Evaluation and willingness to pay of greenhouse gas emissions for leisure buildings: a case hotel

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***Abstract*—**According to the IPCC WGII Fourth Assessment Report, more than 89% of observational data series and studies are consistent with the greenhouse gas change, which is produced from human activities, as a response to global warming. In the previous point, the tourism and leisure industry is regarding as the non-smokestack industry. However, with an increase of leisure and tourism activities, the carbon dioxide emission and energy use have been growing. Recognizing these risks, the Agenda 21 for the Tourism and Travel Industry promulgated by the World Travel and Tourism Council, the WTO and the Earth Council addressed energy consumption as a key issue of concern. The buildings are a major part of the leisure industry. Therefore, this work aims to investigate the energy use and carbon emission of a hotel building, located in the middle of Taiwan, for four seasons. The consumption generated from each visitor activating in the building also were conducted. The results will be used as a reference for further investigations into the reduction of energy use and carbon emission in the leisure buildings. By investigation of proposed carbon neutral model, the willing price to pay is highly larger than both of the shifted and non-shifted prices. Most people has always inclined to pay for self-related GHG emission. Green development and sustainable operations in the leisure industry should be attended because the real costs of a green building are less than you think.

***Keywords*—**Greenhouse gas, Leisure industry, Tourism, Energy consumption.

I. Introduction

NOWADAYS, global warming is one of the most important issues all over the world. Most of the developed countries and mega cities have already established their reduction policy/strategy for greenhouse gas (GHG). A considerable amount of GHG emission in Taiwan is high (1% of the world GHG emission). Although Taiwan is not a member of Kyoto Protocol, two National Energy Meetings had already been held in 1998 and 2004. Some main cities of Taiwan, such as Taipei, Kaohsiung, Taichung, have involved in the international GHG reduction league.

According IPCC WGII Fourth Assessment Report (2007), more than 89% of observational data series and studies are consistent with the change of greenhouse gas, which is produced from human activities, as a response to global warming [1]. The report also indicted that the warming rate for the past 25 years is 2.8 times more than that of the past 100 years. For facing the problems of global warming and GHG reduction, the most of governments and businesses worked hard on GHG reduction. More and more businesses developed green products, and did the reduction willing of GHG and tree planting for the sink. Taiwan Environmental Protection Administration (2007) applied the water saving, energy saving, green product using, and waste reduction to be the evaluating guideline of green hotel. It's an honor to be an environment-friendly hotel proprietor [1].

In the previous point, the tourism was regarding as the "non-smokestack industry". However, with technology and tourism industry increasing, the carbon dioxide emission and energy use from the tourism activities were growing. Recognizing these risks, the Agenda 21 for the Tourism and Travel Industry promulgated by the World Travel and Tourism Council, the WTO and the Earth Council addressed energy consumption as a key focus area. The hotel is part of the tourism industries. Due to the hotel is a public place with high-energy uses and resource density, to comprehend the GHG emission amounts of the hotel will have a positive efficiency on establish an energy saving standard of hotel in Taiwan. Thus, this study quantified the GHG emission levels of a case hotel, and analyzed its GHG emission level and GHG emission level per person. Therefore, the aim of this work is to establish GHG-emission calculation method of hotel business. Further, an international business hotel was applied as a case hotel for analyzing the GHG emission levels per person. These data is useful for calculating the willingness to pay for GHG emission.

II. Experimental Methods

A. Case Hotel

This work selected a commercial hotel, which is a seven-storey building and has 77 guest rooms in the middle of Taiwan, as a case hotel. The case hotel provides various tourist services, including relaxing rooms, a banquet room, two restaurants, a sport club, and several shops. Its gross floor area is 3872 m^2. Standard room area is from 21 to 39 m^2. The number of workers is 26. Hotel age is 6 years old.

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B. GHG Emission Level of the Case Hotel

This work applied the calculating method from the Greenhouse Gas Protocol to evaluate the GHG Emission Amount of the Case Hotel. The GHG emission calculating range of the case hotel is based on their whole business license. The direct and indirect emissions of the GHG were both calculated. The calculating method was taken all GHG emission's emission coefficient. The calculation process is shown below:

1. select a case hotel,
2. identify the emission sources,
3. collect the data of activities,
4. calculate the GHG emission levels,
5. evaluate the GHG emission level per person.

The emission coefficients of fuels from the IPCC report (2006) [2] were applied in this work and shown in Table 1. The carbon converting rates of gas phase, liquid phase, and solid phase were regarded as one.

The GHG emission from the HFCs emission of the air-conditioning apparatus was calculated by their emission coefficients shown in Table 2. The emission coefficient of electricity using is about 0.637 kg CO_2 e/kg shown from Taiwan Industrial Development Bureau. The emission coefficient of septic tank is about 3.825 kg CH_4/person-year illustrated from Taiwan Environmental Protection Administration.

The global warming potential (GWP) of GHG from the IPCC report (2001) was first using for calculating the CO_2 equivalent of all GHG [3]. The data from Taiwan Industrial Development Bureau was applied for calculating the CO_2 equivalent of all GHG. Table 3 plots the GWP of CH_4, N_2O, R22, R507, and R134 [4].

