



Using fuzzy multiple criteria decision making approaches for evaluating energy saving technologies and solutions in five star hotels: A new hierarchical framework



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ABSTRACT

The purpose of this study is to present a hierarchical framework for evaluating and ranking the important key energy-saving technologies and solutions in the 10 biggest Iranian hotels through integrating fuzzy set theory, as well as qualitative and quantitative approaches. The important key energy factors for the evaluation of energy saving technologies and solutions are gathered through a literature survey. This paper proposes a framework based on the fuzzy Delphi method, fuzzy multiple criteria decision-making, including fuzzy analytic hierarchy process and fuzzy techniques for order performance by similarity to ideal solution. In the fuzzy Delphi method step of the study, 17 key energy factors were selected from among a total of 40 energy factors and categorised into five groups. Fuzzy analytic hierarchy process was used for the ranking of 17 key energy factors, and fuzzy techniques for order performance by similarity to ideal solution employed for ranking of the 10 biggest Iranian hotels in different provinces. The results of this study revealed that the first rank of main groups was equipment efficiency (0.403), system efficiency (0.225) had the second rank, third rank was related to reduction of heating and cooling demands (0.151) and energy management (0.091) and renewable energy (0.083) had the fourth and fifth ranks respectively. In the ranking weights of 17 sub-groups of energy saving technologies and solutions, the results of fuzzy analytic hierarchy process showed that efficient solutions for active space cooling (0.662) was as first rank, building insulation had the second rank with score (0.541) and third rank was European Eco-label for tourist accommodation service (0.532).

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1. Introduction

The tourism industry has been one of profitable industries for developing economies in every nation; however, the emission of energy consumption is generally linked with this industry [1,2] and the growth of this industry over the years has created an increasing amount of stress on the environment. The negative effects of

tourism have been widely discussed since the development of tourism studies and continue to be debated from various perspectives up to the present. It is also generally accepted that the tourism industry is the one of the largest consumers of energy, mainly through the transportation of tourists and provision of amenities and supporting facilities at destinations [3]. Although households and businesses have long been the targets of eco-friendly and energy saving schemes and campaigns, the contribution made by the tourism industry to climate change has only recently been recognized by policy-makers and campaigners [4]. The tourism industry is one among many facets of the global business community which accounts for a significant portion of global carbon emissions, especially through aviation which is

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becoming an increasingly popular mode of transport among tourists [5]. Furthermore, several researchers have been studying hotels' environmental performance and energy use [6]. Most developing countries such as Iran are facing key challenges in attempting to meet the increasing energy requirements and, particularly, electricity needs. Energy using is a major cause of CO₂ emissions in the tourism industry and has thus attracted the interest of many scholars [7,8]. These scholars have focused not only on tourist behavior with regard to their travel choices, but also business practices toward saving-energy. Becken and Carboni [9], have conducted empirical investigations of energy use in tourism businesses. They demonstrate that all components of the tourism industry (accommodation, attraction/activity, transport, and others) tend to have good understandings of how much energy they use and how to monitor it.

There are several studies that indicate 20% and more energy savings can be brought by integrating energy conservation and energy-efficiency measures in hotel buildings [10]. In other studies, several reasons were highlighted for the high-energy usage and barriers to adopting energy-saving and renewable energy technologies in the hotel industry. Zografakis, Gillas [11], carried out a study in Crete hotels and indicated that age of building dictated the energy building code followed at the time of construction. Information gaps among hotel managers about available technologies and accessing programs was a prominent issue in developing countries such as Iran. Zografakis, Gillas [11], found that financial incentives and better awareness and information material are preferred means for better market penetration of these technologies, as suggested by hotel managers. Furthermore, Wahab [12] expresses the important of energy saving and implies that energy conversation and focus on renewable sources of energy should be home of choice in the developing countries and tourism industry which is considered as a prime user of energy should be involved in the issue and is expected to be sensitive to the changes in the area of energy.

In different countries, there are regulations to control energy consumption in different sectors of economy or the entire economy through applying energy-saving measures.

