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Carbon footprints of hotels: Analysis of three archetypes in Hong Kong

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ABSTRACT

The need of curbing greenhouse gas (GHG) emissions, especially those arising from operations in existing buildings, has been well recognized. Incessant hotel operations, in particular, result in significant GHG emissions. Given the limited in-depth findings about the emissions from hotels of different classes, a study was conducted to probe into the carbon footprints of three typical hotels in Hong Kong. Through face-to-face meetings, detailed and reliable data under scopes 1–3 of the GHG Protocol were collected for analysis. The emission levels, when normalized by number of guestrooms, were different from those normalized by floor area. Use of purchased electricity was the dominant contributor to the emissions; emissions from use of portable liquefied petroleum gas and emergency operation of power generator were negligible. Reference levels of emissions due to staff daily travels were determined. The hotels' emissions bore a strongly positive correlation with outdoor air temperature rather than occupancy rate. Regression models that can estimate the hotels' emissions with changes in outdoor temperature were developed. Recommendations were made to tackle the problems with recording the necessary data and mitigate the emissions from the hotels. Wider adoption of the methodology of this study can establish carbon emission benchmarks, which are essential for monitoring and optimizing the carbon footprints of hotels.

1. Introduction

Resources utilization during the long operational stage of buildings gives rise to enormous greenhouse gas (GHG) emissions, which are central to the global warming problem. To tackle this problem for attaining a sustainable built environment, it is essential to assess the environmental performance of buildings (Dakwale, Ralegaonkara, & Mandavganec, 2011), especially the huge volume of existing buildings.

Recognizing the need of monitoring GHG emissions, there has been a growing trend of enforcing mandatory schemes on reporting of GHG emissions (Lai, 2013). Examples around the world include: GHG Emission Reporting Scheme in Canada, Mandatory GHG Accounting and Reporting System in Japan, National Greenhouse and Energy Reporting Scheme in Australia, and Mandatory Reporting GHG Rule in the USA (Kauffmann, Less, & Teichmann, 2012).

In other places such as Hong Kong, however, reporting of GHG emissions remains voluntary. The first set of guidelines on quantification of carbon emissions from buildings was launched in 2008 (Environmental Protection Department & Electrical and Mechanical Services Department, 2008) and implementation of carbon audits has not been common. But according to the latest available statistics (Environmental Protection Department, 2012), the total GHG emissions in Hong Kong amounted to 42,900 kt CO_2-e in year 2009, or 6.1 t per capita, representing a significant increase of 22% from the level of year 1999 (5.0 t per capita).

Given the round-the-clock operations of hotels, their resources consumptions are intensive and so are their GHG emissions. Studies on this area have grown in recent years. For instance, Taylor, Peacock, Banfill, & Shao (2010) used computer simulations to study the feasibility of reducing the emissions from hotels in the UK. In a benchmarking study in Singapore (Wu, Rajagopalan, & Lee, 2010), surveyed data of some hotels were analyzed to determine their emission levels. Earlier in Hong Kong, a case study was conducted to audit the emissions from a hotel (Lai, Yik, & Man, 2012). But research that analyses and compares the emissions from different classes of hotels is yet to be seen. Therefore, a research project was carried out to probe into the GHG emissions from hotels of three different grades and analyze their carbon footprints in a comparative manner.

In the next section, the scope of the study, the process of data collection, and the types of data collected are described. Then, analyses of the data, which reveal the characteristics of the hotels and the comparative findings about their emission levels, are reported. Based on the data collection experience and the analyzed findings,