TABLE I
EMISSION COEFFICIENTS OF FUELS

Item	CO_2 emission coef. ($kgCO_2/kg$)	CH_4 emission coef. ($kg\ CH_4/kg$)	N_2O emission coef. ($kg\ N_2O\ /kg$)
Natural gas	2.09	3.73 E-05	3.73 E-06
Diesel oil	2.7	1.84 E-04	2.21 E-05

TABLE II
EMISSION COEFFICIENTS OF AIR-CONDITIONING APPARATUS

Item	Emission Coef.(%)
Manufactured air-conditioning	3
Manufactured refrigeration apparatus	5.5

TABLE III
GWP VALUE

Items	GWP Value	Reference
CH_4	23	IPCC 2001
N_2O	296	IPCC 2001
R11	4,400	Industrial Development Bureau, Ministry of Economic Affairs, Taiwan, ROC
R507	1,300	Industrial Development Bureau, Ministry of Economic Affairs, Taiwan, ROC
R134a	1,300	IPCC 2001

III. Results and Disscussions

A. Direct GHG emission

The direct GHG emission sources of the case hotel includes, fuel gas, boiler, air-conditioning, and septic tank. According to the calculation method, the direct GHG emission is about 59.13 ton CO_2e/year. The major source is the fuel oil for boiler burning. The result is similar to previous studies. Heating in UK hotels was responsible for 65% emissions of total mean CO_2e/year [5]. Diesel used in Singapore's hotels was the major energy source, with a proportion of 77% for total fuel consumption, including gas and diesel [6]. Boiler heating was significant to total energy consumption in the hotel industry of Thailand [7].

B. Indirect GHG emission

The indirect GHG emission source of the case hotel is only electricity use. According to the above calculating methods, the indirect GHG emission is about 224.41 ton CO_2e/year.

Combining the direct and indirect GHG emissions, the total GHG emission of the case hotel is about 283.54 ton CO_2e/year. The indirect GHG emission is obviously larger than the direct one. Energy use of a hotel is divided into electricity, heating/cooling and transportation fuels. Electricity for heaters, lighting, refrigerators and coolers, and escalators, is a dominant energy form in hotels. In comparison of GHG contributing from various sources, the major source is the indirect emission from electricity use, and the secondary source is the fuel oil for boiler burning. According to our calculations, the GHG emission contribution from CO_2 is 80.5%, from CH_4 is 19.5%, and from N_2O is near zero%.

C. GHG emission levels per person in the hotel

This work identified the denominator of the GHG emission levels per person in this case hotel is the number of the staff and housing tourists per day. According to the above calculating methods, the GHG emission level per person in the case hotel is about 5.18 kg CO_2e/day, which is lower than the GHG emission mean level per person of Taiwan (31.95 kg CO_2e/day).

This case hotel is a commercial hotel. People in this hotel not only included staff and housing tourists, but also contained the tourists form restaurant and sport club. Therefore, it is probability that when we only consider the staff and housing tourists to calculate the GHG emission levels per person, the value of GHG emission levels per person would be over evaluated.

D. Carbon neutral model

A relationship between the willing price (Y) paid by the common people and personal parameters was established. The parameters include sex (*Sex*), age (*Age*), marriage (*Mar*), income (*Inc*), education ($Edu_{1—4}$), occupation ($Ocu_{1—5}$), and residence (*Cou*). The parameter of μ is a residual. The β parameters are statistically measurable.

$$Y_i^t = \alpha + \beta_1 Sex + \beta_2 Age + \beta_3 Mar + \beta_4 Edu_1 + \beta_5 Edu_2 + \beta_6 Edu_3 + \beta_7 Edu_4 + \beta_8 Ocu_1 + \beta_9 Ocu_2 + \beta_{10} Ocu_3 + \beta_{11} Ocu_4 + \beta_{12} Ocu_5 + \beta_{13} Inc + \beta_{14} Cou + \mu_i. \quad (1)$$

For a questionnaire survey, the Cronbach's Alpha value is

larger than 0.735. The overall reliability is good. The validity value is 0.854. The tourist conditions are below. Sexual proportion is for male 48.4% and female 51.6%. The age ranged from 21 to 30 is in the majority (40.7%). Unmarried state accounts for 61.7%. The popular level of education is the recognized college degree (71.4%). Labor and business are in the majority (29.3%). A monthly salary is below €530 (24.9%), €530-1050 (26.2%), €1050-1580 (24.2%), and > €1580 (24.7%), respectively. Residence area is in the north, middle, south, and east of Taiwan for 24.9, 24.7, 25.4 and 24.9%, respectively. Distribution of the sample mean was achieved.

The carbon price is presented by € per person. If GHG emissions from the staffs are transferred to the GHG emissions of tourists in the hotel, the carbon price is shifted. According to the carbon price provided by Point Carbon Co. [8], the shifted and non-shifted carbon prices are €0.081 and 0.034 per person, respectively, for the business case hotel. The shifted price is about twice as large as the non-shifted price. By investigation of the carbon neutral model, the price of willingness to pay is about €2.87 per person for the common people. The willing price to pay is highly larger than both of the shifted and non-shifted prices. The result implies that most people has always inclined to pay for self-related GHG emission. Hotel developers and managers should attend to green development and sustainable operations in the leisure industry because the real costs of a green building are less than you think.

TABLE IV
EVALUATED CARBON PRICE

Items	Price (€)
Shifted carbon	0.081
Non-shifted carbon	0.034
Willingness to pay	2.870

IV. Conclusions

The conclusions of this work were presented below.

1. This work has established a GHG-emission calculation method of a hotel building. The calculating process demonstrated below: to identify the emission sources, to collect the activity data, to calculate the GHG emission amount, and to calculate the GHG emission levels of each person.
2. The GHG emission of one year of the case hotel is about 283.54 ton CO_2e/year.
3. The GHG emission level per person of the case hotel is about 5.18 kg CO_2e/day.
4. The major source of GHG emissions from the international business hotel is electricity use. It means that the biggest reduction capability of whole GHG emissions is electrical energy saving.
5. The carbon neutral model coupled with a questionnaire survey evaluated the willing price to pay for GHG emissions from accommodations of tourists. The willingness to pay is high because its price is larger than both of the shifted and non-shifted carbon prices.

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