems (NREAP, 2010). Also, in Italy, more than 60% of Italian school buildings were built without any energy-related regulation in force (prior to 1976) and less than 10% were built after the adoption of the Law 10:1991 which is the first regulation in Italy introducing clear constraints about energy efficiency (Gaitani et al., 2015).

Therefore a promising plan for future was announced to increase the energy efficiency through “20-20-20”. This policy aims to reduce 20% of the greenhouse gases emissions from 1990 levels, increase the efficiency of energy by 20% and use the renewable energy for 20% of the total generated power (Brás et al., 2015). Besides, in Dubai, the government announced to cut the energy cost by 30% until 2030 (Etihad, 2015). Several tools and rating systems have been developed and implemented to improve the schools' facility energy performance. Furthermore, these programs assess the buildings energy efficiency and benchmark their performance. Especially that most of the existing schools' buildings don't comply with the sustainability criteria in energy efficiency and indoor environmental quality (Boeri and Longo, 2013). These international rating programs, such as Leadership in Energy and Environmental Design (LEED), Comprehensive Assessment System for Built Environment Efficiency (CASBEE) and Building Research Establishment Environmental Assessment Methodology (BREEAM) have addressed the sustainability aspects and strategies for the schools' facilities (Reza et al., 2011). According to the Center for Green Schools at the U.S. Green Building Council, a “green school” is a school building or facility that creates a healthy environment conducive to learning as well as saving energy, resources and money (Lysgaard et al., 2015). These strategies will reduce the operating cost of the energy consumption in schools. For instance, USA pays more than $ 6 billion per annum to cover the annual energy cost of schools' buildings (Lane et al., 2014). Therefore, several initiatives and energy programs have been recommended in USA to cut the energy cost. According to U.S. Department of Energy, an effective maintenance works and development and implementation of energy management program for schools may increase the energy efficiency to 20%, regardless of the installed systems or building's age (Princeton Energy Resources International et al., 2004) (Schools, 2009). Furthermore, in Europe, regular energy audits should be conducted for the buildings as per the new Energy Efficiency Directive (201/27/EU) (Directive, 2012), (Jeffries, 2014). Many assessment systems for green schools exist to guide schools toward environmentally responsible choices (Henderson and Tilbury, 2004; Mogensen and Mayer, 2005; Zhao et al., 2015). To identify a nation's green schools, an assessment system must be developed for their selection. When green school standards are lacking, measures must be created, including an information model enabling decision makers to recognize these schools (Meiboudi et al., 2016). Moreover, in the gulf region wide steps have been performed toward the sustainability of the buildings. In Abu Dhabi, ESTIDAMA rating system is a mandatory requirement for the new construction including the school buildings. For the retrofitting industry of the existing buildings, energy management program is adopted under Energy Service Company (ESCO) model in Dubai.

Many of energy efficiency regulations for schools and other buildings address the systems that should be improved to increase the energy efficiency. These systems are identified as follows; building envelope, schools appliances and equipments, effective maintenance works, students and teachers behavior and indoor air quality (Pacheco et al., 2012), (Li et al., 2014). Thus, in terms of building retrofitting, the data collection of the basic facility's information and the schools' energy profile are important to assess the building and to benchmark the energy performance against the standards. Accordingly, the energy analytics technique is a vital process to appraise the life cycle cost, energy behavior and weather data changes in order to track the energy performance for the school buildings (Hong et al., 2014), (Xia et al., 2014). Therefore, it is encouraged to develop and implement energy management program for schools to optimize the energy performance and manage all these factors. In Italy, more than 30% of the school's buildings have a poor energy performance (Lara et al., 2015). The reason