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Carbon dioxide emissions generated by energy consumption of hotels and homestay facilities in Taiwan

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HIGHLIGHTS

- CO_2 emission values were calculated and analyzed for several hotel types in Taiwan.
- Hotels with higher service levels can be characterized with higher CO_2 emissions per person-night.
- Strategies involving tourist decision making and hotel management would be able to mitigate CO_2 emissions in great extent.

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ABSTRACT

In the field of the tourism, hotels and homestay facilities account for considerable amounts of energy consumption and CO_2 emissions. This study presents an investigation conducted on the CO_2 emissions from four types of hotel in Taiwan. According to the results, the average CO_2 emissions of international tourist hotels, standard tourist hotels, general hotels, and homestay facilities are 28.9, 19.2, 12.5, and 6.3 kg-CO_2/person-night, respectively. Hotels with higher service levels produce higher average CO_2 emissions per person-night. Analytical results indicate that increasing stays at hotels with low CO_2 emissions (such as homestay facilities and general hotels), accommodating more guests together per room, and enhancing energy usage efficiency, can effectively reduce hotel CO_2 emissions without reducing the total number of guests. The results of this study may be applied to CO_2 reduction programmes for tourists, hotel enterprises, and contribute toward the formulation of government policy in Taiwan.

1. Introduction

CO_2 is emitted generally by the direct use of fossil fuels and indirectly by electricity consumption in the tourism sector. Numerous previous studies have calculated and discussed the energy consumption, including CO_2 emissions, of tourism taking into account the transportation, accommodation, and activities of tourists. Due to the rapidly rising number of tourists, the impact of the tourism industry on the climate cannot be ignored (Becken, Simmons, & Frampton, 2003; Gössling et al., 2005; Tabatchnaia-Tamirisa, Loke, Leung, & Tucker, 1997) since it is now a major global environmental issue which faces all governments.

Tourist transportation is a major contributor to environmental pollution associated with the transportation mode and distances traveled during a journey, the consumption of fossil fuels and generation of CO_2 emissions. In Taiwanese National Park tourist transportation, Lin (2010) indicated that the transportation modes chosen by tourists directly influence CO_2 emissions. In hotels, air conditioning and lighting mean direct and indirect energy consumption; thus, CO_2 emission volume can be calculated accordingly. Previous studies indicated that the energy consumption of hotels in Taiwan is related to the floor area, number of guest rooms, occupancy rate, building construction year, and the departure place of tourists (Wang, 2012; Wang & Huang, 2013). In addition, the consumption of electricity and fossil fuels is affected by the various activities carried out at the tourist sites, such as boat trips, jet-skiing, and city tours, as well as visiting museums and eating in restaurants.

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Accommodation supply and demand is essential for the tourism industry. For trips requiring an overnight stay accommodation is required. Investigation of hotel energy usage and CO_2 emissions is crucial because tourists are extremely autonomous in the selection of accommodation with various facilities and levels of services. Numerous studies have indicated that the energy usage of hotels differs from that of other industries and have demonstrated that hotels are among the highest energy consumption building types (Beccali, La Gennusa, Lo Coco, & Rizzo, 2009; Erdogan & Baris, 2007; Rahman, Reynolds, & Svaren, 2012; Rossello-Batle, Moia, Cladera, & Martinez, 2010; Taylor, Peacock, Banfill, & Shao, 2010; Teng, Horng, Hu, Chien, & Shen, 2012; Warnken, Bradley, & Guilding, 2005).

Previous studies that assessed the energy consumption intensity of hotels generally adopted one of the two following approaches. The first is from the building perspective, probing energy utilization in various building and air conditioning designs. Most of these studies have used energy use intensity (EUI) in kWh/(m^2-year) to represent the annual energy consumption for a unit floor area. Higher values indicate higher building energy usage. Numerous global studies have discussed EUI for various types of building (Deng & Burnett, 2000; Priyadarsini, Xuchao, & Eang, 2009; Xin, Lu, Zhu, & Wu, 2012). Wang (2012) showed that the EUI for standard tourist hotels in Taiwan was 186.3 kWh/(m^2-year), whereas the EUI for international tourist hotels was 280.1 kWh/(m^2-year). Most studies have indicated that those hotels that offer higher service quality use more energy. For example, international tourist hotels consume more energy than general hotels, and five-star hotels expend substantially higher energy than homestay facilities.

The second approach assessed hotel energy consumption or CO_2 emissions by considering the number of tourists in megajoule (MJ) per person-night or kg-CO_2/person-night to reflect the average energy consumed by one person during one night at a hotel. Becken, Frampton, and Simmons (2001) indicated that the CO_2 emissions of a hotel were as high as 155 MJ per visitor per night. Lower-level accommodation such as a youth hostel had considerably lower values: 39 MJ per visitor per night. This indicates that the potential CO_2 emissions are greater for higher-level hotels. Gössling (2002) and Warnken et al. (2005) also stated that energy use per person per night is higher in hotels with higher service quality and greater consumption.

