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Energy Management Strategies for a Governmental Building in Oman

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Abstract

This work describes the outcome of a study that has been performed to reduce the energy consumption of a library building in a hot climate of Oman. The project follows a systematic approach of collecting data from the project and maintenance department, conducting an energy audit and generating a building simulation model. The building has three floors with a total floor area of 2756 m^2 and its average yearly consumption of 1397 MWh. The average energy-use-intensity (EUI) for this building is 507kWh/m^2/year. Energy audit has identified many energy-retrofitting strategies including replacing the current florescent lights with LED, switching the air conditioning systems outside the occupancy hours, increase the thermostat setpoint, and reduce the air infiltration. Based on the field measurements and observations, building energy model was generated using DesignBuilder and was subsequently calibrated. Using the calibrated model, several energy management opportunities (EMOs) were evaluated. Only four top most energy management opportunities were top listed because they were technically and economically feasible. The EMOs include adjusting the thermostat setpoint, change the air conditioning operation schedules, replace the fluorescent lights with LED and increase the airtightness. The results show that the energy consumption can be reduced as much as 38.5%.

Keywords: Energy audit; energy management opportunities; energy simulation; library; hot climate

1. Introduction

In Oman, power stations are heavily dependent on either natural gas or diesel for producing electrical energy. Significant amount of electrical energy is consumed by building sector. According to recent statistics realized by the Authority for Electricity Regulation (AER), more than three quarter of the yearly generated electrical energy is consumed by building sector with the remaining goes to industrial, tourism, agriculture and fishery sectors [1]. Buildings in Oman are neither built with energy-efficient design strategies nor operated to minimize the energy

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consumption. Hence, their energy performance is lower than counterparts in other countries of similar climates. Energy management for buildings is perceived as an inexpensive source of energy. Through proper energy management practices, significant amount of energy can be saved. Several studies in extreme hot climates, similar to that in Oman, have shown the potential of reducing energy consumption through potential energy management strategies. In hot humid climate of Saudi Arabia, energy conservation measures including design and operation strategies were elevated for existing office building using energy audit, site surveys and simulation model [2]. For design strategies, wall insulation, double glazing, upgrading lighting systems, replacing constant air system with variable air volume systems were considered. Several operation strategies such as altering the thermostat setpoint, night-time set back in summer, adjusting the schedules of lighting and equipment during unoccupied or low occupancy period were also explored. The study found that the combined effect of all energy conservation measures would achieve 36% savings in annual electrical energy. A similar energy conservation study was performed to enhance the operation of typical governmental buildings in Kuwait [3]. Eight governmental buildings with different construction and system characteristics were selected for enhanced operation. The operation strategies include switching off fresh air handling unit before the end of the occupancy period, control of air conditioning system and lighting systems after the occupancy period. In a typical national peak hour, an energy saving of 3 to 13% with an average of 9% was realized for all eight buildings. An energy audit of an educational building was also conducted in harsh climate of Kuwait [4]. A number of energy conservation opportunities (ECOs) such as no-cost ECOs and retrofitting ECOs were evaluated for this building using a calibrated energy model. No-cost ECOs includes changing the lighting and equipment schedule and reducing infiltration. The retrofitting ECOs includes control of indoor air temperature, setback schedule, turning off the air conditioning in the weekends, upgrading to high efficient lightning, and through proper HVAC maintenance. When no-cost ECOs are implemented, a 6.5% savings in annual energy is realized while it was 49.3% for the retrofitting ECOs. When all measures are combined, a total saving of 52% was realized.

2. Methodology

The information center (i.e. hereafter a library) is located inside the Sultan Qaboos University's (SQU) campus in the capital city of Oman, Muscat. The project was subdivided into different tasks and followed several phases as described in the following sections:

2.1. Data collection phase

In this phase, basic data collection and information about the physical characteristics of the building including the historical electrical bills is collected. The library consists mainly of two floors and the third floor is dedicated to the plant room with a total floor area of 2756 m^2. The building is served with two air-cooled chillers located at the roof level. The fresh air to the building is provided by a dedicated air handling unit (FAHU). Heat recovery system using rotary wheel is used to recover the energy from the exhausted air. Based on a walk-through survey, the building was found to have three lighting types: a 60 x 60 lighting luminaires with 4 fluorescent lights (rated at 18 W), a 120 x 30 lighting luminaires with 2 fluorescent lights (rated at 36 W) and a round luminaire with either 1 or 2 compact fluorescent lights. All lights are kept on during the occupancy regardless of the need. In addition to the lighting system, office's equipment was surveyed in this building.

The monthly energy consumption and the utility cost were collected from the SQU's maintenance department from 2012 to 2016. Early 2016, the air cooled chillers in this building were replaced. The energy consumption available after the recent upgrade is limited and only provided for 5 months in year 2016. It was also observed that the Feb/2012 is reported with higher value than any other months and therefore year 2012 was omitted from the average values which have been determined for 2013 to 2015. During this period, the building has an average yearly consumption of 1397 MWh and an energy-use-intensity (EUI) of 507kWh/m2/year.

2.2. Energy audit phase

An energy audit was conducted which involved several site visits to the building. Spot field measurement and diagnostic tests were conducted. The information collected during this phase has helped to identify the weak thermal points in the audited building, characterize the internal load profile, and identify the operational characteristics. Several instrumentations were utilized during this phase depending on the purpose of the test. Fig. 1 shows the instrumentation used during the energy audit phase.