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Notation

$A_{(E)t}$	amount (kWh) of electricity used in the tth period
$A_{f,t}$	amount (l) of the fth type of fuel used in the tth period
$A_{(G)t}$	amount (unit; 1 unit = 48 MJ) of gas used in the tth period
$A_{p[a]}$	amount (kg) of the pth type of paper added to the inventory during the reporting period
$A_{p[e]}$	inventory (kg) of the pth type of paper at the end of the reporting period (in storage)
$A_{p[r]}$	amount (kg) of the pth type of paper collected for recycling during the reporting period
$A_{p[s]}$	inventory (kg) of the pth type of paper at the beginning of the reporting period (in storage)
$A_{r[a]}$	amount (kg) of the rth type of refrigerant added to the inventory during the reporting period
$A_{r[d]}$	amount (kg) of the rth type of refrigerant disposed of through environmentally responsible means during the reporting period
$A_{r[e]}$	inventory (kg) of the rth type of refrigerant at the end of the reporting period (in storage, not equipment)
$A_{r[s]}$	inventory (kg) of the rth type of refrigerant at the beginning of the reporting period (in storage, not equipment)
$A_{(W)t}$	amount (m^3) of fresh water used in the tth period
C_a	activity-dependent factor (0.7 for restaurants and catering services; 1.0 for other commercial, residential and institutional purposes)
$C_{s,tr}$	cost paid by the sth staff for taking the trth type of transportation
$D_{s,fl}$	flight travel distance of the sth staff
$D_{s,tr}$	travel distance of the sth staff taking the trth type of transportation
$E^C_{CH_4}$	CH_4 emission (kg) due to stationary or mobile sources of fuel combustions
$E^P_{CH_4}$	CH_4 emission (kg) due to use of paper
$E^C_{CO_2}$	CO_2 emission (kg) due to stationary or mobile sources of fuel combustions
$E^E_{CO_2}$	CO_2 emission (kg) due to use of purchased electricity
$E^{fl}_{CO_2}$	CO_2 emission (kg) due to flights taken by staff
$E^G_{CO_2}$	CO_2 emission (kg) due to use of purchased gas
$E^S_{CO_2}$	CO_2 emission (kg) due to processing of sewage
$E^{tr}_{CO_2}$	CO_2 emission (kg) due to transportation taken by staff
$E^W_{CO_2}$	CO_2 emission (kg) due to use of fresh water
E^R_{HFC}	HFC emission (kg) due to uncontrolled release of refrigerants
$E^C_{N_2O}$	N_2O emission (kg) due to stationary or mobile sources of fuel combustions
E^R_{PFC}	PFC emission (kg) due to uncontrolled release of refrigerants
$E^R_{SF_6}$	SF_6 emission (kg) due to uncontrolled release of refrigerants
$F_{B/E}$	business–economic factor of flight class (economy: 0.9; business: 1.4)
$F_{(CH_4)f}$	emission factor of CH_4 for the fth type of fuel
$F_{(CO_2)f}$	emission factor of CO_2 for the fth type of fuel
$F_{D\|(W)t}$	default emission factor (kg/m^3) of electricity consumed associated with the amount of sewage processed in the tth period
$F_{(E)t}$	emission factor of electricity used in the tth period (specific for individual power companies)
F_{fl}	emission factor of flight (short haul: 0.15; medium haul: 0.12; long haul: 0.11)
$F_{(G)t}$	emission factor (kg/unit) of gas used in the tth period
$F_{(N_2O)f}$	emission factor of N_2O for the fth type of fuel
F_p	emission factor of the pth type of paper
$F_{(S)t}$	emission factor ($kgCO_2$-e/kWh) of electricity consumed associated with the amount of sewage processed in the tth period
$F_{tr\|C}$	emission factor (based on cost) of the trth type of transportation
$F_{tr\|D}$	emission factor (based on travel distance) of the trth type of transportation
$F_{(W)t}$	emission factor (kg CO_2-e/m^3) of electricity consumed associated with the amount of water used in the tth period
f	1, 2, . . ., F (assigned to the fth type of fuel; F = total number of fuel types)
$G_{(CH_4)}$	global warming potential of CH_4
$G_{(N_2O)}$	global warming potential of N_2O
G_r	global warming potential of the rth type of refrigerant
N	net number of additional trees (at 5 m in height)
R	removal factor of tree (23 kg/tree/per year)
R_{CO_2}	removal of carbon emission (kg)
r	1, 2, . . ., R (assigned to the rth type of refrigerant; R = total number of refrigerant types)
s	1, 2, . . ., S (assigned to the sth staff; S = total number of staff)
T	length of reporting period (years)
t	1, 2, . . ., T (assigned to the tth period; T = total number of time periods)

recommendations that can minimize the carbon emissions from the hotels are made. Finally, the conclusions drawn from the study and the further works needed are given.

2. Scope and data collection

To start with, it is vital to define the boundary of carbon footprint the study covered (Matthews, Hendrickson, & Weber, 2008). With reference to the GHG Protocol (World Resources Institute & World Business Council for Sustainable Development, 2004) and the International Standard on Greenhouse Gases (ISO 14064-1), the Environmental Protection Department and the Electrical and Mechanical Services Department of the Hong Kong government jointly formulated a guidance document to facilitate accounting for GHG emissions/removals from buildings. Following the latest version of such document (Environmental Protection Department & Electrical and Mechanical Services Department, 2010), the scopes of emissions studied, namely direct emissions/removals (scope 1), energy indirect emissions (scope 2), and other indirect emissions (scope 3), are listed in Table 1.

Prior to data collection, the study team convened a briefing during which the purpose, scope, work plan, and expected outcome of the study were outlined. Afterwards, the study team visited the hotels, walked through their key and typical areas, and met with the hotels' representatives. After the representatives briefed about the operations of their hotels, the study team explained to them the contents of two electronic templates that were tailored for collecting the required data.

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