Regarding the data collection of previous studies that focused on the CO_2 emissions of hotels per person per night, several types of energy usage were not considered thoroughly because of the complex usage or difficulties with the electrical meter separation. In addition, the previous results were generally limited to representing the average values, while the hotel types, occupancy rate, and staying habits of the tourists were usually ignored. Assessments of overall CO_2 emissions in different scenarios were not mentioned in the reports of such studies.

The government of Taiwan keeps inventories on greenhouse gas emissions in the field of the energy industry, manufacturing and transportation, while the inventories miss the hotel industry. This regrettable lack of information about the energy consumption and CO_2 emissions of accommodation makes it impossible to make comparisons with other domestic industries in Taiwan or with hotel industries in other countries. The Master Plan of Energy Conservation and Carbon Mitigation (Council for Economic Planning and Development, 2010) aims to reduce the national CO_2 emissions in 2020 to the level of 244 million tons (as it was in 2005) and in 2025 to the level of 208 million tons (as it was in 2000), as well as to decrease the energy intensity by at least 20% in 2025 compared with the level in 2005. However, the goal of energy conservation and CO_2 emission mitigation in the hotel industry is not included in the master plan. Therefore, it is important and urgent for Taiwan to have a comprehensive CO_2 emission database for the hotel industry.

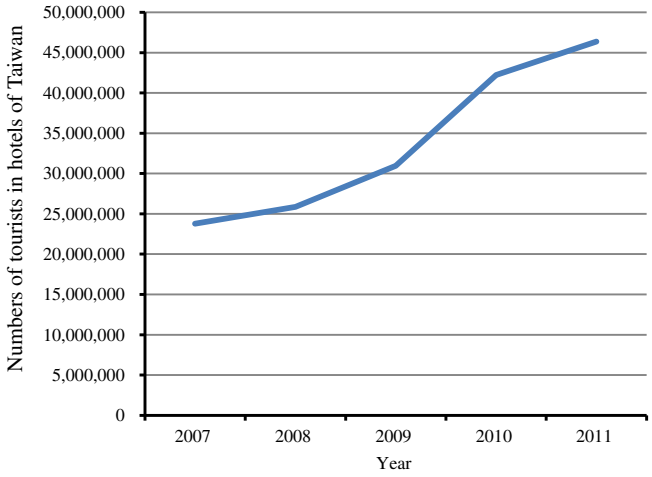

Fig. 1. Number of tourists stayed in hotels of Taiwan from 2007 to 2011.

Local CO_2 emissions per person per night in the hotels of Taiwan remain a neglected field of study including the analysis and inventory of the CO_2 emissions in the tourism accommodation sector. Therefore, this study focuses on the CO_2 emissions of various types of hotel in Taiwan to help tourists, hotel enterprises, and governmental authorities to understand the average energy consumption and CO_2 emissions in the accommodation industry. Thus, the results could serve as references for tourist choices, hotel enterprise improvements, and for governments to develop and monitor standards.

Currently approximately 45 million people stay at hotels each year in Taiwan (Tourism Bureau, 2011), and the number of tourists has been rising over the past five years (Figure 1). The innovation of this study lies in adopting a detailed (microscopic) view to investigate average CO_2 emissions at hotels from the user perspective. We also adopted a coarser (macroscopic) view to analyze the CO_2 emissions of hotels in the entire country and performed dedicated scenario simulations. The main contributions of this paper are to clarify the suggestions regarding the state of Taiwanese hotels, as well as the essential measures that are undertaken to reduce CO_2 emissions in the hotel industry in Taiwan.

2. Methods

2.1. Hotel classification

This section defines firstly the types of Taiwanese hotels as a reference for subsequent classification adopted in this study. As defined by Taiwan's Tourism Development Act, tourist accommodation can be divided into four main types: international tourist hotels, standard tourist hotels, general hotels, and homestay facilities. International and standard tourist hotels have at least 300 rooms and provide a higher level of services. As basic facility demands, they have a hall, reception areas, and elevators, as well as air conditioning in rooms and public spaces. These properties also provide additional spaces with specific functions, such as a restaurant, café, and conference hall. The criteria for hotel space requirements and facilities are higher in international tourist hotels than in standard tourist hotels. For example, international tourist hotels have to include bars, ballrooms, gymnasiums, and shops. In addition, the required net area of each room (not including washrooms) of international tourist hotels is approximately 25% higher than that of standard tourist hotels. The criteria for general hotels