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Development of an Energy-Aware Intelligent Facility Management System for Campus Facilities

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Abstract

According to the U.S. Green Building Council, buildings consumed 36% of total energy consumption in United States. With the concept of sustainability continues to grow in importance, more researches have been focused on improving energy efficiency during a building's operation phase. Academic settings, such as university facilities, pose a unique set of challenges to facility managers and administrators in achieving energy efficiency. Unlike commercial, residential or industrial buildings, campus facilities are composed of different building types with different requirements for indoor air quality, humidity, temperature and ventilation from continuously changing occupants. The current practice with campus facility management requires facility managers to manually schedule tasks, often based on the order of incoming requests without considering their impact on building energy consumption. This paper aims to develop an energy-aware intelligent facility management system for campus facilities. It first builds a knowledge database which includes two main parts: basic information on common daily work request and work instructions; and also the impact on building energy performance. An artificial intelligent model is then proposed to automatically analyze and prioritize future work requests based on factors such as safety, energy consumption impact, occupant satisfaction, etc. A case study is conducted on campus to validate the system with focus on HVAC tasks. The goal is to help facility managers improve building energy efficiency while meeting other restraints.

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1. Introduction

It has been reported that in the U.S. and the European Union, two representative countries/regions with GHG emission reduction obligations, about 40% of the total fossil fuel consumption comes from the building sectors [1]. Improving the energy efficiency of the building is significant for energy saving in the world.

The energy efficiency evaluation of a building can be finished as soon as the building is completed. The equipment and the structure of the building affect the energy efficiency. However, these characteristics have been determined since the completion of construction. Therefore, it is difficult for building manager to optimize them regularly for the purpose of energy saving. This paper argues that during the operation stage of the building, facility managers act as an important role to improve the energy efficiency by considering their work schedule with energy impact.

In a medium-sized building (between 5,000 square feet and 50,000 square feet), occupants can typically submit more than 50,000 requests for FM service every year [2]. Among these requests, most of the problems come from the building electric and HVAC systems, which cover more than 40% of the energy consumption [3]. Therefore, much effort could be done to improve the energy efficiency here. Traditionally, FM is mainly regarded as a business function that requires facility managers' work experience and judgment to make decisions [2]. That is to say, few facility managers would consider the energy impacts while finishing their work. For the campus facility, the above problems are also prevailing. But due to the unique character such as complex building types, the campus facility management needs much more effort to meet different requirements from stakeholders, including professors, students and visitors.

This research attempted to evaluate the energy impact of the FM work orders in a campus. This factor will serve as a crucial factor to prioritize the daily tasks for facility managers. Besides, the occupants' satisfaction level is also taken into account when determine the work schedule. The proposed framework aims at improving the energy efficiency while meeting other goals raised by facility managers such as safety and building damage. The illustrative example is coming from a campus so all the data is coming from this campus facility.

2. Literature Review

2.1. Campus Facility Energy Problem

Healthcare facility management is worth of research effort because of the complexity of healthcare buildings and the significance of its well performance. In a hospital building, the systems including fire alarm, HVAC, water and emergency require much effort of facility managers to operate them [4]. Similarly, the campus facility is also complicated because there are many different types of buildings in the campus such as lab, classroom, gym, office and so on. Moreover, different occupants may have various requirements for the indoor environment. Therefore, improving the quality of FM for campus facility is a challenge work for facility managers.

One of the most important considerations of FM is energy efficiency. In the FM handbook, the author emphasized the importance of sustainable concept for the work of facility managers. The energy audit is also a crucial part of the basic function of FM [2]. In 2013, only commercial and industrial buildings took more than 50% of the whole energy consumption of United States [5]. Among the energy consumed by buildings, more than 60% is used in the building systems such as electrical and HVAC [5]. This paper focuses on an area which is easily neglected by facility managers but also impacts a lot on energy consumption: HVAC problem maintenance and requirement. A research figure demonstrated by ASHRAE estimates that daily faults of HVAC system take about 1-2 percent of energy consumption in commercial buildings [6]. The extra energy consumption is mainly due to the delay detection as well as solution of problems [7]. The situation is the same when author interviewed the campus facility managers. This research raised a framework to consider the energy impact of service requests to prioritize the tasks. This mechanism can minimize the energy consumption while meeting other constraints.

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