



Energy use and maintenance costs of upmarket hotels



Joseph H.K. Lai*

Department of Building Services Engineering, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong

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ABSTRACT

Aimed at examining the relation between energy use and maintenance costs of hotels, face-to-face interviews were conducted under a study to collect reliable energy and cost data of 30 upmarket hotels in Hong Kong, including those in the 4-star and 5-star classes. Analyzing the data revealed that for both normalized energy consumptions and maintenance costs, they were not significantly different between the two classes of hotels. Charts for benchmarking energy performance and maintenance costs were established. Electricity accounted for most of the energy used by the hotels and, among the maintenance cost elements, capital project cost dominated. Neither the cost for capital projects nor that for routine repair and maintenance was correlated with the total energy use. Causes for such missing links between energy use and maintenance costs, which are crucial information for formulation of energy reduction measures, require further investigations.

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1. Introduction

The global energy use has continued to rise (Intergovernmental Panel on Climate Change, 2007; World Business Council for Sustainable Development, 2009). Energy use in cities, especially for those with a high density of buildings, has become progressively intensive. This has resulted in various environmental issues, including the increase in greenhouse gas emissions, which is central to the global warming problem.

Hong Kong, a metropolis in Asia, is well-known for its overcrowded buildings. Being a popular tourist destination, it received over 54 million visitors in 2013, among them over 25 million were overnight visitors and their average length of stay was 3.4 nights (Tourism Commission, 2014). Accommodating these visitors were many sizable hotels built with quality facilities. Apart from engineering facilities (e.g. chiller, boiler, lift, lighting, etc.), amenities such as swimming pool, sauna and gym equipment are common provisions in the hotels.

According to the government's statistics (Electrical and Mechanical Services Department, 2012), the biggest share (42%) of the total energy use of Hong Kong was due to the commercial sector. Hotels belong to the commercial segments that used 63,962 TJ (17,767 GWh) in 2010, a substantial increase from 40,255 TJ (11,182 GWh) in 2000. As such, it is necessary to minimize

the energy use of the hotels in order to help reduce the growth of energy consumption.

The energy use of hotels is dependent on a multitude of factors over their building life cycles, including designed efficiency of their facilities; installation workmanship and hence constructed quality of the facilities; whether the facilities have been properly tested and commissioned before use; and how well the facilities are operated and maintained. Among the different stages of a building life cycle, the operation stage accounts for the major portion of energy consumption (Ramesh et al., 2010; de Wilde et al., 2011). The long term costs of building operations also far outweigh the costs incurred during the design and construction stages of buildings (Evans et al., 1998). Yet little research work has been made to examine the relation between energy use and maintenance costs of hotels. Aimed at contributing knowledge to this techno-economic area, a study was carried out. After completing the preliminary work of the study (Lai, 2014), more comprehensive and meticulous analyses of its findings were made, as reported in the following.

The next section is a review of the past research works that are relevant to the study. Section 3 describes the premise based on which the study was formulated and the method used for data collection and analysis. Shown in Section 4 are the analyzed findings, which include the physical and operational characteristics of the hotels, comparisons of the findings between two classes (4-star, 5-star) of hotels covered in the study, benchmarking curves of their energy consumptions and maintenance costs, and relations among the hotels' characteristics, energy use and maintenance costs. The

* Corresponding author.

E-mail address: bejlai@polyu.edu.hk

final section consolidates the conclusions drawn from the study results and the future works needed.

2. Past relevant studies

Over the years, numerous studies have been carried out to study the energy use in buildings, including many focusing on hotel buildings. In studying the efficiency of hotels, some research (Barros, 2005; Neves and Lourenco, 2008) investigated parameters such as business performance (e.g. revenue, return on investment), management or administrative expenses (e.g. labour cost, front-of-the-house hours) associated with hotel operations. In view of the limited findings about operation and maintenance (O&M) costs of hotels, a benchmarking study was carried out on 10 luxury hotels (Lai and Yik, 2008) and it unveiled the considerable amounts of resources used for maintenance and the predominance of energy cost over other O&M cost elements.

Among the resources used in hotels, energy has attracted the greatest attention. In Hong Kong, a research team studied the energy use of 16 quality hotels and found that electricity consumption was dominant (Deng and Burnett, 2002). Another study (Bohdanowicz and Martinac, 2007), covering a sample of 184 Hilton International and Scandic hotels in Europe, investigated the utilizations of energy and water in the hotels. According to a survey of 29 quality hotels in Singapore (Rajagopalan et al., 2009), the average total energy use intensity of the hotels was 427 kWh/m² (1 kWh = 3.412 kBtu). A study in Taiwan (Wang, 2012), based on the data collected from 200 hotels, showed that on average electricity consumption accounted for 84% of their total energy use. Through 18 semi-structured interviews, a study team developed 32 energy conservation and carbon reduction indicators for the hotel industry (Teng et al., 2012).