There are standards and incentives and punitive measures, defined by governments, which oblige manufacturers and users of appliances to saving energy for reducing of energy flow and control energy consumption levels. Given the high potential of energy saving in different economic sectors of the country, comprehensive energy related regulations would result in logical use of energy and increase value added. Hence, through planning and guiding different economic sectors this way, the future need for energy will partly be met through energy savings. While the energy saving improvements is necessary, but in Iran, there is lack of a plan regarding the improvement of the energy saving technologies programs and there is not sufficient strategy for addressing the energy saving problems in Iran. To attain the energy saving and efficiency need to improvements based on appropriate planning with a specific measures and timelines [15]. The building sector such as hotels is the biggest energy consumer worldwide. Nowadays, energy saving in the building sector is predominantly completed through cost- and energy-intensive measures, such as the use of insulation materials, renewable energy systems and new technologies and solutions. Nevertheless, for production of these technologies, a great amount of resources are consumed and a high amount of CO₂ is emitted [16]. From an economic point of view, the investment costs of such buildings are sometimes is high, that they are economically not viable for the national capital. However, available technologies and solutions measures must also be utilised for improving the energy performance of buildings such as hotels. Beside the general problems of energy saving through cost- and

energy-intensive methods, there are additional problems regarding energy saving through these cost-intensive measures especially for Iran. In addition; lack of standard related to energy saving building section such as hotels, lack of energy management for following the optimization of energy saving in buildings, lack of unsuitable and inadequate using of saving energy technologies in hotels buildings are the most important lacks for using energy saving technologies in Iranian hotels buildings. Therefore, management of technologies energy saving in hotels would be prepared with the purpose of emphasizing of the culture, behavior and knowledge of technologies for optimization of energy saving in hotels, awareness of managers with new technologies and solutions in energy management and encouraging novel approaches to reduce energy saving costs in hotels buildings.

The importance and necessity of energy saving has been discussed in Iran for many years. However, finding a clear logical solutions are still one of the challenges and concerns of Iran's economy. Rapid increase in energy consumption during the last two decades has endangered national energy security [17]. Energy saving in recent decades has increased extraordinarily and reducing energy use in buildings is a critical component of meeting carbon reduction commitments. There are several ways of accomplishing this goal, each of which emphasizes actions by a different set of stakeholders, therefore; for implementing the saving energy technologies, several measures must be consider, Energy technologies and solutions for hotels aim to enhance energy efficiency in hotels and their use of renewable energies in reaction to the challenge of climate change. Hotel energy solutions link the gap between available renewable energy and energy efficiency technologies and their genuine use in tourist industry hotels and accommodation types.

For showing the significant role of energy saving technologies and solutions (ESTS's) in hotels, an extensive search was carried out in relevance literature, covering several previous reports and papers on hotels and their use of energy saving technologies and solutions. It was found that while a number of papers examined overall energy use in hotels, but the use of energy saving technologies and solutions in developing countries such as Iran which are facing with challenges to meet the increasing energy requirements, particularly, electricity needs is limited and new study is required to overcome this limitation for achieving further improvement in saving energy through the comprehensive technologies and solutions in hotels. In addition, we found that, while several of published papers analyzed and investigate the overall energy saving in hotels, but few of these previous papers have addressed the employ of specific measures for performance improvements in hotels energy saving. For example; Beccali, Cellura [13], emphasised producing renewable energy diffusion strategies through the application of the fuzzy set theory and by employing the Elimination Et Choix Traduisant la REalité (ELECTRE) methods family. Xiaohua and Zhenmin [14], presented the index system for evaluating the sustainable growth of rural energy and by using the analytic hierarchy process (AHP). Hence; in light of all the above mentioned problems regarding saving energy technologies and solutions in Iran, there is lack regarding the saving energy technologies and solutions in hotels buildings, therefore; this study, attempted to identify, evaluate the important saving energy technologies and solutions measures in building sector such as hotels by proposing the new hierarchical framework and fuzzy multiple criteria decision making approaches. To achieve this goal, we performed extensive literature searching in various saving energy reports, papers, books and newspapers for finding the important technologies and solutions in hotels buildings.

The energy consumption of hotels depends on many

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