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Building automation systems as tool to improve the resilience from energy behavior approach

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Abstract

This paper shows how the building automation systems (BAS) are a powerful tool for companies face some permanent or temporary changes that can occur in the surrounding environment, which can affect the welfare of users, increase the energy consumption and/or demand more financial investment to strengthen or to replace the actual systems to attend the needs of users. However, these systems not properly used because of designers and owners ignore the specific qualities of these and the designs lacks of scenario analysis. The automation systems can monitor several variables in real time and analyze historical data to adjust quickly the operation of the devices to provide comfort of users and integrity of devices; this capacity keeps the core purpose in the face of changed circumstances. Also, this work shows how would be the potential behavior of two buildings considering some changes in their environment for specific tropical conditions, one of them with automation system and the other without this system; for that, we made first the characterization of a BAS implemented in a building in Bucaramanga (Colombia) and after specific simulations. The changes considered are heat island, energy outages, new construction and new habits of users.

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Keywords: Building automation system, resilience, efficiency energy, green building

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1. Introduction

Currently, the buildings demands around 40% of energy [1], therefore it is necessary that existing and new buildings reduce the energy consumption. This is possible from implementation of applications aim to rational use of energy, which can be renewable energy in site, passive strategies, efficient systems and smart hybrid systems.

These smart applications can achieve high use of micro-climatic conditions as daylighting and natural ventilation to reduce the energy consumption by lighting and HVAC systems [2]. In addition, they can integrate renewable, storage and back-up systems with the network; this enables energy management [3]. These applications are a part of building automation systems – BAS.

The implementation of BAS may generate many benefits for users and increase of sustainability level of buildings because it is possible to reduce the energy consumption and the environmental impact during building lifespan. In addition, the versatility of the building automation and management systems may provide the ability to buildings to respond favorably to changes of the normal operating conditions [4], [5], which benefits the building resilience; however, researches must continue doing works to improve the ability of BAS to face unexpected change in the operating conditions [1].

The building resilience is an emergent issue [6], and it can be defined as the capability of a building to respond to changing scenarios and to keep the inner operating conditions during the lifespan [7], [8]. The effect of these changes may increase the energy consumption, such as the increasing of ambient temperature due to urban heat island [9] that can be mitigated with smart hybrid applications [8], which are common in BAS.

2. Methodology

This work was built from three stages In order to explain why the automation applications may be useful tool to improve the building resilience. The first stage concerns about a brief literature review to describe the importance of automation applications in the operation of buildings (to see section 3). The second stage presents the characterization of some applications of an automation system installed in a university building since 2012, which is located in a tropical city; the applications considered are lighting system and climatization system (to see section 4).

Finally, the third stage analyzes what is the effect of this BAS on energy behavior when this building faces four specific changes (to see section 5). The factors considered are power outage, new habits of users, new construction and urban heat island, and the Table 1 presents them.

Table 1. Description of factors considered.

Factor		Criteria of analysis
Power outage	This temporary event is the absence of electrical power, either short- or long-term.	No grid power $P_{grid} = 0 \quad [kW]$
New habits of users	Changes as schedules, equipment use or number of users can cause this temporary or permanent change, which implies a variation of the power demand.	Analysis of schedule by time-slots of 2 hours from
New construction	This permanent change in the surroundings of a building might cause interference of the solar radiation and wind speed, which reduces the benefits of daylighting and natural ventilation, and causes more power demand.	Decreasing solar radiation and wind speed on facades $SR'_{fac} = 0.75 \cdot SR_{fac} \quad [W/m^2]$ $WS'_{fac} = 0.75 \cdot WS_{fac} \quad [W/m^2]$
Heat island	This permanent phenomenon explains why the metropolitan area is warmer than its surroundings. This increases the energy consumption by air conditioning units.	Increasing ambient temperature $T'_{amb}(t) = T_{amb}(t) + \Delta T(t) \quad [°C]\ ;\ \Delta T_{\max} = 2°C$

3. Literature review

The BAS is formed by software and hardware and integrates several systems such as access control, security, CCTV, lighting, HVAC, power generation, etc. [1]. Its main purpose are aimed to ensure the comfort of users and the security of people and installations, but are increasing the applications to support the energy management and to monitor several variables to make decisions and/or to display data, among others [10], [11].