In recent years, research probing into the maintenance performance of hotels has grown. A study (Lai and Yik, 2012a), conducted based on the computerized maintenance management data of a 618-room hotel, identified the existence of a significant correlation between equipment downtime and amount of maintenance work orders, and developed a range of performance curves for assessing maintenance performance of hotel engineering facilities. A further study (Lai, 2013) introduced a model enabling analysis of maintenance data according to the period, place, and physical installation ("3P") of maintenance works. The analyses carried out in that study showed that the maintenance works for the hotel were highly correlated with their demands but had little correlations with the manpower input.

The above studies have delved into either the energy use or the maintenance issues of buildings. Attention to activities throughout the operational phase of buildings, in particular maintenance and energy use for climate control, has increased (Blom et al., 2010). Research on relationship between energy use and maintenance cost of commercial buildings has emerged (Lai et al., 2008). A study in Hong Kong (Chan et al., 2003) was among the few that attempted to explore both the maintenance practices and energy performance of hotels. Performance-based models that can link built asset maintenance with the strategic performance of buildings, however, have yet to be developed (Jones and Sharp, 2007). Not long ago, three case studies covering a college district, a laboratory building and a medical center were completed (Lewis et al., 2011), which showed the existence of an interdependent link between energy use and maintenance management of the buildings. To date, analyses focusing on the empirical relation between energy use and maintenance costs of hotels remain unavailable. In order to contribute findings to this under-researched area and hence provide researchers and hospitality professionals with a better understanding of whether the energy use of hotels may be affected by the level of maintenance resources, the study as reported in this article was initiated.

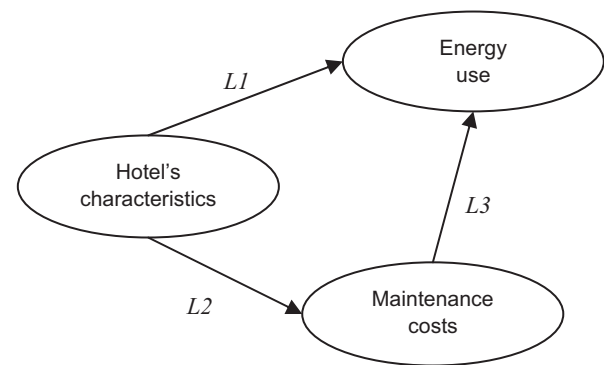


Fig. 1. Conceptual links among hotels' characteristics, energy use and maintenance costs.

3. Materials and methods

The premise based on which the study was formulated is that the level of energy use of buildings is subject to a variety of factors, including not only design and construction characteristics but also occupants' operation, behavior and maintenance factors (Chung et al., 2006). As such, factors associated with the physical and operational properties of hotel buildings as well as how well the buildings are maintained would affect the energy use of hotels. The first hypothesis of the study is that a bigger hotel would consume more energy, so when a hotel is occupied by more users, its energy consumption would be larger. This is represented by the link between the properties and energy use of a hotel, denoted as *L1*, in Fig. 1. The second hypothesis is that the resources needed for maintaining a bigger hotel, including maintenance works and manpower, would be more than that required for a smaller one. The link between such properties of a hotel and its maintenance costs is indicated as *L2*. The third hypothesis is the existence of a link between maintenance costs and energy use (i.e. *L3*). An example of such a relation is given a higher level of maintenance resources input for a hotel, it would allow more and better maintenance work to be carried out, enabling the energy-consuming facilities of the hotel to perform more efficiently, thus using less energy. Whereas energy use of hotels can be classified into different groups including the part due to the operation of engineering installations (e.g. air-conditioning system, lighting, lifts and escalators, etc.) and that for running amenities such as swimming pool, sauna and gym equipment, analyses covered by the study focus on total energy use and its main subdivided categories (i.e. electricity, gas and diesel oil).

On the basis of the above, the three objectives of the study were to identify the relations among: (i) characteristic parameters of hotels and their energy uses; (ii) the parameters and maintenance costs of hotels; and (iii) the maintenance costs and energy uses of hotels. An essential part of energy use of a hotel refers to the amounts of utilities consumed by the hotel. Costs for maintaining a hotel include those needed to hire maintenance staff, execute routine repair and maintenance work, and implement some capital projects (e.g. replacement of air-cooled chillers with energy efficient water-cooled chillers) to improve the conditions of the existing facilities. Such utilities and costs data are sensitive and, as experienced before, it is difficult to collect them from the data owners (Lai et al., 2008). Therefore individual face-to-face interviews with the hotels' representatives, which assure keeping the identities of their hotels and data owners confidential, were adopted to collect reliable data for the study. To facilitate the data collection process, a data template was devised. The types of data solicited include: grade of hotel (star rating); building age; gross floor area; number of guestrooms; annual average occupancy rate; annual costs of maintenance staff, repair and maintenance work,

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